CITY OF TUCSON

AND

PIMA COUNTY

STANDARD SPECIFICATIONS FOR PUBLIC IMPROVEMENTS

- 2003 -

In Memory of Steve Mellum

The 2003 edition of the City of Tucson/Pima County Standard Specifications and Standard Details for Public Improvement is dedicated to the memory of Steve Mellum.

Steve had the distinction of being one of only two individuals to have been a member of the Review Committee for the creation of the original edition of the City of Tucson/Pima County Standard Specifications and Standard Details for Public Improvements in 1988, as well as the 1994 edition, and this current 2003 edition. Steve's extensive construction experience and knowledge of the industry together with his passion and dry wit added significantly to the success and value of each of these publications.

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ABBREVIATIONS AND TERMS

101-1 GENERAL

Titles and headings are for convenience of reference and have no bearing on the interpretation of these specifications.

When a publication is specified, it refers to the most recent date of issue, including interim publications, before the date of advertisement for the Project, unless a specific date or year of issue is provided.

In the contract, the words "or equal", referring to a product, material, or process, mean "equal as determined by the Agency".

In the contract, the words "as indicated" or "indicated" mean "as indicated or indicated on the project plans".

101-2 ABBREVIATIONS

Wherever the following abbreviations are used in these Specifications, on the project plans or on the Standard Details, they are to be construed the same as the respective expressions represented:

AAA	Aluminum Alloy Association
AAMA	Architectural Aluminum Manufacturer's Association
AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
AEC	Arizona Electric Code
AGA	American Gas Association
AGC	Associated General Contractors of America
AIA	American Institute of Architects
AIEE	American Institute of Electrical Engineers
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ALS	American Lumber Standards
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute, Inc.

APA	American Plywood Association
APHA	American Public Health Association
ARA	American Railway Association
AREA	American Railway Engineering Association
ARS	Arizona Revised Statutes
ARTBA	American Road and Transportation Builders Association
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASHVE	American Society of Heating and Ventilating Engineers
ASLA	American Society of Landscape Architects
ASLD	Arizona State Land Department
ASME	American Society of Mechanical Engineers
ASRE	American Society of Refrigerating Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers' Association
AWPI	American Wood Preservers' Institute
AWS	American Welding Society
AWWA	American Water Works Association
AZI	American Zinc Institute
CFR	Code of Federal Regulations
CISPI	Cast Iron Soil Pipe Institute
CPI	Clay Pipe Institute
CRA	California Redwood Association
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standards
DBE	Disadvantaged Business Enterprise
EIA	Electronic Industries Association
FCC	Federal Communications Commission
Fed Spec	Federal Specifications (See FSS)
FGJA	Flat Glass Jobber's Association
FHWA	Federal Highway Administration
FM	Factory Mutual

FSS	Federal Specifications and Standards, General Services Administration
IAL	Independent Approved Laboratory
IAPMO	International Association of Plumbing and Mechanical Officials
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
IPCEA	Insulated Power Cable Engineer's Association
IRI	Industrial Risk Insurers
ISA	Instrument Society of America
ITE	Institute of Transportation Engineers
MUTCD	Manual on Uniform Traffic Control Devices
NAAMM	National Association of Architectural Metal Manufacturers
NBFU	National Board of Fire Underwriters'
NBS	National Bureau of Standards
NCMA	National Concrete Masonry Association
NCPI	National Clay Pipe Institute
NCPRC	National Clay Pipe Research Corporation
NESC	National Electrical Safety Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NIST	National Institute for Standards and Technology (U.S. Department of Commerce)
NLMA	National Lumber Manufacturer's Association
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association
PLP	Plastic Laminate Producers
PS	Product Standard, Product Standard Section U.S. Department of Commerce
PUESR	Pacific Utilities Electrical Service Requirements
RMA	Radio Manufacturer's Association
SAE	Society of Automotive Engineers
SHA	State Highway Agency
SSPC	Steel Structures Painting Council
SWPPP	Stormwater Pollution Prevention Plan

TCA	Tile Council of America
UBC	Uniform Building Code
UL	Underwriters' Laboratories, Inc.
UPC	Uniform Plumbing Code
USS	United States Standard
WCLA	West Coast Lumberman's Association
WCLIB	West Coast Lumber Inspection Bureau
WIA	Woodwork Institute of Arizona
WWPA	Western Wood Products Association

101-3 TERMS

Whenever in these specifications or in other contract documents the following terms are used, the intent and meaning shall be interpreted as follows:

Acceptance - Activities performed by the Agency or its designated representative to determine the quality and acceptability of the materials and workmanship incorporated into the project.

Addendum - A revision to the Contract Documents made available to Bidders after advertisement of, but prior to the opening of, bids for a contract.

Advertisement for Bids - The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

Agency - The governmental body for whom the construction is being done, either by permit or contract.

Aggregate - Inert material such as sand, gravel, broken stone, crushed stone or a combination thereof.

Amendment - Refer to "Addendum".

As-Built Plans - Plans annotated by the contractor or Engineer and kept current with the progress of the work which clearly show the work constructed and any variations from the "as-bid" plans.

Award - The acceptance by the Agency of a bid to do work or furnish materials.

Backfill - Material placed in an excavated space to fill such space.

Bedding - Material placed in the area of an excavated trench from the bottom to the springline of the pipe or conduit.

Bid - The offer of a bidder, on the prescribed form, to perform the work and to furnish the labor and materials at the prices quoted.

Bid Bond - The security furnished with a bid to guarantee that the bidder shall enter into the contract if the bid is accepted.

Bidder - An individual, partnership, firm, corporation, or any acceptable combination thereof, or joint venture submitting a bid.

Bid Document - The document which describes the construction and its location, the quantities and kinds of work to be performed or materials to be furnished, a schedule of items for which unit bid prices are invited, and any SPECIAL PROVISIONS or requirements which vary from or are not included in the STANDARD SPECIFICATIONS.

Bid Form - The approved form on which the Agency requires bids to be prepared and submitted for the work, commonly called the bidding schedule.

Bidding Schedule - The prepared schedule, included as a part of the bid document, containing the estimated quantities of the pay items for which unit bid prices are invited.

Blue Stake - The centralized contact point for scheduling the field location of utility lines within the limits of the project.

Board of Directors - The Pima County Board of Supervisors sitting as a special Board as provided for and acting under the authority of the laws of the State of Arizona.

Board of Supervisors - The Pima County Board of Supervisors.

Bond Issue Project - A project financed from bonds issued by the City, County or Town pledging credit or a revenue resource.

Bridge - A structure, including supports, erected over a depression or an obstruction, such as a highway, railway or water and having a track or passageway for carrying traffic or other moving loads as well as an opening, measured along the center of the roadway, of more than 20 feet (*6.1 meters*) between undercopings of abutments or extreme ends of openings for multiple boxes.

Bridge Length - The greater dimension of a structure measured along the center of the roadway between the backs of abutment backwalls or between ends of the bridge floor.

Bridge Roadway Width - The clear width of structure measured at right angles to the center of the roadway between the bottom face of curbs or, if curbs are not used, between the inner faces of parapet or railing.

Budget Project - A project financed by funds from General Tax levies and shared revenue funds set aside in the annual budget adopted by the Council or Board of Supervisors.

Calendar Day - Any day shown on the calendar, beginning at midnight, extending for a 24 hour period, and ending at midnight.

Change Order - A written order, issued by the Engineer to the contractor, to make changes in the work or to perform additional work, and establishing the conditions for payment or adjustment in the time of completion.

Channel - A natural or artificial watercourse.

City - A municipal corporation, organized and existing under and by virtue of the laws of the State of Arizona.

Compensable Delay - Refer to "Delay".

Complete-in-Place - Complete-in-place means that the payment shall be full compensation for all work necessary to complete that portion of the contract in its entirety to the satisfaction of the Engineer, in accordance with the requirements of the plans and specifications. When the basis of payment states the work shall be paid for complete-in-place it shall be the contractor's responsibility to determine the elements necessary to complete the work. When the basis of payment includes a list of elements associated with the complete-in-place work, the list shall not be construed to limit the work to the listed elements.

Conduit - A pipe used for receiving and protecting wire(s) or cable(s).

Construction Easement - A right to use or control property outside of the established right-of-way limits for a designated project.

Contract Agreement - The written agreement between the Agency and the contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials and the basis of payment.

Contract Amount - The total amount to be paid the contractor for completion of the work specified in the Contract Documents within the contract time and to the satisfaction of the Engineer.

Contract Documents - The Contract Documents include the advertisement for bids, bid document, contract agreement and contract bond, certificate of insurance, Standard Specifications, supplemental specifications, SPECIAL PROVISIONS, project plans, Standard Details and any supplemental agreements or change orders that are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

Contract Bond - The approved form of security, extended by the contractor and the contractor's surety or sureties, guaranteeing complete execution of the contract and all supplemental agreements and/or change orders pertaining thereto and the payment of all legal debts arising from the construction of the project.

Contract Time - The number of working days or calendar days allowed for completion of the contract, including authorized time extensions.

If a specified completion date is shown in the bid documents in lieu of the number of working or calendar days, the contract time expires on that date, and the construct shall be completed on or before that date.

Contractor - The individual, partnership, firm, corporation, or any acceptable combination thereof, or joint venture, entering into a contract with the contracting Agency for performance of the prescribed work.

Council - The city or town Council which, by law, constitutes the legislative body of the entity.

County - Pima County, organized under, and existing by virtue of the laws of the State of Arizona.

Culvert - Any structure not classified as a bridge which provides an opening under the roadway.

Day - Unless otherwise designated, day shall be understood to mean a calendar day.

Deficiency - Departure from, or noncompliance with, specified criteria.

Delay - Any event, action, force or factor that causes the length of time needed to perform the work to increase.

(A) Compensable Delay - An excusable delay for which the contractor may be entitled to additional compensation.

(B) Excusable Delay - A delay to the contract or a milestone completion date which was unforeseeable and beyond the contractor's control for which a time extension may be granted.

(C) Noncompensable Delay - An excusable delay for which the contractor may be entitled to an extension of time without additional compensation.

(D) Nonexcusable Delay - A delay to the contract or milestone completion date that was reasonably foreseeable or within the control of the contractor for which no compensation or time extension will be granted.

Engineer - The city, county or town Engineer, appointed by the Council or Board of Supervisors, acting directly or through the Engineer's duly authorized representative, who is responsible for engineering supervision of the construction.

Equipment - All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

Excusable Delay - Refer to "Delay".

Extra Work - Work to be performed by the contractor not provided for in the contract as awarded but found essential to the satisfactory completion of the project.

Force Account - Work paid for on a time and materials basis pursuant to Subsection 109-5.

Grade Stakes - Any stake used to establish a plan elevation on the ground.

Highway, Street or Road - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Holiday - The legal holidays recognized by the particular city, county or town with whom the contract has been executed.

Improvement District Project - A project financed, either in part or whole, by assessments against the property included in a special assessment district authorized under ARS Title 48, Chapter 4, Article II.

Independent Approved Laboratory - A testing laboratory which has been approved by the Engineer to perform testing and which has been determined by the Engineer to be free from any conflict of interest.

Inspector - The Engineer's authorized representative assigned to make detailed inspections of contract performance.

Item (Pay Item) - A detail of work for which separate payment is made under the contract.

Laboratory - The testing laboratory of the Agency or any other testing laboratory which is certified or approved by the Agency.

Liquidated Damages - A specified monetary amount set forth in the contract as a reasonable estimate of the Agency's damages caused by the contractors failure to substantially complete the contract within the contract time.

Lump Sum - The price bid by the contractor as a single amount for a complete contract item as defined by the specifications, or a price proposed by a contractor for a single amount for the performance of extra work.

Materials - Any substances specified for use in the construction of the project and its appurtenances.

Median - The portion of the highway, street, or road which separates the traveled roadway from traffic flowing in opposite directions.

Neat Lines - The lines defining the sides of an excavation to be paid for.

Noncompensable Delay - Refer to "Delay".

Nonexcusable Delay - Refer to "Delay".

Notice of Award - Written notice to the contractor stating that the bid submitted to the contracting Agency has been accepted.

Notice to Proceed - Written notice to the contractor stating that the contractor is to commence work on the project and specifying the date on which the contract time begins.

Or Equal - The equality of material, equipment and/or method, offered by the contractor, supplier, or manufacturer in lieu of the material, equipment and/or method specified in the contract documents. The Engineer shall be the sole judge as to whether a product is equal for the purpose of a particular project.

Pavement Structure - The combination of subbase, base course, and/or surface course placed to support the traffic load.

- Subgrade: The prepared and compacted soil immediately below the pavement structure and extending to such depth as will affect the structural design.
- Subgrade Treatment: Modification of roadbed material by stabilization.
- Subbase: One or more layers of specified or selected materials, of designed thickness, placed on the subgrade to support a base course.
- Base Course: One or more layers of specified materials, of designed thickness, placed on a subbase course or a subgrade to support a surface course.
- Surface Course: One or more layers of pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion and the disintegrating effects of climate. The top layer is sometimes called a "wearing course."

Payment Bond - The security provided by the contractor solely for the protection of claimants supplying labor and materials to the contractor or to subcontractors of the contractor.

Performance Bond - The security provided by the contractor solely for the protection of the contracting Agency and conditioned upon the faithful performance of the contract in accordance with the plans, specifications and conditions thereof.

Permit - The license to progress construction in public rights-of-way or easements as issued by the Agency holding title to the right-of-way or easement.

Plans - The official project plans, Standard Details and working drawings, or reproductions thereof, approved by the Engineer, which show the location, character, dimensions, and details of the work to be performed. All such documents are to be considered as a part of the plans whether or not they are reproduced in the bid document.

- Standard Details: Drawings approved for repetitive use, showing details to be used where appropriate.

- Project Plans: Specific details and dimensions peculiar to the work which are supplemented by the Standard Details insofar as they may apply.

- Working Drawings: Supplemental design sheets, shop drawings, or similar data which the contractor is required to submit to the Engineer such as stress sheets, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, computations or any other supplementary data required of the contractor.

Professional Engineer - The term Professional Engineer or Registered Professional Engineer means a person who has been granted registration in one or more of the branches of engineering by the Arizona State Board of Technical Registration for Architects, Assayers, Engineers, Geologists, Landscape Architects and Land Surveyors, and is authorized to practice professionally in the State of Arizona. If a branch of engineering is included in the title, such as Professional Civil Engineer, registration in that branch shall be required.

Profile Grade - The trace of a vertical plane corresponding to the top surface of the proposed wearing surface or finished channel grading, usually along the longitudinal center line of the roadbed or channel. Profile grade means either elevation or gradient of such trace according to the context.

Project - The specific coordinated construction or similar undertaking identified by a single project number and bid and awarded as one contract. On occasion two or more projects may be bid and awarded as a single project.

Project Plans - The official plans of the project. Refer to definition of "Plans".

Purchased Service - A purchased service is a minor portion of work not provided for in the contract, which may be accomplished by the use of specialized labor or equipment not normally utilized by either the contractor or a subcontractor. The cost of the purchased service is invoiced to either the contractor or a subcontractor as a purchased service.

Quality Control - Contractor or supplier techniques and activities that are performed or conducted to fulfill the contract requirements.

Reasonably Close Conformity - Reasonably close conformity means compliance with reasonable and customary manufacturing and construction tolerances where working tolerances are not specified. Where working tolerances are specified, reasonably close conformity means compliance with such working tolerances. Without detracting from the complete and absolute discretion of the Engineer to insist upon such tolerances as establishing reasonably close conformity, the Engineer may accept variations beyond such tolerances as reasonably close conformity where they will not materially affect the value or utility of the work and the interests of the Agency.

Registered Land Surveyor - A person who has been granted registration in Land Surveying by the Arizona State Board of Technical Registration for Architects, Assayers, Engineers, Geologists, Landscape Architects and Land Surveyors, and who is authorized to practice professionally in the State of Arizona.

Right-of-Way - A general term, denoting land, property or interest therein, usually in a strip, acquired for or devoted to transportation or other public works purposes.

Roadbed - The graded portion of a highway within top and side slopes, prepared as a foundation for the pavement structure and shoulders.

Roadside - A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadside Development - Those items necessary to the complete highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching, and the placing of other ground covers; such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

Roadway - That portion of a highway, street, or road right-of-way required for construction, limited by the outside edges of slopes, including ditches, channels and all structures pertaining to the work.

Shoulder - The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use and, for lateral support of base and surface courses.

Sidewalk - That portion of the roadway primarily constructed for the use of pedestrians.

SPECIAL PROVISIONS - Additions and revisions to the Standard Specifications covering conditions and requirements peculiar to an individual project.

Specifications - The compilation of provisions and requirements for the performance of prescribed work.

Specified Completion Date - The date on which the contract work is specified to be completed.

Standard Details - Drawings approved for repetitive use, showing details to be used where appropriate.

Standard Specifications - A book of specifications approved for general application and repetitive use.

State Highway Agency - Refer to "Agency".

Structures - Bridges, culverts, catch basins, drop inlets, retaining walls, manholes, endwalls, buildings, sewers, service pipes, under drains, foundation drains, and other features which may be encountered in the work.

Subcontractor - An individual, partnership, firm, corporation, or any acceptable combination thereof, or joint venture, to which the contractor sublets a part of the Contract.

Subgrade - The road bed materials beneath the pavement structure. The top prepared surface of the subgrade is called the finished subgrade elevation.

Substructure - All of that part of the structure below the bearings of simple and continuous spans, skewbacks for arches, or tops of footings of rigid frames, together with the backwalls, wingwalls, and wing protection railings.

Superintendent - The contractor's authorized representative in responsible charge of the work.

Superintendent of Streets - The individual duly appointed by the Council or Board of Supervisors, as provided by A.R.S. §§ 48-501, 48-571 and 48-901.

Superstructure - All that part of a structure above the bearings of simple and continuous spans, skewbacks or arches, or top of footings of rigid frames; excluding backwalls, wingwalls and wing protection railings.

Supplemental Agreement - A written agreement made and entered into by and between the Agency and the contractor covering work not otherwise provided for; revisions in or amendments to the terms of the contract; or conditions specifically prescribed in the specifications as requiring a supplemental agreement. Such supplemental agreement shall become a part of the Contract when approved and properly executed.

Supplemental Specifications - Additions and revisions to the **Standard Specifications** that are adopted subsequent to issuance of the printed book.

Supplier - One who fabricates, or processes an item off the project site, and who may or may not deliver this to the project. For purposes of this definition, a supplier shall not include one who establishes a fabricating process or facility expressly for use of the project, whether on or off the project site; or one who performs work on the project site that is incorporated into the project.

Surety - The corporate body bound with and for the contractor, for the full and complete performance of the Contract and for payment of all debts pertaining to the work.

Town - A municipal corporation, organized and existing under and by virtue of the laws of the State of Arizona.

Township or District - A subdivision of the county used to designate or identify the location of the proposed work.

Traveled Way - The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Unbalanced Bid (Materially) - A bid that generates a reasonable doubt that award to the bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Agency.

Unbalanced Bid, (Mathematically) - A bid containing lump sum or unit bid prices that do not reflect reasonably anticipated actual costs plus a reasonable proportionate share of the bidder's anticipated profit, overhead costs and other indirect costs and which, in the judgement of the Agency, would allow the bidder to receive an advantage from any quantity overrun or underrun.

Unit Prices - The price bid by the contractor for one unit of work, as defined by the specifications.

Work - Work shall mean the furnishing of all labor, materials, equipment and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the Contract.

Working Day - A calendar day, exclusive of Saturdays, Sundays and Agency recognized holidays, on which weather and other conditions not under the control of the contractor permit construction

operations to proceed for the major part of the day with the normal working force engaged in performing the controlling item or items of work which would be in progress at that time.

Working Drawings - Supplemental design sheets, shop drawings, or similar data which the contractor is required to submit to the Engineer such as stress sheets, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, computations or any other supplementary data required of the contractor.

Work Order - A written order, signed by the Engineer, of a contractual status requiring performance by the contractor without negotiation of any sort.

101-3.01 Repetition of Expressions. In order to avoid cumbersome and needless repetition of such phrases as "to the Engineer" and "by the Engineer" throughout the specifications, it shall be understood that when an order, instruction, decision, exercise of judgement or other similar action is indicated, such order, instruction, decision, exercise of judgement or other similar action will be issued, given, made by or reserved to the Engineer.

101-3.02 Interpretation of terms. When not inconsistent with the context, words used in the present tense include the future, words in the singular number include the plural; and words in the plural number include the singular.

101-3.03 Titles; Headings. The titles or headings of sections and subsections are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

SECTION 102

BIDDING REQUIREMENTS AND CONDITIONS

102-1 ADVERTISEMENTS FOR BIDS

Projects are advertised in a newspaper of general circulation within Pima County, Arizona. The bidder may obtain information regarding the specific newspaper and advertisement period from the appropriate Agency. A copy of the advertisement for bids is also bound in each bid document. The advertisement for bids may contain the following information:

- Project number and name.
- Date, time and place of public opening of bids.
- Location and length of project.
- General description of work, principal items and approximate quantities.
- Specified contract time (working days, calendar days or fixed date(s)) for completion of contract work.
- Statement of bid requirements.
- Date, time and place of the prebid conference.
- Manner in which project plans and specifications may be obtained and the cost of same.
- Type and amount of bid bond.
- Number of days after bid opening within which the contract will be awarded, if awarded.
- Number of days that the successful bidder has to return the signed contract, bonds and certificates of insurance.

102-2 PREQUALIFICATION OF BIDDERS

The advertisement for bids may require the bidder to file an experience questionnaire, a confidential financial statement and proof of licensure pursuant to state statute prior to submitting a bid.

102-3 SUSPENSION FROM BIDDING

The Agency may suspend any person and any subsidiary or affiliate of any person from further bidding to the Agency and from being a subcontractor to a contractor with the Agency or a supplier to the Agency if that person or any officer, director, employee or agent of that person is convicted of a crime involving any of the following elements or activities:

Entering into any contract, combination, conspiracy or other unlawful act in restraint of trade or commerce;

Knowingly and willfully falsifying, concealing, or covering up a material fact by trick, scheme, or device;

Making false, fictitious, or fraudulent statements or representations;

Making or using a false writing or document knowing it to contain a false, fictitious, or fraudulent statement or entry;

Misrepresentation or false statement on any application for bonding;

Misrepresentation or false statement on any application for prequalification; or

Under this Subsection, a person means any individual, partnership, corporation, association or other entity formed for the purpose of doing business as a contractor, subcontractor or supplier.

102-4 CONTENTS OF BID DOCUMENT

Upon request, the Agency shall furnish the prospective bidder a bid document. This document shall state the location and description of the contemplated construction and shall show the approximate estimate of the various quantities and kinds of work to be performed or materials to be furnished and shall have a schedule of items for which unit bid prices are invited. The bid document shall state the time in which the work must be completed, the type and amount of the bid bond and the date, time and place of the opening of bids. The document shall also include any Special Provisions or requirements which vary from or are not included in the Standard Specification.

All papers bound with or attached to the bid document are considered a part thereof and shall not be detached or altered when the bid is submitted.

The project plans, specifications, Standard Details and other items designated in the bid document, shall be considered a part of the bid whether attached or not.

Each and every provision of law and clause required by law to be inserted in the contract shall be deemed to be inserted herein, and the contract shall be read and enforced as though it were included herein.

The project plans and bid document are available at the price per set indicated in the advertisement for bids.

102-5 ISSUANCE OF BIDS

The Agency reserves the right to disqualify a bidder or refuse to issue a bid document for any of the following reasons:

- Lack of competency and adequate machinery, plant and other equipment, as revealed by the financial statement and experience questionnaires addressed in Subsection 102-2.

- Uncompleted work which, in the judgment of the Agency, might hinder or prevent the prompt completion of additional work if awarded.

- Failure to pay or settle satisfactorily, all bills due for labor and material on former contracts in force at the time of issuance of a proposal bid document.

- Failure to comply with any qualification regulations of the Agency.

- Default under previous contracts.

- Unsatisfactory performance on previous work.

- Entering into any contract, combination, conspiracy, or other unlawful act in restraint of trade or commerce.

- Knowingly and willfully falsifying, concealing, or covering up a material fact by trick, scheme, or device.

- Making false, fictitious, or fraudulent statements or representations.

- Making or using a false writing or document knowing it to contain a false, fictitious, or fraudulent statement or entry.

- Misrepresentation or false statement on any application for bonding.

- Misrepresentation or false statement on any application for prequalification.

- Lack of sufficient ability or integrity to complete the contract.

- Failure to hold all licenses required by law for the work to be performed.

102-6 INTERPRETATION OF QUANTITIES IN BIDDING SCHEDULE

The quantities appearing in the bidding schedule, except as provided elsewhere, are approximate only and are prepared for the comparison of bids. Payment to the contractor shall be made only for the actual quantities of work performed and accepted or materials furnished in accordance with the requirements of the contract. The scheduled quantities of work to be done and materials to be furnished may each be increased, decreased or omitted as provided in Subsection 104-2.

102-7 EXAMINATION OF PLANS, SPECIFICATIONS, AND SITE OF WORK

The Agency shall prepare project plans and Special Provisions in accordance with acceptable engineering standards, giving such directions as will enable any competent contractor to carry them out. The bidder shall carefully examine the site of the proposed work, including material pits and haul routes, the bid documents, project plans, Standard Details, Standard Specifications, Special Provisions and contract forms before submitting a bid. The

submission of a bid shall be conclusive evidence that the bidder has investigated and is satisfied as to the conditions to be encountered, as to the character, quality, and scope of work to be performed, the quantities of materials to be furnished, and as to the requirements of the bid documents.

Submission of a bid shall be conclusive evidence that the bidder has reviewed the federal, state and local laws, ordinances, rules and regulations that may affect the performance of the work and is aware of the limitations, conditions, and restrictions that may be placed on the work by other agencies with regulatory jurisdiction, whether or not stated within the Contract Documents.

Where the Agency has made investigations of site conditions including subsurface conditions in areas where work is to be performed under the contract, or in other areas, some of which may constitute possible local material sources, such investigations are made only for the purpose of study and design. Where such investigations have been made, bidders may, upon written request, inspect the records of the Agency as to such investigations subject to and upon the conditions hereinafter set forth. Such inspection of records shall be made at the office of the Agency having control of the work.

The records of such investigations are not a part of the contract and are shown solely for the convenience of the bidder. It is expressly understood and agreed that the Agency assumes no responsibility whatsoever in respect to the sufficiency or accuracy of the investigations thus made, the records thereof, or of the interpretations set forth therein or made by the Agency in its use thereof and there is no warranty or guarantee, either express or implied, that the conditions indicated by such investigations or records thereof are representative of those existing throughout such areas, or any part thereof, or that unlooked for developments may not occur, or that materials other than, or in proportions different from those indicated, may not be encountered.

When a log of test borings or other record of geotechnical data obtained by the Agency's investigation of subsurface conditions is included with the contract documents, it is expressly understood and agreed that the record does not constitute a part of the contract, represents only the opinion of the Agency as to the character of the materials or the conditions encountered by it in its investigations, is included in the plans only for the convenience of bidders and its use is subject to all of the conditions and limitations set forth in this Subsection.

In some instances, the information from such site investigations considered by the Agency to be of possible interest to bidders has been compiled as "Materials Information." The "Materials Information" is not a part of the contract and is furnished solely for the convenience of bidders. It is understood and agreed that the fact that the Agency has compiled the information from such investigations as "Materials Information" and has exhibited or furnished to the bidders such "Materials Information" shall not be

construed as a warranty or guarantee, express or implied, as to the completeness or accuracy of such compilations and the use of such "Materials Information" shall be subject to all of the conditions and limitations set forth in this Subsection.

When contour maps were used in the design of the project, the bidders may inspect such maps and, if available, they may obtain copies for their use.

When an earthwork mass diagram is included with the contract plans, it is expressly understood and agreed that the mass diagram does not constitute a part of the contract, and represents only an opinion of the Agency as to the swell or shrinkage of excavated material and the direction and quantities of haul. It is included in the plans only for the convenience of bidders and its use is subject to all of the conditions and limitations set forth in this Subsection.

The availability or use of information described in this Subsection is not to be construed in any way as a waiver of the provisions of the first paragraph in this Subsection and a bidder is cautioned to make such independent investigation and examination as the bidder deems necessary to satisfy itself as to conditions to be encountered in the performance of the work and, with respect to possible local material sources, the quality and quantity of material available from such property and the type and extent of processing that may be required in order to produce material conforming to the requirements of the specifications.

No information derived from such inspection of records, investigations, or compilation thereof made by the Agency or obtained from the Engineer, or the Engineer's assistants, shall in any way relieve the bidder from any risk or from properly fulfilling the terms of the contract.

The bidder shall take no advantage of any apparent error or omission in the plans, bid schedule items, estimated quantities, specifications or other contract documents. In the event the bidder discovers such an apparent error or omission or be in doubt as to their meaning, the bidder shall immediately notify the Agency, in writing, requesting a clarification or interpretation as appropriate. Any clarification or interpretation deemed necessary by the Agency shall be issued to all prospective bidders in the form of an Addendum. Any Addendum so issued shall form a part of the contract documents.

No oral clarifications or interpretations shall be made to any bidder regarding the contents of the contract documents. The Agency shall not be bound by and a bidder shall not rely on any oral statement interpreting or clarifying the contract documents made by the Engineer or any employee or agent of the Agency.

102-8 PREPARATION OF BID

The bidder shall submit the bid only upon the forms furnished by the Agency. No consideration shall be given to any purported bids on other forms, or to any request to modify or change a bid, regardless of whether such request is submitted orally, by wire, by letter, over the telephone, or by other similar means.

The bidder shall specify a unit price in figures for each pay item for which a quantity is given in the bidding schedule and shall also show the amount extended as the product of the quantity and unit price for each bid item in the column provided for that purpose. In the event that more than two decimal places are used in representing a unit price, all digits beyond the second decimal place will be truncated and the extended amount for the affected item(s) and the total bid will be recomputed accordingly. The total amount of the bid shall be obtained by adding the amounts of the several items. All of the figures shall be in ink or typed. In case of a discrepancy between a unit price and the amount extended, the unit price shall govern. All revisions or corrections to figures on the bidding schedule shall be initialed in ink by an authorized officer or agent of the bidder.

When an item in the bid contains a choice to be made by the bidder, the bidder shall indicate a choice in accordance with the specifications for that particular item and thereafter no further choice shall be permitted.

All signatures required on the bidder's bid documents shall be signed in ink.

The bidder shall clearly show his or her name, post office address and signature.

All signatures on the bid documents shall be by individuals duly authorized to bind the business entity or firm.

In addition, the following shall be completed by the bidder in the bid unless otherwise indicated in the Agency's advertisement for bids.

(A) Signature of the bidder acknowledging receipt of the bid document and all Addenda and agreeing that the bid includes the listed Addenda received with or after receipt of the bid document and that the listed addenda were considered in preparing the bid.

(B) Inclusion of the bidder's Arizona State Contractors License number and classification.

(C) A list of all subcontractors and suppliers intended to be used on the project, and the type of the work to be subcontracted to each.

(D) Any other requirements indicated by the Agency's Special Provisions.

The complete bid document shall be submitted and the bid sheets shall not be separated from the remainder of the document. Bid documents are not transferable.

102-9 AFFIDAVIT AND CERTIFICATION FORMS

Each bidder shall certify on behalf of the person, firm, association, or corporation submitting the bid, that such person, firm, association, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action, in restraint of free competitive bidding in connection with the submitted bid. This certification shall be on the form provided in the bid document and sworn to by the bidder before a person who is authorized by the laws of the State to administer oaths.

The required forms for the affidavit and the certification with respect to receipt of addendums are included in the bid document and shall be completed and signed in ink by each bidder.

102-10 REJECTION OF BIDS

Bids may be rejected if they show unauthorized alteration of words or figures, unauthorized conditional or uncalled for alternate bids, obviously unbalanced bids, any authorized alteration of words or figures or erasures not initialed by the person or persons signing the bid or a submission of any kind which may tend to make the bid incomplete, indefinite or ambiguous as to its meaning.

The Agency reserves the right to waive such minor irregularities as to form or substance and to accept the bid if doing so would be in the best interest of the taxpayers or improvement district participants funding the project.

Bids may be rejected for any of the following reasons:

- If the bid or bidding schedule is on a form other than that furnished by the Agency.
- If the bidder or surety fails to sign the bid bond, unless a certified or cashier's check is submitted with the bid.
- If the bidder fails to sign the bid document.
- If the bidding schedule does not contain a unit price for each pay item listed except in the case of authorized alternate pay items.
- If the bidder fails to meet the required goal for Disadvantaged Business Enterprises (DBE) as may be established in the Special Provisions or show good faith effort as determined by the Agency.
- If the bidder fails to sign and notarize (if notarization is required) the non-collusion affidavit form.

In addition, the bid may be rejected for non-compliance with any of the items listed in Subsection 102-5 or if the bid is deemed to be unbalanced.

An unbalanced bid is as defined in Subsection 101-3.

102-11 DELIVERY OF BIDS

Each bid, together with the required bid bond, shall be placed in an envelope bearing the project name, number and date and time of closing as specified in the Advertisement for Bids. The envelope shall be sealed. All bids shall be submitted prior to the time and at the place specified in the advertisement for bids. Bids received after the time set for opening the bids shall be returned to the bidder unopened. The contractor shall be issued a receipt at the time of bid submittal indicating the time and date of the submittal.

102-12 BID BOND

A bid bond in the form of a certified or cashier's check or surety bond in an amount not less than that specified by Arizona Revised Statute (ARS) Section 34.201 shall accompany the bid. The bidder is advised to review the character and the amount of the bid bond specified in the Advertisement for Bids.

Surety bonds shall be accepted only on the form acceptable to the Agency and only from corporate sureties duly authorized to do business in Arizona.

Surety bonds shall be signed by the bidder and by the surety with a current Power of Attorney attached.

102-13 WITHDRAWAL OF BIDS

A bidder will be permitted to withdraw a bid unopened after it has been submitted to the Agency, provided the request, in writing, is received by the Agency prior to the time specified for the opening of bids.

102-14 COMBINATION OR CONDITIONAL BIDS

If the Agency so elects, a bid document may be issued for projects in combination or separately so that bids may be submitted either on the combination or on separate units of combination. The Agency reserves the right to make awards on combination bids or separate bids to the best advantage of the Agency. No combination bids, other than those specifically set up in the bid document issued by the Agency, shall be considered. Separate contacts shall be written for each individual project included in the combination.

Conditional bids shall be considered when so stated in the Special Provisions.

102-15 PUBLIC OPENING OF BIDS

Bids shall be opened and read aloud at the time and place indicated in the Advertisement for Bids. Bidders, their authorized agents and other interested parties are invited to be present.

102-16 Licensing

It is the responsibility of the bidder to determine whether it has the appropriate contracting licenses to perform the work. The Agency will make the award, if any, to the lowest responsible bidder who has the proper licenses. For all projects except Federal-aid funded projects, the bidder must have the proper licenses at the time the bid is submitted to the Agency. On Federal-aid funded projects, the bidder is not required to have the licenses at the time of bidding, but it must procure the licenses before award can be made, and no later than 60 days after the date bids are opened. Licensing information is available from the Arizona Registrar of Contractors.

SECTION 103

AWARD AND EXECUTION OF CONTRACT

103-1 CONSIDERATION OF BIDS

After the bids are opened and read aloud, they shall be compared on the basis of the sum of the products of the quantities shown in the bidding schedule multiplied by the unit bid prices shown in the bidding schedule. In the event of a discrepancy between unit bid prices and extensions, the unit bid price shall govern. The results of such comparisons shall be available to the public.

The right is reserved to reject any or all bids, to waive technicalities or to advertise for new bids if, in the judgement of the Agency, the best interests of the Agency will be promoted thereby.

103-2 AWARD OF CONTRACT

The award of contract, if awarded, shall be made by the Agency, within the time period, or any extension of such time period, specified in the Invitation to Bid, to the lowest responsible and qualified bidder whose bid complies with all the requirements prescribed. The successful bidder shall be notified that the bid has been accepted and that the successful bidder has been awarded the contract by:

(A) Written notice mailed to the address shown in the bidder's bid for Bond Issue or Budget Projects, and,

(B) Publication in accordance with the requirements of the Arizona Revised Statutes for Improvement District Projects.

The notice of award letter may be withheld pending receipt by the Agency of concurrence by any participating entity or for other good cause.

At any time after completion of the period set forth above for award of contract, the successful bidder may, by letter, notify the Engineer of the Agency's failure to issue a notice of award letter. If the notice of award letter has not been issued within ten days from the date that the successful bidder's letter has been filed with the Agency, the successful bidder shall have the right to withdraw the bid without forfeiture of the bidder's bid bond.

103-3 CANCELLATION OF AWARD

The Agency reserves the right to cancel the award of any contract at any time, before the execution of the contract by all parties, without any liability against the Agency.

103-4 RETURN OF BID BOND

Bid bonds in the form of certified or cashiers checks or surety bonds shall be returned immediately following the opening and

checking of bids, except for the bid bond of the lowest qualified bidder; however, the Agency may also retain the bid bond of the second lowest qualified bidder at its discretion.

Bid bonds in the form of certified or cashier's checks or surety bonds that have been retained shall be returned promptly upon completion of both of the following actions:

- The award of contract.
- The filing with the Agency of satisfactory bond, insurance and contract forms executed by the bidder.

103-5 BONDS

Concurrent with the execution of the contract, the successful bidder shall furnish each of the following bonds to the Agency; each bond shall be 100 percent of the total contract amount.

(A) Performance Bond. A Performance Bond which shall be conditioned upon the faithful performance of the contract in accordance with the plans, specifications and conditions thereof. Such bond shall be solely for the protection of the Agency awarding the contract.

(B) Payment Bond. A Payment Bond for the sole protection of claimants supplying labor (inclusive of all workmen's compensation, occupational disease and unemployment compensation premiums), or materials to the contractor or subcontractors in the prosecution of the work provided for in the contract.

The bonds shall be written or countersigned by an authorized representative of a surety company or companies duly authorized to do business in the State of Arizona, as by law required and which are also acceptable to the Agency. The bonds shall have attached the power of attorney of the signing official.

A required form of bonds may be provided by the Agency. Each bond shall include a provision allowing the prevailing party in a suit on such bond to receive, as part of the judgment, such reasonable attorney's fees as may be fixed by the court.

103-6 CONTRACTOR'S INSURANCE; INDEMNIFICATION

The contractor shall carry all insurance required by the Standard Specifications together with any additional insurance which may be required by the Agency as specified in the Special Provisions.

Concurrent with the execution of the contract, the contractor shall furnish the Agency with certificates of insurance for the types of insurance and minimum coverage limits specified in Subsection 107-18.

Neither the contractor nor any subcontractor shall commence work under a contract until the Agency has accepted all required insurance coverage.

The contractor shall indemnify, defend and hold harmless the Agency, its officers, employees, agents and representatives, from any suit, action, proceeding, demand, loss, damage, expense, cost or claim of any character or nature, including attorney's fees and costs of litigation, which may be brought, made or incurred on account of loss or damage to any property or for injuries to or death of any person, caused by, arising out of or contributed to by, in whole or in part, any alleged act, omission, professional error, fault, mistake or negligence of the contractor, its employees, agents or representatives, or subcontractors, their employees, agents or representatives, in connection with or incident to the performance of the work, or arising out of Workmen's Compensation claims, Unemployment Compensation claims or Unemployment Disability Compensation claims of employees of the contractor or its subcontractors or claims under similar such laws or obligations or arising out of the failure of the contractor or those acting under contractor to conform to any statute, ordinance, regulation or court decree.

The contractor shall indemnify, defend and hold harmless any county or incorporated city or town within the limits of which the work is performed, and any jurisdiction or entity issuing permits for any work included in the project, and its officers, employees and agents, all in the same manner and to the same extent as provided in the above paragraph.

The contractor's obligations to indemnify, defend and hold harmless under this Subsection shall not extend to any liability caused by the sole negligence of the Agency or its employees.

103-7 EXECUTION OF CONTRACT

The contract shall be signed by the successful bidder and returned, together with satisfactory bonds and insurance certificates within the time period specified in the Invitation to Bid.

The Agency shall execute the contract within the time period specified in the Invitation to Bid. No contract shall be considered as effective until it has been fully executed by all the parties thereto.

103-8 FAILURE TO EXECUTE CONTRACT

Failure of the contractor to execute a contract, and file satisfactory contract bonds as provided herein, within the calendar day periods after the date of the notice of award letter as specified in Subsection 103-7, shall be just cause for the cancellation of the award and may be cause for the forfeiture of the bid bond, which shall become the property of the Agency, not as a penalty, but in liquidation of damages. Award may then be made to the next lowest responsible bidder, or the work may be re-advertised or abandoned, as the Agency may decide.

SECTION 104

SCOPE OF WORK

104-1 INTENT OF CONTRACT

The intent of the contract is to provide for the construction and completion, in every detail, of the work to the satisfaction of the Agency. The contractor shall furnish experienced supervision and labor, and all materials, equipment, tools, transportation and supplies required to complete the work in accordance with the plans, specifications and terms of the contract.

104-2 ALTERATIONS OF CONTRACT

104-2.01 By the Agency. The Agency reserves the right to make, at any time during the progress of the work, alterations to the contract as a result of changes in the details of construction, increases or decreases in quantities of items of work, subsurface or latent physical conditions discovered during construction or due to unplanned work which was not originally contemplated. Such alterations shall not invalidate the contract nor release the surety, and the contractor shall perform the work as altered the same as if it had been a part of the original contract.

The contract price shall be equitably adjusted, if warranted, to account for any alteration in accordance with the terms of this Subsection, and the contract time shall be equitably adjusted in accordance with the terms of Subsection 108-8. The scope of any alteration and the terms of the equitable adjustment, if any, affecting contract price or contract time, shall be agreed to by the Agency and the contractor and evidenced in a supplemental agreement executed by both parties. In order to avoid delay to the project, the Agency may issue to the contractor a written directive to proceed with the alteration before a final agreement on the equitable adjustment to the contract prices or time is reached.

Payment for alterations or modifications to the contract shall be in accordance with Subsection 109-3.

104-2.02 Due to Physical Conditions. Should the contractor encounter or the Agency discover during the progress of the work subsurface or latent physical conditions at the site including archaeological or cultural features as noted in Subsection 107-6, differing materially from those indicated in the contract or unknown physical conditions at the site of an unusual nature (that is, differing materially from those ordinarily encountered and generally recognized as inherent in work of the character provided for in the contract), the contractor shall immediately notify the Engineer in writing of such conditions before they are disturbed. If such conditions are further disturbed after discovery and notification, and prior to an investigation by the Engineer, the contractor waives any claim for equitable adjustment due to the differing site conditions. The Engineer shall investigate such conditions as expeditiously as possible, in order that the work may continue to progress in an orderly and continuous manner.

Any adjustment in compensation or contract time because of a change or changes resulting from one or more of the conditions described in the foregoing paragraph shall be made in accordance with the requirements of this Subsection 104-2.

104-2.03 Due to Work Not Conforming to the Requirements of the Contract. If, instead of requiring corrections or removal of work not conforming to the requirements of the contract, the work is determined to be acceptable in accordance with the requirements of Subsection 105-3 and Section 110, a change order shall be issued incorporating the necessary revisions in the contract, including an appropriate reduction in the contract price. Such a change order shall not require the signature or approval of the contractor. Such acceptance of defective work shall not constitute a waiver of any other work required under this contract.

104-2.04 Due to Failure to Prosecute Work. If the contractor fails to prosecute the work in accordance with the contract, including requirements of the progress schedule, the Agency may correct these deficiencies after three days of having given written notice to the contractor. The costs of these remedies shall be charged against the contractor. A change order may be issued to make the necessary changes in the contract and to make an appropriate reduction in the contract price. Such a change order shall not require the signature or approval of the contractor. This remedy shall not prejudice the Agency's use of any other remedy which the Agency may be entitled to use.

104-3 EXTRA WORK

The contractor shall perform unplanned work for which there is no price included in the contract whenever the Engineer deems it necessary or desirable in order to complete the work as contemplated. The contractor shall furnish a written, detailed cost analysis for the extra work, itemizing labor, equipment, materials and anticipated production rates. The contractor shall be allowed a markup for overhead and profit for work performed in accordance with supplemental agreements resulting from alteration of the contract. Except as provided in Subsection 109-5(B) Force Account Work, the maximum allowable markup for the prime contractor shall be 15 percent for work performed by the prime contractor and 5 percent for work performed by subcontractors. In no event shall the cumulative amount paid for overhead, profit or other markups claimed for any work performed by the prime contractor or sub-contractors exceed 20 percent of the cost of the work.

At the sole option of the Engineer, the equitable adjustment to the contract price may be determined in accordance with the provisions of Subsection 109-5(B). Any adjustment in contract time because of such change or changes shall be made in accordance with the requirements of Subsection 108-8. Such work shall be performed in accordance with the specifications and as directed by the Engineer. Extra work shall not involve work beyond the project limits except as may be considered necessary to complete the project satisfactorily.

104-4 NOTIFICATION

(A) As required by these specifications or any time the contractor believes that the action of the Agency, lack of action by the Agency, or for some other reason will result in or necessitate the revision of the contract, the Engineer must be notified immediately. If within three working days the identified issue has not been resolved between the Agency and the contractor, the contractor shall provide a written notice. At a minimum the written notice shall provide a description of the nature of the issue, the time and date the problem was discovered, and if appropriate, the location of the issue. After initial written notice has been provided, the Engineer will proceed in accordance with Subsection 104-2. If the issue cannot be quickly resolved the contractor will proceed to the next step in this subsection.

(B) Within seven calendar days of the date of the initial written notice the contractor shall provide in writing the following information to the Engineer:

(1) The date of occurrence and the nature and circumstances of the issue for which initial notice was given.

(2) Name, title, and activity of each Agency representative knowledgeable of the issue.

(3) Identity of any documents and the substance of any oral communication related to the issue.

(4) Basis for an assertion that work required is a change from the original contract work or schedule.

(5) Identity of particular elements of contract performance for which additional compensation may be sought, including:

(a) Pay item(s) that has been or may be affected by the issue;

(b) Labor or materials, or both, that will be added, deleted or wasted by the problem and what equipment will be idled or required;

(c) Delay and disruption in the manner and sequence of performance that has been or will be caused;

(d) Adjustments to contract price(s), delivery schedule(s), staging, and contract time estimated due to the issue; and

(e) Estimate of the time within which the Agency must respond to the notice to minimize cost, delay, or disruption of issue.

(6) The contractor's written certification, under oath, attesting to the following:

(a) The request is made in good faith.

(b) Supportive data is accurate and complete to the contractor's best knowledge and belief.

(c) The amount requested accurately reflects the contractor's actual cost incurred.

(C) The failure of the contractor to comply with the requirements of this subsection constitutes a waiver of entitlement to additional compensation or a time extension.

(D) Within 10 calendar days after the contractor's submission in accordance with Subparagraph (B), the Engineer will respond in writing to the contractor to:

(1) Confirm that a supplemental agreement is necessary and, when necessary, give appropriate direction for further performance, or

(2) Deny that the contract has been revised and, when necessary, direct the contractor to proceed with the contract work, or

(3) Advise the contractor that adequate information has not been submitted to decide whether (1) or (2) applies, and indicated the needed information and date it is to be received by the Engineer for further review. The Agency will respond to such additional information within 10 calendar days of receipt from the contractor.

104-5 MAINTENANCE OF TRAFFIC

Work considered under this Subsection includes, but is not limited to, sweeping, roadway and subgrade repair, safety feature repair, debris removal, repair of pedestrian features and other work necessary to provide a smooth and safe traveled way. The work herein listed shall be paid for as provided in Subsections 701-4.01 and 701-5.01.

Unless otherwise provided, a road, while being improved, shall be kept open to all vehicular and pedestrian traffic by the contractor in accordance with the provisions of Subsection 701-3.01. Traffic shall be kept on a paved surface unless otherwise approved by the Engineer. When so requested by the contractor and approved by the Engineer, the contractor may bypass traffic over an approved paved detour route conforming to the requirements of Subsection 701-3.04. Regardless of whether it is through or local traffic, the contractor shall keep the portion of the project being used by traffic in such condition that traffic shall be adequately accommodated. The contractor shall assume maintenance responsibility through the project at the time its operations begin using the roadway or interrupt normal traffic

operations. The contractor shall also provide and maintain in a safe condition temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages and farms so as to accommodate both vehicular and pedestrian traffic.

Before any detour is opened to traffic, the Engineer shall have been satisfied that traffic is able to proceed in a safe manner.

The contractor shall bear all expense of maintaining traffic over a road being improved as well as constructing, maintaining and subsequently removing contractor requested detours, approaches, crossings, intersections, and other features as may be necessary, without direct compensation except as provided below.

(A)Maintenance of Traffic During Suspension of Work. Prior to or during any extended suspension of the construction work, the contractor shall make passable, place in a maintainable condition and shall open to traffic such portions of the project and temporary roadways or portions thereof as may be agreed upon between the contractor and the Engineer for the temporary accommodation of necessary traffic during the anticipated period of suspension. Thereafter, and until an order has been issued for the resumption of construction, the maintenance of the temporary route or lane of travel agreed upon as well as all signs shall be by, and at the expense of, the Agency. When construction is resumed, the contractor shall replace or renew any work or materials lost or damaged because of such temporary use, shall remove to the extent ordered any work or materials necessary for the temporary maintenance by the Agency, and shall complete the work in every respect as though its prosecution has been continuous and without interference. Such work and any additional work caused by such suspension, for reasons beyond control of the contractor, shall be paid for under the respective pay items or in accordance with the requirements of Subsection 109-5.

(B)Maintenance Directed by the Engineer. If the Engineer orders maintenance beyond that required by the contract for the benefit of the traveling public, the contractor shall be paid for such maintenance under the respective pay items or in accordance with the requirements of Subsection 104-2. The Engineer shall be the sole judge of work to be classed as maintenance beyond that required by the contract. Work considered under this Subsection includes, but is not limited to, sweeping, roadway and subgrade repair, safety feature repair, debris removal, repair of pedestrian features, and other work necessary to provide a smooth and safe traveled way. This work shall only pertain to that accomplished on portions of the roadway being used by the traveling public prior to commencement of construction improvements or after acceptance of a completed portion of the work.

104-6 MAINTENANCE OF THE PROJECT SITE

Throughout all phases of construction, including suspension of work, and until final acceptance of the project, the contractor shall keep the work area clean and free from rubbish, excess materials and debris generated by construction activities.

All existing improvements (including, but not limited to, paved parking areas decomposed granite and plastic sheeting, irrigation systems, sidewalks, curb, grass areas as indicated on the plans, and property corners) disturbed or damaged by the contractor shall be repaired and/or replaced by the contractor. The cost of such repair and/or replacement shall be incidental to the project. It is the responsibility of the contractor to become thoroughly familiar with all visible features of the site before preparing its proposal.

The contractor shall employ all appropriate methods and procedures required to prevent any dust nuisance resulting from the project. Dust control measures shall be maintained at all times.

Dust control measures shall include, but not be limited to the following:

(1) The contractor shall apply water to all traffic areas and loose soil areas when necessary to minimize visual emissions.

(2) All work/haul roads, including routes used by work site commuter traffic, must be maintained to prevent or minimize visible emissions. Vehicle speed shall be limited to 15 mph within the construction area.

(3) The contractor responsible for acquiring the Air Quality Activity Permit shall assure that appropriate measures are taken to prevent or minimize visible emissions during non-working hours. These measures may include:

Keeping stockpiles low, wet and/or covered;
Wetting and controlling traffic on grade areas;
Using fencing and/or barricades;
Scheduling extra watering.

(4) The contractor shall cease all dust producing activities when steady wind speeds exceed 25 miles per hour as confirmed by the National Weather Service. The contractor shall increase the frequency of watering to prevent or minimize wind blown dust during gusting wind conditions or when wind speeds are below 25 miles per hour.

(5) The contractor shall maintain a daily Dust Control Plan Check List as provided by Pima County Department of Environmental Quality, to track emission control methods.

(6) The contractor shall use sprinklers and or hoses in locations not accessible to water trucks.

(7) The contractor shall use hoses to wet the face of stockpiles during loading operations to prevent or minimize visible emissions. When not being used, stockpiles shall be wetted sufficiently to form a "crust" sufficient to prevent or minimize visible emissions.

(8) The contractor shall be required to use an adequate quantity of water at each dust producing project activity to prevent or minimize visible emissions.

(9) Track-out of dust producing materials by vehicles leaving the site shall be controlled by the contractor. The method(s) used by the contractor to prevent track-out shall be documented on the Dust Control Plan Check List.

Gravel pads or paving at access points or washing of wheels are recommended. Other methods may be approved by the engineer.

Gravel pads should be constructed with course aggregate 1 inch (*25 millimeters*) to 3 inches (*75 millimeters*) in diameter and should be laid 6 inches (*150 millimeters*) thick. The minimum dimension of the stabilized access area shall be 50 feet (*15.2 meters*) by 30 feet (*9.1 meters*).

Presoaking may be used in lieu of some of the above requirements if approved by the Engineer.

104-7 RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK

The contractor, with the approval of the Engineer, may use on the project such excess stone, gravel, sand or other material determined suitable by the Engineer as may be found in the required excavation. Unless otherwise specified, all other items specified to be removed shall become the property of the contractor and shall be removed from the site. The contractor shall be paid both for the excavation of such materials at the corresponding contract unit price and for the pay item for which the excavated material is used. The contractor shall replace, at no additional cost to the Agency and with material acceptable to the Engineer, all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches etc. No charge for the materials so used shall be made against the contractor. The contractor shall not excavate or remove any material from within the project limits which is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

Unless otherwise provided, the material from any existing structure may be used temporarily by the contractor in the erection of the new structure. Such material shall not be cut or otherwise damaged except with the approval of the Engineer.

104-8 FINAL CLEAN UP

Before final acceptance, the project, any borrow and local material sources, and all areas occupied by the contractor in connection with the work shall be cleaned of all rubbish, excess materials, temporary structures and equipment, and all parts of the work shall be left in a condition acceptable to the Engineer.

104-9 VALUE ENGINEERING PROPOSALS

The contractor may submit to the Engineer proposals for modifying the plans, specifications or other requirements of the contract for the sole purpose of reducing the total cost of construction without impairing, in any manner, the essential functions or characteristics of the project, including but not limited to service life, economy of operations, ease of maintenance, desired appearance or design and safety standards.

After execution of the contract, a proposal may be recommended by the contractor. The proposal must be identified as a Value Engineering Proposal (VEP), and may include modifications to the plans or specifications, construction phasing or procedures, or other contract requirements.

Any cost savings generated to the contract as a result of VEP offered by the contractor and approved by the Agency will be shared equally between the contractor and the Agency as specified in Subsection 104-9(D).

Bid prices are not to be based on the anticipated approval of a VEP. If a VEP is rejected, the work shall be completed in accordance with the original terms of the contract or as otherwise modified.

Any decision whether to approve or accept a VEP shall be within the sole discretion of the Agency. The Agency will bear no liability for any delay in considering a VEP, the refusal to accept or approve such a proposal, or any other matter connected with a VEP.

(A) Submittal and Review of VEP Concept:

(1) The contractor shall initially submit a brief letter proposal with graphics to the Agency to illustrate the VEP concept. The contractor shall provide an estimate of the time required to prepare a formal submittal as well as the time to be provided for review by the Agency. The contractor shall also indicate whether adequate time is available in its schedule for the formal submittal and Agency review of the VEP prior to its implementation.

(2) The Agency will review the concept and within 10 days of the contractor's initial submittal inform the contractor, in writing, whether the concept has merit and should be submitted as a formal VEP.

(3) If the Agency determines that the time indicated in the contractor's letter proposal is insufficient for its review or to otherwise meet the schedule, the Agency may choose to evaluate the need for a noncompensable time extension to the contract. Its evaluation will be based on the time required to prepare the VEP submittal and any additional time needed by the Agency for its review and the effect on the contractor's schedule occasioned by the added time. The need for such a time extension will be evaluated in accordance with Subsection 108-8.

(B) Formal Submittal of the VEP: Within 30 days after the Agency has determined the VEP concept has merit, the contractor shall formally submit a proposal. The proposal shall include sufficient data for the Agency to make an informed decision regarding the proposal and shall include, at a minimum, the following information:

(1) A statement that the Proposal is submitted as a VEP.

(2) A description of the difference between the existing contract and the proposed change and the advantages and disadvantages of each, including effects on service life, economy of operations, ease of maintenance, benefits, desired appearance, and safety.

(3) A complete set of plans and specifications showing the proposed revisions relative to the original contract features and requirements supported by design computations as necessary for a thorough and expeditious evaluation.

(4) A complete analysis indicating the final estimated costs and quantities to be replaced by the VEP compared to the new costs and quantities generated by the VEP.

(5) A statement specifying the date by which a supplemental agreement adopting the VEP must be executed to obtain the maximum cost reduction.

(6) A statement detailing the effect the VEP will have on the time for completing the contract.

(7) A description of any previous use or testing of the VEP and the conditions and results. If the VEP was previously submitted on another Agency project, indicate the date, contract number, and the action taken by the Agency.

(8) A detailed statement indicating the costs for developing the changes, along with the costs for preparing the value engineering joint proposal.

(C) Conditions: Value Engineering Proposals will be considered only when all of the following conditions are met:

(1) A VEP, approved or not approved by the Agency applies only to the contract on which it is submitted. A submitted VEP becomes the property of the Agency. The VEP shall contain no restrictions imposed by the contractor on its use or disclosure. The Agency has the right to use, duplicate and disclose in whole or in part any data necessary for the utilization of the Proposal. The Agency retains the right to use any accepted VEP or part thereof on other projects without obligation to the contractor. This provision is not intended to deny rights provided by law with respect to patented materials or processes.

(2) If the Agency is already considering certain revisions to the contract or has considered or approved changes in the contract of a like nature on other contracts which are subsequently incorporated in a VEP, the Agency may reject the VEP and may change the contract without obligation to the contractor.

(3) The contractor shall have no claim for additional costs or delays resulting from the rejection of a VEP, including development costs, loss of anticipated profits, increased material or labor costs except as allowed in Subsection 104-9(D).

(4) The Agency will determine if a VEP qualifies for consideration and evaluation. It may reject any VEP that requires excessive time or costs for review, evaluation or investigation, or that is not consistent with the Agency's design policies and criteria for the project.

(5) The Engineer will reject all or any portion of work performed under an approved VEP if unsatisfactory results are obtained. The Engineer will direct the removal of rejected work and require construction to proceed under the original contract requirements without reimbursement for rejected work performed under the VEP, or for its removal. Where modifications to the VEP are approved to adjust to field or other conditions, reimbursement will be limited to the total amount payable for the work at the contract bid prices as if it were constructed under the original contract requirements. The rejection or limitation of reimbursement shall not constitute the basis of any claim against the Agency for delay or for other costs.

(6) The proposed work shall not contain experimental features but shall contain features that have been used under similar or acceptable conditions on other projects or locations acceptable to the Agency.

(7) VEPs will not be considered if equivalent options are already provided in the contract.

(8) The savings generated by the VEP must be sufficient to warrant a review and processing. A savings resulting solely from the elimination or reduction in quantity of a single bid item will not be considered as a VEP. A savings resulting from the elimination or reduction in quantity of a bid item specified as part of a VEP will be considered.

(9) A VEP changing the type of pavement structure or the type or basic design of a bridge structure will not be considered. Changes in the pavement structural section or in structure design details may be considered with prior approval by the Agency. Changes to contingency items such as traffic control and dust palliative will not be considered if they are part of a pre-determined lump sum contract amount. Contingency items such as traffic control and dust palliative may be considered when they are reduced as part of a VEP to change scope, method or procedure, provided they are specified as individual contract bid items.

(10) Additional information needed to evaluate VEPs shall be provided in a timely manner. Untimely submittals of additional information will result in rejection of the VEP. Where design changes are proposed, the additional information could include results of field investigations and survey, design computations, and field change sheets.

(11) The contractor may submit VEPs for an approved subcontractor. Reimbursement will be made to the contractor. Subcontractors may not submit a VEP except though the contractor.

(12) The contractor shall ensure the VEP is sealed by an Engineer registered in the State of Arizona.

(D) Acceptance, Rejection and Payment: Within 30 days of the contractor's formal submission of the VEP, the Agency will accept or reject the VEP.

(1) The contractor will be notified in writing by the Engineer as to whether the proposal has been accepted. The decision by the Agency is final and shall not be subject to the provisions of Subsection 105-18.

(2) Unless otherwise agreed to, in writing, if the VEP is rejected, the contractor shall solely be responsible for all costs incurred in developing and presenting the proposal. The Agency will be solely responsible for the cost associated in investigating and evaluating the proposal.

(3) If the VEP is accepted in whole or in part, the necessary contract modifications and contract price adjustments will be made by the execution of a supplemental agreement which will specifically state that it is executed pursuant to the

provisions of this subsection. The Agency will be the sole judge of the acceptability of a VEP and of the estimated net savings in construction costs from the adoption of all or any part of the VEP.

(4) The contractor shall continue to perform the work in accordance with the requirements of the contract until a supplemental agreement incorporating the VEP has been executed, or until the contractor has been given written acceptance or rejection by the Engineer.

(5) The executed supplemental agreement shall incorporate the changes in the plans, specifications, or other requirements of the contract which are necessary to permit the VEP, or such part of it which has been accepted, to be put into effect, and shall include any conditions upon which the Agency's approval thereof is based. The executed supplemental agreement shall extend or decrease the contract time if required by the Agency.

(6) The executed supplemental agreement shall provide that the contractor be paid 50 percent of the net savings amount as reflected by the difference between the cost of the revised work and the cost of the related construction required by the original contract computed at contract bid prices. The net savings will take into account the contractor's cost of developing the VEP and implementing the change, and reducing this amount by the Agency's cost for investigating and evaluating the VEP, including any ascertainable collateral costs to the Agency. Such collateral costs may include increased costs for maintenance, operation, related work items, additional work items, or elements of related or additional work items.

(7) The executed supplemental agreement shall also provide for the adjustment of contract prices. Contract prices shall be adjusted by subtracting the Agency's share of the accrued net savings.

(8) The amount specified to be paid to the contractor in the executed supplemental agreement shall constitute full compensation to the contractor for the VEP and the performance of the work thereof pursuant to the said supplemental agreement.

104-10 FINAL CLEAN UP

Before final acceptance, all areas within the limits of the project and all areas occupied by the contractor in connection with the work shall be cleaned of all rubbish, excess materials, temporary structures and equipment, and all parts of the work shall be left in a condition acceptable to the engineer.

SECTION 105

CONTROL OF WORK

105-1 AUTHORITY OF THE ENGINEER

The Engineer shall decide all questions which may arise as to the quality and acceptability of materials furnished and work performed and as to the rate of progress of the work, all questions which may arise as to the interpretation of the plans and specifications, all questions as to the acceptable fulfillment of the contract on the part of the contractor and all questions or claims relating to compensation.

The Engineer shall have the authority to suspend the work wholly or in part due to the failure of the contractor to correct conditions unsafe for the workmen or the general public, to carry out provisions of the contract, or for failure to carry out directions. The Engineer may suspend the work for such periods as the Engineer may deem necessary due to adverse weather conditions, for conditions considered adverse for the prosecution of the work or for any other condition or reason deemed to be in the public interest.

The Engineer has the authority to reject defective material or work. The Engineer's failure to discover or reject materials or work not in accordance with the plans, specifications or contract documents shall not be considered an acceptance of the work or materials or a waiver of defects. Neither the failure of the Engineer to properly perform inspections, tests or approvals required by the contract documents nor the activities or duties of the Engineer in the administration of this contract shall relieve the contractor from its responsibility for the means, methods, techniques, sequences or scheduling of the construction or the obligation to perform the work in strict accordance with the contract documents.

Failure of the Engineer to note unsafe working conditions or conditions dangerous to the general public, or to stop work on account of such conditions, shall not relieve the contractor of sole responsibility for such conditions. In this connection, the contractor warrants that the contractor is fully familiar with all of the safety requirements of the current edition of the Occupational Safety and Health Act promulgated by the Federal Government and implemented by the State of Arizona, and that the contractor shall be solely responsible for implementing and enforcing the same at all times. The contractor shall also indemnify and defend the Agency and the Engineer from any and all claims arising out of or caused by such unsafe conditions.

105-2 PLANS AND WORKING DRAWINGS

The plans will show details of all structures, the lines, grades, typical cross sections of the work and the location and design of all structures. The contractor shall keep one set of the plans for the project available at the project site at all times.

The plans shall be supplemented by such working drawings as are necessary to control the work adequately. Working drawings shall be furnished by the contractor and shall consist of such detailed plans as may be required to control the work adequately and are not included in the plans furnished by the Agency. They shall include stress sheets, shop drawings, erection plans, falsework plans, cofferdam plans, dewatering plans, bending diagrams for reinforcing steel, computations, or any other supplementary data required of the contractor.

Drawings, detailed plans, diagrams, etc. shall not be prepared until the elevations, lengths, geometrics, etc. have been verified with the Engineer.

All items to be engineered by a manufacturer under a performance specification (i.e., precast bridge girders, cattle guards, reinforced earth type retaining walls, etc.) shall be prepared under the direct supervision of and bear the seal and signature of an Arizona Registered Professional Engineer of the appropriate discipline on each sheet of drawings and the cover or table of contents of all engineering calculations.

Drawings for falsework, shoring, soldier piles and other major temporary support structures, together with all engineering calculations shall be prepared under the direct supervision of and bear the seal and signature of a Arizona Registered Professional Civil or Structural Engineer. Minor support structures as defined in Subsection 601-1 are exempt from this requirement. Falsework submittals shall not be required for single and multiple barrel concrete box culverts with a clear span of 12 feet (*3.6 meters*) or less. This exemption does not relieve the contractor of the responsibility for providing adequate and safe falsework for these structures.

Prior to submittal, the contractor shall review all working drawings for conformity with the plans and specifications. Any substitution or variance from the plans and specifications shall be clearly noted. The contractor's transmittal letter shall serve as certification that the requirements of the plans and specifications have been met.

The contractor shall submit working drawings allowing at least three weeks for review of each of the initial and supplementary or revised submittals. The contractor shall allow a minimum of three months for the review of any working drawings submitted for structures involving railroads. Review periods for work involving railroads which extends beyond the three months shall be the basis for a time extension, if requested in writing by the contractor. The granting of such a time extension by the Agency shall not give rise to a claim by the contractor for additional compensation due to delays caused by the extended review period. Working drawings, plans and other data shall be submitted to the Engineer in accordance with the requirements of Subsection 108-3 in a timely manner, well in advance of their need, taking into account the complexity of the work, the detailed review by the Engineer and the possibility of rejections, revisions and resubmittals.

The Agency will endeavor to return the reviewed plans and working drawing submittals with a minimum of delay. In order to assist in expediting the review of critical drawings, the contractor should indicate in its submittal the order of preference for review and return of drawings and submit all drawings in the order of importance.

All working drawings, plans and other data shall be reviewed for conformance with the design intent by the Engineer. Following the Engineer's review of each submittal of working drawings, the Engineer shall indicate the action taken by the Engineer in response to the submittal by a written response to the contractor showing action as follows:

"NO EXCEPTION TAKEN," which means the contractor may initiate construction, fabrication or manufacture, subject to the provision that the work shall be in accordance with the requirements of the contract. Final acceptance of the work shall be contingent upon such compliance.

"MAKE CORRECTIONS NOTED," which means, unless otherwise noted on the drawings, the contractor may initiate construction, fabrication or manufacture, subject to the provision that the work shall be carried out in compliance with all annotations or corrections required and in accordance with requirements of the contract. Final acceptance of work shall be contingent upon such compliance. If also marked "REVISE AND RESUBMIT," the submittal is valid but a corrected submittal of drawings is required.

"REJECTED," which means that deviations from the requirements of the contract exist in the submittal such that no work based on such drawings shall be constructed, fabricated or manufactured. The contractor shall revise the drawing in compliance with the Engineer's annotations and pursuant to all requirements of the contract and shall resubmit the working drawings to the Engineer for another review.

The Engineer's review is only for general conformance with the design concept of the project and general compliance with the information provided in the contract documents. The Engineers action shall not relieve the contractor of the contractor's responsibility under the contract for the successful completion of the work, including confirmation and correlation of dimensions at the job site; fabrication processes and techniques of construction; and coordination of the work with the work of all other contractors. Any work done or materials ordered prior to receipt of the appropriate review response for such working drawings shall be at the sole risk of the contractor.

All falsework drawings, shop drawings and other working drawings shall be 36 inches by 22 inches (*914 millimeters by 559 millimeters*) in size. There shall be a 2 inch (*50 millimeter*) margin on the left side of the 36 inch (*914 millimeter*) dimension

and a 1/2 inch (*13 millimeters*) margin on the remaining three sides. A blank space, 4 inches (*100 millimeter*) wide by 3 inches (*75 millimeters*) high shall be left inside the margin in the lower right hand corner. All working drawings shall be made in such a manner that clear and legible copies can be made from them.

Three sets of blue prints or other acceptable type copies shall be submitted to the Engineer. One set shall be returned to the contractor with revisions noted thereon. The contractor shall resubmit the three sets as many times as is necessary, until all corrections and revisions have been made and are acceptable to the Engineer. After the Engineer has determined all corrections have been made, the contractor shall submit six sets of prints and one set of positive reproducibles, such as positive mylars or positive sepias, on which all details shown on the corrected drawings are printed on the front side of the reproducibles. The prints and the reproducibles shall be clear, precise and suitable for microfilm photography. The corrected prints shall be stamped "No Exception Taken" and returned to the contractor. Positive reproducibles shall not be required for falsework unless requested by the Engineer.

No changes shall be made by the contractor to any drawing after it has been approved by the Engineer.

The cost of furnishing all working drawings shall be considered as included in the contract unit price for one or more of the contract items.

105-3 CONFORMITY WITH PLANS AND SPECIFICATIONS

All work performed and all materials furnished shall be in reasonably close conformity to the lines, grades, cross sections, dimensions and material requirements, including tolerances shown on the plans or indicated in the specifications. The Engineer shall determine the limits of reasonably close conformity in each individual case and the Engineer's judgment shall be final and conclusive. Where specific provisions regarding quality control standards are set forth elsewhere in the contract, they shall be controlling.

In the event the Engineer finds the materials furnished, work performed, or the finished product in which the materials are used or the work performed, are not within reasonably close conformity with the plans and specifications, but that reasonably acceptable work has been produced, the Engineer shall then determine if the work shall be accepted and remain in place. If the Engineer determines that the work may be accepted and may remain in place, the Engineer shall document the basis of acceptance by contract modification which provides for an appropriate adjustment in the contract price for such work or materials in accordance with Section 110 or, if not addressed therein, as the Engineer deems necessary to conform to the Engineer's determination based on engineering judgment.

In the event the Engineer finds the materials furnished, work performed, or the finished product in which the materials are used or the work performed, are not in reasonably close conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product, the work or materials shall be removed and replaced or otherwise corrected by and at no additional cost to the Agency.

When the work is performed under a restricted performance specification, the target values studied shall be considered to be the values strived for and from which any deviation is allowed.

It is the intent of the specifications that the materials and workmanship shall be uniform in character and shall conform as closely as realistically possible to the prescribed target value or to the middle portion of the tolerance range. The purpose of the tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons. When either a maximum and minimum value or both are specified, the production and processing of the material and the performance of the work shall be so controlled that material or work will not be preponderantly of borderline quality or dimension.

The Engineer shall determine acceptability of materials or construction as outlined in the applicable sections of the specifications. When materials or construction are not within specification limits, an adjusted payment shall be made as delineated in these specifications, except where the variation of test results is so great that the material or construction is unacceptable.

Subject to the provisions of Section 110, the contractor shall bear all the costs of providing the burden of proof that nonconforming work is reasonable and adequately addresses the design purpose. The contractor shall bear all risk for continuing with nonconforming work in question until a determination regarding its acceptability is made by the Engineer.

Subject to the provisions of Section 110, the Engineer may impose conditions for acceptance of the nonconforming work. The contractor shall bear all costs for the fulfillment of the conditions so imposed. All decisions regarding whether the product satisfies the design purpose, whether nonconforming work is reasonably acceptable, and the conditions for acceptance shall be at the sole discretion of the Engineer.

In addition to other remedies, work and materials that do not conform to the plans and specifications may be remedied pursuant to Subsections 104-2.03 and 104-2.04.

105-4 COORDINATION OF PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS

The Special Provisions, the plans, the Standard Specifications, and all supplementary documents are essential parts of the contract and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for the complete work.

In case of discrepancy or conflict, the order in which they govern shall be as follows:

1) Special Provisions
2) Project Plans
3) Standard Details
4) Standard Specifications

Where dimensions on the plans are given or can be computed from other given dimensions they shall govern over scaled dimensions.

The contractor shall take no advantage of any error or omission in the plans, estimated quantities or specifications. In the event the contractor discovers such an error or omission, the contractor shall immediately notify the Engineer in accordance with Subsection 104-4.

105-5 COOPERATION BY CONTRACTOR

The contractor shall be supplied with six complete sets of approved plans and contract documents including Special Provisions, one set of which the contractor shall keep available on the work at all times. Requests for sets in addition to the six provided shall be made through the Engineer. The cost of reproduction for all additional sets shall be paid by the contractor.

The contractor shall give the work the constant attention necessary to facilitate the progress thereof and shall cooperate with the Engineer, the Engineer's inspectors and other contractors in every way possible.

The contractor shall have on the work at all times, as the contractor's agent, a competent superintendent capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the type of work being performed. The superintendent shall be present at the site of the work at all times while work is actually in progress on the contract. When work is not in progress and during periods when work is suspended, arrangements acceptable to the Engineer shall be made for any emergency work which may be required.

Whenever the contractor or the contractor's superintendent is not present on any particular part of the work where it may be desired to give direction, such direction shall be given by the Engineer, which shall be received and followed by the foreman in charge of the particular work for which the direction is given.

Any direction given by the Engineer, not otherwise required by the specifications to be in writing, shall, if so requested by the contractor, be given or confirmed by the Engineer in writing.

The superintendent shall have full authority to execute orders or directions of the Engineer without delay and to promptly supply such materials, equipment, tools, labor and incidentals as may be required. A superintendent shall be furnished irrespective of the amount of work subcontracted. In an emergency effecting the safety of life or adjoining property, the contractor, without special instruction or authorization from the Engineer, is permitted to act at the contractor's discretion to prevent such threatened loss or injury. Any compensation claimed by the contractor arising from such emergency work shall be determined by the Engineer in accordance with Subsection 104-3.

105-6 COOPERATION WITH UTILITY COMPANIES

The Agency shall notify all utility companies, all pipe line owners or other parties affected and endeavor to have all necessary adjustments of the public or private utility fixtures, pipe lines and other appurtenances within or adjacent to the limits of construction made as soon as practicable.

Water lines, sanitary sewer lines, gas lines, wire lines, service connections, water and gas meter boxes, water and gas valve boxes, light standards, cableways, signals and all other utility appurtenances within the limits of the proposed construction which are to be relocated or adjusted shall be moved by the appropriate utility at their expense, unless otherwise provided for in the Special Provisions or noted on the project plans.

The contract may indicate various utility items, some of which may be relocated or adjusted by the utility, including the date by which the work is expected to be completed, and other utility items which shall be relocated or adjusted by the contractor.

It is understood and agreed that the contractor has considered in its bid all of the permanent and temporary utility appurtenances in their present or relocated positions as shown on the project plans or described in the Special Provisions. The contractor shall notify all utilities at least 48 hours in advance of beginning any work which may affect their facilities so as to allow a representative to be present. The contractor shall provide at least fourteen days notice to utility companies prior to the date that the subgrade for approach slabs to bridges will be completed. Utility companies shall be given seven days to complete the installation of their facilities through or adjacent to the bridge abutments and to a location outside the roadway.

Materials for utility inserts and sleeves on new bridges shall be furnished and installed by the contractor in accordance with the details shown on the plans or as directed by the Engineer.

The contractor shall make every effort to cooperate fully with each utility company and acknowledges and agrees that delays to its operations may necessarily occur. Extensions in the contract time for delays resulting from utility company operations or schedules may be requested by the contractor in accordance with Subsection 108-8.

The contractor shall be responsible for the coordination and cost of all utility relocations indicated on the plans as being the responsibility of the contractor. The contractor shall not be liable for the cost of any utility relocation which was not indicated on the plans when the cost exceeds $100.00. Such extra work shall be performed in accordance with the provisions of Subsection 104-3. In the absence of a supplemental agreement, compensation for relocating such utilities shall be made in accordance with the requirements of Subsection 109-5.

105-7 COOPERATION BETWEEN CONTRACTORS

The Agency reserves the right at any time to contract for and perform other or additional work on or near the work covered by the contract.

When separate contracts are awarded within the limits of any one project, each contractor shall conduct its work so as not to interfere with or hinder the progress or completion of the work being performed by other contractors. Contractors working on the same project shall cooperate with each other as directed. If requested by the Engineer, each contractor shall furnish the Engineer with written evidence that the contractor has made the necessary arrangements with the other contractors for the successful prosecution of the work for the benefit of all parties.

Each contractor involved shall assume all liability, financial or otherwise, in connection with its contract and shall indemnify, defend, and hold harmless the Agency from any and all damages or claims that may arise because of inconvenience, delay or loss experienced by it because of the presence and operations of other contractors working within the limits of the same project.

The contractor shall arrange its work and shall place and dispose of the materials being used so as not to interfere with the operations of the other contractors within the limits of the same project and on adjoining projects. The contractor shall join the contractor's work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

105-8 CONSTRUCTION STAKES, LINES AND GRADES

Unless the contract provides for construction survey and layout by the contractor, the Engineer shall set construction stakes establishing lines, slopes and continuous profile grade in road work and center line and bench marks for bridge work, culvert work, channelization work, protective and accessory structures and appurtenances and shall furnish the contractor with all necessary information relating to lines, slopes and grades. These stakes

and marks shall constitute the field control by, and in accordance with, which the contractor shall establish other necessary controls and perform the work.

During the course of construction, the contractor shall submit requests for staking. The Agency will not be responsible for staking delays unless the Engineer is provided ten calendar days notice before commencing work on an item and thereafter 48 hours notice that stakes are needed.

When the contractor is aware of errors or suspects that there are errors in the staking, the contractor shall immediately bring them to the attention of the Engineer prior to beginning any work on the basis of the errors. The contractor shall take no advantage of any staking error.

The contractor shall be responsible for the preservation of all stakes and marks and, if any of the construction stakes or marks have been carelessly or willfully destroyed or disturbed by the contractor, the cost of replacing them shall be charged against the contractor and shall be deducted from the payment for the work.

The Agency shall be responsible for the accuracy of lines, slopes, grades and other engineering work which it provides under this Subsection.

The following procedure shall be followed for bluetop grade staking provided by the Engineer:

(A) The contractor shall prepare the grade to within $\pm$ 0.2 foot of the elevation specified on the plans prior to requesting bluetops. Prior to achieving the bluetopping tolerance specified, the Engineer shall provide rough staking of the grade, on a one time only basis, if requested to do so by the contractor.

(B) The Engineer shall check center line elevations at intervals of 100 feet or less as well as verifying the cross slope, if applicable.

(C) When the Engineer verifies that at least eighty percent of the points checked are within the specified tolerance, density testing of the grade shall be conducted.

(D) The Engineer shall set bluetops after verification that the results of density testing have achieved the specified values.

It is the contractor's responsibility to direct traffic away from the area being bluetopped and to protect all bluetops from being disrupted or destroyed by traffic until such time as the grade is accepted by the Engineer. The Agency shall provide one set of bluetops over a given area. In addition, Bluetops accounting for up to a maximum 25% of the original number shall be reset by the Agency. Bluetops required in excess of this maximum shall be charged against the contractor and deducted from payments due the contractor.

105-9 BLANK

105-10 DUTIES OF THE INSPECTOR

Inspectors employed by the Agency shall be responsible to accurately document and inspect all work detailed in the plans and specifications and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication or manufacture of the materials to be used. The inspector shall not be authorized to alter or waive the provisions of the contract. The inspector shall not be authorized to issue instructions contrary to the plans and specifications or to act as foreman for the contractor; however, the inspector shall have the authority to reject work or materials until any questions at issue can be referred to and decided by the Engineer.

105-11 INSPECTION OF WORK

All materials and each part or detail of the work shall be subject to inspection by the Engineer. The Engineer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the contractor as is required to make a complete and detailed inspection.

Inspections of the contractor's work by the Engineer, inspectors or other agents or employees of the Agency are for the purpose of ensuring the technical quality of the work as well as adherence to the provisions of the contract. Such inspections are not for the purpose of insuring the safety of workmen on the project which shall be the sole responsibility of the contractor. In this regard, the contractor warrants that the contractor is fully knowledgeable with all of the requirements of Title 29 Code of Federal Regulations Part 1926, Safety and Health Regulations for Construction (OSHA) as implemented by the State of Arizona, and that the contractor shall be solely responsible for the implementation and enforcement of these requirements.

The contractor shall schedule its operations to allow a reasonable amount of time for engineering inspection of the work. The Engineer shall perform the inspection as expeditiously as possible in order that the work might progress in an orderly and continuous manner. In most cases, inspection will be completed in 8 work hours or less. The contractor shall not be entitled to additional compensation or an extension of contract time for delay resulting from such inspections.

Additional inspection costs incurred due to contractor errors shall be at no additional cost to the Agency.

The contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as directed by the Engineer. After examination, the contractor shall restore such portions of the work to the standard required by the plans and specifications. Should the work thus exposed or examined prove acceptable, payment for uncovering or removal and

replacement of the covering or making good of the parts removed shall be made in accordance with the requirements of Subsection 104-3. Should the work so exposed or examined prove unacceptable, the uncovering or removal and replacement of the covering or making good of the parts removed shall be at no additional cost to the Agency.

Any work done or materials used without inspection by the Engineer may be ordered removed and replaced at no additional cost to the Agency unless the Engineer failed to inspect same after having been given a minimum of 48 hours notice, in writing, that the work was to be performed. Failure to reject any defective work or materials shall not in any way prevent later rejection when such defect is discovered nor obligate the Engineer to final acceptance.

When any unit of government, political subdivision, utility or any railroad corporation is to pay a portion of the cost of the work covered by the contract, its respective representatives shall have the right to inspect the work. Such inspection shall in no sense make any unit of government, political subdivision or any railroad corporation a party to the contract and shall in no way interfere with the rights of either party to the contract.

105-12 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK

All work which does not conform to the requirements of the contract, inclusive of the warranty and guarantee period specified in Subsection 106-13, shall be considered as unacceptable work unless otherwise determined to be acceptable in accordance with the requirements of Subsection 105-3 and Section 110.

Unacceptable work, whether the result of poor workmanship, use of defective materials, damage through carelessness or any other cause, found to exist prior to the final acceptance of the work shall be removed immediately and replaced in an acceptable manner.

When the removal and replacement or repair of unacceptable or unauthorized work causes damage or destruction to previously completed work, to the work of others, or to existing structures, equipment or material, the contractor shall bear the expense of repairing or removing and replacing the facilities or improvements that were damaged or destroyed.

No work shall be done without lines and grades having been previously established. Work done contrary to the instruction of the Engineer, work done beyond the lines shown on the project plans or as given, except as herein specified, or any extra work done without authority, shall be considered as unauthorized and shall not be paid for under the provisions of the contract. Work so done may be ordered removed or replaced at no additional cost to the Agency.

Upon failure on the part of the contractor to comply with any order of the Engineer made under the provisions of this Subsection, the Engineer shall have authority to cause unacceptable work to be remedied or removed and replaced and unauthorized work to be removed and to deduct the costs from any monies due the contractor.

105-13 LOAD RESTRICTIONS

The contractor shall comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the project. A pamphlet, Sizes and Weights of Vehicles and Loads upon Highways, which has been extracted from Title 28, Chapter 6, Arizona Revised Statutes, is available from the Motor Vehicle Division, Arizona Department of Transportation. A special permit shall not relieve the contractor of liability for damage which may result from hauling of material or moving of equipment.

The operation of equipment of such weight or so loaded as to cause damage to structures or the roadway or to any other type of construction shall not be permitted. Hauling of materials over the subgrade or the base course or surface course under construction shall be limited as directed by the Engineer. No loads shall be permitted on a portland cement concrete pavement, base or structure before the expiration of the curing period. The contractor shall be responsible for all damage done by the contractor's hauling equipment. In no case shall legal load limits be exceeded unless permitted, in writing, by the Engineer.

105-14 MAINTENANCE DURING CONSTRUCTION

Unless special maintenance bid items have been included in the contract document, the contractor shall maintain the work during construction and until the project is accepted except as otherwise specified in Subsection 104-5(B).

The contractor shall use adequate equipment and forces to keep the work in satisfactory condition at all times.

In the case of a contract for the placing of a course upon a course or subgrade previously constructed, the contractor shall maintain the previous course or subgrade during all construction operations.

All costs of maintenance work during construction and before the project is accepted shall be considered as included in the contract unit price for one or more of the items specified in Section 701.

The contractor shall not be responsible for vandalism of any work that has been accepted, in writing, by the Agency.

105-15 FAILURE TO MAINTAIN THE WORK

If at any time the contractor fails to comply with the provisions of Subsection 105-14, the Engineer will immediately notify the contractor of such noncompliance. If the contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice, the Engineer may immediately proceed to maintain the project and the entire cost of this maintenance shall be deducted from monies due or to become due the contractor on the contract.

Maintenance work initiated by the Engineer shall not void the contractor's obligations under the warranty/guarantee provisions of Subsection 106-13.

105-16 RELIEF FROM MAINTENANCE AND RESPONSIBILITY

Upon the request of the contractor, the Engineer may relieve the contractor of the duty of maintaining and protecting certain portions of the work as described below, which have been completed in all respects in accordance with the requirements of the contract and to the satisfaction of the Engineer, and thereafter, except with the contractor's consent, the contractor shall not be required to do further work thereon. In addition, such action by the Engineer shall relieve the contractor of responsibility for injury or damage to the completed portions of the work resulting from use by public traffic or from the action of the elements or from any other cause but not from injury or damage resulting from the contractor's own operations or from the contractor's negligence.

Portions of the work for which the contractor may be relieved of the duty of maintenance and protection as provided in the above paragraph include, but are not limited to, the following:

(1) The completion of one-quarter mile of roadway or one-quarter mile of one roadway of a divided highway or a frontage road including the traveled way, shoulders, drainage control facilities, planned roadway protection work, lighting and any required traffic control and access facilities.

(2) A bridge or other structure of major importance.

(3) A complete unit of traffic control signal system or of a roadway lighting system.

(4) Non-roadway facilities constructed for other agencies.

However, nothing herein providing for the relief from maintenance and responsibility shall be construed as relieving the contractor of full responsibility for making good defective work or materials found at any time before either the formal written acceptance of the entire contract by the Engineer or the expiration of warranties and guarantees.

105-17 ACCEPTANCE

(A) Partial Acceptance. If at any time during the prosecution of the project the contractor substantially completes a unit or portion of the project, the contractor may submit a written request to the Engineer to make final inspection of that unit. The Engineer shall approve or disapprove the request within five working days.

If approved, and the Engineer finds upon inspection that the unit has been satisfactorily completed in compliance with the contract, the Engineer may accept that unit as being completed and the contractor may be relieved of further responsibility for that unit. Such partial acceptance shall in no way void or alter any of the terms of the contract.

(B) Final Acceptance. Upon notice from the contractor of presumptive completion of the entire project, the Engineer shall make an inspection. If all construction provided for and contemplated by the contract is found completed to the Engineer's satisfaction, that inspection shall constitute the final inspection and the Engineer shall make the final acceptance and notify the contractor, in writing, of this acceptance as of the date of the final inspection. Final acceptance does not necessarily constitute complete performance by the contractor of all provisions of the contract. In that event the Agency may make a specific written finding justifying delay in payment of retention monies to the contractor beyond the period stipulated in Subsection 109-11.

If, however, the inspection discloses any work, in whole or in part, as being unsatisfactory or not complete, the Engineer shall give the contractor written notice of the unsatisfactory or uncompleted work and the contractor shall immediately correct such work. In such case, the Engineer shall also give the contractor written notice as to whether or not the work is substantially complete. In addition, final acceptance will not be made until all completed plans and working drawings as required in Subsection 105-2 have been submitted and deemed acceptable by the Engineer.

Upon completion and correction of the work, another inspection shall be made which shall constitute the final inspection provided the work has been satisfactorily completed. In such event, the Engineer shall make the final acceptance and notify the contractor, in writing, of this acceptance as of the date of final inspection.

105-18 CLAIMS

(A) Notice of Claim. It is the purpose of this Subsection that claims for additional compensation and any difference between the parties arising under and by virtue of the contract be brought to the attention of the Engineer or authorized representative at the earliest possible time and at the first responsible level so as to increase the possibility for such matters to be resolved or for appropriate action to be taken promptly. This Subsection shall be

construed to apply to all claims including, but not limited to, claims based on contract clauses as well as claims based on breach of contract or tort.

In the event any basis for additional compensation or time extension arising under, by virtue of, or out of the contract, is perceived by the contractor to have occurred, the contractor shall call such matter to the immediate attention of the Engineer for the earliest possible decision, instruction, notice or action duly taken by the Engineer.

Should the contractor disagree with any decision, order, instruction, notice, act or omission of the Engineer, or authorized representative, the contractor may submit a Notice of Claim to the Engineer or authorized representative. The Notice of Claim shall be submitted, in writing, within three working days after the contractor has learned of such occurrence or event, and the notice shall indicate, insofar as possible, the basis and the nature of the claim. The contractor shall give the Notice of Claim before the contractor begins the work on which the contractor bases the claim. If such notification is not given, the contractor hereby agrees to waive any claim for additional compensation. Within a 10 day period from the submission of the Notice of Claim, the contractor shall submit, in writing, a projection of the contractor’s additional costs resulting from the alleged incident. Such costs shall include both the present and future cost resulting from the alleged incident.

If the contractor fails to submit costs resulting from the claim to the Engineer within 60 days after all of the contractor's costs have been incurred, the contractor hereby agrees to waive any claim for additional compensation.

At the time the contractor gives written notice of the claim, the contractor shall immediately begin to keep and maintain complete and specific records to the extent possible, including, but not limited to, cost records concerning the details of the claim.

The contractor shall give the Engineer or authorized representative access to any such record and, when so requested, shall furnish the Engineer or authorized representative copies thereof.

Unless otherwise agreed to in writing, the contractor shall continue with and carry on the project work and progress during the pendency of any claim, dispute, decision or determination by the Engineer, and any arbitration proceedings, and the Agency shall continue to make progress payments to the contractor in accordance with the contract documents.

(B) Submission of Claims. As promptly as possible following the submission of a notice of claim in accordance with paragraph (A) of this Subsection, but in no event later than 60 days after all

of the contractor's costs have been incurred, the contractor shall submit the claim to the Engineer or authorized representative concerning the matter so noticed.

The claim shall set forth clearly and in detail, for each item of additional compensation or extension of time requested, the reasons for the claim, references to applicable provisions of the specifications, the nature and the specific cost ascribed to each element of the claim or for each period of time involved, the basis used in ascribing each such element of cost or for each such period of time, and all other pertinent factual data. The contractor, insofar as it is possible to do so, shall promptly furnish any clarification and additional information or data deemed necessary and requested in writing by the Engineer or authorized representative.

(C) Decision on Claims. The Engineer shall make a written decision in relation to any claim presented by the contractor within the following time frames:

(1) For an adjustment in compensation, or other contractual dispute between the parties where the amount in controversy is $100,000.00 or less, 60 days from the receipt of the contractor's claim;

(2) For an adjustment in compensation or other contractual dispute between the parties where the amount in controversy is more than $100,000.00, the Engineer shall make a decision within 90 days from the receipt of the contractor's claim.

Unless the contractor and the Engineer otherwise stipulate in writing to a later time, if the Engineer does not make a decision or determination within the time frames prescribed in this subsection, the claim shall be deemed denied and the contractor may proceed with the legal remedy prescribed herein.

The decision of the Engineer or authorized representative in relation to the contractor's claim shall be final and binding unless the contractor commences a lawsuit within the time prescribed by law or unless the contractor invokes arbitration as prescribed in Subsection 105-19. Any lawsuit brought pursuant to this Section shall be filed in the Pima County Superior Court. Nothing contained in this Section shall be construed to preclude the contractor from bringing a legal action for claims in excess of $25,000.00; however, the contractor's sole legal remedy for claims of $25,000.00 or less shall be arbitration as set forth in Subsection 105-19. Claims between $25,000.00 and $100,000.00 shall be subject to arbitration only upon the written consent of both parties. The written consent shall state whether the arbitration shall be binding or non-binding. In making a determination of the amount in controversy, any requested extensions of contract time or the release or remission of liquidated damages previously assessed under Subsections 108-8 and 108-9 of these Specifications shall not be considered, quantified or taken into account. A contractor having a claim, adjustment or dispute for an amount in excess of the jurisdictional amounts set

forth in this paragraph may waive or abandon the dollar amount of any such claim in excess of the jurisdictional amount so as to bring the claim, adjustment or dispute within the scope and coverage of Subsection 105-19, provided, however, that the amount allowed to any such party by the arbitration panel shall not exceed such jurisdictional amount.

105-19 ARBITRATION OF CLAIMS AND DISPUTES

(A) All arbitration proceedings arising under this Subsection shall be conducted in Tucson, Arizona, at a location mutually agreed upon by the arbitrating parties.

(B) If the contractor elects to invoke arbitration, the contractor shall file a Demand for Arbitration in writing with the Engineer of the Agency against which the arbitration is filed. Such Demand for Arbitration shall be made within 30 days measured from actual receipt of the Engineer's decision as provided for in Subsection 105-18 above. The scope of the arbitration proceeding shall be restricted and limited to the matters presented to the Engineer or authorized representative upon which the decision or determination was made and shall include no other matters.

(C) All arbitrations arising under this Subsection shall be conducted by an arbitration panel consisting of the following members:

(1) One arbitrator selected by the Agency. If the Agency is an arbitrating party, such arbitrator shall not be an Agency employee, but may be a contract consultant employed by the Agency on projects other than the project giving rise to the arbitration.

(2) One arbitrator selected by the contractor from the local contracting community. Such arbitrator shall not be an employee or agent of the contractor.

(3) One arbitrator mutually acceptable to the arbitrating parties. Such arbitrator shall not be an employee or agent to any party to the arbitration proceedings.

(4) One non-voting member mutually acceptable to the arbitrating parties. This individual shall be an attorney duly licensed to practice law in the State of Arizona, who is not an employee, agent or contract counsel to any party to the arbitration proceedings. The non-voting attorney member of the arbitration panel shall act as moderator of the arbitration proceedings.

(D) The procedure for arbitration shall be in accordance with the current Construction Industry Arbitration Rules of the American Arbitration Association, with the following amendments:

(1) The arbitrator shall not be employed by the American Arbitration Association, but shall instead be the panel described in paragraph (A) set forth above.

(2) Parties to an arbitration proceeding shall be entitled to a reasonable discovery period and all parties shall cooperate in producing requested documents, files and other records and papers relevant to the claim being arbitrated and in giving testimony by way of deposition, affidavits, or otherwise as may be reasonably requested. In addition to the methods and procedures for discovery set forth in the current Construction Industry Arbitration Rules of the American Arbitration Association, arbitrations occurring pursuant to these Standard Specifications shall be entitled to any and all discovery methods and procedures set forth in the Arizona Rules of Civil Procedures, Rules 26 through 37. The non-voting attorney member of the arbitration panel shall have the discretion to determine whether or not discovery requests are reasonable and relevant.

(E) Within thirty days after a Demand for Arbitration is filed, a party against whom a claim has been filed may assert a claim for indemnification against a third party as a matter of right and without requesting leave of the arbitration panel or the party filing the Demand for Arbitration. After the thirty day period, a party against whom a claim has been filed may assert a claim for indemnification against a third party only upon consent of the party filing the Demand for Arbitration or upon order of the arbitration panel.

(F) Fees charged and costs incurred by members of the arbitration panel shall be borne, in equal shares, by the parties arbitrating the claim, including any third parties participating in the arbitration proceedings by reason of claims of indemnity, or otherwise.

(G) Any award rendered by the arbitration panel in a binding arbitration shall be final and judgment may be entered upon it in accordance with applicable law in any court having jurisdiction thereof.

105-20 LITIGATION

In the event that the contractor elects to litigate a dispute with the Agency, the venue shall be in Pima County, Arizona. Each party to the litigation shall be responsible for their own costs of litigation including attorney's fees and any expenses of whatsoever nature.

SECTION 106

CONTROL OF MATERIAL

106-1 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS

The contractor shall furnish all materials required to complete the work, except materials that are designated in the Special Provisions to be furnished by the Agency as set forth in Subsection 106-12.

Only materials conforming to the requirements of the specifications shall be incorporated into the work. Materials shall be new except as may be provided elsewhere in the contract documents. The materials shall be manufactured, handled and used in a workmanlike manner to insure completed work in accordance with the requirements of the plans and the specifications.

In order to expedite the inspection and testing of materials, the contractor shall notify the Engineer of the proposed sources of materials prior to delivery. At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found after trial that sources of supply for previously approved materials do not produce specified products, the contractor shall furnish materials from other sources.

Whenever water is required on a project, as part of either a process or a product, it shall be free of contaminants which, in the judgment of the Engineer, constitute a health hazard to those individuals employed on the project and to the general public.

Untreated effluent shall not be utilized in any aspect of the work.

A permit shall be required for utilizing treated effluent. When treated effluent is used on the project, the contractor shall notify the Engineer and all workers of this use.

106-2 ITEMS OF SPECIAL MANUFACTURE

Either at the time of the preconstruction conference, or in no case later than ten days after the preconstruction conference, the contractor shall furnish the Engineer a list of all items of special manufacture or items which are, or may be, in short supply and which will be incorporated into the work. Items of special manufacture shall include, but shall not be limited to, materials and equipment for traffic signal and lighting systems, steel bridge members, precast, prestressed concrete bridge members, or other structural components, and materials of special manufacture.

The items of special manufacture which have been agreed upon by the Engineer and the contractor shall be ordered by the contractor promptly so that they will be available as required and will not delay the work.

The contractor shall advise the Engineer regarding the dates of the orders and the dates that the items are expected to be received.

If there is any delay in the prosecution of the work because of a delay in the delivery of items of special manufacture, an extension of the contract time shall only be granted in accordance with Subsection 108-8 if the Engineer is completely satisfied that the contractor has made every effort to obtain the items in a timely manner.

106-3 LOCAL MATERIALS SOURCES

Sources of local borrow, base or surfacing materials shall be furnished by the contractor. When the contractor obtains material from other than a commercial source, it shall determine for itself the amount of equipment and work required to produce a material meeting the specifications.

When a non-commercial source is used, the contractor shall acquire the necessary rights to take materials from the sources and shall pay all costs related thereto, including any which may result from an increase in length of haul. All costs of exploring and developing sources shall be borne by the contractor. The use of material from other than commercial sources shall not be permitted until tests on preliminary samples indicate general acceptability of the material. Additional samples may be required of the contractor for inspection and testing by the Engineer prior to approval of and authorization to use the source.

The use of material sources situated in the 100-year floodplain of any stream or watercourse, and located within one mile upstream and two miles downstream of any highway structure or surfaced roadway crossing, shall be governed by the governmental entity having jurisdiction over said feature.

The location of any new material source or existing non-commercial material source proposed for use on the project shall be reviewed by the appropriate agency having floodplain management jurisdiction for the area in which the proposed source is located. The contractor shall obtain a letter from the floodplain management agency certifying that the location of the proposed source conforms to the requirements of their regulations.

Contractors seeking a floodplain material source are cautioned that Section 404 of the Federal Clean Water Act may prevent use of the source unless an appropriate permit is first obtained from the U.S. Army Corps of Engineers.

If a floodplain source is being considered for use, the contractor is advised to ensure that the source will be obtainable within the required time frame.

106-4 TESTS AND ACCEPTANCE OF MATERIALS

All materials shall be inspected, tested and approved by the Engineer prior to incorporation in the work. Any work in which materials not previously approved are used shall be performed at the contractor's risk and may be considered as unauthorized and unacceptable and not subject to the payment provisions of the contract. Failure of the Engineer to inspect or test any material shall not relieve contractor from its obligations under this Agreement and any liability for injury or damage.

Materials shall be sampled and tested by a qualified representative of the Agency and at the expense of the Agency unless otherwise specified in the Special Provisions. Copies of all test results shall be furnished to the contractor's representative at the contractor's request.

The contractor shall submit a request for materials testing a minimum of 24 hours in advance.

In the case where a density test fails to achieve the minimum requirement, one additional test will be conducted at that location after the contractor has reworked the area. Should this test also yield unacceptable results, additional retesting, after reworking by the contractor, will be conducted at the expense of the contractor. The unit charges for retests are available from the Engineer.

Whenever a reference is made in the specifications to an Arizona Test Method, it shall mean the test method of the Arizona Department of Transportation as found in their Materials Testing Manual that is in effect on the day the advertisement for bids for the work is dated.

Whenever a reference is made in the specifications to a Federal Specification, or to a specification or test designation of the American Association of State Highway and Transportation Officials, the American Society for Testing and Materials, or any other recognized national organization, it shall mean the year of adoption or latest revision of the specification or test designation in effect on the day the advertisement for bids for the work is dated.

106-5 CERTIFICATES

106-5.01 General. The contractor shall submit to the Engineer an original and two copies of either a Certificate of Compliance or a Certificate of Analysis, as required, prior to the use of any materials or manufactured assemblies for which these specifications or the Special Provisions require that such a certificate be furnished.

The Engineer may permit the use of certain materials or manufactured assembles prior to, or without, sampling and testing if accompanied by a Certificate of Compliance or a Certificate of Analysis, as herein specified. Materials or manufactured

assemblies for which a certificate is furnished may be sampled and tested at any time, and, if found to be not in conformance with the requirements of the plans and the specifications, will be subject to rejection, whether in place or not.

Certificates shall comply with the requirements specified herein and as contained in the ADOT Materials Testing Manual.

106-5.02 Certificate of Compliance

The Certificate of Compliance shall contain the following information:

(1) A description of material supplied.

(2) Quantity of material represented, by the certificate.

(3) Means of material identification, such as label, lot number, marking.

(4) Statement that the material complies in all respects with the specific requirements of the cited specifications, including the test method or the specification section or Special Provision. Certificates may cite both the test method and the specification/Special Provision section, if applicable.

(5) The name, address, and telephone number of the manufacturer or supplier together with the signature and title of a person having legal authority to bind the manufacturer or supplier of the material. The signature shall be dated. A copy or facsimile reproduction is acceptable. However, the original certificate bearing the original signature shall be made available upon request.

The person signing the certificate shall be one of the following:

- An officer of a corporation.
- A partner in a business partnership or an owner.
- A general manager.
- Any person having been given the authority by one of the above. The delegation of authority shall accompany the Certificate of Compliance in writing. The delegation of authority will be kept on file should subsequent certificates be received for that material on that project.

Each of the first four items specified above, shall be provided by the firm or organization that is certifying the material prior to the signing as defined in item five, and all of the first four shall be in one type style or handwriting. No certificate shall be accepted that has been altered, added to, or changed in any way

after the authorized original signature of the person that has legal authority to bind the firm or organization has been affixed to the original certificate. Materials or assemblies shall not be incorporated into the project without a valid certificate of compliance or proper testing.

The Agency reserves the right to refuse to permit the use of material on the basis of a Certificate of Compliance.

106-5.03 Certificate of Analysis. The Certificate of Analysis shall include all the information required in a Certificate of Compliance and, in addition, shall include the results of all tests required by the specifications.

106-6 INSPECTION OF THE PLANT

The Engineer may undertake the inspection of materials at the source. In the event plant inspection is undertaken, the Engineer shall have the cooperation and assistance of the contractor and the producer with whom the contractor has contracted for materials, and the Engineer shall have full entry at all times to such parts of the plant as may be involved in the manufacture or production of the materials being furnished. Adequate safety measures shall be provided and maintained.

The Agency reserves the right to retest all materials which have been tested and accepted at the source of supply after the same have been delivered and prior to incorporation into the work and to reject all materials which, when retested, do not meet the requirements of the specifications.

106-7 SAMPLING DEVICE

All secondary crushers and screening plants used in producing materials shall be equipped with a mechanical sampling device or devices that can either be operated from the ground or is accessible to the operator on a platform.

These devices shall be constructed and operated so that they will move at a constant rate across the full width of material and collect a representative sample of the falling column of material from the discharge belt or chute while the plant is in operation. The sampling device shall be substantially constructed so that a sample weighing up to 100 pounds (*45 kilograms*) can be taken.

The sampling devices shall be equipped with necessary attachments to convey the samples to the ground so that they can be safely and conveniently collected.

The sampling devices shall be approved by the Engineer and shall be maintained in a satisfactory working condition so that samples may be taken at any time, as required by the Engineer.

106-8 PROPRIETARY PRODUCTS, TRADE NAMES AND SUBSTITUTIONS

Plans or specifications may contain references to equipment, materials or patented processes by manufacturer, trade name, make or catalog number.

Such references shall be regarded as establishing a standard of quality, finish, appearance or performance or as indicating a selection based upon compatibility with existing equipment or materials and shall not be construed as limiting selection to a specific item or source.

The use of an alternative or substitute article of equipment, material or process which, for the purpose intended, is of equal quality, finish, appearance, or performance and which is compatible with existing equipment and materials when required, may be permitted at the discretion of the Agency.

A written request for substitution shall be made by the contractor and shall include all information necessary for proof of equality and suitability for substitution, including samples for testing, if required. The request for substitution shall meet the stipulations set forth in Subsection 104-9 for cost reduction incentive proposals, items (1) through (7). The Agency shall evaluate the information submitted, perform tests when necessary and make comparisons. The Engineer shall then make the final decision as to the acceptability of the proposed substitution. The Agency shall not be liable for any delay in acting upon any request for substitution nor for any failure to accept any request pursuant to this substitution.

If acceptance of a substitution requires modifications to foundations, structures, piping, electrical or other related designs or existing facilities, these costs shall be borne by the contractor.

106-9 STORAGE OF MATERIALS

Materials shall be so stored as to insure the preservation of their quality and fitness for the work. Stored materials, even through approved before storage, may again be inspected prior to their use in the work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes and for the placing of the contractor's plant and equipment, but any additional space required for this purpose shall be provided by the contractor at the contractor's expense. Private property shall not be used for storage purposes without written permission of the owner or lessee, all permits and approvals required by federal, State and local laws and regulations, compliance with zoning and, if requested by the Engineer, copies of such written permission and approvals shall be furnished to the Engineer. All storage sites shall be restored to their original condition by the contractor at no additional cost to the Agency. This shall not apply to the stripping and storing of topsoil or to other materials salvaged from the work.

106-10 HANDLING MATERIALS

All materials shall be handled in such a manner as to preserve their quality and fitness for the work.

Aggregates shall be transported from the storage site to the work in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order that there may be no inconsistencies in the quantities of materials as loaded and intended for incorporation into the work and the quantities of materials as actually received at the place where they are to be incorporated into the work.

106-11 UNACCEPTABLE MATERIALS

Materials not conforming to the requirements of the specifications, whether in place or not, shall be rejected and shall be promptly removed from the site of the work, unless otherwise directed by the Engineer. No rejected material, the defects of which have been corrected, shall be returned to the work site until such time as approval for its use has been given by the Engineer.

106-12 AGENCY FURNISHED MATERIAL

The contractor shall furnish all materials required to complete the work, except those specified to be furnished by the Agency.

Material furnished by the Agency shall be delivered or made available to the contractor as specified in the Special Provisions.

The contractor shall receive, inventory, store, inspect, protect, distribute, and install Agency furnished material unless otherwise specified in the Special Provisions.

The cost of handling and placing all materials after they are delivered to the contractor shall be considered as included in the contract price for the item in connection with which they are used.

The contractor shall be held responsible for all material delivered to the contractor. Deductions shall be made from any monies due the contractor to make good any shortages or deficiencies, from any cause whatsoever and for any damage which may occur after such delivery, and for any late delivery charges.

106-13 WARRANTIES AND GUARANTEES

The contractor shall warrant and guarantee all the work against defective workmanship or materials for a period of one year commencing on the date of final acceptance of the work under the contract, ordinary wear and tear and unusual abuse or neglect

excepted. In the case of a latent defect, the warranty shall commence on the date the defect is discovered, except that this warranty period shall not extend beyond the period allowed by law.

Any omission on the part of the Engineer to condemn defective work or materials at the time of construction shall not be deemed an acceptance. Payment shall not be conclusive evidence of the completion of the work, either in whole or in part, or be construed as an acceptance of defective work or improper materials, or relieve the contractor from making good such defects. The contractor shall be required to correct defective work or materials at any time before full acceptance and within the warranty and guarantee period.

Should any defects develop within the warranty and guarantee period due to faults in workmanship or materials, the contractor shall, within 14 calendar days of receipt of written notice from the Engineer, begin making the necessary repairs. Such work shall include the repair or replacement of other work or materials damaged or affected by making the above repairs or corrective work, all to the satisfaction of the Engineer and at no additional cost to the Agency.

The contractor shall obtain such manufacturer's or producer's warranties or guaranties on all items, materials, electrical, or mechanical equipment consistent with those provided as customary trade practice. The form in which such warranties or guaranties are delivered to the contractor shall include the provision that they are subject to transfer to the maintaining agency as named by the Agency, and shall be accompanied by proper validation of such fact. Transfer of warranties or guaranties shall occur at the time of final acceptance of the work or equipment by the Agency.

In addition, a contractor warranty or guarantee shall be furnished providing for satisfactory in-service operation of the mechanical and electrical equipment and related components for a period of 12 months following project acceptance.

Should any defect develop during this 12 month period, the malfunction or defect shall be corrected by and at the expense of the contractor, including all labor, material, and associated costs.

The warranties and guarantees provided herein shall be in addition to and not in limitation of any other warranties, guarantees, or remedies required by law.

If the contractor fails to make any repair, adjustment, or other work that may be made necessary by a defect, the Agency may cause the work to be properly done, in accordance with the provisions of the Contract documents, and to pursue whatever recourse it deems necessary to recover, from the contractor, any additional expense or cost it may have incurred. The performance bond shall remain in full force and effect through the warranty and guarantee period.

106-14 DOMESTIC MATERIALS (FEDERAL-AID PROJECTS ONLY)

Portland cement used on the project may be of foreign or domestic manufacture.

The manufacturing process to produce all steel products used on the project shall occur in the United States. The iron used in the process shall be domestic. Other raw materials used in manufacturing the steel products may be foreign or domestic. Steel not meeting these requirements may be used in products on the project provided that the invoiced cost to the contractor for such steel products incorporated into the work does not exceed either one-tenth of one percent of the total (final) contract cost or $2,500.00, whichever is greater.

Any process which involves the application of a coating to iron or steel shall occur in the United States. These processes include epoxy coating, galvanizing, painting, or any other coating which protects or enhances the value of covered materials.

The contractor shall furnish a Certificate of Analysis in accordance with Subsection 106-5.03 which states that steel products utilized on the project meet the requirements of the specifications and identifies whether the steel products are domestic or foreign.

SECTION 107

LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107-1 LAWS TO BE OBSERVED

The contractor shall keep fully informed of all federal and state laws, all local laws, ordinances and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the work or which in any way affect the conduct of the work. The contractor shall at all times observe and comply with all laws, ordinances, regulations, orders and decrees and shall protect and indemnify the Agency, its representatives and agents against any claim or liability arising from or based on the violation of any such law, ordinance, regulation, order or decree, whether by the contractor or by any of the contractor's subcontractors or suppliers, or by any of their employees.

The contractor shall comply with the Drug-Free Workplace Act, Americans with Disabilities, Occupational Safety and Health Act, and all other pertinent laws relating to conditions of employment or hiring/retention practices.

107-2 PERMITS, LICENSES AND TAXES

Unless otherwise specified in the Special Provisions, the Agency shall obtain and provide to the contractor the following permits, as applicable to the project: U.S. Army Corps of Engineers 404 Permit; Arizona Department of Water Resources Dewatering Permit; Grading Permit; Floodplain Use Permit; and Railroad Permits with the exception of the contractor's Right-of-Entry Agreement.

The contractor shall procure all other permits and licenses not herein specified as being provided by the Agency, pay all charges, fees and taxes and give all notices necessary and incidental to the due and lawful prosecution of the work.

The Motor Vehicle Division has specific requirements for the licensing of vehicles base plated outside the State of Arizona. Licensing information is available from Motor Vehicle Division, Motor Carrier Services, 1801 West Jefferson, Room 234M, Phoenix, Arizona, 85007.

107-3 PATENTED DEVICES, MATERIALS AND PROCESSES

If the contractor employs any design, device, material or process covered by letter of patent or copyright, the contractor shall provide for such use by suitable legal agreement with the patentee or owner.

The contractor and the surety shall indemnify, defend and hold harmless the Agency, and any affected third party or political subdivision, from any and all claims for infringement by reason of the use of any patented design, device, material or process or any

trademark or copyright and shall indemnify the Agency for any costs, expenses and damages which it may be obliged to pay by reason of any infringement at any time during the prosecution or after the completion of the work.

107-4 RESTORATION OF SURFACES OPENED BY PERMIT

The right to construct or reconstruct any utility service in any public right of way or to grant permits for same, at any time, is hereby expressly reserved by the Agency for itself or the proper authorities having jurisdiction over the work.

Any individual, firm or corporation wishing to make an opening in any public right of way shall secure a permit from the Agency or the proper authority having jurisdiction over the work if other than the Agency. The contractor shall allow parties bearing such permits, and only those parties, to make openings in the right of way. When ordered by the Engineer, the contractor shall make, in an acceptable manner, all necessary repairs due to such openings and such necessary work will be paid for as extra work or as otherwise provided in these specifications, and will be subject to the same conditions as original work performed.

107-5 FEDERAL AID PARTICIPATION

When the United States government pays all or any portion of the cost of a project, the federal laws and the rules and regulations made pursuant to such laws shall be observed by the contractor and the work shall be subject to the inspection of the appropriate federal agency.

Such inspection shall in no sense make the federal government a party to the contract and shall in no way interfere with the rights of either party to the contract.

107-6 ARCHAEOLOGICAL FEATURES

The attention of the contractor is directed to Article 4, Archaeological Discoveries, A.R.S. §§ 41-841, 41-842, 41-844 and 41-846, which make it a felony, punishable by a fine and imprisonment, to investigate, explore or excavate on State land, in or on prehistoric ruins, ancient burial grounds, fossilized footprints, hieroglyphics and all other archaeological features of the State of Arizona without permits from the Arizona State Museum.

Section 6(a) of the Federal Archaeological Resources Protection Act of 1979 specifies that no person may excavate, remove, damage or otherwise alter or deface any archaeological resource located on public (Federal) lands or Indian lands unless such activity is pursuant to a permit issued under Section 4 of the Act. Violations of this Act are a felony and are punishable by fine and imprisonment.

Additionally, the contractor shall be subject to and comply with all local ordinances, policies and directives governing archaeological and historical resources.

Although the Agency shall make every effort, prior to construction, to identify all cultural resources in a project area, previously unidentified archaeological materials could be found during the construction of the project. When archaeological, historical or paleontological features are encountered or discovered during any activity related to the construction of the project, the contractor shall stop work immediately at that location and shall take all reasonable steps to secure the preservation of those features.

The Engineer shall immediately make arrangements for the proper treatment of those resources. The contractor shall not resume work until the contractor is so directed by the Engineer.

Extensions in the contract time for delays resulting from the discovery of archaeological, historical or paleontological features may be requested by the contractor in accordance with Subsection 108-8.

107-7 SANITARY, HEALTH, AND SAFETY PROVISIONS

The contractor shall provide and maintain in a neat and sanitary condition such accommodations for the use of the contractor's employees as may be necessary to comply with the requirements and regulations of the Arizona State Department of Health Services, the Pima County Health Department or other authorities having jurisdiction.

Attention is directed to Federal, State and local laws, rules and regulations concerning construction safety and health standards. The contractor shall not require any workers to work in surroundings or under conditions which are unsanitary, hazardous or dangerous to their health or safety.

Occupational Safety and Health Standards shall apply at all times. Should the contractor fail to follow OSHA regulations, the Engineer may suspend the work by written notice until compliance has been achieved. Any such failure to comply with OSHA regulations shall constitute waiver of any right to claim for such suspended work. If regulations are in conflict, the more strict regulation shall apply.

The contractor shall hold harmless, indemnify and defend the Agency, and its employees, officers and agents, against any claims or liability arising from or based on the violation of the U.S. Occupational Safety and Health Act or any other safety provisions.

The contractor shall provide at the site such equipment and medical facilities as are necessary to supply first-aid service to anyone who may be injured in connection with the work.

The contractor shall promptly report in writing to the Engineer all accidents arising out of or in connection with the performance of the work, whether on or adjacent to the site, which caused death, personal injury or property damages, giving full details and the names and addresses of any witnesses. If death or serious damages are caused, the accident shall be reported **immediately** by telephone or messenger to the Engineer.

If any claim is made by anyone against the contractor or any subcontractor on account of any accident, the contractor shall promptly report the facts in writing to the Engineer, giving full details of the claim.

107-8 PUBLIC CONVENIENCE AND SAFETY

The contractor shall at all times so conduct the work as to insure the least possible obstruction to traffic.

The safety and convenience of the general public and the residents in the vicinity of the work and the protection of persons and property shall be provided for by the contractor in accordance with the requirements of Subsection 104-5.

The contractor shall submit a Safety Plan to the Engineer at the preconstruction conference detailing the procedures the contractor will implement to satisfy OSHA and the State Occupational Safety Guidelines related to the worker as well as public safety in the construction of excavation, structures and confined air spaces as identified by the Engineer. The contractor's Safety Plan shall included the requirement that all workers and visitors must wear hard hats while within the project limits.

The Safety Plan submitted by the contractor shall include proposed methods to prevent unauthorized persons from gaining access to the work areas. The Safety Plan shall also address the training methods and procedures for ensuring compliance with all dust control measures required to prevent or minimize visual emissions from the contractors operations and activities.

107-9 RAILROAD PROVISIONS

If the project plans or Special Provisions require that materials be hauled across the tracks of any railroad, the Agency will usually make arrangements with the owner of the railroad for any new crossings required or for the use of any existing crossings.

If the contractor elects to use crossings other than those shown on the project plans or described in the Special Provisions, the contractor shall make its own arrangements for the use of such crossings.

All work to be performed by the contractor within the railroad right-of-way shall be performed at such times and in such a manner as not to interfere unnecessarily with the movement of trains or traffic upon the track of the railroad company. The contractor

shall use all care and precaution in order to avoid accidents, damage or unnecessary delay or interference with the railroad company's trains or other property.

Prior to commencing work within or adjacent to the railroad right-of-way, the contractor shall obtain the following insurance coverage:

- Contractor's Public Liability and Property Damage Liability Insurance.
- Contractor's Protective Public Liability and Property Damage Liability Insurance.
- Railroad Protective Public Liability and Property Damage Liability Insurance.

Additionally, the contractor shall execute a Contractor's Right of Entry Agreement with the appropriate railroad and provide all fees for inspections conducted by railroad personnel. The form of the Agreement as well as all applicable requirements and conditions are available from the appropriate railroad company or through the Agency. Compensation for railroad inspection fees shall be made in accordance with the requirements of Subsection 109-5.

107-10 BARRICADES AND WARNING SIGNS

The contractor shall provide, erect and maintain all necessary barricades, suitable and sufficient lights, danger signals, signs and other traffic control devices and shall take all necessary precautions for the protection of the work and safety of the public. Roadways closed to traffic shall be protected by effective barricades, and obstructions shall be illuminated during hours of darkness. Suitable warning lights shall be provided to control and direct traffic properly.

The contractor shall erect warning signs in advance of any place on the project where operations may interfere with the use of a road by traffic, and at all intermediate points where the new work crosses or coincides with an existing road. No signs, barricades, lights or other protective devices shall be dismantled or removed without permission of the Engineer.

All signs, barricades, lights, temporary signals and other protective devices shall conform to the requirements of the Manual on Uniform Traffic Control Devices published by the U.S. Department of Transportation, Federal Highway Administration, as amended by the appropriate jurisdiction and Section 701 of these Standard Specifications.

107-11 USE OF EXPLOSIVES

When the use of explosives is necessary for the prosecution of the work, the contractor shall exercise the utmost care not to endanger life or property, including new work. The contractor shall be responsible for all damage resulting from the use of explosives.

The contractor shall furnish and erect special signs to warn the public of the contractor's blasting operations. Such signs shall be placed at appropriate points within the limits of the project and these signs shall be maintained so as to be clearly evident to the public during all critical periods of the blasting operations.

If the blasting to be done involves the use of electric blasting caps, the signs shall include a warning statement that all mobile radio transmitters shall be turned off.

In advance of doing any blasting work involving the use of electric blasting caps within 200 feet of any railroad track or structure, the contractor shall notify the railroad company of the locations, date, time and approximate duration of such blasting operations.

The method of use, storing and handling of explosives and liquid inflammable materials shall conform with all state and local laws, regulations and safety codes. All storage places shall be marked clearly and in large letters: DANGEROUS EXPLOSIVES.

Where no local laws or ordinances apply, storage shall be provided satisfactory to the Engineer and, in general, not closer than 1,000 feet from any road, building, camping area or place of human occupancy.

The contractor shall notify each property owner and public utility company having structures or facilities in proximity to the site of work of the contractor's intention to use explosives. Such notice shall be given sufficiently in advance to enable them to take such steps, as they may deem necessary, to protect their property from damage.

The contractor shall obtain necessary permits from and comply with the requirements of any authority having jurisdiction over the area before any explosives are used.

The Engineer shall have the right to require the use of controlled blasting, whether specified by the plans or Special Provisions or not, when in the opinion of the Engineer general blasting may endanger any part of an existing structure, utility or public or private property.

107-12 PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE

The contractor shall be responsible for the preservation of all public and private property and shall protect carefully from disturbance or damage all land monuments and property marks until

the Engineer has witnessed or otherwise referenced their location. Land monuments and property marks shall not be moved by the contractor until directed by the Engineer. Land monuments and property marks disturbed or destroyed by the contractor shall be restored or replaced by the contractor at no cost to the Agency.

Private mail boxes within the limits of operations shall be temporarily or permanently relocated, as required, by the contractor in such manner and in accordance with U.S. Postal Services regulations so as to permit uninterrupted mail service.

Existing fences, pole lines, signs, buildings and structures that are to remain in place shall be protected from injury or damage.

The contractor shall be responsible for all damage or injury to property of any character, during the prosecution of the work, resulting from any act, omission, neglect or misconduct in the contractor's manner or method of executing work or at any time due to defective work or materials and the contractor shall not be released from this responsibility until the project shall have been completed and accepted.

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect or misconduct in the execution of the work or in consequence of the nonexecution thereof by the contractor, the contractor shall restore, at the contractor's own expense, such property to a condition similar to or equal to that existing before such damage or injury was done, by repairing, rebuilding or otherwise restoring, as may be directed, or the contractor shall make good such damage or injury in an acceptable manner.

Existing drainage channels, of any size, disturbed by construction, whether shown on the plans or not, shall be reconstructed by the contractor at their original location and in a manner to drain properly without adverse erosion.

The contractor shall not deface, injure or destroy trees, shrubs or cacti except as required to complete the proposed construction. The attention of the contractor is called to the requirements of the Arizona Native Plant Law. The contractor shall give the Arizona Commission of Agriculture and Horticulture at least sixty days notice prior to any clearing operations.

Native plants, as defined by the Statutes, shall neither be transported from the land or offered for sale without the written permission of the Commission.

Notice shall be sent to:

Assistant Director
Division of Compliance
Arizona Commission of Agriculture and Horticulture
State Office Building, Room 414
1688 West Adams Street
Phoenix, Arizona 85007

Materials removed during construction operations such as trees, stumps, building materials, irrigation and drainage structures, broken concrete and other similar materials shall not be dumped on either private or public property without the contractor having obtained written permission from the owner in the case of private property, or from a responsible official of the agency with jurisdiction over the land in the case of public property. Written permission shall not be required, however, when materials are disposed of at an operating public dumping ground, with the exception of asbestos cement pipe and materials, which require a disposal permit from Pima County.

Under no circumstances shall the disposal of debris from construction operations be such as to create a blemish on the landscape.

Hauling outside of slope staked areas shall not be permitted except around concrete structures, structural plate pipe and at locations where topographical or other features render it impracticable to confine hauling operations within slope staked areas.

Haul routes outside of slope staked areas shall be as short as practicable and shall be so located as to minimize defacement of or injury to landscape features and vegetation. Such haul routes shall be obliterated and the ground restored to a condition similar to or equal to that existing before such hauling was started.

107-13 FOREST PROTECTION

If a project or a material pit is located on land which is under the jurisdiction of the Forest Service, the contractor shall comply with all applicable state and federal laws, federal rules and regulations, and the requirements of the National Forest in which the work is located.

Additional requirements of the National Forest may be specified in the Special Provisions and may include a clearing plan, a mining plan and an erosion and seeding plan.

Unless provided for otherwise in the Special Provisions, the contractor shall conform with the following minimum requirements:

- The contractor shall do everything reasonably within the contractor's power to prevent forest fires and shall not dispose of material by burning without a written permit from the Forest Service.

- The contractor shall not cut timber or brush or commence work in any material pit unless a permit to do so has been obtained from the Forest Service.

- The contractor shall fully repair all damage caused by its operations and provide maintenance commensurate with the contractor's use of National Forest roads and trails.

- The contractor shall fully comply with all requirements regarding air quality.

107-14 PREVENTION OF AIR AND NOISE POLLUTION

The contractor shall control, reduce, remove or prevent air pollution in all its forms, including air contaminants, in the performance of the contractor's work.

The contractor shall comply with the applicable requirements of Title 49 - Public Health and Safety, Chapter 3 Air Quality, of the Arizona Revised Statutes, and with the Arizona Administrative Code, Title 18 - Environmental Quality, Chapter 2 Air Pollution Control, and Chapter 3, Air Pollution Control Hearing Board, adopted by the Arizona Department of Environmental Quality pursuant to the authority granted by the Statutes.

The contractor shall comply with all local sound control and noise level rules, regulations and ordinances which apply to any work performed pursuant to the contract.

Each internal combustion engine used for any purpose on the work or related to the work shall be equipped with a muffler of the type recommended by the manufacturer. No internal combustion engine shall be operated on the work without its muffler in good working condition.

107-15 PREVENTION OF LANDSCAPE DEFACEMENT; PROTECTION OF STREAMS, LAKES AND RESERVOIRS

The contractor shall give special attention to the effect of the contractor's operations upon the landscape and shall take special care to maintain natural surroundings undamaged.

The contractor shall take sufficient precautions, considering various conditions, to prevent pollution of washes, streams, lakes, and reservoirs and the storm drainage system(s) tributary to these natural features with fuels, oil, bitumens, calcium chloride, fresh portland cement, fresh portland cement concrete, raw sewage, muddy water, chemicals or other harmful materials. None of these materials, other organic substances or construction debris shall be discharged buried or disposed of in or into any storm draining channels or lands which lead to such streams, lakes or reservoirs.

Where the contractor's working area encroaches on a running or an intermittent stream, barriers shall be constructed and maintained between the working areas and the stream or stream bed adequate to prevent the discharge of any contaminants into the stream or stream bed.

Streams, lakes and reservoirs shall be promptly cleared of all falsework, piling, debris or other obstructions placed thereby or resulting from construction operations.

At the time of the preconstruction conference, the contractor shall submit, for the Engineer's approval, a program to implement all the measures which the contractor proposes to take for the construction of permanent erosion control work specified in the contract and all the temporary control measures to prevent erosion and pollution of streams, lakes and reservoirs. The program shall indicate "good housekeeping" practices including details and locations of vehicle wash-down areas, on site storage areas for materials, equipment storage and maintenance areas and the sweeping of roadways used for hauling activities.

Permanent erosion control work and pollution prevention measures shall be performed at the earliest practicable time consistent with good construction practices and the SWPPP. Temporary work and measures are not meant to be performed in lieu of permanent work specified in the contract.

Construction of drainage facilities as well as the performance of other contract work which will contribute to the control of erosion and sedimentation shall be carried out in conjunction with earthwork operations or as soon thereafter as possible.

Except for that approved in writing by the Engineer, the contractor shall perform no clearing and grubbing or earthwork until the contractor's implementation program has been approved.

If in the opinion of the Engineer clearing and grubbing, excavation, or other construction operations are likely to create an erosion problem because of the exposure of erodible earth material, the Engineer may limit the surface area to be disturbed until satisfactory control measures have been accomplished.

The Engineer may order the contractor to provide immediate measures to control erosion and prevent pollution. Such measures may involve the construction of temporary berms, dikes, dams, sediment basins and slope drains, the use of temporary mulches, mats and seeds, and the use of other devices, methods, items etc. as necessary.

At any time the contractor proposes to change its schedule of operations, the contractor shall review and update the contractor's erosion and pollution control implementation program and submit it to the Engineer for approval.

The contractor shall not be entitled to additional compensation or an extension of contract time for any delays to the work because of the contractor's failure to submit an acceptable erosion and pollution control program.

Erosion control and pollution prevention work specified in the contract, which is to be accomplished under any of the various contract items, shall be paid for as specified under those items.

The cost of any erosion control and pollution prevention work which may be proposed by the contractor in its program, in addition to that specified in the contract, shall be considered as included in the prices bid for contract items.

107-15.01 National Pollution Discharge Elimination System

(A) General. On projects where a National Pollutant Discharge Elimination System (NPDES) permit is required, the contractor shall implement the requirements of the permit for erosion control due to storm water runoff during construction, as specified under the Environmental Protection Agency (EPA) General Permit for Arizona and, if applicable, the municipality's Separate Storm Sewer System Permits. (When obtaining construction permits, the contractor must notify Pima County Development Services or the City of Tucson Stormwater Section that they will be doing work subject to the NPDES requirements.)

The work shall include providing, installing, maintaining, removing and disposing of erosion control measures such as gravel filter berms, dikes, catch basin inlet protection, end-of-pipe filtering devices, silt fences, dams, sediment basins, netting, straw bale barriers, slope drains, and other erosion control devices or methods.

(B) Materials. The Agency has prepared a Stormwater Pollution Prevention Plan (SWPPP) which includes a description of the proposed measures to be implemented and a site specific diagram indicating the proposed locations where erosion control devices or measures may be required during construction. This SWPPP is included in the plans. The Agency and the contractor shall prepare and submit separate Notices of Intent (NOI) and Notices of Termination (NOT) forms for the project.

Prior to the start of construction, the contractor and all subcontractors may be asked to sign a certification that they understand all requirements of the NPDES permit.

At the preconstruction conference, the contractor shall specify "good housekeeping" practices and requirements, including vehicle wash-down areas, on-site and off-site tracking control, protection of equipment storage and maintenance areas, sweeping of highways and roadways related to hauling activities, a construction sequence of major activities, and a listing of pollutants in the SWPPP.

(C) Construction. Prior to the start of construction, the Engineer and contractor will jointly review the SWPPP, make any revisions needed, and approve and sign the SWPPP. The contractor shall implement the SWPPP as required throughout the construction period. The Engineer and contractor will perform a minimum of one inspection of disturbed areas that have not been stabilized at least every 14 calendar days. Inspections of stabilized areas or during seasonable arid periods shall be conducted at least once per month In addition, an inspection shall be required within 24

hours after each rainfall of 1/2 inch (*25 millimeters*) or greater. After each inspection, the Engineer shall document the findings and revise the SWPPP as necessary. The Engineer and contractor shall jointly approve and sign each revision to the SWPPP before implementation. The contractor shall implement any changes within 7 calendar days following the inspection.

The contractor shall maintain all related erosion control elements in proper working order.

No condition of local grading ordinances or the SWPPP shall release the contractor from any responsibilities or requirements under other environmental statutes or regulations.

Erosion control and pollution prevention work specified in the contract which is to be accomplished under any of the various contract items will be paid for as specified under those items.

Until final written acceptance of the project by the Engineer, the contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements, or from the nonexecution of the work. The contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance. No reimbursement shall be made for work necessary due to the contractor's failure to comply with the requirements of the SWPPP.

Except as specifically provided under Subsection 108-4, in the case of suspension of work from any cause whatsoever the contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities. During such period of suspension of work, the contractor shall properly and continuously maintain, in an acceptable growing condition, all newly established plantings, seedings and soddings, furnished under its contract and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

(D) Method of Measurement. Work required by the SWPPP as included in the bid package, and as may be approved prior to construction, and "good-housekeeping" practices and requirements will be measured on a lump sum basis under NPDES (Original).

No measurement or direct payment will be made to the contractor for time spent in reviewing or revising the SWPPP, or providing other required documentation, the cost being considered as included in the price for the Item NPDES (Original).

(E) Basis of Payment. Payment for NPDES (Original) will be made at the contract lump sum price which shall be full compensation for supplying and furnishing all materials, facilities, and services and performing all work involved as specified herein.

Partial payments under this item shall be made in accordance with the following provisions:

(1) When work shown on the (approved) SWPPP is in place, 50 percent of the amount bid for NPDES (Original) will be paid.

(2) 40 percent of the bid amount will be paid incrementally over the life of the contract to cover maintenance.

(3) The remaining 10 percent will be paid upon final acceptance of the project.

No additional payments will be made for this item of work.

If circumstances require changes to the approved SWPPP and such changes are determined by the Engineer to be beyond the scope of NPDES (Original), payment will be made in accordance with the requirements of Subsection 109-4, Force Account work. Payment will be made under Item NPDES (Modified).

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107-18 INSURANCE

Concurrent with the execution of the contract, the contractor shall file with the Agency a certificate or certificates of insurance executed by an insurance company authorized to do business in the State of Arizona and acceptable to the Agency. The certificate of insurance shall be on a form acceptable to the Agency and shall state that the contractor carries insurance in accordance with the requirements of this Subsection.

Without limiting any liabilities or any other obligations of the contractor, the contractor shall provide and maintain the minimum insurance coverage listed below until all obligations under this contract are satisfied:

(1) Commercial General Liability insurance with a minimum combined single limit of $1,000,000.00 each occurrence applicable to all premises and operations. The policy shall include coverage of bodily injury, broad form property damage (including completed operations), personal injury (including coverage for contractual and employee acts), blanket contractual, independent contractors, products, and completed operations. Further, the policy shall include coverage for the hazards commonly referred to as XCU (explosion, collapse, and underground) when required, and for the coverage type and limits specified in the Special Provisions. The products and completed operations coverage shall extend for one year past acceptance, cancellation or termination of the work. The policy shall contain a severability of interests provision.

(2) Comprehensive Automobile Liability insurance with a combined single limit for bodily injury and property of not less than $1,000,000.00 each occurrence with respect to contractor's owned, hired, or non-owned vehicles, assigned to or used in performance of the work.

(3) Workers' Compensation insurance to cover obligations imposed by federal and state statutes having jurisdiction of its employees engaged in the performance of the work, and Employers' Liability insurance with a minimum limit of $100,000.00. Evidence of qualified self-insured status will suffice for this section.

(4) Builder's Risk/Course of Construction Insurance when required by the Special Provisions or as elected by the contractor in conjunction with the provisions required in Subsections 105-16 and 107-19, to cover all risks of loss to any or all specified or unspecified premises under the contract in accordance with the provisions of Subsection 103-6. When required by the Special Provisions, Builders Risk/Course of Construction Insurance coverage shall be for the full amount of the contract.

The policies required by 1 and 2 above shall be endorsed to include the Agency, its agents, officials, employees and the governmental jurisdiction of the Agency as additional insureds and shall stipulate that the insurance afforded the contractor shall be primary insurance and that any insurance carried by the Agency, its agents, officials, employees or governmental body shall be excess and not contributory insurance to that provided by the contractor.

All insurance policies or certificates shall include a requirement providing for 30 days prior written notice to the Agency of any cancellation or reduction of coverage. The contractor shall cease operations on the occurrence of any such cancellation or reduction and shall not resume operations until the required insurance is in force and new certificates of insurance have been filed with the Agency.

The certificates of insurance shall be issued to the Agency by the contractor's insurer as evidence that policies providing the required coverages, conditions and limits are in full force and effect.

Failure on the part of the contractor to produce or maintain required insurance shall constitute a material breach of contract upon which the Agency may immediately terminate the contract or, at its discretion, produce or renew such insurance and pay any and all premiums in connection therewith, and all monies so paid by the Agency shall be repaid by the contractor to the Agency upon demand, or the Agency may offset the cost of the premiums against any monies due to the contractor.

Costs for coverage maintained by the contractor, in excess of those required, shall not be charged to the Agency without prior approval of the Agency.

The Agency reserves the right to request and receive certified copies of any or all of the above policies or endorsements.

The contractor and its insurers providing the required coverage shall waive all rights of recovery against the Agency and its agents officials and employees.

107-19 CONTRACTOR'S RESPONSIBILITY FOR WORK

Prior to the advertisement for bids for a project, the Agency conducted a review of the project area for items such as archaeological features, discolored soils, dead vegetation or animals, suspect odors, hazardous materials, landfilling, asbestos including cement asbestos utility lines, native plants, and wells. If any of these items were encountered, they have been addressed in the Special Provisions or removed by the Agency prior to bidding or construction.

If, during the course of construction, it is suspected that any of the above items are present, activities within the immediate area shall cease and the Engineer shall be notified. The contractor shall secure the area and wait for notification from the Engineer as to when the activities within the area can be resumed.

The Engineer shall coordinate the assessment of the materials and the appropriate course of action. If necessary, the materials shall be removed by a third party under contract to the Agency.

Until final written acceptance of the project by the Engineer, the contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the nonexecution of the work. The contractor shall rebuild, repair, restore and make good all injuries or damages to any portion of the project including material sites occasioned by any of the above causes before final acceptance and shall bear the expense thereof except damage to the work as specified in Subsection 107-20.

Except as specifically provided under Subsection 104-6, in case of suspension of work from any cause whatever the contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs or other facilities at the contractor's expense. During such period of suspension of work, the contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings and soddings furnished under the contract and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

107-20 DAMAGE BY STORM, FLOOD, OR EARTHQUAKE

Attention is directed to Subsection 107-19, "Contractor's Responsibility For The Work". In the event damage to the work is caused by a storm, flood or earthquake which constitutes an "Occurrence," as hereinafter defined, the provisions herein delineated shall be applicable and the contractor may apply in writing to the Engineer for the Agency to pay or participate in the cost of repairing damage to the work from such cause or, in lieu thereof, and at the sole discretion of the Agency, terminate the contract and relieve the contractor of further obligation to perform the work, subject to the following:

(A) Occurrence. Occurrence shall include earthquakes in excess of a magnitude of 3.5 on the Richter Scale, and storms and floods for which the Governor has proclaimed a state of emergency when the damaged work is located within the territorial limits to which such proclamation is applicable or, which were, in the opinion of the Engineer, of a magnitude at the site of the work sufficient to have caused such a proclamation had they occurred in a populated area.

(B) Application by contractor. The contractor's written request for the Agency to pay or to participate in the cost of rebuilding, repairing, restoring or otherwise remedying the damage to the work caused by the occurrence shall be submitted to the Engineer before performing any work other than emergency work, including emergency work necessary to provide for passage of public traffic.

(C) Protecting the Work from Damage. Nothing in this section shall be construed to relieve the contractor of the responsibility to protect the work from damage. The contractor shall bear the entire cost of repairing damage to the work caused by the occurrence which the Engineer determines was due to the failure of the contractor to comply with the requirements of the plans and specifications, take reasonable and adequate measures to protect the work or exercise sound engineering and construction practices in the conduct of the work, and such repair costs shall be excluded from consideration under the provisions of this Subsection.

(D) Repair Work. Repair of damaged work under the provisions of this Subsection shall be pursuant to a contract change order issued hereunder and specifying the repair work to be performed on the damaged facility. Such repair work shall consist of restoring the in-place construction (for the purposes of this Section erected falsework and formwork shall be considered in-place construction) to the same state of completion to which such work had advanced prior to the Occurrence. Emergency work which the Engineer determines would have been part of the repair work if it had not previously been performed, shall be considered to be part of said repair work.

The Agency reserves the right to make changes in the plans and specifications applicable to the portions of the work to be repaired, and if such changes increase the cost of repairing the damage over the Engineer's estimate of the cost of repair without the changes, the contractor shall be paid for such increased costs in accordance with Subparagraph E and the increased cost amount shall not be considered in determining the cost of repair to be borne by the contractor under Subparagraph F.

Nothing in this Section shall be construed to relieve the contractor of full responsibility for the risk of injury, loss or damage to materials not yet incorporated in the work and to materials, tools and equipment (except erected falsework and formwork) used to perform the work, or to relieve the contractor of responsibility under Subsection 107-17. The provisions of this Section shall not be applicable to the repair of damage caused by an occurrence to any portion of the work accepted by the Agency in accordance with Subsection 105-17 (A) or (B).

(E) Determination of Costs. Unless otherwise agreed between the Engineer and the contractor, the cost of the work performed pursuant to this Section shall be determined in accordance with the provisions of Subsection 109-5(B), "Force Account Work". The cost of emergency work, which the Engineer determines would have been part of the repair work if it had not previously been performed will be determined in the same manner as the authorized repair work. The cost of repairing damaged work which was not in compliance with the requirements of the plans and specifications shall be borne solely by the contractor, and such costs shall not be considered in determining the costs of repair under this Subsection E.

(F) Payment for Repair Work. When the occurrence that caused the damage was an earthquake, the Agency shall pay the cost of repair determined as provided in Subparagraph E, that exceeds 5 percent of the amount of the contractor's bid for bid comparison purposes.

When the occurrence that caused the damage was a storm or flood, the Agency shall participate in the cost of the repair determined as provided in Subparagraph E in accordance with the following:

(1) On projects for which the amount of the contractor's bid for bid comparison purposes is $2,000,000 or less, the Agency shall pay 90 percent of the cost of repair that exceeds 5 percent of the amount of the contractor's bid for bid comparison purposes.

(2) On projects for which the contractor's bid for bid comparison purposes is greater than $2,000,000, the Agency shall pay 90 percent of the cost of repair that exceeds $100,000.

(G) Termination of Contract. If the Agency elects to terminate the contract, the termination and the determination of the total compensation payable to the contractor shall be governed by the provisions of Subsection 108-11.

107-21 CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTY AND SERVICES

At points where the contractor's operations are adjacent to properties of railroad, telegraph, telephone, water, sewer, electric, gas, and cable television companies, hereinafter referred to as utilities, or are adjacent to other facilities and property, damage to which might result in considerable expense, loss, inconvenience, injury or death, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

At least two working days prior to commencing excavation, the contractor shall call the Blue Stake Center, between the hours of 7:00 a.m. and 4:30 p.m., Monday through Friday for information relative to the location of buried utilities. The Blue Stake Center number is:

Tucson and Pima County 1-800-STAKE-IT

The contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner, that duplication of rearrangement work may be reduced to a minimum and that services rendered by these parties will not be unnecessarily interrupted.

The contractor shall contact the owners of the various utilities prior to the start of construction and shall obtain from them any information pertaining to existing utilities that will either supplement information shown on the project plans or will correct any such information that may be incorrect. The contractor shall furnish the Engineer with evidence that the contractor has contacted the utility companies and shall furnish the Engineer with a copy of the information furnished the contractor as a result of such contacts.

If the contractor learns, from either the owner of the utility or from any other source, of the existence and location of properties of railroad, telegraph, telephone, water, sewer, electric, gas and cable television companies either omitted from or shown incorrectly on the project plans, the contractor shall immediately notify the Engineer and shall not disturb the utilities. Relocation or adjustment of such utilities, if deemed necessary, shall be either performed by others or shall be performed by the contractor in accordance with the provisions of Subsection 105-6.

The exact locations and depths of all utilities that are underground or the location of those on or near the surface of the ground, which are not readily visible, shall be determined. Such locations shall be marked in such a manner so that all workmen or equipment operators shall be thoroughly apprised of their existence and location. It shall be the contractor's responsibility to see that every effort possible has been made to acquaint those actually involved in working near utilities not

only with the type, size, location and depth, but with the consequences that might follow any disturbance. No trenching or similar operation shall be commenced until the Engineer is satisfied that every possible effort has been taken by the contractor to protect utilities.

When the operations of the contractor result in any damage to any utility line or service connection, the location of which has been brought to the contractor's attention, the contractor shall assume full responsibility for such damage.

In the event of interruption to water or utility services as a result of accidental breakage or as a result of lines being exposed or unsupported, the contractor shall promptly notify the proper authority and shall cooperate with the authority in the restoration of service. When service is interrupted, repair work shall be continuous until the service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

Temporary or permanent relocation or adjustment of any utility line or service connection desired by the contractor for the convenience of the contractor shall be the responsibility of the contractor. The contractor shall obtain the approval of both the Engineer and the utility company and upon approval shall make all necessary arrangements with the utility company and shall bear all costs in connection with such relocation or adjustment.

Should any provision contained herein be contrary to the provisions of the A.R.S. §§ 40-360.21 through 40-360.29, the statutory provisions shall prevail.

107-22 FURNISHING RIGHT-OF-WAY

The Agency shall be responsible for the securing of all necessary rights-of-way in advance of construction. Any exceptions shall be indicated in the contract documents.

107-23 PERSONAL LIABILITY OF PUBLIC OFFICIALS

In carrying out any of the provisions of these specifications or in exercising any power or authority granted to them by or within the scope of the contract, there shall be no liability upon the governing body and any member thereof, the Engineer, or their authorized representatives, either personally or as government officials, it being understood that in all such matters they act solely as agents and representatives of the appropriate governing body.

107-24 NO WAIVER OF LEGAL RIGHTS

Upon completion of the work, the Agency shall expeditiously make final inspection and notify the contractor of acceptance. Such final acceptance, however, shall not preclude or prohibit the Agency from correcting any measurement, estimate, or certificate made before or after completion of the work, nor shall the Agency

be precluded or prohibited from recovering from the contractor or the contractor's surety, or both, such overpayment as it may sustain, or by failure on the part of the contractor to fulfill obligations under the contract. A waiver on the part of the Agency of any breach of any part of the contract shall not be held to be a waiver of any other or subsequent breach.

The contractor, without prejudice to the terms of the contract, shall be liable to the Agency for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards to the Agency's rights under any warranty or guarantee.

107-25 CONTRACTOR AND SUBCONTRACTOR RECORDS

The contractor shall keep one copy of all specifications, plans, addenda, modifications, working drawings, and shop drawings at the site, in good order and annotated to show all changes made during the construction process as they occurred. Upon completion of the project and prior to submittal of the final application for payment, the annotated set of plans together with any annotated working and shop drawings of significance shall be delivered to the Engineer for the Agency's record.

The contractor, subcontractors and all material suppliers shall keep and maintain all books, papers, records, files, accounts, reports, bid documents with backup data, and all other material relating to the contract and project for five years following completion and acceptance of the work.

All of the above material shall be made available to the Agency for auditing, inspection and copying and shall be produced, upon request, at the Agency office.

The contractor shall insert the above requirement in each subcontract, purchase order and lease agreement and shall also include in all subcontracts a clause requiring subcontractors to include the above requirement in any lower-tier subcontract, purchase order or lease agreement.

SECTION 108

PROSECUTION AND PROGRESS

108-1 SUBLETTING OF CONTRACT

The contractor shall not sublet, sell, transfer, assign or otherwise dispose of the contract or contracts or any portion thereof or of the contractor's right, title or interest therein without written notification to the Engineer. When such notification is given, the contractor may sublet a portion thereof, but shall perform, with the contractor's own organization, work amounting to not less than 40 percent of the total contract amount. No subcontracts or transfer of contract shall release the contractor of liability under the contract and bond.

"The contractor's own organization" shall be construed to include only workers employed and paid directly by the prime contractor and equipment owned or rented by the contractor, with or without operators. Such term does not include employees or equipment of a subcontractor, assignee or agent of the prime contractor.

The contract amount upon which the 40 percent requirement is computed includes the cost of materials and manufactured products which are to be purchased or produced by the contractor under the contract provisions.

Although the contractor, in submitting the bid, may have indicated that it was not the contractor's intent to sublet a portion of the work, the contractor shall not be precluded in subletting such work so long as a request is made in writing to the Engineer at least ten working days prior to the commencement of work by the subcontractor, the proposed subcontractor is eligible to perform work on public projects pursuant to A.R.S. § § 32-1101 through 32-1170.03, the subletting of such work is in conformance with the requirements specified herein, and the subcontractor is acceptable to the Engineer.

All requests to subcontract work on the contract, whether made at the time of bid submittal, bid award or after work on the contract has started, shall be accompanied by an Intent to Sublet request, executed by a person having legal authority to bind the contractor.

The Agency's consent to a subcontract will be given only after the Agency determines that the entity to whom the work is being subcontracted to could not be suspended from bidding in accordance with the provisions of Section 102-3 or declared non-responsible. Additionally, the Agency shall determine that the subcontract, purchase order, or lease agreement is evidenced in writing and that it contains all pertinent provisions and requirements of the prime contract. The following data shall be submitted seven calendar days prior to the start of each subcontractor's work. On projects requiring DBE participation, the data regarding DBE subcontracts must be submitted at the preconstruction conference.

(A) A complete copy of each subcontractor agreement and each second tier subcontractor.

(B) Subcontracts must show the total price subcontracted. The items of work, and quantities of each item subcontracted shall be shown. Unit Prices or Extended Prices may be deleted except in the case of DBE subcontractors.

(C) DBE subcontracts shall include full extensions of all unit prices.

(D) Partial items shall be explained in detail and show the amount of each contract item being subcontracted. Non-contract item work shall be fully explained, i.e., Trucking 1,000 hours, Truck Asphaltic Concrete.

(E) The contractor shall certify to the Agency that all of its subcontractors have all required registrations.

(F) On Federally funded projects only, verification that all required Federal Provisions, i.e., Federal Form 1273, Executive Order, and Wage Determination Decisions are attached to each subcontract.

The Engineer will not consent to subletting of any portion of the contract if a copy of the subcontract or lower tier subcontract is not received. The Engineer's consent shall in no way be construed to be an endorsement of the subcontractor or its ability to complete the work in a satisfactory manner.

Calculation of the 60 percent subcontracting limit will be based upon the amount of work subcontracted and verified by subcontract documents.

Subcontractors performing contracting work subject to Arizona Revised Statutes Sections 32-1101 et seq. shall be duly licensed in accordance with those statutes. Subcontractors providing other services shall be licensed in accordance with the requirements of Arizona Law.

108-2 START OF WORK

Work shall not be started until the contract has been executed by both the contractor and the Agency. The contractor shall not begin work before the date specified in the Notice to Proceed issued by the Agency.

When the contract time is on a calendar day basis or on a working day basis, contract time shall be charged commencing on the date specified in the Notice to Proceed, with the exception of Improvement District Projects whose contract time will commence with the day following the date of execution of the contract. In either case, should this date fall on a Saturday, Sunday or holiday, the next working day shall be considered the starting date for the purpose of charging contract time.

108-3 PRECONSTRUCTION CONFERENCE

The contractor shall meet with the Engineer for a preconstruction conference prior to commencing work. At this time, or within ten calendar days thereafter, the contractor shall submit a progress schedule showing the order in which the contractor proposes to carry out the work, the dates on which the contractor and the subcontractors will start the salient features of the work, including procurement of materials, equipment, etc., the ordering of articles of special manufacture, the furnishing of drawings, plans and other data required under Subsection 105-2 for the review and approval of the Engineer, the inspection of structural steel fabrication, and the contemplated dates for the completion of the salient features.

The contractor shall furnish authorized signature forms and a list of the contractor's proposed subcontractors and major material suppliers.

Progress schedules shall have considered the time requirement for ordering articles of special manufacture to meet specific requirements of the work and Subsection 604-3.04 when structural steel fabrication inspection is required.

Progress schedules shall be reviewed by the Engineer and returned to the contractor, with any comments, within 10 calendar days of their receipt.

In accordance with the requirements of Subsection 701-1, the contractor shall also submit a traffic control and safety plan and designate an employee whose qualifications are satisfactory to the Engineer and who is experienced in construction traffic control and safety to be responsible for the implementing, monitoring, and altering as necessary, of the plan. If, in the opinion of the Engineer, the complexities of the work are such, the Engineer may require that the designated employee be someone other than the contractor's superintendent.

If the project requires that contractor or Agency personnel work from falsework, within shoring, or in any other hazardous area the contractor shall submit, as part of the contractor's safety plan, specific measures the contractor will use to insure worker safety.

The contractor shall also submit an implementation plan for stormwater pollution prevention, as set forth in Subsection 107-15, on all projects requiring submittal of a National Pollutant Discharge Elimination System (NPDES) Notice of Intent (NOI) or when such work is likely to create erosion or pollution problems.

If the contractor fails to provide the required submittals, the Engineer may order the conference suspended until such time as they are furnished. Work shall not begin until the conference has been concluded. Additional contract time may be allowed because of any Agency caused delays due to any suspension of the conference.

108-4 PROSECUTION AND PROGRESS

The contractor shall start the work in accordance with the requirements of Subsection 108-2. The contractor shall notify the Engineer at least 24 hours before beginning work.

Unless suspended, as herein provided, the work shall be diligently and continuously carried on to completion and the contractor agrees to provide, at all times, an adequate force of labor and sufficient materials and equipment to insure the completion of the contract within the time allowed. The progress of the work shall be at a rate sufficient to complete the contract in an acceptable manner within the time allowed.

At a mutually convenient location and time, the contractor shall meet weekly with the Engineer to discuss construction activities; however, some meetings may be waived if mutually agreed to, due to weather conditions, work progress, or for other reasons. At these meetings, the contractor shall provide the Engineer with a detailed, written schedule of major construction activities and phases of work for the forthcoming two week period. This written schedule shall detail the start and anticipated completion dates of major phases of work as well as indicate the status of major ongoing activities. Minutes of the weekly meetings shall be kept by the contractor and a copy given to the Engineer. Failure to provide an accurate, appropriate schedule may be grounds for the suspension of the work.

Schedule changes requiring an increase in the Agency's engineering personnel shall not be put into effect for five working days after the submission of weekly schedules detailing such activities, or until the Engineer has made arrangements for additional personnel, whichever is the shorter time.

Should construction progress differ significantly from the progress schedule presented at the preconstruction conference, the Engineer may request that the contractor submit a revised progress schedule and anticipated completion dates of the major phases of work remaining and the anticipated completion date of the work.

Except as indicated in Section 104-5, Maintenance of Traffic, the care, control, and scheduling of the work and construction activity on the project are the sole responsibility of the contractor. The Agency shall not be responsible for the contractor’s means, methods, techniques, sequences or procedures of construction, or the safety precautions and programs incident thereto.

108-5 LIMITATION OF OPERATIONS

The contractor shall conduct the work, at all times, in such a manner and in such sequence as will insure the least interference with traffic and the safety of the public and the protection of the workmen. The contractor shall have due regard to the location of detours and to the provisions for handling traffic. The

contractor shall not open up work to the prejudice or detriment of work already started. The Engineer may require the contractor to finish a section of work which is in progress before work is started on any additional sections, if the opening of such section is essential to public convenience.

Except as required to protect work already accomplished, to provide dust control and for work of a similar nature, the contractor shall advise the Engineer at least 24 hours in advance if the contractor elects to work on any Saturday, Sunday or holiday.

In general, all work shall be performed during daylight hours. If the contractor elects to perform work at night or if the contractor is required to do so in the Special Provisions, the contractor shall furnish, erect and maintain an amount of artificial lighting sufficient for the construction, flagging, inspection, etc. and for the safety of the workmen and the traveling public. No night work shall be performed until the Engineer is satisfied that an adequate amount of artificial light has been furnished and placed properly.

108-6 CHARACTER OF WORKERS

The contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to fulfill completion in the manner and within the time required by these specifications.

All workers shall have sufficient skill and experience to perform properly the work assigned to them. Workers engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Any person employed by the contractor or by any subcontractor who, in the opinion of the Engineer, does not perform the contractor's work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the Engineer, be removed immediately by the contractor or subcontractor employing such person and shall not be employed again in any portion of the work without the approval of the Engineer.

Should the contractor fail to remove such person or persons as required above or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until compliance.

108-7 METHODS AND EQUIPMENT

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet the requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no damage to the improvements being constructed, adjacent property or other existing improvements will result from its use.

When the construction methods and types of equipment to be used by the contractor in accomplishing the construction are not set forth in the contract, the contractor may use any methods or equipment that will satisfactorily accomplish the contract work in conformity with the requirements of the contract.

When the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the contractor desires to use a method or type of equipment other than those specified in the contract, the contractor may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the method and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it shall be on the condition that the contractor shall be fully responsible for producing construction work in conformity with the contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet contract requirements, the contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The contractor shall either remove the deficient work or replace it with work of specified quality or take such other corrective action as the Engineer may direct.

108-8 DETERMINATION AND EXTENSION OF CONTRACT TIME

The number of days allowed for the completion of the work included in the contract shall be stated in the contract and shall be known as the "contract time."

When the contract time is on a working day basis, the Engineer shall furnish the contractor a weekly statement showing the number of days charged to the contract for the preceding week and the number of days specified for completion of the contract. The contractor shall be allowed one week after the contractor has received the statement in which to file a written protest setting forth in what respect such statement is incorrect; otherwise the statement shall be deemed to have been accepted by the contractor as correct.

When the contract time is on a calendar day basis, it shall consist of the number of calendar days stated in the contract counting from the starting date and including all Sundays, holidays and nonwork days. All calendar days elapsing between the effective dates of any orders of the Engineer to suspend work and to resume work for suspensions not the fault of the contractor shall be excluded.

When the contract completion time is a fixed calendar date, this date shall be the date on which all work on the project is required to be substantially completed.

Contract time is based on the amount of work included in the original contract. If satisfactory fulfillment of the contract involves alterations to the contract that affect the contractor's completion time, the contractor may request a supplemental agreement which extends the contract time. The supplemental agreement shall be in the form of a Request for Extension of Contract Time and shall include the contractor's revised schedule and all other pertinent data. The request shall show why an increase of contract time is warranted.

An extension of contract time shall not be considered unless the work affected is or becomes a controlling item on the contractor's schedule.

If a nationwide shortage exists in basic materials or standard items which are necessary in the fabrication or manufacture of equipment, parts, or articles to meet the specific requirements of the project, a serious widespread shortage of such equipment, parts, or articles may be considered as a valid reason for the extension of contract time. Delivery delays or shortages caused by ordinary supply fluctuations are not nationwide shortages and therefore are not valid reasons for extension of time. The contractor's plea that insufficient time was specified is not a valid reason for extension of time. If the contractor requests additional time in accordance with the procedures set forth in Subsection 105-18 and if the Engineer finds that the work activities controlling overall job progress and the projected completion date were delayed because of conditions beyond the control and without the fault of the contractor, the Engineer may extend the time for completion in such amount as the conditions justify. The extended time for completion shall then be in full force and effect the same as though it were the original time for completion.

When substantial completion has been duly determined by the Engineer in accordance with the requirements of Subsection 105-17, the daily time charge shall cease.

108-9 FAILURE TO COMPLETE THE WORK ON TIME

For each calendar day or working day that the contractor shall fail to achieve substantial completion after the contract time or calendar date specified for the completion of the work provided for in the contract, the sum shown in the Schedule of Liquidated Damages specified below will be deducted from any monies due the contractor, not as penalty, but as liquidated damages; provided however, that due account will be taken of any adjustment of the contract time for the completion of the work allowed under the provisions of Subsection 108-8.

The sums set forth in the Schedule of Liquidated Damages are fixed and agreed upon between the parties since the actual loss to the Agency and to the public caused by the delay in completion is both impractical and extremely difficult to ascertain and compute.

Permitting the contractor to continue and finish work or any part of it after the time fixed for its completion or after the date to which the time for completion may have been extended shall in no way operate as a waiver on the part of the Agency of any of its rights under the contract.

Schedule of Liquidated Damages

Original Contract Amount ($)		Daily Charge ($)	
From More Than	To and Including	Calendar Day or Fixed Date	Working Day
0	100,000	290	400
100,000	500,000	430	600
500,000	1,500,000	640	900
1,500,000	3,000,000	860	1,200
3,000,000	5,000,000	1140	1,600
5,000,000	10,000,000	1420	2,000
Over 10,000,000		1780	2,500

108-10 TERMINATION OF CONTRACT FOR DEFAULT

If the Contractor:

- Fails to begin the work under the contract within the time specified, or
- Fails to perform the work with sufficient workers and equipment or with sufficient materials to insure the prompt completion of the work, or
- Performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable, or
- Discontinues the prosecution of the work, or
- Fails to resume work which has been discontinued within a reasonable time after notice to do so, or
- Becomes insolvent, or
- Allows any final judgement to stand against it unsatisfied for a period of ten days, or
- Makes an "assignment for the benefit of creditors," or

- Fails to comply with contract requirements regarding minimum wage payments or equal employment opportunity requirements, or

- Is a party to fraud, or

For any other cause whatsoever, fails to carry on the work in an acceptable manner, the Engineer shall give notice, in writing, to the contractor and to the contractor's surety of such delay, neglect or default.

If the contractor or the contractor's surety within a period of ten days after such notice shall not proceed in accordance therewith, the Agency shall, upon written notification from the Engineer of the fact of such delay, neglect or default and the contractor's failure to comply with such notice, have full power and authority, without violating the contract, to terminate the contract. The Agency may appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable and may enter into an agreement for the completion of the contract according to the terms and provisions the contract or use such other methods as in the opinion of the Engineer will be required for the completion of the contract in an acceptable manner.

All costs and charges incurred by the Agency, together with the cost of completing the work under contract, shall be deducted from any monies due or which may become due the contractor. If such expense exceeds the sum which would have been payable under the contract, then the contractor and the contractor's surety shall be liable and shall pay to the Agency the amount of such excess.

If it is determined, after termination of the contractor's right to proceed that the contractor was not in default, the rights and obligation of the parties will be the same as if the termination had been issued for the convenience of the Agency in accordance with Subsection 108-11. Thus, damages to which a contractor may be entitled as a result of an improper default termination will be limited to the amounts provided for in subsection 108-11.

108-11 TERMINATION OF CONTRACT FOR CONVENIENCE OF THE AGENCY

The Agency may terminate the entire contract, or any portion thereof, if the Engineer determines that a termination is in the Agency's best interest. The Engineer will deliver to the contractor a Written Order of Termination specifying the extent of termination and the effective date.

(A) Submittals and Procedures. After receipt of a Written Order of Termination the contractor shall immediately proceed with the following obligations:

(1) Stop work as specified in the notice.

(2) Place no further subcontracts for orders or materials, services, equipment or facilities, except as necessary to complete the continued portion of the contract.

(3) Terminate all subcontracts or orders for materials, services, equipment or facilities to the extent they relate to the work terminated.

(4) Transfer title and deliver to the Agency:

(a) The fabricated, partially fabricated, or unfabricated parts; work in process; completed work; supplies; and other material produced or acquired for the work terminated, and

(b) The completed or partially completed plans, drawings, information, and other property that, if the contract had been completed, would be required to be furnished to the Agency.

(5) Take any action necessary, or that the Engineer may direct, for the protection and preservation of the property related to the contract that is in the possession of the contractor and in which the Agency has or may acquire an interest.

(6) Complete performance of the work not terminated.

(B) Inventory. Acceptable materials obtained by the contractor for the project that have not been incorporated in the work shall be inventoried in conjunction with the Engineer at a date identified by the Engineer.

(C) Settlement Provisions. When the Agency orders termination of all or a part of the contract effective on a certain date, completed items of work as of that date will be paid for at the contract bid price. Payment for partially completed work or for items that are eliminated in their entirety will be made either at agreed prices or under the provisions below.

(1) Additional Costs. Unless otherwise specified in the Invitation to Bid, within 60 calendar days of the effective termination date, the contractor shall submit a claim to the Engineer for additional damages or costs not covered above or elsewhere in the contract. Such claim may include such cost items as reasonable idle equipment time, mobilization efforts, bidding and project investigative costs, overhead expenses attributable to the project terminated, legal and accounting charges involved in claim preparation, subcontractor costs not otherwise paid for, actual idle labor cost if work is stopped in advance of termination date, guaranteed payments for private

land usage as part of the original contract, and any other cost or damage for which the contractor feels reimbursement should be made. Anticipated profits will not be considered as part of any settlement.

The contractor and the Agency may agree upon the whole or any part of the amount to be paid because of the termination. The amount may include a reasonable allowance for profit on work done. The agreed amount may not exceed the total contract price as reduced by the amount of payments previously made, and the contract price of work not terminated. The contract shall be amended, and the contractor paid the agreed amount.

(2) Additional Cost Review. If the contractor and the Agency fail to agree on the whole amount to be paid the contractor, because of the termination of work, the Agency will pay the amounts determined as follows, but without duplication of any amounts agreed upon above.

(a) For contract work performed before the effective date of termination, the actual and reasonable costs of work performed and inventoried materials, plus a reasonable profit thereon, not to exceed unit bid prices.

(b) The reasonable costs of settlement of the work terminated, including:

1) Accounting, legal, clerical, and other expenses reasonably necessary for the preparation of termination settlement proposals and support data.

2) The termination and settlement of subcontracts and orders for materials, services, equipment and facilities, and

3) Storage, transportation, and other costs incurred, as reasonably necessary for the preservation, protection, or disposition of the termination inventory.

(c) Except for normal spoilage, and to the extent that the Agency expressly accepts the risk of loss, the Agency will exclude from the fair value, all that is destroyed, lost, stolen, or damaged so as to become undeliverable to the Agency or to the buyer.

(d) In arriving at the amount due the contractor under this clause, the Agency will deduct:

1) All unliquidated advance or other payments to the contractor under the terminated portion of the contract;

2) Any claim that the Agency has against the contractor under the contract; and

3) The agreed price for, or the proceeds from the sale of materials, supplies, or other things acquired and sold by the contractor not recovered by or credited to the Agency.

If the termination is partial, the contractor may file a Proposal with the Agency for an equitable adjustment of the price(s) of the continued portion of the contract. The Agency will make any equitable adjustment agreed upon. Any proposal for an equitable adjustment under this clause shall be requested within 30 calendar days after the expiration of the period provided in Subsection 105-18 for the Submittal of a Notice of Claim and all supporting cost information, with said period commencing on the effective date of termination. The request period may be extended in writing by the Engineer.

The Agency may, under the terms and conditions it prescribes, make partial payments and payments against costs incurred by the contractor for the terminated portion of the contract, if these payments will not exceed the amount to which the contractor is entitled.

The contractor shall maintain and make available all project cost records to the Agency for audit to the extent necessary to determine the validity and amount of each item claimed. This includes all books and other evidence bearing on the contractor's costs and expenses under the contract. These records and documents shall be made available to the Agency at the contractor's office, at all reasonable times, without any direct charge. If approved by the Agency, photographs, microphotographs, or other authentic reproductions may be maintained instead of original records and documents.

Termination of the contract or portion thereof shall not relieve the contractor of contractual responsibilities for the work completed, nor shall it relieve the surety of its obligation for and concerning any just claim arising out of the work performed.

SECTION 109

MEASUREMENT AND PAYMENT

109-1 MEASUREMENT OF QUANTITIES

All work completed under the contract shall be measured by the Engineer according to United States standard measures.

A station when used as a definition or term of measurement shall be 100 linear feet (*or 1 kilometer in International System of measure*).

The methods of measurement and computation to be used in determination of quantities of material furnished and of work performed under the contract shall be those methods generally recognized as conforming to good engineering practice.

All items measured on an area basis shall be measured, unless otherwise specified, by longitudinal and transverse measurements made along the surface area, and in such manner as to reasonably ascertain the true area of the item actually placed in accordance with contract requirements. No deductions shall be made for individual fixtures having an area of 9 square feet (*1 square meter*) or less when payment is made on a square yard (*square meter*) basis.

Structures shall be measured to neat lines shown on the project plans or as altered to fit field conditions.

Unless otherwise specified, all items which are to be measured by the linear foot (*meter*) shall be measured along or parallel to the longitudinal axis of that item in such manner as to reasonably ascertain the true length of the item.

In computing volumes of excavation, the differential digital terrain model (DTM) method or other acceptable methods shall be used. When the average end area method is accepted for use, corrections shall not be made for curvature, prismoidal corrections and/or other similar refinements.

When computing volumes of excavation for payment, measurements shall be made to the finished surface or to the finished subgrade for roadway excavation.

The nominal diameter of wire, and the thickness of plates and sheets used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches, and metal cribbing shall be specified and measured in decimal fractions of inches (*millimeters or micrometers*).

The wire size in welded wire fabric used for concrete reinforcement shall be identified by a "W" number directly corresponding to the cross-sectional area of the wire in hundredths of a square inch (*millimeters*).

The term "ton" shall mean the short ton consisting of 2,000 pounds avoirdupois (or in the case of the International System of Units, metric ton consisting of 1000 kilograms). All materials which are measured or proportioned by weight shall be weighed on accurate approved scales.

Where the specifications require scales for the determination of weight, the use of load cells and electronic digital readout shall be acceptable for all applications. The weighing system shall conform to and be maintained in accordance with the requirements of the Weights and Measures Division, Department of Administration, State of Arizona.

Scales of acceptable size shall be furnished by the contractor and shall be sealed either by an inspector of the Department of Weights and Measures, State of Arizona, or by a Licensed Service Agency approved by the above named Department. The Licensed Service Agency certifying the scales shall not be affiliated with the contractor or company supplying materials that are to be paid for by weight.

During weighing operations, weights shall be read and recorded to the nearest 100 pounds (*50 kilograms*). The gross, tare and net weights of each load shall be recorded and documented with all or part of the following information as applicable to the type of scales and recording system used:

- Project Identification
- Materials Source/Plant Identification
- Date
- Load Number
- Truck Identification
- Time of Weighing
- Applicable Weights
- Weigh Person's Signature
- Type or Class of Material

Scales shall be resealed as often as required to assure accurate weights. Scales shall be resealed at least once every 365 calendar days. The contractor shall also provide with each scale at least 20 fifty-pound (*26 – 18 kilogram or 20 – 20.680 kilogram*) certified weights to be used in checking the scale. Each weight shall be re-certified one year from the date of previous certification by the Department of Weights and Measures Metrology Laboratory. Each weight shall be stamped with a number and the contractor shall furnish a certificate showing the number of the weights and the date of certification.

Tests conducted by the Engineer to check the accuracy of scales shall not relieve the contractor of the responsibility of maintaining the accuracy of the scales.

No measurement or direct payment shall be made for any or all of the steps, hereinbefore described, taken to seal scales, provide and certify weights and to weigh materials.

Each scale installation shall be provided with a shelter for the scale operator. The shelter shall be weatherproof and shall be provided with adequate ventilation, light, a stool and a work bench.

The contractor shall provide means for heating or cooling the shelter to a reasonably comfortable degree if the work is in progress during cold or hot weather. The approximate minimum dimensions for the shelter shall be 6 feet (*1.8 meters*) in width, 8 feet (*2.4 meters*) in length and 7 feet (*2.1 meters*) in height.

Trucks used to haul materials being paid for by weight shall be weighed empty at least once daily and at such other times as the Engineer directs and each truck shall bear a plainly legible identification mark.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to at least their water level capacity subject to the legal weight limitation for the vehicle.

When requested by the contractor and approved by the Engineer in writing, materials specified to be measured by the cubic yard (*cubic meter*) may be weighed and such weight shall be converted to cubic yards (*cubic meters*) for payment purposes. Factors for conversion from weight measurement to volume measurement shall be determined by the Engineer and shall be agreed to by the contractor before such method of measurement of pay quantities is used.

Bituminous materials shall be measured either by the gallon (*liter*) or by the ton (*metric ton*).

Volumes shall be measured at 60° F (*16 °C*) or shall be corrected to the volume at 60° F (*16 °C*) in accordance with the requirements of Table 1005-5 for asphalts or ASTM D 633 for tars.

Emulsified asphalt shall be converted from volume to weight by using a factor of 240 gallons per ton (*1000 liters per metric ton*), regardless of temperature.

Net certified scale weights or weights based on certified volumes in the case of rail shipments, shall be used as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted or otherwise not incorporated into the work.

When bituminous materials are shipped by truck or rail, net certified weights or volume, subject to correction for loss or foaming, may be used for computing quantities.

Cement shall be measured by the ton or the hundredweight (*metric ton or kilogram*).

Timber shall be measured by the 1,000 feet board measure (M.F.B.M.) (*cubic meters*) incorporated in the structure. Measurement shall be based on nominal (actual) widths and thicknesses and the extreme length of each piece.

The term "lump sum" when used as an item of payment shall mean complete payment for the work described in the bid.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit shall be construed to include all necessary fittings and accessories.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by unit weight, section dimensions, etc., such identification shall be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved shall be accepted.

109-2 SCOPE OF PAYMENT

The contractor shall accept the compensation provided in the contract as full payment for furnishing all labor, materials, tools, equipment, and incidentals necessary to the completed work and for performing all work contemplated and embraced under the contract; also for loss or damage arising from the nature of the work, or from the action of the elements, or from any unforeseen difficulties which may be encountered during the prosecution of the work until the acceptance by the Agency and for all risks of every description connected with the prosecution of the work; also for all expenses incurred in consequence of the suspension or discontinuance of the work as provided in the contract; and for completing the work according to the plans and specifications. Neither the payment of any estimate nor of any retained percentage shall relieve the contractor of any obligation to make good any defective work or material.

No compensation shall be made in any case for loss of anticipated profits.

If the "Basis of Payment" clause in the specifications relating to any unit price in the bidding schedule requires that the unit price cover and be considered compensation for certain work or materials essential to the item, this same work or material shall not also be measured or paid for under any other pay item which may appear elsewhere in the specifications.

The contractor shall pay all subcontractors and material suppliers in a timely manner. The right of the contractor to receive payment is conditioned on the contractor furnishing evidence that subcontractors and material suppliers have been paid. The Agency may at any time require lien waivers or releases of claims as evidence.

The Agency may at any time require the consent of surety prior to payment.

109-3 COMPENSATION FOR ALTERATIONS OR MODIFICATIONS TO THE CONTRACT WORK

Altered work shall be performed as a part of the contract and shall be paid for at the same contract prices as for other parts of the work, unless the alterations in the details of construction or increases or decreases in quantities materially change the character of the work to be performed or the cost thereof. The term "materially change," for purposes of intent under the contract, shall be construed to apply in either or both of the following circumstances:

When the character of the work as altered differs in kind or nature from that involved or encountered in the original proposed construction.

When the total quantity under any item of work in the contract varies from the bidding schedule quantity for that item by more than 25 percent.

If alterations in the details of construction or increases or decreases in quantities materially change the character of the work or the cost thereof, an adjustment in compensation may, at the request of either party to the contract, be made on the basis agreed to in advance of the performance of the work or, in the event that no such basis has been previously agreed upon, on a basis determined by the Engineer to be in accordance with the following:

- Adjustments covering alterations in the character of the work shall apply only to the units of work actually altered and determined to be materially changed. The adjustment to be made shall be an increase or a decrease in the unit bid price commensurate with the cost of the alteration.

- Adjustments in unit prices for increased quantities of items shall be made on such basis as is necessary to cover a reasonable estimate of cost, plus an allowance for profit and applicable overhead, said allowance not to exceed 25 percent of the estimated cost. The adjusted price shall apply only to that quantity in excess of 125

percent of the bidding schedule quantity. The Agency reserves the right to require that units of work represented by increases in quantities in excess of 120 percent of the bidding schedule quantity be performed in accordance with the requirements of Subsection 104-3.

- When the quantity of any work to be done under any item of the contract is reduced to less than 80 percent of the quantity shown in the bidding schedule, then either party to the contract, upon demand, shall be entitled to an equitable price adjustment for the work actually performed. In no case shall the product of the adjusted unit price and the quantity of work performed exceed the product of the contract unit price and 80 percent of the bidding schedule quantity. No allowance shall be made for profit on units of work not performed.

- No adjustment shall be made in the contract unit price for any item that has materially changed if neither party requests an adjustment in the contract unit price for that item or if the total adjustment under that item amounts to less than $1,000.00.

When no work is done under an item, no adjustment in the unit bid price shall be made. The item shall be eliminated in accordance with the provisions of Subsection 109-6.

Payment for work that has materially changed shall be made in accordance with the requirements of Subsection 109-4.

If the alterations made or increases in the quantities are of sufficient magnitude as to require additional time in which to complete the project, such time adjustment shall be made in accordance with the requirements of Subsection 108-8.

109-4 COMPENSATION FOR ALTERED QUANTITIES

When the accepted quantities of work vary from the quantities in the bidding schedule, the contractor shall accept as payment in full, so far as contract items are concerned, payment at the original contract unit prices for the accepted quantities of work done.

No allowance, except as provided in Subsection 104-2 and 108-11, shall be made for any increased expense, loss of expected reimbursement or loss of anticipated profits suffered or claimed by the contractor resulting either directly from such alterations or indirectly from unbalanced allocation among the contract items of overhead expense on the part of the contractor and subsequent loss of expected reimbursements therefor or from any other cause.

109-5 EXTRA AND FORCE ACCOUNT WORK

(A) Extra Work. Unless determined by the Agency to be force account work, extra work to be performed in accordance with the requirements and provisions of Subsection 104-3 shall be set forth on a supplemental agreement form. Upon request by the Engineer, the contractor shall submit a detailed cost analysis for extra work items which includes estimated or assumed production rates, estimated manhours in specific labor craft categories, estimated hours of specific equipment use, listings of basic materials and costs, and other additional costs, as appropriate. The supplemental agreement form shall specify the work to be done, the basis of compensation and the detailed cost analysis of the work. Where such work does not differ materially from specified contract work, it shall be measured and paid for at contract unit prices; otherwise, compensation shall be made at a price agreed upon by the contractor and the Agency.

Upon receipt of an approved supplemental agreement, the contractor shall proceed with the ordered work; however, if so ordered by the Engineer, the contractor shall proceed with the work, before the receipt of an approved supplemental agreement.

The agreed upon prices shall be full compensation for furnishing all labor, materials and equipment required to do the extra work set forth in the supplemental agreement. Should the extra work require an extension in the contract time, the contractor shall include this request in the submittal to the Engineer in fulfillment of the requirements of Subsection 108-8.

(B) Force Account Work. When force account work is shown in the bidding schedule or when work is to be performed in accordance with the requirements and provisions of Subsection 104-3 and such work is to be paid for as force account, the amount of such payments shall be determined in accordance with the provisions of this Subsection.

The contractor shall submit payrolls or other cost data documents for all force account work. There shall be no partial or full payments made for force account work until receipt of proper and correct documentation.

(1) Labor. For all labor, including foreman in direct charge of specific operations, but excluding general superintendence, the contractor shall be paid:

(a) Regular pay (RP) which will be determined as follows:

RP = (WR + FR) x 1.5

Where:

WR = hourly wage rate as determined by payroll

FR = fringe benefit rate as determined by payroll

The contractor shall provide the hourly wage rates and fringe benefit rate at the preconstruction conference. The rates will be verified by comparison to the contractor's payrolls.

(b) Overtime pay (OT) which will be determined as follows:

OT = [(WR x 1.5) + FR] x 1.5

(c) Subsistence and travel allowances paid to workers as required by collective bargaining agreements.

(2) Materials. For all materials accepted by the Engineer and used in the work, the contractor shall be paid the actual invoice cost of such materials purchased for the work including actual freight and express charges, less all offered or available discounts and rebates not withstanding the fact that they may not have been taken by the contractor. To the above cost shall be added a sum equal to 15 percent thereof.

The Agency reserves the right to furnish such materials as it deems appropriate, and the contractor shall have no claims for any costs, overhead or profit on such materials.

No partial payment will be allowed. The contractor shall be compensated for materials after the materials invoice is submitted along with any documentary backup for the cost of materials.

(3) Equipment. Equipment which the Engineer considers necessary for the performance of work will be eligible for payment at the established rates only during the hours that it is operated except as otherwise allowed elsewhere in these specifications. Equipment hours shall be recorded to the nearest one-half hour.

Rental charges shall not be allowed for tools that show a daily rate less than five dollars.

For the use of equipment owned by the contractor and approved by the Engineer, the contractor will be paid the rental rates, as modified herein, set forth in the Rental Rate Blue Book (RRBB) for Construction Equipment which is published by the Equipment Guide - Book Company, a division of Nielson - Dataquest, 1290 Ridder Park Drive, San Jose, California 95131, Phone (800) 669-3282. All rate determinations will be based on the Blue Book rental rate chapter revisions that are applicable at the time the equipment is being used.

(a) Rental Rates (Without Operators)

The hourly equipment rental rate (HERR) will be determined by the following formula:

$$HERR = F \times \frac{(1.15 \times R}{176)} + HOC$$

Where:

F = Adjustment factor to R as shown in the Special Provisions.
R = Current RRBB Monthly Rate
HOC = Hourly operating cost

NOTE: An overhead and profit adjustment of 15 percent of the rates provided in the Rental Rate Blue Book is included in the above formula.

The hourly operating cost represents the major costs of equipment operation, such as fuel and oil, lubrication, field repairs, tires, expendable parts and supplies.

For each piece of equipment used, whether bought or rented, the contractor shall provide the Engineer with the following information: the manufacturer's name, equipment type, year of manufacture, model number, type of fuel used, horsepower rating, attachments required, together with their size or capacity and any further information necessary to ascertain the proper rate.

When multiple attachments are included with the rental equipment, only the attachment having the higher rental rate will be eligible for payment, provided the attachment has been approved by the Engineer as being necessary to the force account work.

Rental charges will not be allowed for tools or equipment that show a daily rate less than five dollars or for unlisted equipment that has a value of less than four hundred dollars.

The above provisions apply to approved equipment of modern design and in good working condition. The equipment shall be handled and used to provide normal output or production. Equipment that is not in good working condition or is not of proper size for efficient performance of the work may be rejected by the Engineer. Equipment ordered for force account work shall be paid for until such time as the Engineer directs that the use of such equipment be discontinued or until completion of the work.

Unless otherwise specified, manufacturer's ratings and manufacturer-approved modifications shall be used to classify equipment for the determination of applicable rental rates. Equipment which has no direct power unit shall be powered by a unit of at least the minimum rating recommended by the manufacturer.

If it is deemed necessary by the Engineer to use equipment not listed in the above publication, a suitable rate for such equipment will be established by the Engineer. The contractor may furnish cost data which might assist the Engineer in the establishment of such rental rate. The rental rates shall be agreed to in writing prior to the use of such equipment on force account work or paid for by invoices in the case of outside rented equipment.

(b) Stand-By Time. Equipment that is in operational condition and is standing by with the Engineer's approval for participation in Force Account Work shall be paid for according to the following Stand-By Rate (SBR):

SBR = F x (R/176) x 1/2

Payment for "stand-by" will be limited to not more than eight hours in a 24 hour day or 40 hours in a normal week. No compensation shall be allowed for equipment that is inoperable due to breakdown. No payment shall be allowed for equipment that is not operating because work has been suspended in accordance with the specifications or because the work has been suspended by the contractor for the contractor's reasons.

(c) Outside Rented Equipment. In cases where a piece of equipment to be used is rented or leased by the contractor from a third party exclusively for force account work, the contractor will be paid as follows:

Rental Invoice + HOC

(d) Owner-Operated Equipment. Payment for rental of equipment owned and operated by persons other than the prime contractor's or subcontractor's will be based on the actual paid invoice.

An amount equal to ten percent of the total rental of the equipment, including the owner-operator, will be added for overhead, profit and all other costs incidental to furnishing and operating the equipment. The Engineer shall approve the rental rates prior to commencement of the work.

(e) Moving of Equipment. Rental time will also be allowed for the time required to move needed equipment to the location of the force account work and to return it to its original location. Loading and transportation costs will be allowed in lieu of moving times when equipment is moved by means other than its own power. Moving time back to the

original location or loading and transportation costs shall not be allowed if the equipment is used at the site of the force account work on contract items or related work.

For use of equipment moved on the work exclusively for force account work, the actual cost of transferring the equipment to the site of the work and returning it to the original location shall be allowed, as specified herein, as an additional item of expense.

The original location of the equipment to be hauled to the site of the work shall be agreed to by the Engineer in advance.

Where the move of the equipment is made by common carrier, the allowance shall be the invoiced amount paid for the freight plus fifteen percent. If the contractor hauls the equipment with the contractor's own forces, rental will be allowed for the hauling unit plus the driver's wages and the cost of loading and unloading the equipment.

The maximum rental period for the day that the equipment is moved on the work and the day that the use of the equipment is discontinued shall be the actual time that the equipment is in operation on force account work.

(4) Superintendence. No part of the salary or expense of anyone connected with the contractor's forces above the grade of foreman and having general supervision of the work will be included in the labor items as specified above, except when the contractor's organization is entirely occupied with force account work, which case the salaries of the superintendent and the timekeeper may be included in the labor item specified above when the nature of the work is such that their services are required.

(5) Compensation. The compensation as set forth above shall be received by the contractor as payment in full for work done on a force account basis. In addition, the contractor shall be paid an amount equal to 65 percent of the force account compensation times the applicable sales tax rate.

(6) Statements. All statements shall be accompanied and supported by receipted invoices for all materials used and transportation charges. If materials used on the force account work are not specifically purchased for such work but are taken from the contractor's stock, then instead of invoices, the statements shall contain or be accompanied by an affidavit of the contractor certifying that such materials were taken from stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the contractor.

The contractor and subcontractor will submit an equipment list for all equipment to be used during the contract, an equipment rate sheet, and a labor rate sheet, all within 30 days after contract award, but prior to the start of any force account work.

The contractor shall submit payrolls and other cost data documents for all force account work within 30 calendar days after completion of the work. No partial payment will be made. All invoiced work must have documentation for payment. Final payment will not be made for work performed on a force account basis until the contractor has furnished duplicate itemized statements of the cost of such force account work detailed to the following:

Name, classification, date, daily hours, total hours, rate and amount for each foreman and labor classification.

Designation, dates, daily hours, total hours, rental rate and amount for each unit of equipment.

Quantities of materials, prices and amounts.

Transportation charges on materials, FOB jobsite.

(C) Force Account Work by Subcontractor. When force account work is determined by the Engineer to require specialized labor or equipment not normally utilized by the contractor and such force account work is performed by subcontractors, the contractor shall be allowed an additional markup based on the following:

For the first $10,000.00 of work performed by subcontractors (less markups for overhead and profit), the contractor shall be allowed a ten percent supplemental markup.

For all work in excess of $10,000.00 performed by subcontractor (less markups for overhead and profit), the contractor shall be allowed a five percent supplemental markup.

The ten percent supplemental markup shall apply to the first accumulated total of all force account work performed by subcontractors.

The contractor shall submit payrolls or other cost data documents for all force account work performed by subcontractors. There shall be no payments made for force account work until receipt of proper and correct documentation.

(D) Purchased Services. The cost of a single purchased service shall not exceed $5,000.00, and the aggregate amount of purchased services shall not exceed $25,000.00.

If the payment of predetermined minimum wages is a requirement of the contract, all labor employed in the performance of a purchased service shall be paid the appropriate predetermined minimum wage.

For a purchased service, either the contractor or a subcontractor shall be allowed a ten percent supplemental markup. No additional markup shall be allowed.

(E) Bonding. An amount of 0.5 percent of the total amount will be added for the Performance and Payment Bond.

(F) Taxes. Applicable taxes shall be reimbursable.

(G) Non-Allowable Charges. If the contractor chooses to accept Force Account, then the contractor's compensation in any supplemental Agreement will only be for what is stated in the above Force Account provisions.

Whether the amount of Supplemental Agreement negotiated is for unit price, Lump Sum Agreement or Force Account, in no case will the contractor be reimbursed for the following items:

(1) Profit in excess of that provided herein;

(2) Loss of profit;

(3) Home office overhead;

(4) Consequential damages, including loss of bonding capacity, loss of bidding opportunities and insolvency;

(5) Indirect costs of expenses of any nature;

(6) Attorney's fees, claims preparation expenses or costs of litigation; or

(7) Interest

(H) Disagreement on Cost. Should both parties fail to agree on the above basis of payments, the Engineer may have the work done or cause the work to be done by parties or means other than the contractor. This work shall not invalidate the Contract nor release the surety.

109-6 ELIMINATED ITEMS

The Engineer may, upon written order to the contractor, eliminate items from the contract and such action shall in no way invalidate the contract. When a contractor is notified of the elimination of items, the contractor shall be compensated under the provisions of Subsection 108-11.

109-7 PARTIAL PAYMENTS

If satisfactory progress is being made, the contractor shall receive a payment each month based on the amount of work completed during the preceding month. Except as herein provided, the Agency, in lieu of securities, shall retain ten percent of each monthly statement of amount earned until the final acceptance of the work.

If 50 percent of the contract work has been completed, one-half of the amount retained to date, including substitute securities, shall be paid to the contractor upon receipt of a written request from the contractor and provided satisfactory progress is being made on the contract and there is no other specific cause or claim requiring a greater amount to be retained, all as determined by the Engineer. So long as the contractor continues to make satisfactory progress, the Agency, in lieu of securities, shall retain five percent of each of the remaining monthly statements of amount earned.

Should any defective work or material be discovered prior to the final acceptance or should a reasonable doubt arise prior to the final acceptance as to the integrity of any part of the completed work, the payment for such defective or questioned work shall not be allowed until the defect has been remedied or cause for doubt removed.

The monthly payments will be approximate only and all partial statements and payments shall be subject to correction in the final statement and payment. If the total amount of the retained percentage of the contract is greatly in excess of the uncompleted and unaccepted portion of the contract, the contractor may be allowed a portion of this suspended payment, provided that the contractor files with the Agency a consent of the contractor's surety to such payment and provided that the Agency at all times retains an amount sufficient to enable it to complete the unaccepted or uncompleted work in the contract.

Partial payment on either a lump sum item or on an item paid for as a unit (each) may be made if the amount of work, in the opinion of the Engineer, is of sufficient magnitude to warrant partial payment. The amount of the partial payment to be made shall be in proportion to the percentage of the work completed on the item, as estimated by the Engineer.

The contractor shall not assign payments to be made under the contract, or any portion thereof, without the written approval of both the surety and the Agency.

109-8 PARTIAL PAYMENT FOR MATERIAL ON HAND

Materials listed below may be considered for partial payment without the execution of a supplemental agreement, when the materials are delivered and stockpiled or produced on the project

site or on another site approved by the Engineer. Such partial payment shall be made at the contract unit price for the quantity of material on hand multiplied by the Partial Payment Factor.

Type of Material	Partial Payment Factor	
Aggregate Subbase	0.45	
Aggregate Base	0.60	
Mineral Aggregate	0.40	
Cover Material	0.35	
Structural Steel	0.60	
Reinforcing Steel	0.60	
Corrugated Metal Pipe	0.50	
Structural Plate Pipe or Pipe-Arch	0.65	
Concrete Pipe	0.45	
Flared End Section for Pipe Culvert	0.70	
Cattle Guard Grill	0.60	(of total cattle guard item)
Guard Rail (Rail and Brackets)	0.50	
Guard Rail (Posts)	0.20	
Fencing (Posts and Wire)	0.40	
Precast Concrete Bridge Members (after curing period is completed)	0.80	
Vertical Support for Breakaway Sign	0.60	
Perforated Sign Posts	0.50	
Cantilever and Bridge Sign Structures	0.60	
Sign Panel	0.40	

Material for items of work, whether shown above or not, may be considered for partial payment without the execution of a supplemental agreement, when the materials are delivered and stockpiled or produced on the project site or on another site approved by the Engineer. Such partial payment shall be made at 100 percent of invoice cost, but shall not exceed 80 percent of the total item bid amount.

The method of partial payment for materials other than those presented above may be agreed upon by a supplemental agreement properly executed and approved.

Partial payment shall be made only if the material is approved by the Engineer and if satisfactory progress is being made on the contract work by the contractor.

No partial payment shall be made for living or perishable plant materials until they are planted.

No partial payment shall be made for materials stockpiled at a commercial source.

109-9 PAYMENT OF WITHHELD FUNDS

Attention is directed to Subsection 109-7 and in particular to the retention provisions of that Subsection.

Upon the contractor's request, the Agency shall make payment of funds withheld from progress payments if the contractor makes an assignment to the Agency of time certificates of deposit or securities.

The securities shall be deposited in a joint escrow account to be held by a bank or savings and loan institution licensed by the State of Arizona and having an office in Pima County and in an amount that at all times is equal to or greater than the amount that would normally be withheld under the provisions of Subsection 109-7.

109-10 DEFICIENT WORK

When the contractor fails to achieve the minimum standards required by the specifications for a particular item of work the Agency, depending on the degree of the deficiency, may allow the contractor the option of accepting a reduction in payment as detailed in Section 110, in lieu of removing and replacing the deficient work. The decision to provide this option shall be at the sole discretion of the Engineer.

Payment for asphaltic concrete failing to achieve the minimum standards required by the specifications shall be subject to the provisions of Subsection 110-2.

Payment for portland cement concrete pavement which fails to achieve the minimum standards required by the specifications shall be subject to the provisions of Subsections 110-3.01 and 3.02.

Payment for portland cement concrete used in structures, curbs, gutters, sidewalks, driveways and bank protection which fails to achieve the minimum standards required by the specifications shall be subject to the provisions of Subsections 110-3.02, 3.03 and 3.04.

Payment for treated subgrade and treated base which fails to achieve the minimum standards required by the specifications shall be subject to the provisions of Subsection 110-4.

109-11 ACCEPTANCE AND FINAL PAYMENT

When final acceptance has been made in accordance with the requirements of Subsection 105-17, the Engineer shall prepare the final estimate of quantities of the various items of work performed.

Final payment shall be made in accordance with the Engineer's final statement of the total amount earned by the contractor.

The final payment shall not be made until all quantities have been checked and verified, and complete performance of the contract has been rendered, including verification of all lien releases when requested. The final payment on Improvement District Projects shall be made in accordance with A.R.S. §§48-571 through -597. The final payment and release of retention for projects, other than

Improvement District Projects, shall occur within sixty days after final acceptance. In the event that final acceptance does not constitute complete performance of the contract, the Agency may make a specific written finding justifying the delay in final payment and release of retention monies to the contractor beyond the aforementioned sixty days. Any undisputed amounts shall be released by the Agency within sixty days of final acceptance.

The contractor agrees to accept payment for City of Tucson Improvement District Projects (only) in the form of Assessments with attached Warrants or Improvement Bonds at the rate of interest for which the bonds are sold when such a payment mechanism is deemed in the best interest of the Agency.

The cost of any work, material, equipment or incidentals specified in Division 100 of these Standard Specifications for which no direct payment has been specified in the bid, shall be considered as included in the contract unit price for one or more of the contract items.

109-12 LUMP SUM PAYMENT FOR STRUCTURES

(A) General. When the Bid Schedule contains separate sheets indicating the items and approximate quantities required to complete specific structures or designated groups of structures and a lump sum total for each structure or group of structures, the contractor shall be compensated on a lump sum basis.

Bidders shall specify a unit price and an extended amount for each item within the lump sum structure or group of structures for which a quantity is given. Bidders shall also show the lump sum bid price for each complete structure or group of structures such that the total of the extended amounts shall equal the lump sum bid for that specific structure or group of structures. In case of a discrepancy between a unit price, an extended amount, or the lump sum price, the unit price shall govern.

Bidders shall verify the accuracy and completeness of the quantities listed in the Bid Schedule, and bid prices shall reflect the cost of quantities which the contractor determines to be necessary to construct the structures and shall also include any additional costs for work necessary to complete the structures but for which no bid quantities are listed.

The contractor shall provide the Engineer with a schedule of values for all components comprising the work at the time of the preconstruction conference.

(B) Adjustments Due to Quantity Variations. For all items of work, other than Structural Concrete, Structural Steel and Reinforcing Steel items, no adjustment to the Bid Schedule's quantities, unit prices, extended amounts, and resulting lump sum amount shall be made following the award of contract because of any errors made either by the Agency in its calculations of quantities or by the contractor in its calculations.

Adjustments in the Bid Schedule quantities for Structural Concrete, Structural Steel, or Reinforcing Steel may be initiated by the contractor or the Engineer if evidence indicates that the required quantity varies by an amount greater than five percent of the Bid Schedule quantity. The contractor shall advise the Engineer in writing, submitting such evidence and requesting an adjustment of the quantities. The Engineer shall determine the amount of adjustment, if any. The quantity upon which payment shall be based shall be the Bid Schedule quantity plus or minus only that portion of the adjustment that exceeds five percent of the Bid Schedule quantity. No adjustment to the contract time shall be allowed due to lump sum structure quantity variations.

(C) Adjustments Due to Revisions Ordered by the Engineer. If the Engineer orders a revision in the project plans or specifications for a specific structure or group of structures contracted under this provision and the revision affects work for which bid schedule items have been established, the unit price shall be subject to revision in accordance with the requirements of Subsection 104-2. Payment to the contractor shall be adjusted by an amount equal to the product of the quantity adjustment and the unit price bid or the revised unit price as appropriate.

If the revisions affect work for which no Bid Schedule item has been established, payment for this work shall be made in accordance with the requirements of Subsection 104-3.

(D) Payment. Payment for all work necessary to construct the structures, including but not necessarily limited to all excavating, backfilling, foundations, concrete, reinforcing steel, structural steel, expansion joints, bearings, approach slabs, post tensioning systems, handrails, and utility and lighting conduit systems, shall be made on the basis of the lump sum amount, except as may be adjusted in accordance with (B) and (C).

Driven piles, caisson concrete and caisson reinforcement shall be paid for under the respective contract items and shall not be paid for under lump sum payment for structures.

Partial payments shall be made in accordance with the requirements of Subsection 109-8, on the basis of the quantities shown in the Bid Schedule for each structure and the respective unit prices. No later than the 20th day of each month the contractor shall furnish the Engineer an estimate of the quantity of each item of work shown in the Bid Schedule for which the contractor expects to be compensated. The Engineer shall be the sole judge as to the approximate quantities of work eligible for payment in any month. The total amount of all partial payments shall equal the lump sum amount bid, adjusted as specified herein.

SECTION 110

CORRECTIVE REQUIREMENTS FOR DEFICIENCIES

110-1 DESCRIPTION

The failure to achieve the minimum standards required by the specifications is classified as a deficiency. It is recognized that deficiencies vary in the degree to which they affect the quality of the work.

In the case of a deficiency or failure to achieve the requirements of the specifications, the contractor shall remove and replace the work at no additional cost to the Agency. However, based on the degree of the deficiency, the contractor may be given the option of accepting a reduction in payment for the Agency allowing the deficient work to remain in place.

The contractor shall be responsible for the cost of all sampling and testing, beyond the initial routine sampling and testing conducted by the Agency, for materials found to be deficient. This includes cores of asphaltic concrete and portland cement concrete pavement, sidewalk, bank protection or treated subbase or base courses for which a payment reduction has been levied or removal and replacement has been ordered. Testing costs shall be the actual costs incurred by the Agency, whether the testing is performed by an independent, approved materials laboratory or is performed by Agency personnel. The costs listed in the Agency's Materials Laboratory Cost Schedule, existing at the date of the bid opening for the project, shall serve as the basis for charges incurred by the Agency for "in-house" testing. The Materials Laboratory Cost Schedule is available through the Agency's Materials Laboratory.

The quantity of deficient material that may be subject to a reduction in payment will be based upon the sampling frequency for the material. A schedule of standard test procedures and sampling frequencies are available from the Agency.

110-2 ASPHALTIC CONCRETE

110-2.01 Thickness. When, in the opinion of the Engineer, there is reason to believe that the pavement may be less than the thickness specified in the project plans, exclusive of overlays less than 1-1/2 inches (*38 millimeters*) in thickness, cores shall be taken by the Engineer at random locations, in accordance with the provisions of Subsection 110-2.05.

When a deficiency of more than 1/4 inch (*6 millimeters*) is found, two additional cores shall be taken, not closer than 200 feet (*60 meters*) to the original core. Should these cores also prove to be deficient in thickness by more than 1/4 inch (*6 millimeters*), coring shall continue at a minimum interval of 200 feet (*60 meter*) until the area of the deficiency has been determined. The average of all cores within a deficient area shall then be used to determine the magnitude of the deficiency. Additional cores may be taken by the contractor to further define the limits of the

deficiency. These additional cores shall be at no additional cost to the Agency, and shall not be considered in determining the average thickness of the pavement. Thickness of the cores shall be determined by average caliper measurement.

The deficient area shall be determined by the length encompassed by the deficient cores multiplied by the lane or ribbon width placed.

The tonnage (*metric tonnage*) of deficient material shall be calculated by multiplying the volume of deficient asphaltic concrete, as determined from previously defined dimensions, by the in-place unit weight applicable to the deficient area.

Where the pavement thickness is deficient by 1/4 inch (*6 millimeters*) or less, it shall be paid for at the contract unit price.

Where the pavement is deficient in thickness by more than 1/4 inch (*6 millimeters*), but not more than 1/2 inch (*13 millimeters*), the contract unit price shall be adjusted as indicated in Table 110-1.

TABLE 110-1

ASPHALTIC CONCRETE THICKNESS DEFICIENCES
UNIT PRICE ADJUSTMENT FACTORS
(1/4 INCH TO 1/2 INCH (*6 millimeters to 13 millimeters*))

Specified Mat Thickness	Unit Price Adjustment Factor(1)
1 inch (*25 millimeters*)	0.50
1-1/2 inch (*38 millimeters*)	0.67
2 inch (*51 millimeters*)	0.75
2-1/2 inch (*64 millimeters*)	0.80
3 inch or over (*76 millimeters*)	0.83

Note(1): Payment shall be computed by multiplying the applicable Unit Price Adjustment Factor by the unit price bid for the asphaltic concrete mixture and applying this adjusted unit price to the quantity of asphaltic concrete represented by the test results.

When the deficiency in the pavement thickness exceeds 1/2 inch (*13 millimeters*), the pavement shall be overlayed throughout the affected area, but in no case shall the overlay length be less than one block or 660 feet (*200 meters*), whichever is less. The overlay shall extend for the full width of the pavement, with material approved by the Engineer, and equal in thickness to the deficiency. However, in no case, shall the overlay thickness be less than 1/2 inch (*13 millimeters*). This work shall be at no additional cost to the Agency.

When the pavement is deficient in thickness by more than 1/4 inch (*6 millimeters*), all coring conducted to establish the limits of the deficiency shall be at the expense of the contractor.

Payment for pavement thickness exceeding that shown on the plans shall not be considered unless such additional thickness had been authorized, in writing, by the Engineer.

110-2.02 Asphaltic Concrete Mixture Properties. When tests show that the asphaltic concrete mixture properties vary from the approved mix design target values by the amounts shown in Table 110-2 and 110-3, payment for the asphaltic concrete quantities represented by the tests will be adjusted. Payment adjustments for deficiencies in Mixture Properties are as provided in Table 110-2 and 110-3.

For each approximate 500 tons (*450 metric tons*) of asphaltic concrete, or portion thereof, the Agency will take at least one sample as described in Section 406. The sample will be tested for the mixture properties listed in Table 110-2 and Table 110-3. The applicable payment adjustment shall be applied to the quantity represented by each sample.

TABLE 110-2
ASPHALTIC CONCRETE MIXTURE DEFICIENCIES
PAYMENT ADJUSTMENT AMOUNTS FOR GRADATION AND ASPHALT CEMENT CONTENT

Gradation (% Passing)	Variation from Mix Design Target Value (*Percent*)	Payment Adjustment Amount *Dollars/Ton*	Payment Adjustment Amount (*Dollars/ Metric Ton*
3/8 inch (*9.5 millimeter*) sieve and larger	±6 ±7 ±8 ±9 or greater	0.00 -1.00 -2.00 -3.00 (2)	*0.00* *-1.10* *-2.20* *-3.30 (2)*
#8 sieve (*2.36 millimeter*)	±6 ±7 ±8 ±9 or greater	0.00 -1.00 -2.00 -3.00 (2)	0.00 -1.10 -2.20 -3.30 (2)
#40 sieve (*425 micrometer*)	±5 ±6 ±7 ±8 or greater	0.00 -1.00 -2.00 -3.00 (2)	*0.00* *-1.10* *-2.20* *-3.30 (2)*
#200 sieve (*75 micrometer*) (w/ mineral admixture)	±1.8 ±2.5 ±3.0 ±3.1 or greater	0.00 -1.00 -2.00 -3.00 (2)	*0.00* *-1.10* *-2.20* *-3.30 (2)*

Asphalt Cement Content (%)	Payment Adjustment Amount	
Variation From Mix Design Target Value (Percent)	Dollars/Ton	(*Dollars/ Metric Ton*
±0.00-0.40 ±0.41-0.50 ±0.51-0.60 ±0.61 or greater	0.00 -1.00 -2.00 -3.00 (2)	*0.00* *-1.10* *-2.20* *-3.30 (2)*

TABLE 110-3
ASPHALTIC CONCRETE MIXTURE PROPERTIES DEFICIENCIES
PAYMENT ADJUSTMENT AMOUNTS FOR EFFECTIVE VOIDS

Effective Voids (%)	Payment Adjustment Amount	
Variation from Mix Design Target Value (*Percent*)	*Dollars/Ton*	(*Dollars/ Metric Ton*
-2.0 to +1.0	0.00 (1)	*0.00 (1)*
-2.1 to -2.5 or +1.1 to +1.5	-1.00	*-1.10*
-2.6 to -3.0 or +1.6 to +2.0	-2.00	*-2.20*
<-3.0 or >+2.0	-3.00 (2)	*-3.30 (2)*

Note (1): Refer to Subsection 110-2.02 (A)(3).

Note (2): Reject Status: The payment adjustment shall apply only if the asphaltic concrete is allowed to remain in place subject to the provisions of Subsection 110-2.02 (B).

(A) Payment Adjustment Determination for Deficiencies in Mixture Properties. The total payment adjustment for deficiencies in mixture properties shall be determined as follows:

(1) The individual payment adjustment amounts for deficiencies in 3/8 inch (*9.5 millimeter*) and larger sieves; #8 (*2.36 millimeter*) sieve; #40 (*425 micrometer*) sieve; #200 (*75 micrometer*) sieve, asphalt cement content and effective voids shall be determined in accordance with Table 110-2 and Table 110-3.

(2) A single payment adjustment amount shall be determined from Table 110-2 for the following mixture properties: 3/8 inch (*9.5 millimeters*) and larger sieves, #8 (*2.36 millimeters*) sieve, #40 (*425 micrometers*) sieve, #200 (*75 micrometers*) sieve, and asphalt cement content. The payment adjustment amount from Table 110-2 will be the single most severe adjustment for the mixture properties as obtained from this Table.

(3) The Mixture Properties Total Payment Adjustment amount shall be the sum of the most severe adjustment amount obtained from Table 110-2 as determined in (2) above and the effective voids adjustment amount from Table 110-3. The Mixture Properties Total Payment Adjustment amount shall not exceed minus $3.00/Ton (*$3.30/metric Ton*).

A Mixture Properties Total Payment Adjustment in excess of minus $3.00/Ton (*$3.30/ metric Ton*) shall not be applied. Instead, the asphaltic concrete shall be rejected and the material removed and replaced at no additional cost to the Agency. The Mixture Properties Total Payment Adjustment amount shall be applied to the quantity of material represented by the sample for mixture properties. The

reduction in payment shall be computed by multiplying the applicable Mixture Properties Total Payment Adjustment amount by the quantity of asphaltic concrete represented by the sample. When no mixture property from Table 110-2 is in reject status and the effective voids payment adjustment from Table 110-3 is $0.00/Ton (*$0.00/Metric Ton*), the Mixture Properties Total Payment Adjustment amount shall be $0.00/Ton (*$0.00/Metric Ton*) for the quantity of material represented by the sample.

(B) Mixture Properties Acceptability. Asphaltic concrete represented by a sample with any single mixture properties payment adjustment of minus $3.00 per Ton (*$3.30/metric Ton*) will be rejected. The contractor may submit to the Engineer a written proposal to accept the material at the maximum Mixture Properties Total Payment Adjustment amount. The proposal shall contain an engineering analysis of the anticipated performance of the asphaltic concrete if left in place. The proposal shall also detail any proposed corrective action and the anticipated effect of such corrective action on the performance. If the proposal is not accepted, the asphaltic concrete shall be removed and replaced with asphaltic concrete meeting the requirements of Section 406. If the proposal is accepted, the asphaltic concrete shall remain in place and the maximum Mixture Properties Total Payment Adjustment amount shall be assessed. Any necessary corrective action shall be performed at no additional cost to the Agency.

110-2.03 Asphalt Cement. When the properties of asphalt cement vary from the range established in the Standard Specifications or the Special Provisions, payment for the asphaltic concrete mixture, into which the asphalt cement was incorporated, shall be reduced in accordance with the requirements of Table 110-4 for the quantities represented by the test.

TABLE 110-4

ASPHALT CEMENT

PAYMENT ADJUSTMENT AMOUNTS FOR PROPERTY DEFICIENCES (1)

Test Property	Test Value	Payment Adjustment Amount Dollars/Ton		*Dollars/Metric Ton*	
Dynamic Shear of Original Binder: G*/Sin δ, kPa	0.90 - 0.99 0.70 - 0.89 Less than 0.70	-1.00 -2.00 -3.00	(2)	*-1.10* *-2.20* *-3.30*	*(2)*
Dynamic Shear of RTFO Binder: G*Sin δ, kPa	2.00 - 2.19 1.60 - 1.99 Less than 1.60	-1.00 -2.00 -3.00	(2)	*-1.10* *-2.20* *-3.30*	*(2)*
Dynamic Shear of PAV Binder: G*/Sin δ, kPa	5001 - 5500 5501 - 7000 7001 - 8000 More than 8000	-1.00 -2.00 -3.00 -4.00	(2)	*-1.10* *-2.80* *-3.30* *-4.40*	*(2)*
Creep Stiffness of PAV Binder: S, Mpa	301 - 330 331 - 450 451 - 600 More than 600	-1.00 -2.00 -3.00 -4.00	(2)	*-1.10* *-2.20* *-3.30* *-4.40*	*(2)*
m-value at 60 sec	0.270 - 0.299 0.230 - 0.269 Less than 0.230	-1.00 -2.00 -2.00	(2)	*-1.10* *-2.20* *-3.30*	*(2)*

Note (1): The reduction in payment shall be computed by multiplying the applicable payment adjustment amount by the quantity of asphaltic concrete represented by the test results.

Note (2): Reject Status: The monetary payment adjustment amount applies if the asphaltic concrete is allowed to remain in place.

General Notes:

Specified properties in AASHTO Provisional Standard MP1 for flash point, viscosity at 135 °C, and mass loss are not considered performance related. Specification deficiencies for these properties shall be cause for a work stoppage until specification properties are met, but will not be cause for a pay adjustment.

Should the bituminous material be deficient on more than one property, the payment adjustment amount will be the greatest adjustment possible considering individual test results.

The information presented in this table does not apply to

asphalt cement used for tack coats.

110-2.04 Asphaltic Concrete Compaction. Asphaltic concrete compaction shall be verified from cores taken for each 250 tons (*275 metric tons*) or portion thereof of compacted asphaltic concrete pavement placed. The Engineer shall select the location for coring; however, the outside 1 foot (*300 millimeters*) of an unconfined pavement course shall be excluded from testing. Samples will be taken utilizing mechanical coring equipment in accordance with the requirements of Arizona Test Method 104. The material will be tested for acceptance by the Engineer in accordance with the requirements of Arizona Test Method 415.

Payment adjustments for deficiencies in the compaction of asphaltic concrete pavements are as provided in Table 110-5. The payment adjustment amounts shall be applied to the quantity represented by each core.

TABLE 110-5
ASPHALTIC CONCRETE
PAYMENT ADJUSTMENT AMOUNTS FOR COMPACTION DEFICIENCIES

Laboratory Density (Percent)	Payment Adjustment Amount	
	Dollars/Ton	Dollars/Metric Ton
95.0% or greater	0.00	*0.00*
94.0 - 94.9	-1.00	*-1.10*
93.0 - 93.9	-2.00	*-2.20*
Less than 93.0	-3.00 (1)	*-3.30 (1)*

Note (1): Reject Status: The payment adjustment amount shall apply only if the asphaltic concrete is allowed to remain in place, subject to the provisions of Subsection 110-2.04(B).

(A) Payment Adjustment Determination for Deficiencies in ~~of~~ Compaction. The compaction payment adjustment amount shall be as shown in Table 110-5. The compaction payment adjustment amount shall not exceed minus $3.00/Ton (*$3.30/Metric Ton*). The compaction payment adjustment amount shall be applied to the quantity of material represented by the core sample. The reduction in payment shall be computed by multiplying the applicable compaction payment adjustment amount by the quantity of asphaltic concrete represented by the core sample.

(B) Compaction Acceptability. Asphaltic concrete represented by a core sample with a compaction payment adjustment amount of minus $3.00 per ton (*$3.30 per metric ton*) will be rejected. The contractor may submit to the Engineer a written proposal to accept the material at the maximum compaction payment adjustment amount. The proposal shall contain an engineering analysis of the anticipated performance of the asphaltic concrete if left in place. The proposal shall also detail any proposed corrective action and the anticipated effect of such corrective action on the performance. If the proposal is not accepted, the asphaltic

concrete shall be removed and replaced with asphaltic concrete meeting the requirements of Section 406. If the proposal is accepted, the asphaltic concrete shall remain in place at the maximum compaction payment adjustment amount. Any necessary corrective action shall be performed at no additional cost to the Agency.

110-2.05 Pavement Surface. When the finished surface of asphaltic concrete pavement exceeds the tolerance specified in Subsection 406-3.10, the deficient area shall be removed to a minimum depth of 2 inches (*50 millimeters*) by cold planing, and replaced to the proper grade at no expense to the Agency. The ends of the cold planing shall be trued by saw cutting to a minimum depth of 1 inch (*25 millimeters*). The saw cuts shall be skewed as directed by the Engineer.

110-3 PORTLAND CEMENT CONCRETE

110-3.01 Portland Cement Concrete Pavement. Adjustments in the unit price for deficiencies in the thickness of nine inch thick portland cement concrete (PCC) pavement are as provided in Table 110-6.

Table 110-6 shall be modified to address thickness deficiencies in portland cement concrete pavements having a plan thickness of other than 9 inches (*230 millimeters*) by adjusting the ranges found in the column. "Deficiency in Thickness As Determined by Cores" by the ratio of nine inches to the thickness indicated on the plans.

The coring frequency shall be in accordance with that specified in Subsection 110-2.01 for thickness deficiencies found in excess of those permitted in Table 110-6 for 100 percent payment.

TABLE 110-6
PCC PAVEMENT (NINE INCH THICK)
UNIT PRICE ADJUSTMENT FACTORS FOR THICKNESS DEFICIENCIES

Deficiency in Thickness As Determined by Cores		Unit Price Adjustment Factor
Inches	*Millimeters*	
0.00 to 0.25	*0.00 to 6.4*	1.00
0.26 to 0.35	*6.6 to 8.9*	0.93
0.36 to 0.45	*9.1 to 11.4*	0.85
0.46 to 0.55	*11.6 to 14.0*	0.75
0.56 to 0.75	*14.2 to 19.0*	0.63
0.76 to 1.00	*19.3 to 25.4*	0.50
Greater than 1.00	*25.4*	(1)

Note (1): The concrete represented by the test result shall be removed and replaced at no additional cost to the Agency.

110-3.02 Compressive Strength. Adjustments in the unit price for deficiencies in the compressive strength of Class S or Class B concrete are as provided in Table 110-7. Table 110-8 indicates the unit price adjustments for deficiencies in the compressive strength of concrete mix designs used for roadway paving.

TABLE 110-7
PORTLAND CEMENT CONCRETE (CLASS 'S' AND 'B')
UNIT PRICE ADJUSTMENT FACTORS FOR
STRENGTH DEFICIENCIES

Percent of Specified 28-Day Compressive Strength Attained at 28 Days, to the Nearest Whole Percent	Unit Price Adjustment Factor
100 or More	1.00
98 – 99	0.95
96 – 97	0.90
95	0.85
Less than 95	0.55 (1)

Note (1): Reject Status: The unit price adjustment factor applies only if the concrete represented by the test results is allowed to remain in place.

TABLE 110-8
PORTLAND CEMENT CONCRETE PAVEMENT (ROADWAYS)
UNIT PRICE ADJUSTMENT FACTORS FOR
STRENGTH DEFICIENCIES

Percent of Specified 28-Day Compressive Strength Attained, to the Nearest Whole Percent	Unit Price Adjustment Factor
100 or More	1.00
97 - 99	0.92
94 - 96	0.85
90 - 94	0.77
85 - 89	0.68
80 - 84	0.60
75 - 79	0.50 (1)
Less than 75	Note (2)

Note (1): Reject Status: The unit price adjustment factor applies only if the concrete is allowed to remain in place.

Note (2): The concrete represented by the test result shall be removed and replaced at no additional cost to the Agency.

No payment shall be made for concrete permitted to remain in place when the average compressive strength of the three 42-day cores, permitted under Subsections 1006-7.05 (A) or (B), fails to meet 95 percent of the required 28-day compressive strength. Payment shall be made in accordance with Table 110-8 for 42-day cores whose compressive strength achieves an acceptable percentage of the 28-day compressive strength as specified in Table 110-7.

110-3.03 Concrete Curbs and Gutters. Concrete curb, gutter, or

curb and gutter which is cracked, damaged, or fails to meet the straightedge requirements found in Section 908, shall be removed from joint to joint (i.e., either scored or expansion) and replaced at no additional expense to the Agency. If the removal limits are defined by a scored joint, the concrete shall be saw cut along the scored joint.

110-3.04 Concrete Sidewalk and Concrete Bank Protection. Concrete sidewalk which is cracked, damaged, or fails to meet the straight-edge requirements found in Section 908 (sidewalk only), shall be removed from expansion joint to expansion joint, except that the contractor may sawcut a section at the approximate midpoint between expansion joints providing the remaining panel is not less than eight feet in length and the saw cut is made at a scored joint and at no additional cost to the Agency.

When in the opinion of the Engineer, there is reason to believe that the sidewalk or bank protection may be deficient in thickness, cores will be taken by the Engineer at random locations, with one core for every 500 linear feet (*150 meters*) of distance. When a deficiency of more than 1/4 inch (*6 millimeters*) is found, additional cores will be taken, as needed, to determine the area of the deficiency.

Where concrete sidewalk or bank protection is deficient by 1/4 inch (*6 millimeters*) or less, payment shall be made at the contract price.

Where the work is deficient in thickness by more than 1/4 inch (*6 millimeters*) but less than or equal to one-fourth of the design thickness, payment will be made as follows:

$$\frac{\text{Avg Core Thickness (in) (mm)} \times \text{Contract Unit Price}}{\text{Specified Plan Thickness (in) (mm)}} = \text{Payment}$$

Where the work is deficient by more than one-fourth of the specified thickness, the work shall be removed and replaced, from joint to joint, at no additional cost to the Agency.

110-4 TREATED SUBGRADE AND BASE COURSES

110-4.01 Surface. Areas of treated subgrade or treated base course which have compaction planes or seams or are damaged or severely cracked shall be saw cut, removed and replaced for the full depth of the course at no additional cost to the Agency.

Areas of treated subgrade and base course which fail to meet the finishing requirements specified in Subsection 301-3.05, 302-3.08 or 304-3.03 shall be corrected or removed and replaced for its full depth so as to meet the specified requirements. Correction of low areas by the addition of a thin layer of treated material shall not be acceptable.

110-4.02 Thickness. When, in the opinion of the Engineer, there is reason to believe that the treated subgrade or treated base course may be less than the thickness specified in the plans, cores will be taken by the Engineer at random locations, with a minimum of one core for each twelve feet of width or portion thereof, and every 500 feet (*150 meters*) of distance. When a deficiency of more than 1/4 inch (*6 millimeters*) is found, two additional cores will be taken, not closer than 100 feet (*30 meters*) to the original core. Should these cores also prove to be deficient in thickness by more than 1/4 inch (*6 millimeters*), coring shall continue at a minimum of 100 foot (*30 meters*) intervals until the area of the deficiency has been determined. The average of all cores within a deficient area will then be used to determine the magnitude of the deficiency. At the contractor's option, the contractor may core the treated subgrade or base course to further define the limits of the deficiency. These additional cores shall be taken at the sole expense of the contractor and shall not be considered in determining the average thickness of the treated subgrade or base course. Thickness of cores shall be determined by average caliper measurement.

Where the thickness of the treated course is deficient by 1/4 inch (*6 millimeters*) or less, payment shall be made at the contract unit price.

Where the magnitude of the deficiency exceeds 1/4 inch (*6 millimeters*), but is less than, or equal to, one-fourth the design thickness of the treated course, as specified on the plans, payment shall be adjusted using the following formula:

$$\frac{\text{Avg Core Thickness (in)(mm)} \times \text{Area of Deficiency} \times \text{Contract Unit Price}}{\text{Specified Plan Thickness (in) (mm)}} = \text{Payment}$$

Where the work is deficient by an amount greater than one-fourth the specified plan thickness, the treated subgrade or base course shall be removed for its full depth and replaced at no additional cost to the Agency.

Treated subgrade or base course thickness exceeding that shown on the plans shall not be considered as a basis for additional payment unless such additional thickness had been authorized, in writing, by the Engineer.

110-4.03 Compressive Strength. Samples of portland cement treated subgrade or portland cement treated base for compressive strength tests will be taken at random for each lot of production. A lot shall be considered to be the production during one eight hour shift. Each lot shall be represented by five random samples, each sampled and tested in accordance with ASTM C 39 and C 42. The mean value of the sample strengths will be reported to the nearest pound per square inch (*5 kilopascals*). The contract unit price shall be adjusted for any lot represented by the mean value of the seven-day compressive strengths shown in Table 110-9.

TABLE 110-9
TREATED SUBGRADE AND BASE COURSES
UNIT PRICE ADJUSTMENT FACTORS FOR STRENGTH DEFICIENCIES TREATED SUBGRADE AND BASE COURSES
(F'c = 500 psi minimum)

Mean Compressive Strength	Unit Price Adjustment Factor (1)
500 psi or More (*3.4 megapascals*)	1.00
450 to 499 psi (*3.1 to 3.4 megapascals*)	0.90
400 to 449 psi (*2.8 to 3.1 megapascals*)	0.77
350 to 399 psi (*2.4 to 2.75 megapascals*)	0.65
Less than 350 psi (*2.4 megapascals*)	0.50 (2)

Note (1): The contract unit price for treated subgrade or base material shall be inclusive of stabilizing/treatment agent, even if stabilizing/treatment agent is paid for under a separate bid item.

Note (2): Reject Status: The unit price adjustment factor applies only if the treated subgrade or base course is allowed to remain in place. Treated subgrade or loose material allowed to remain in place shall be subject to the unit price adjustment. Treated subgrade or base not allowed to remain in place shall be replaced at the contractor's expense.

110-5 SANITARY SEWER INSTALLATION

110-5.01 Alignment. Adjustments in the unit price of sanitary sewer pipe for alignment deficiencies may be made as provided in Table 110-10A and Table 110-10B, when the pipe is allowed to remain in place by the Engineer.

TABLE 110-10A
SANITARY SEWER PIPE
UNIT PRICE ADJUSTMENT FACTORS FOR DEFICIENCIES IN SLOPE

Deviation From Design Slope (Percent)	Unit Price Adjustment Factor (1)
0 - 15	1.00
16 - 20	0.80
21 - 25	0.70
26 - 30	0.60
31 - 35	0.50 (2)
36 and greater	Note (3)

TABLE 110-10B

SANITARY SEWER PIPE
UNIT PRICE ADJUSTMENT FACTORS FOR
DEVIDIENCIES IN HORIZONTAL

Fraction of Full Circle (Moon) Observed Under Illumination	Unit Price Adjustment Factor (1)
Full circle - 3/4 circle	1.00
3/4 - 1/2	0.75
1/2 - 1/4	0.50 (2)
1/4 - none	Note (3)

Note (1): Payment shall be computed by multiplying the applicable Unit Price Adjustment Factor by the unit price bid for sanitary sewer pipe, and multiplying the result by the applicable length of pipe from manhole to manhole, complete-in-place.

Note (2): Reject Status: The unit price adjustment factor applies only if the pipe is allowed to remain in place.

Note (3): The pipe installation represented by the test result shall be removed and reinstalled/replaced at no additional cost to the Agency.

The Engineer may require correction of the vertical alignment of any sanitary sewer pipe installation that results in a low point in the alignment of the pipe invert that creates a ponding condition. Correction of such a deficiency shall be at no additional cost to the Agency.

110-6 MULTIPLE DEFICIENCIES

Should the completed work be found deficient in multiple areas and the work is allowed to remain in place, the unit price adjustment factor utilized shall be the sum of the applicable individual adjustment factors.

110-7 WAIVER OF DEFICIENCY PENALTIES

The Agency may waive any or all penalties for deficiencies in the completed work when, in the judgement of the Agency, such deficiencies are limited in their adverse impact on the completed project and once known, the contractor, expeditiously took the appropriate actions necessary to correct the cause of the deficiency, thus minimizing its extent.

SECTION 201

CLEARING AND GRUBBING

201-1 DESCRIPTION

The work under this section shall consist of clearing, grubbing, removing, and disposing of all trees, brush, vegetation, stumps, debris, rubbish, miscellaneous structures not covered under other contract items, and other objectionable matter from within the right-of-way, bridge construction area(s), road approaches, areas through which ditches and channels are to be constructed, and such other areas as may be specified in the Special Provisions. Clearing and grubbing shall be performed in advance of embankment construction and grading operations and in accordance with the requirements of these specifications.

All vegetation and objects designated to remain shall be preserved from injury or defacement. Property and landscape shall be protected and restored in accordance with the requirements contained in Subsection 107-12.

201-2 MATERIALS (None Specified)

201-3 CONSTRUCTION DETAILS

201-3.01 Clearing and Grubbing. The Engineer will establish the limits of areas to be cleared and grubbed, to be cleared but not grubbed, or areas, objects or features that are designated to remain undisturbed. In general, the work areas shall include the road section, channels, ditches, structures, temporary approaches to bridges, detours and other areas shown on the plans or as specified or directed by the Engineer. The Engineer will designate structures, debris, rubbish, trees, brush and vegetation to be cleared where grubbing is not required. Clearing beyond the limits of construction shall be only where specified or directed. Removal of cacti and native plants shall be in accordance with the provisions of the "Native Plant Law" of the Arizona Revised Statutes, Chapter 7 and applicable local ordinances.

During the life of the contract the Engineer may order the clearing of any trees within the R.O.W. that he determines to be hazardous or dead and unsightly.

The contractor shall carefully prune all branches of trees less than 16 feet (*5 meter*) above any part of the roadway and all branches which have been broken or injured during construction. Scarred surfaces, resulting from the work, shall be treated with an approved tree paint.

Whenever trees are felled or trimmed on/or adjacent to highways, all wood shall be immediately removed from the roadway or any area that would present a hazard to traffic. Grubbed stumps shall be moved immediately, at least 30 feet (*9 meters*) from the edge of pavement.

No trees, tree trunks, stumps or other debris shall be felled, sidecast or placed outside the limits of the right-of-way.

No grubbing will be required beneath the embankment where the subgrade will be 5 feet (*1.5 meters*) or more above the original ground surface unless in an area where a structure is to be built, piles are to be placed, unsuitable material is to be removed or as may be otherwise specified in the plans or Special Provisions.

Where trees or existing stumps are cleared and grubbing is not required, the tree trunk or existing stump shall be cut off not more than 6 inches (*150 millimeters*) above the original ground surface unless otherwise approved. Exposed stumps not required to be removed but which are within 30 feet (*9 meters*) of the edge of the pavement or are in a built-up area shall be chipped out to a depth of not less than 6 inches (*150 millimeters*) below the finished grade. Cavities resulting from the grubbing or removal of stumps or trees, unless in areas to be excavated, shall be backfilled with material approved by the Engineer within seven calendar days after grubbing or removal. The material shall be compacted to a density of not less than 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the Arizona Department of Transportation Materials Testing Manual, as directed and approved by the Engineer

No burning shall be permitted at the project site.

Burning at other locations may be permitted only after the contractor has obtained a permit from the Arizona Department of Health Services and from any other Federal, State, County or City Agency requiring such approval.

All materials removed under this section shall be disposed of within seven calendar days after cutting, felling or removal unless otherwise approved, in writing, by the Engineer.

In the disposal of all tree trunks, stumps, brush, limbs, roots, vegetation and other debris, the contractor shall comply with the requirements of Title 36-Public Health and Safety, Chapter 6, Article 8, Air Pollution of the Arizona Revised Statutes and with the Rules and Regulations for Air Pollution Control, Article 7, adopted by the Arizona Department of Health Services pursuant to the authority granted by Statute and as may be amended by local agency requirements.

Unless otherwise specified in the Special Provisions, marketable timber and other vegetation not designated to remain shall become the property of the contractor.

Combustible material may be reduced to chips of a maximum thickness of 1/2-inch (*13 millimeters*) and disposed of in areas between the slope lines and right-of-way lines as approved by the Engineer. The chips may either be buried or distributed uniformly on the ground surface and mixed with the underlying earth to such extent that the chips will not support combustion.

The roadway and adjacent areas shall be left with a neat and finished appearance. No accumulation of material shall remain on or adjacent to the right-of-way.

201-4 METHOD OF MEASUREMENT

Clearing and grubbing will be measured on either a lump sum or acre(*hectare*) basis. Measurement by the acre (*hectare*) will be to the nearest tenth of an acre (*hectare*) measured on a horizontal plane.

201-5 BASIS OF PAYMENT

The accepted quantities of clearing and grubbing, measured as provided above, will be paid for at the contract lump sum price or by the acre (*hectare*) as designated in the bidding schedule, including furnishing, placing and compacting the material required to fill the cavities resulting from the removal of tree stumps or other materials.

When measured on a lump sum basis, payments will be made monthly in proportion to the amount of work done as determined by the Engineer.

No payment will be made for clearing and grubbing outside the specified limits, unless such work is authorized by the Engineer.

When clearing and grubbing is not included as a contract pay item, full compensation for any clearing and grubbing necessary to perform the construction operations designated on the project plans or specified in the Special Provisions shall be considered as included in the price of contract items.

SECTION 202

REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202-1 DESCRIPTION

The work under this section shall consist of the removal, wholly or in part, and satisfactory disposal of all structures and obstructions within the right-of-way which have not been designated on the project plans or specified in the special provisions to remain, except for those structures and obstructions which are to be removed and disposed of under other items of work in the contract. The work shall also include salvaging of designated materials and backfilling the resulting cavities.

Existing structures, pavement, sidewalks, curbs, gutters and other existing improvements which are to become an integral part of the planned improvements shall remain even though not specifically noted.

Materials removed and not designated to be salvaged or incorporated into the work shall become the property of the contractor.

202-2 MATERIALS (None Specified)

202-3 CONSTRUCTION DETAILS

202-3.01 General. Bridges, culverts and other structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate the traffic in accordance with the contractor's approved traffic control plan.

Prior to commencing any excavation or subgrade activity that could disturb an existing utility facility, the contractor shall contact the Blue Stake Center and utilities in conformance with the requirement specified in Subsection 203-2.

Blasting or other operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to commencing the new work. Blasting requirements and precautions shall be as specified in the Special Provisions or as approved by the Engineer.

Items designated to be salvaged shall be carefully stockpiled or stored by the contractor at locations designated in the special provisions or within a secured area on the project site. Items which are to be salvaged or reused in the new construction and are damaged or destroyed as a result of the contractor's operations shall be repaired or replaced by the contractor at no additional cost to the Agency.

Holes, cavities, trenches and depressions within the roadway prism resulting from the removal of structures or obstructions, except in areas to be excavated, shall be backfilled with suitable material which shall be compacted to a density of not less than 95 percent of the maximum density as determined in accordance with

the requirements of the applicable test methods of the Arizona Department of Transportation Materials Testing Manual, as directed and approved by the Engineer.

202-3.02 Removal of Pipe. All removed pipe which is to be salvaged or relaid shall be cleaned of all earth and other material from the inside and outside prior to being stockpiled or reused. Pipe to be reused shall be stored, when necessary, so as to avoid damage or loss before relaying.

Existing pipe to be partially removed shall be cut with straight and smooth edges on a plane perpendicular to the center line of the pipe.

202-3.03 Removal of Pavement.

(A) Portland Cement Concrete Pavement. Unless otherwise specified in the Special Provisions, concrete pavement, designated on the project plans to be removed, shall either be disposed of by the contractor at a site secured by him or buried in embankment areas. If the contractor chooses to bury the concrete pavement in embankment areas, the concrete shall be broken into pieces no larger than 12 inches (*300 millimeters*) in their greatest dimension. Reinforcement in the broken concrete pavement shall be cut within 3 inches (*75 millimeters*) of the concrete pieces.

Embankment material containing broken concrete whose pieces are larger than 6 inches (*150 millimeters*) in greatest dimension shall not constitute more than 50 percent of the embankment material and shall be placed at a depth of not less than 3 feet (*0.9 meters*) below the finished subgrade and slope lines and not within 5 feet (*1.5 meters*), horizontally, of any piling, pipe or structure. The use of broken concrete may be permitted in the upper 3 feet (*0.9 meters*) of the subgrade if the pieces do not exceed 3 inches (*75 millimeters*) or the greatest dimension is less than one-half the thickness of an individual compacted lift, whichever is less. Broken concrete placed in the upper 3 feet (*0.9 meters*) of this subgrade shall be free of reinforcing steel.

Where new construction is to join the existing concrete pavement, the pavement shall be saw cut to a true line with straight vertical edges free from irregularities.

(B) Bituminous Pavement. Unless otherwise specified in the Special Provisions, all bituminous pavement, designated on the plans to be removed, shall either be disposed of by the contractor at a site secured by him, buried in embankment areas, or if adequately pulverized and approved by the Engineer, used for aggregate base, backfill or pipe bedding material. Should the contractor choose to bury the bituminous pavement in the embankments, it shall not constitute more than 50 percent of the embankment material and shall be broken into pieces no larger than 6 inches (*150 millimeters*) and buried at least 3 feet (*0.9 meters*) below the finished subgrade and slope lines and not within 5 feet (*1.5 meters*) horizontally of any piling, pipe, or structure. The use of bituminous pavement materials may be permitted in the upper 3

feet (*0.9 meters*) of the subgrade if the pieces do not exceed 3 inches (*75 millimeters*) or the greatest dimension is less than one-half the thickness of an individual compacted lift, whichever is the lessor.

Where new bituminous pavement is to join existing bituminous pavement, the existing pavement shall be saw cut to a straight line with vertical edges free from irregularities. The removal of asphaltic concrete at the approaches to structures shall be accomplished in a manner approved by the Engineer.

(C) Bituminous Pavement Removal By Milling. When milling is specified, the existing asphaltic concrete shall be removed in accordance with the details shown on the project plans with equipment specifically designed to remove such material by means of grinding or chipping to a controlled line and grade. The equipment used shall be capable of removing the existing asphaltic concrete to within 0.01 foot (*3 millimeters*) of the specified removal depth. The removal shall be accomplished in a manner which does not destroy the integrity of any asphaltic concrete pavement that remains and which does not result in a contamination of the milled asphaltic concrete with the underlying base material. The milled material shall be removed and disposed of or reused as aggregate base, backfill, or pipe bedding material as specified in the Special Provisions.

Under no circumstances shall the removal of existing asphaltic concrete begin until the mix design for replacement asphaltic concrete has been approved by the Engineer.

The extent of removal of existing asphaltic concrete must be in keeping with the contractor's ability to produce, haul, place and compact replacement asphaltic concrete so that at all times the length of open "trench" is at a minimum. "Trench" as used herein is defined as the depressed swath formed by the milling process. If the contractor's production of replacement asphaltic concrete is stopped for any reason, the removal of asphaltic concrete shall either cease or shall be reduced.

Replacement asphaltic concrete shall be placed as soon as possible after the "trench" has been opened up. The surface on which the material is to be placed shall be uniform and free of loose material. Any exposed aggregate base material or subgrade material shall be compacted to the extent required by the Engineer. Payment for compaction of exposed aggregate base material or subgrade material shall be paid in accordance with Subsection 104-2.

The "trench" in which asphaltic concrete is being placed shall be filled before sunset and the lane opened to traffic. The length of open "trench" at any one time shall not exceed 1 mile (1.5 kilometer) or 1/2 the length of the work, whichever is the lesser length.

In the event of circumstances beyond the control of the contractor or if the production of the replacement asphaltic concrete has been stopped by the Engineer and the contractor is unable to comply with the requirements in the preceding paragraph, the contractor shall provide and maintain such traffic control devices as specified in the approved traffic control plan and conforming to Section 701 in order to provide safe and efficient passage through the work zone.

The contractor shall take appropriate steps to maintain drainage of areas where the pavement surface has temporarily been removed.

Pavement striping that has been removed by the milling operation shall be replaced with temporary pavement marking as required, prior to sunset, in order to provide proper delineation of traffic lanes.

Pavement, to be removed by milling, adjacent to manholes, valve boxes, small radius curbs and other fixed objects that produce confined areas shall be removed with milling equipment specifically designed to operate in restricted areas and capable of removing asphaltic concrete of the specified thickness without damage or displacement of the adjacent object.

Unless otherwise specified in the Special Provisions, the adjustment of manholes and valve boxes to accommodate milling operations or replacement of asphaltic concrete together with necessary traffic control elements to protect this work shall be undertaken at the contractors sole discretion.

On projects with existing curb and gutter, any asphaltic concrete buildup in the gutter shall be removed. The equipment and methods used shall be capable of removing the asphaltic concrete buildup without causing damage to the curb and gutter.

202-3.04 Removal of Miscellaneous Concrete. Miscellaneous concrete shall be defined as all or portions of mortared rubble masonry, sidewalks, driveways, aprons, slope paving, island paving, retaining walls, spillways, drainage structures, concrete box culverts, foundations, footings, manholes and all other portland cement concrete or masonry construction, except bridges and pavement. All existing miscellaneous concrete shall be removed to a depth of at least 4 feet (*1.2 meters*) below finished grade unless otherwise specified in the special provisions or on the project plans or as approved by the Engineer.

Where new concrete is to join existing concrete, the existing concrete shall be saw cut to a straight line with vertical edges free from irregularities.

Existing concrete sidewalk, curb, curb and gutter, driveway, access ramp, slope paving, slab, etc. shall be removed to the nearest joint, if said joint is within 10 feet (*3 meters*) of the area to be removed. If the joint is a scored joint the contractor shall saw cut the concrete to its full depth.

Concrete removal operations shall be performed without damage to any portion that is to remain in place. All damage to the existing concrete, which is to remain in place, shall be repaired to a condition equal to that existing prior to the beginning of removal operations. The repairing of existing concrete damaged by the contractor's operations shall be at no additional cost to the Agency.

Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of all adhering material before being embedded in new concrete.

Concrete shall be disposed of as provided in Subsection 202-3.03(A).

The floors of concrete basements, pits and structures, that are not required to be removed and which are located within the roadway shall be broken in a manner that will prevent the entrapment of water.

202-3.05 Removal of Bridges. The removal of existing bridges, either wholly or in part, shall be as shown on the project plans or as described in the Special Provisions.

Bridge removal operations shall be conducted in such a manner as to cause the least interference to public traffic.

At least 10 days before beginning bridge removal over or adjacent to public traffic or railroad property, the contractor shall submit to the Engineer details of the removal operations showing the methods and sequence of removal and equipment to be used.

When total bridge removal is specified, all materials designated for salvage, such as structural steel, structural steel members, timber and other reusable materials shall be carefully dismantled, removed and salvaged in accordance with the requirements of Subsection 202-3.01. Steel members shall be match marked as directed by the Engineer.

Piling, piers, abutments, footings and pedestals shall be removed to at least 1 foot (*0.3 meter*) below ground line or 3 feet (*0.9 meter*) below finished grade unless specified otherwise in the Special Provisions or on the project plans.

When partial bridge removal is specified or alteration of an existing bridge requires removal of portions of the existing structure, such removal shall be performed with sufficient care as to leave the remaining portion of the structure undamaged. In case of damage to the existing bridge structure, the contractor shall make all necessary repairs at his expense. Reinforcing steel extending from the remaining portion of the structure shall be protected, cleaned and incorporated in the new portion of the structure in accordance with the details shown on the project plans or as directed by the Engineer.

Flame cutting and saw cutting may be used for removing, widening, or modifying bridges provided the contractor complies with all protection, safety and damage requirements.

Explosives shall not be used in bridge removal operations unless approved by the Engineer.

Before beginning concrete removal operations involving the removal of a portion of a monolithic concrete element, a saw cut approximately 1 inch (*25 millimeters*) deep shall be made to a true line along the limits of removal on all faces of the element which will be visible in the complete work.

Concrete shall be disposed of as provided in Subsection 202-3.03(A).

202-3.06 Removal of Signs and Delineators. Existing warning, regulatory, guide, route marker signs and delineators that are to be removed will be designated by the Engineer. The contractor shall dismantle the sign panels and delineators and remove the sign posts from the ground in such a manner as to prevent damage to the posts. The contractor shall not remove the existing signs prior to the completion of the new sign installation, but shall remove them within five working days after the installation of the new signs or as directed by the Engineer. Signs, delineators, and sign posts shall be removed and salvaged in accordance with the requirements of Subsection 202-3.01.

202-3.07 Removal of Curb. Existing curb designated on the project plans to be removed, shall be removed in accordance with the project plans and in a manner to avoid damage to existing bituminous or portland cement concrete pavement outside the specified removal limits.

Asphaltic concrete obtained either from commercial or other sources and approved by the Engineer shall be used to fill and repair voids on the existing asphaltic pavement surface that result from the removals. In the case of concrete pavement, portland cement concrete shall be used for this purpose.

202-3.08 Removal of Fence. All fence to be removed, shall become the property of the contractor unless designated for salvage on the project plans. If fence is designated to be removed and salvaged, all fence, including gates, shall be salvaged in accordance with the requirements of Subsection 202-3.01.

When designated for salvage, fence and gates shall be carefully dismantled and neatly rolled or coiled. Posts shall be cleaned of all concrete and dirt.

In areas where new fence or relocated fence is to be installed, the contractor shall perform the removals in such a manner as to insure at all times, the security of the area being fenced.

202-3.09 Removal of Guard Rail. All guard rail to be removed, shall become the property of the contractor unless otherwise specified on the project plans.

If guard rail is designated to be removed and salvaged, the contractor shall carefully dismantle the guard rail and remove the blocks and posts in such a manner as to prevent any damage to the removed items. The guard rail, including panels, end sections, posts and all hardware shall be salvaged in accordance with the requirements of Subsection 202-3.01.

202-4 METHOD OF MEASUREMENT

Removal of structures and obstructions will be measured on a lump sum basis with the exception that when the bidding schedule contains specific items under this section on a unit basis, such as milling of pavement, measurement will be made by the units designated in the bidding schedule.

Adjustment of manholes and valve boxes to accommodate milling or replacement asphaltic concrete operations shall be measured as a unit for each manhole or water valve adjusted when a bid item is specified in the bidding schedule.

202-5 BASIS OF PAYMENT

The accepted quantities of removal of structures and obstructions will be paid for at the contract lump sum price except that when the bidding schedule contains specific items for the work under this section, the quantities will be paid for at the contract lump sum or unit prices for the items of work designated. The prices shall include all excavation and subsequent backfill incidental to the removals, the furnishing and placing of asphaltic concrete or portland cement concrete to fill and repair voids resulting from the work under Subsection 202-3.07, compaction of base material resulting from the work under Subsection 202-3.03(C), and the salvaging, hauling, storing and disposing of all materials as provided herein.

When the bidding schedule contains specific items for the adjustment of manholes or valve boxes as part of pavement milling and replacement work, the price bid shall include all adjustments required to accomplish the milling and replacement of the asphaltic concrete.

When the bidding schedule does not contain any removal or adjustment items, full compensation for any removal of structures and obstructions necessary to perform the construction operations designated on the project plans or specified in the Special Provisions shall be considered as included in the price of contract items.

SECTION 203

EARTHWORK

203-1 DESCRIPTION

The work under this section shall consist of performing all operations necessary to excavate all materials, regardless of character and subsurface conditions, from the roadway or adjacent thereto; to excavate drainage and irrigation ditches and channels; to excavate trenches for culverts and other facilities; to excavate all materials necessary for the construction of structures; to excavate borrow material for use as specified; to construct embankments; to place backfill for structures, culverts and other facilities; to backfill holes, pits and other depressions within the roadway area; to remove and replace unsuitable material; to excavate and grade road approaches, driveways, and connections; to construct dikes and berms; and to apply water for compaction, all in conformance with the lines, grades, thicknesses and typical sections designated on the project plans, specified in the Special Provisions, directed by the Engineer and specified herein.

203-2 GENERAL

Operations shall be conducted such that existing roadway facilities, utilities, railroad tracks and other non-roadway facilities which are to remain in place will not be damaged. The contractor, at no additional cost to the Agency, shall furnish and install sheet piling, cribbing, bulkheads, shoring or whatever materials may be necessary to adequately support material underlying such facilities, or to support the facilities themselves and shall maintain such supports until they are no longer needed. Temporary pavements, facilities, utilities and installations shall also be protected until they are no longer required. When temporary supports and other protective means are no longer required, they shall be removed and disposed of by the contractor.

At least 48 hours prior to commencing excavation, the Contractor shall call the Blue Stake Center at (800) 782-5348 between the hours of 7:00 a.m. and 4:30 p.m., Monday through Friday for information relative to the location of buried utilities.

The contractor shall also contact the representatives of the following utility companies concerning the status of their required adjustments and/or relocation of utilities in the project area:

AT&T Company
Southwest Gas Corporation
Pima County Wastewater Management
TCI of Tucson
Tucson Electric Power Company
Tucson Water Department
US West Communications

The names and telephone numbers of the appropriate contact person at each of these utilities shall be provided in the Special Provisions.

The contractor shall make arrangements with utility companies for bracing, shoring, or otherwise protecting power poles, cables conduits, water or drainage pipes, and other improvements, whether shown on the plans or not, including any rerouting of utilities required to maintain continuous utility service, at no cost to the Agency, unless otherwise noted.

Any existing sewer lines, water lines, gas lines, underground telephone lines, and any other underground utility or structure in the right-of-way, that is disturbed or damaged by the contractor, shall be repaired or replaced by the contractor at no additional cost to the Agency immediately following the damage. All repair work shall be to the satisfaction of the affected utility and the Engineer.

Unknown utilities encountered during construction shall be relocated as required with payment being made in accordance with Subsection 109-5. Relocation work shall require the prior approval of the Engineer.

When hauling is done over roadways or city streets, the loads shall comply with legal load requirements, all material shall be removed from shelf areas of vehicles in order to eliminate spilling of material, and loads shall be watered or covered to eliminate dust.

Under this work, the contractor shall furnish and apply water for dust control, for compaction purposes and for such other purposes (not provided for in other sections) called for on the plans, in the itemized proposal, or as directed by the Engineer.

All suitable material removed from excavated areas shall be used in the construction of embankments and in other designated areas prior to the use of any borrow material, as directed by the Engineer.

The contractor shall provide and maintain slopes, crowns and ditches on all excavation and embankments to insure satisfactory surface drainage at all times. Ditches and other drainage facilities necessary to remove ponded water shall be constructed as soon as practical to have the work area dry during the progression of work. All existing culverts and drainage systems shall be maintained in satisfactory operating condition throughout the course of the work. If it is necessary to interrupt existing surface drainage, sewers or under-drainage, then temporary drainage facilities shall be provided until the permanent drainage work is complete. Top-of-slope interceptor ditches, where shown on the plans, shall be completed before adjacent excavation operations are begun.

203-3 ROADWAY EXCAVATION

203-3.01 Description. Roadway excavation shall consist of excavating and grading all types of materials encountered in constructing the roadway, parking areas, turn-outs, private driveway entrances, cut ditches within the roadway and other road related areas as designated on the project plans or specified in the Special Provisions; and the placement of the excavated material, wherever practicable, in embankments as provided under Subsection 203-9.

Roadway excavation will not include drainage excavation or structural excavation when these items are designated as separate items of work in the bidding schedule.

203-3.02 Materials. (None Specified)

203-3.03 Construction Details.

(A) General. All roadway excavation shall be finished to a reasonably smooth and uniform surface, shall not vary by more than 0.04 foot (*12 millimeter*) above or below the grade established, and shall be in reasonably close conformity to the lines, grades, dimensions and cross sections shown on the project plans or established by the Engineer. When either asphaltic concrete pavement or portland cement concrete pavement are to be placed directly on subgrade, the finished subgrade surface shall not vary by more than 0.02 foot (*6 millimeters*) above or 0.04 foot (*12 millimeters*) below the established grade.

When roadway excavation is made in rock, the full cross-sectional width of the roadway, inclusive of shoulder or sidewalk areas shall be overexcavated a minimum of 6 inches (*150 millimeters*) below the subgrade elevation. The overexcavated area shall be backfilled, compacted, and finished in accordance with the requirements of the specifications. In situations where only part of the roadway section intersects areas of rock that portion occurring in the rock zone shall be overexcavated and backfilled as specified above and brought up to match the adjoining subgrade.

No measurement or direct payment will be made for the work in overexcavating the rock areas, or placing and compacting the embankment material, the cost being considered as included in the cost of contract items.

All suitable excavated material shall be used as far as practicable in the construction of embankments and in other designated areas, prior to the use of any borrow material.

During construction, the roadway shall be maintained in a well-drained condition at all times.

The top 6 inches (*150 millimeters*) of the subgrade shall be compacted to a density of not less than 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the Arizona Department of

Transportation Materials Testing Manual, as directed and approved by the Engineer, except that when asphaltic concrete or portland cement concrete is to be placed directly on subgrade, the required density shall be 100 percent of the maximum density.

(B) Slopes. Earth slopes shall be finished to reasonably smooth surfaces and shall be free of all debris and loose material.

All shattered or loosened material shall be removed from rock cut slopes.

Adjustments in slopes shall be made, as directed by the Engineer, to avoid damage to standing trees, marring weathered rock or to harmonize with existing landscape features. The transition of such adjusted slopes shall be gradual. At the intersections of cuts and fills, slopes shall be adjusted and warped to flow into each other or into the natural ground surfaces without noticeable break.

Where directed by the Engineer, the top 6 inches (*150 millimeters*) of topsoil, including duff, within the limits of the rounding, shall be removed and windrowed outside of the rounding limits. After completion of the rounding of the slope, the windrowed materials shall be uniformly spread over the rounded area.

(C) Unsuitable Material. Material below the natural ground surface in embankment areas and below the finished subgrade elevation in excavation areas that is unsuitable shall be excavated and disposed of as directed by the Engineer. Payment shall be in accordance with Subsection 104-2.

When unsuitable material is removed and disposed of, the resulting space shall be filled with material suitable for the planned use. Such suitable material shall be placed and compacted in accordance with the requirements of Subsection 203-9.

(D) Surplus Material. Unless otherwise indicated on the project plans or specified in the Special Provisions, surplus excavated material shall be removed from the job site and disposed of by the contractor in a manner approved by the Engineer and in accordance with the requirements found in Section 107.

Shortages of material caused by the disposal of any material by the contractor before plans embankment quantities are satisfied shall be replaced by the contractor at no additional cost to the Agency.

203-3.04 Method of Measurement. Roadway excavation will be measured by the cubic yard (*cubic meter*) in the original space occupied. The volume of material removed will be computed according to the provisions of Section 109.

Roadway excavation originating outside of the neat lines of cut slopes as a result of necessary blasting operations will be measured in cubic yards (*cubic meters*) and the quantity to be allowed for payment will be the volume in cubic yards (*cubic meters*) determined in the following manner:

> The areas of cut faces that result from the blasting of roadway excavation, which faces are determined to be cut substantially to or beyond the slope line, will be measured in square yards (*square meters*) and multiplied by 0.4 yards (*meters*).

203-3.05 Basis of Payment. The accepted quantities of roadway excavation, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*). The price shall include full compensation for the work complete, including slope rounding, blasting, hauling, stockpiling, placing embankment, disposal of surplus and unsuitable material, and the preparation of the subgrade in accordance with the requirements of these specifications.

203-4 DRAINAGE EXCAVATION

203-4.01 Description. Drainage excavation shall consist of the excavation of ditches, channels or waterways, except that excavation which is required to construct ditches paralleling the roadway and constituting a part of the roadway prism shall be considered as roadway excavation as provided under Subsection 203-3.

203-4.02 Materials. (None Specified)

203-4.03 Construction Details. Ditches, channels and waterways shall be constructed in reasonably close conformity to the lines, grades and slopes as indicated on the plans or as directed by the Engineer.

When necessary, in order to provide outfall, the gradient of ditches, channels and waterways may be continued outside of the limits of the right-of-way with proper authorization from the property owner. Absolute smoothness in lines and slopes will not be required, but the finish shall be consistent with the character of the material encountered. All waterways shall be constructed to drain effectively.

Suitable materials from ditch, channel or waterway excavation shall be used in the construction of embankment or for other purposes as shown on the project plans or specified in the Special Provisions. Unsuitable and surplus excavation material shall be disposed of as directed by the Engineer.

203-4.04 Method of Measurement. Drainage excavation will be measured for payment by the cubic yard (*cubic meter*) in the original space occupied. The volume of material removed will be computed in accordance with the provisions of Section 109. Measurement shall be from the ground line existing prior to

construction to the finished flow line as specified on the plans or as modified by the Engineer. Where bank protection is to be constructed, measurement shall be in accordance with the limits indicated in the Standard Details. Excavation below the finished flow line required to construct bank protection toes is considered incidental to the construction of the bank protection and shall not be measured.

203-4.05 Basis of Payment. The accepted quantities of drainage excavation, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*).

The unit price per cubic yard (*cubic meter*) shall include hauling, placing and compacting the excavated material to form embankments and the disposal of all surplus and unsuitable excavated material.

Payment for ditches will be made as specified under Subsection 203-6.

203-5 STRUCTURAL EXCAVATION AND STRUCTURE BACKFILL

203-5.01 Description. Structural excavation shall consist of the excavation or removal of all materials necessary for the construction of bridges, concrete box culverts, inlet and outlet wings, retaining walls, bank protection including excavation below the flowline required for toe down construction, or other specific items designated on the project plans or in the Special Provisions as structural excavation; the control and removal of water, the construction or installation of all facilities necessary to accomplish the work, and the subsequent removal of such facilities, except when designated on the project plans or specified in the Special Provisions to remain in place.

Structure backfill shall consist of furnishing, placing, and compacting backfill material around structures to the lines designated on the project plans, specified in the Special Provisions, directed by the Engineer and as specified herein.

The work under this section includes the furnishing and installing of a geocomposite drainage system as a foundation or retaining wall drainage media in lieu of porous backfill material, when specified in the project plans. The geocomposite drain shall be of composite construction, consisting of a supporting structure of drainage core material and a geotextile filter fabric bonded to the drainage core on one side only. All geocomposite drainage materials and installation shall be as approved by the Engineer.

203-5.02 Materials.

(A) Structure Backfill. Structure backfill material shall be selected from excavation or from a source selected by the contractor. It shall not contain frozen lumps, stones larger than 3 inches (*75 millimeters*) in diameter, chunks of clay or other objectionable material. Backfill material to be used for metal piles or similar items of metal shall have a value of resistivity not less than 2000 ohm-cm or the value shown on the project plans,

whichever is less. When resistivity is not shown on the plans, the backfill material shall have a value of resistivity not less than that of the existing in-place material or 2000 ohm-cm whichever is less. Backfill material shall have a pH value between 6.0 and 9.0, inclusive, for all installations. Tests for pH and resistivity shall be in accordance with the requirements of Arizona Test Method 236.

Structure backfill material shall conform to the following gradation:

Sieve Size	Percent Passing
3 inch (*75 millimeters*)	100
3/4 inch (*19.0 millimeters*)	60 - 100
No. 8 (*2.36 millimeters*)	35 - 80
No. 200 (*75 micrometers*)	*

*The total sum of the percent passing the No. 200 (*75 μm*) sieve and the plasticity index (P.I.) shall not exceed 25.

NOTE: Toe trench backfill material for bank protection may be in-place material and as such is not required to meet the gradation and plasticity index requirements for structure backfill material.

As an alternate to the material requirements of structure backfill, the Engineer may allow material conforming to the following requirements to be used in a slurry mixture in situations where the slurry will be confined by free-draining soils:

Sieve Size	Percent Passing
1-1/2 inch (*37.5 millimeters*)	100
1 inch (*25.0 millimeters*)	90 - 100
No. 8 (*2.36 millimeters*)	35 - 80
No. 200 (*75 micrometers*)	0 - 8

The plasticity index shall not exceed 8 when tested in accordance with the requirements of AASHTO T 90.

(B) Geocomposite Drain. The geocomposite wall drain materials shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-6 respectively.

(C) Geocomposite Packaging, Handling, and Storage. The identification, packaging, handling, and storage of the geocomposite wall drain material shall be in accordance with ASTM D4873. Geocomposite wall drain shall be furnished in rolls, or in another acceptable manner, wrapped with a suitable protective covering to protect the fabric from mud, dirt, dust, debris, or harmful ultraviolet light. The wall drain material shall be free of defects or flaws which significantly affect its physical properties at the time of delivery and installation. Each roll or package shall be labeled or tagged to provide product identification sufficient to determine the product type,

manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Geocomposite wall drain materials shall be stored on the site or at another location approved by the Engineer in a manner which protects them from the elements. If stored outdoors, the materials shall be elevated and protected with a light colored, opaque, waterproof cover. At no time shall the geocomposite wall drain materials be exposed to direct sun light for a period exceeding 14 days.

203-5.03 Construction Details.

(A) Excavation. The required excavation shall be performed in reasonably close conformity to the lines, grades and cross-sections established by the Engineer or shown on the plans.

The sides of excavations may be sloped as required by soil conditions to stabilize the sides for safe working conditions. Such excavation shall be limited to the amount deemed necessary by the contractor for safety in accordance with Title 29 Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction (OSHA).

When structure footings, concrete box culverts or other structures are to rest on an excavated surface other than rock and no piles are used, care shall be taken to protect the surface from water and not disturb the bottom of the excavation. If suitable material in the bottom of the excavation is disturbed or is removed for the contractor's convenience, the foundation shall be restored by the contractor, at no additional cost to the Agency to a condition at least equal to the undisturbed foundation as determined by the Engineer. When undisturbed original material at the planned grade of the excavation is determined by the Engineer to be unsuitable material, such material shall be removed to the limits directed by the Engineer and the resulting excavation backfilled with structure backfill material.

When structures are to rest upon rock, the rock shall be fully uncovered and the surface thereof shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled or cut to steps, and shall be roughened. Seams in the rock shall be grouted under pressure or treated as directed by the Engineer and the cost thereof will be paid for in accordance with requirements of Subsection 104-2.

Where rock, in either ledge or boulder formation, or other unyielding material is encountered in one portion of structural excavation for a box culvert and a yielding material is encountered in an adjacent area of the structural excavation for the same box culvert, such unyielding materials shall be removed for a minimum depth of 2 feet (*0.6 meter*) below grade and replaced with structure backfill.

When structures are to be supported on piles, excavations shall be completed to the bottom of the footings before any piles are drilled or driven therein. When swell or subsidence results from

driving piles, the contractor shall, at his expense, excavate or backfill with suitable material the footing area to the grade of the bottom of the footings as shown on the project plans.

Excavated material which is not suitable for, or not used as structure backfill shall be utilized either for the construction of embankment or disposed of, in accordance with the applicable requirements of Subsections 203-9 or 203-3 respectively.

Suitable materials from structure excavation shall be used in the construction of the embankment or other purposes shown on the project plans or specified in the Special Provisions, unless otherwise designated for disposal.

Prior to placing concrete or masonry the area excavated shall be inspected and approved by the Engineer.

(B) Backfill.

(1) Placement of Backfill:

All earth material which has loosened or collapsed into the excavation from the adjacent ground and all trash, forms, and loose large rock shall be removed from the excavation before backfill is placed.

Backfill material shall not be placed against the back of concrete abutments, concrete retaining walls, or cast-in-place concrete structures until the concrete has developed its full design strength. Backfill material may be placed against non-earth retaining concrete structures, once the concrete has attained a minimum compressive strength of 2,000 pounds per square inch (*13.8 megapascals*) and in no case less than 72 hours.

Unless otherwise shown on the plans or designated in the Special Provisions, minor structures such as catch basins or cattle guards which are furnished as precast structures shall be placed on a layer of structure backfill at least 6 inches (*150 millimeters*) in depth. The layer shall have been shaped to fit the bottom surface of the precast unit and compacted to a density of not less than 100 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the Arizona Department of Transportation Materials Testing Manual, as directed and approved by the Engineer. At the time the unit is placed the moisture content of the layer shall be at or near the optimum moisture as determined in accordance with the requirements of the applicable test methods of the Arizona Department of Transportation Materials Testing Manual, as directed and approved by the Engineer. After the unit has been initially set in place and checked for line and grade, it shall be removed and any defects in its bearing area shall be corrected by trimming and by placing and compacting similarly moistened structure backfill. The process of removal, correction and replacement shall continue until the imprint of the unit on the

bearing area indicates essentially uniform contact and the unit is in reasonable conformity with the lines and grades shown on the project plans or as determined by the Engineer.

Where a structure is located within a paved area, all backfill material above subgrade elevation shall conform to the requirements of the typical pavement section at the same elevations.

Backfill compacted by pneumatic or mechanical tamping devices, shall be placed in layers not more than 8 inches (*200 millimeters*) in depth before compaction.

Backfill placed as a slurry shall be placed in uniform horizontal layers not exceeding 4 feet (*1.2 meters*) in depth. The maximum water content of the slurry mixture shall be 35 gallons of water per ton (*150 liters of water per metric ton*) of backfill material. Aggregate slurry shall be thoroughly mixed in a mixer approved by the Engineer. Unless otherwise approved by the Engineer, the slurry shall be compacted with internal vibrators in accordance with the requirements Subsection 601-3.03(D).

(2) Compaction of Backfill:

Backfill material shall be compacted to at least 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the Arizona Department of Transportation Materials Testing Manual, as directed and approved by the Engineer unless otherwise specified on the project plans or on the Standard Details.

Backfill material may be compacted by either mechanical or pneumatic tamping devices or backfill material may be placed as a slurry. Compaction equipment or methods which may cause excessive displacement shall not be used.

If backfill is placed as a slurry, the contractor shall excavate holes in the compacted slurry to the depths and at the locations designated by the Engineer. These holes shall be of such size as to allow the required density test. Upon completion of the tests, the contractor shall refill the excavated areas and compact the material to the required density in a manner approved by the Engineer.

When placing backfill material around culverts and pipes, layers shall be deposited to progressively bury the pipe or culvert to equal depths on both sides. When filling behind abutments and similar structures, all material shall be placed and compacted in front of the walls prior to placing fill behind the walls to a higher elevation.

Where sheeting has been used for the excavation and incremental removal of the sheeting is not specified in the plans or Special Provisions, sheeting shall be pulled when the trench

has been backfilled to the maximum unsupported trench depth allowed by Title 29 Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction (OSHA).

(C)Geocomposite Wall Drain: Geocomposite wall drains shall be constructed as a substitute for porous backfill on the soil side of abutment walls, wing walls, retaining walls, and culvert sidewalls where specified or shown on the plans. The concrete surface of the structure against which the geocomposite drain is to be placed shall be free of soil, debris, and excessive irregularities that will prevent intimate contact between the concrete surface and the drain. The geocomposite drain shall be installed with the single fabric surface in contact with the backfill material behind the structure surface.

Unless otherwise specified, geocomposite wall drains shall be constructed in horizontal courses and in accordance with the details shown on the project plans. While being rolled or laid out along the length of the wall, the geocomposite shall be firmly secured either by using adhesive or 1.5 inch (*40 millimeters*) to 2 inch (*50 millimeters*) long concrete nails with approved washers or wood battens not less than 4 square inches (*2500 square millimeters*) in area. The adhesive or alignment of the core shall not affect the drainage area or downward flow within the core. The spacing of concrete nails shall be as directed by the Engineer, but shall not be more than 4 feet (*1.2 meters*) apart, both horizontally and vertically. When nails are utilized, there shall be at least one horizontal row of nails in each course of geocomposite.

Horizontal seams shall be formed by utilizing the 4 inch (*100 millimeters*) flap of geotextile fabric extending from the upper geocomposite course and lapping over the top of the fabric on the next lower course. The fabric flap shall be securely fastened to the lower fabric by means of a continuous strip of 3 inch (*75 millimeters*) wide, waterproof plastic tape.

Where vertical splices are necessary at the end of a geocomposite roll or panel, an 8 inch (*200 millimeters*) wide continuous strip of geotextile fabric may be placed, centering over the seam and continuously fastened on both sides with the 3 inch (*75 millimeters*) wide, waterproof plastic tape.

As an alternative method of splicing, either horizontally or vertically, rolls of geocomposite drain material may be joined together by turning back the fabric at the roll edges and interlocking the cuspations approximately 2 inches (*50 millimeters*). For overlapping in this manner, the fabric is then lapped over and tightly taped beyond the seam with the 3 inch (*75 millimeters*) wide, waterproof tape. Interlocking of the core shall always be in the direction of waterflow.

To prevent soil intrusion, all exposed edges of the geocomposite drainage core shall be covered by tucking the 4 inch (*100 millimeters*) fabric lap over and behind the core edge. Alternatively, a 12 inch (*300 millimeters*) wide strip of fabric

may be utilized in the same manner, taping it to the exposed fabric 8 inches (*200 millimeters*) in from the edge with a continuous strip of 3 inch (*75 millimeters*) wide, waterproof, plastic tape and folding the remaining 4 inches (*100 millimeters*) over and behind the core edge.

Should the fabric become damaged during installation by tearing or puncturing, the damaged section shall be cut out and replaced completely. If, in the judgment of the Engineer, the damage is not serious enough to warrant removal, the damaged area may be repaired by overlaying with a piece of fabric, large enough to cover the damaged area and provide a 4 inch (*100 millimeters*) overlap on all sides, and taping it in place with 3 inch (*75 millimeters*) wide strips of waterproof, plastic tape.

Structural backfill shall be placed immediately next to the geocomposite drain. Care shall be taken during the backfill operation not to damage the geotextile surface of the drain. Care shall also be taken to avoid excessive settlement of the backfill material. The geocomposite drain, once installed, shall not be exposed for more than 14 days prior to backfilling.

203-5.04 Method of Measurement.

(A) Structural Excavation. Unless specified in the Special Provisions, no measurement will be made for structural excavation. The project plans or Standard Details shall serve as the basis for establishing the required limits for structural excavation.

(B) Structure Backfill. Unless specified in the Special Provisions, no measurement will be made for structure backfill. The project plans or Standard Details shall serve as the basis for establishing the required limits for structure backfill.

203-5.05 Basis of Payment. Unless specified in the Special Provisions, no direct payment will be made for structural excavation or structure backfill, its cost being considered incidental to and included in the cost of those items of work for which it is required. Payment for additional excavation, where it is found necessary to excavate to a depth below the elevation shown on the project plans for a footing, or to remove unsuitable material in accordance with the requirements of Subsection 203-5.03(A), will be made in accordance with the provisions of Subsection 104-2.02.

203-6 DITCHES

203-6.01 Description. Ditches shall consist of excavating and finishing ditches, as detailed on the plans, to intercept surface water with the exception that ditches paralleling the roadway and constituting a part of the roadway prism shall be considered as roadway excavation as provided for under Subsection 203-3.

203-6.02 Materials. (None Specified)

203-6.03 Construction Details. In general, ditches shall be constructed to the lines and at the locations designated on the project plans; however, the Engineer will consider the topography and will determine where and for what length the ditches are to be constructed and will stake the ditches to provide continuing bottom slopes so that each ditch will drain and serve as an effective part of the overall drainage system.

203-6.04 Method of Measurement. Ditches will be measured by the linear foot (*meter*) along the center line of the ditch, parallel to the ground surface.

203-6.05 Basis of Payment. The accepted quantities of ditches, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*).

203-7 DIKE

203-7.01 Description. Dikes shall consist of placing material to the lines and grades required to intercept the flow of the surface water and to direct it down continuing slopes to an appropriate discharge point.

203-7.02 Materials. (None Specified)

203-7.03 Construction Details. Crown dikes shall be constructed at the locations designated on the project plans or as directed and staked by the Engineer, in accordance with the details shown on the plans, using material from roadway excavation, drainage excavation, structural excavation or borrow.

The material shall be placed in layers not exceeding 8 inches (*200 millimeters*) in depth before compaction and compacted to a density of at least 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

203-7.04 Method of Measurement. Dike will be measured by the linear foot (*meter*) along the center line of the dike, parallel to the ground surface.

203-7.05 Basis of Payment. The accepted quantities of dike, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*).

203-8 BORROW

203-8.01 Description. The work under this section shall consist of furnishing and placing suitable material obtained from sites outside of the right-of-way for use in embankments, shoulders, berms, dikes and other similar purposes. The widening of roadway cuts and ditches and similar work within the right-of-way shall be considered as roadway excavation, not borrow.

203-8.02 Materials. Borrow material shall be of a quality suitable for the purpose intended, free of vegetation or other unsuitable material. Borrow placed within 3 feet (*0.9 meter*) of finished subgrade shall have a soil support value equal to or greater than the design soil support value of the pavement structure for the area in which the borrow will be placed.

The contractor shall promptly advise the Engineer as to the source of borrow that he proposes to use and shall furnish equipment and personnel and shall obtain representative samples of the material under the supervision of the Engineer. At the option of the contractor, the material shall be tested by either the Agency or by an independent, approved laboratory.

If testing is performed by a testing laboratory, the contractor shall arrange for the samples to be delivered to the testing laboratory. Tests shall be performed using appropriate test procedures referred to in the sections of the specifications in which the specific material requirements are described.

The contractor shall make the arrangements necessary to see that the testing laboratory submits the results of the tests to the Engineer. He shall also submit to the Engineer sufficient material from the samples taken so that the test results may be verified, if necessary.

The cost of all sampling and testing, including the cost of supervision by the Engineer, shall be borne by the contractor until the testing has been satisfactorily completed.

Every effort will be made by the Agency to advise the contractor as quickly as possible that the source he proposes to use has been either approved or disapproved. The contract time will not be adjusted because of any time required by either the contractor or the Agency to sample and test the material and to determine the quality of the material.

The use of a borrow source will require written approval by the Engineer. No approval shall be assumed, nor will it be made, until the Agency has determined that the material not only meets the specified requirements, but is also compatible with the established project design criteria developed by it, and based on the soil support value of the embankment materials and the structural coefficients of the base and surfacing materials.

203-8.03 Construction Details. Borrow material shall be placed in accordance with the requirements of Subsection 203-9.

203-8.04 Method of Measurement. Borrow will be measured for payment by one of three methods. (1) The cubic yard (*cubic meter*) in the original space occupied. The volume of material removed will be computed according to the requirements of Section 109 of the specifications; (2) The cubic yard (*cubic meter*) in its final position. The volume of material placed will be computed according to the requirements of Section 109 of these specifications; (3) The ton (*metric ton*) weighed in accordance

with the requirements of Section 109. The weight of the borrow shall be adjusted when the moisture content of the material exceeds 3 percent when tested in accordance with the applicable test methods of the ADOT Materials Testing Manual, as directed by the Engineer. The method of measurement to be used will be specified in the Special Provisions or will be as noted in the bidding schedule. Upon approval of the Engineer, the method of measurement and resultant unit price may be changed from a cubic yard (*cubic meter*) basis to ton (*metric ton*).

No measurement for payment will be made for borrow material placed prior to completion of roadway excavation, drainage excavation or structural excavation, when such placement results in unauthorized wasting of roadway, drainage or structural excavation materials.

203-8.05 Basis of Payment. The quantities of borrow as shown in the bidding schedule and adjustments to same as described in Subsection 203-8.04, will be paid for at the contract unit price per cubic yard (*cubic meter*) or per ton (*metric ton*) as specified by the Special Provisions or the bidding schedule. The price shall be full compensation for the item complete in place, including furnishing, hauling, placing and compacting the material, and applying water.

203-9 EMBANKMENT REQUIREMENTS

203-9.01 Description. Embankment requirements shall apply to the construction of roadway embankments, including the widening of embankment sections with surplus material and the preparation of the areas upon which embankment material is to be placed; the construction of dikes and berms; the placing and compacting of material where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits and other depressions within the roadway area, in accordance with the requirements of these specifications.

203-9.02 Materials (Metal Pile Locations). Where metal piles for bridge construction are to be driven through a newly placed embankment, the embankment material shall have a value of resistivity not less than 2000 ohm-cm or the value shown on the project plans, whichever is less. When resistivity is not shown on the plans, embankment material shall have a value of resistivity not less than 2000 ohm-cm. Embankment material at pile locations shall have a pH value between 6.0 and 9.0, inclusive. Tests for pH and resistivity shall be in accordance with the requirements of Arizona Test Method 236.

203-9.03 Construction Details.

(A) Placement. All embankments shall be constructed to a reasonably smooth and uniform surface, shall not vary by more than 0.04 foot (*12 millimeters*) above or below the grade established, and shall be in reasonably close conformity to the lines, grades, dimensions and cross sections shown on the project plans or established by the Engineer. When portland cement concrete pavement or asphaltic concrete pavement are to be placed directly

on subgrade, the finished surface of the embankment shall not vary by more than 0.02 foot (*6 millimeters*) above or 0.04 foot (*12 millimeters*) below the established grade.

Embankment construction shall not be started until clearing and grubbing for the embankment area is completed in accordance with the requirements of Section 201 and removal of structures and obstructions is completed in accordance with the requirements of Section 202. When embankment material is to be placed over existing bituminous surfacing, the surfacing shall be scarified prior to placing embankment material, unless otherwise directed by the Engineer. Prior to embankment construction, the embankment foundation area shall be scarified, moistened and compacted in accordance with the details shown on the plans and to the satisfaction of the Engineer.

In constructing embankments on hillsides, or against existing embankments or when constructing embankments one half width at a time, the slopes of the original hillside, except where solid rock is encountered, the existing embankments, or the half width of new embankments shall be cut into a minimum of 6 feet (*1.8 meters*) horizontally, as the work is brought up in layers, in order to minimize the possibility of slippage between the existing materials and the new embankment material. The material thus cut out shall be recompacted along with the new embankment material.

Embankment of earth material shall be placed in uniform horizontal layers not exceeding 8 inches (*200 millimeters*) in depth before compaction and shall be compacted in accordance with the requirements of these specifications before the next layer is placed.

When the embankment material resulting from the required excavations consists predominately of rock fragments of such size that the material cannot be placed in an 8 inch (*200 millimeters*) layer without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment in layers not exceeding in thickness the approximate average size of the larger rocks being excavated with the maximum rock size not to exceed 2 feet (*600 millimeters*) in its largest dimension. The larger rocks shall be separated throughout each layer so that the spalls, finer fragments of rock and earthen material can be evenly distributed between them to form a dense and compact mass. Each layer shall be leveled and smoothed with suitable leveling equipment.

Embankment material containing rocks, broken concrete or other solid materials which are larger than 6 inches (*150 millimeters*) in greatest dimension shall be placed at a depth of not less than 3 feet (*0.9 meters*) below the subgrade and slope lines and not within 5 feet (*1.5 meters*) horizontally of any piling or structures. The use of broken concrete may be permitted in the upper 3 feet (*0.9 meters*) of the subgrade if the pieces do not exceed 3 inches (*75 millimeters*) or the greatest dimension is less

than one-half the thickness of an individual compacted lift, whichever is the lesser. Broken concrete placed in the upper 3 feet (*0.9 meters*) of this subgrade shall be free of reinforcing steel.

Embankment construction shall not take place when the material is frozen or a blanket of snow prevents proper compaction of the embankment material.

(B) Compaction.

(1) Earth:

Embankment, constructed in layers of the depths specified herein, shall be compacted by rolling, tamping, or any other suitable means. Each layer of the embankment material shall be compacted to the specified density before the next layer is placed. Effective spreading equipment shall be used on each layer to obtain uniform thickness prior to compacting. As the compaction of each layer progresses continuous leveling and manipulation of the material will be required to assure uniform density. Water shall be added or removed, if necessary, in order to obtain the required density. Construction equipment shall be routed uniformly over the entire surface of each layer, insofar as is practicable, and separate pieces of equipment shall not follow in the immediate tracks of preceding equipment. At the close of each days work, the working surface shall be crowned, shaped and rolled by the contractor to provide for proper drainage.

Where embankments 5 feet (*1.5 meters*) or less in height are to be constructed, the top 6 inches (*150 millimeters*) of the ground within the roadway prism on which the embankment material is to be placed, but excluding areas to be landscaped, shall be compacted to a density of not less than 95 percent of the maximum density.

Each layer of roadbed embankment shall be compacted to a density of not less than 95 percent of the maximum density, except that when asphaltic concrete is to be placed directly on subgrade, the top 6 inches (*150 millimeters*) of the embankment shall be compacted to a density of not less than 100 percent of the maximum density. Embankment material placed in dikes shall be compacted to a density of not less than 95 percent of the maximum density.

Damage to any compacted lift at any time during the course of construction, such as rutting under the loads imposed by earth moving equipment shall be fully repaired by the contractor at his own expense, prior to placement of any overlying materials.

All determinations of density will be made in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

When the embankment material is composed predominately of rock such that these compaction control procedures will not indicate the density achieved, the Engineer will determine the amount of compaction required and the adequacy of equipment used in obtaining the required compaction.

(2) Rock:

Density requirements will not apply to portions of embankments constructed of materials that cannot be tested by approved methods.

Rocky materials shall be placed, spread, and leveled in 24 inch (*600 millimeters*) thick layers, when possible, over the full width of the embankment, with sufficient earth or other fine material so deposited to fill the interstices to produce a dense compact embankment. The maximum dimension of the largest rock shall not exceed 24 inches (*600 millimeters*). It may be necessary to reduce the size of the excavated material by crushing or otherwise breaking down the material in order to comply with the requirements of this Subsection. Vibratory compactors, grid, paddle-foot, or vibratory rollers or other compacting equipment approved by the Engineer shall be used for fills constructed of materials which are predominately rock.

Rolling may be omitted on any layer, or portion thereof, when, in the judgment of the Engineer, it is physically impractical. In addition to the above rolling, each layer shall be further compacted by routing the hauling equipment uniformly over the entire width of the embankment.

203-9.04 Method of Measurement. No measurement for payment will be made for hauling, placing, shaping, applying water and compacting embankment materials.

203-9.05 Basis of Payment. No direct payment will be made for embankment, its cost being considered incidental to and included in the cost of the various other earthwork items in the contract.

SECTION 205

ROADWAY GRADING

205-1 DESCRIPTION

The work under this section shall consist of removing pavement, excavating, removal and disposal of excess material, furnishing and placing embankment material including borrow, and all grading, shaping and compacting of materials necessary to construct the subgrade to the lines and grades shown in the plans and in accordance with the requirements of these specifications.

205-2 MATERIALS (None Specified)

205-3 CONSTRUCTION DETAILS

205-3.01 General. All existing pavement shall be removed as designated on the plans and in conformance with the requirements of Section 202. Where new asphaltic concrete is to match existing bituminous surfaces, the edges of the existing bituminous surfaces abutting the new paving shall be saw cut to form a neat straight line with vertical edges free from irregularities.

If, at the time of removing any portion of the existing roadway, materials from which the new subgrade is to be constructed contain an excess of moisture such that the required compaction cannot be obtained without additional manipulation, the Engineer will determine the cause of such condition and will determine whether the material shall be aerated or removed and replaced. If the cause of such condition is determined to have been unforeseeable and beyond the control of and without fault or negligence of the contractor, such work shall be done as directed and will be paid for in accordance with the requirements of Subsection 104-2. Excess moisture caused by irrigation water, storm drainage, weather, breakage of mains, or other similar cause will be considered as within the responsibility of the contractor.

205-3.02 Excavation. Excavation shall conform with the requirements of Subsection 203-3.

205-3.03 Embankment. The placing and compaction of embankment shall conform with the requirements of Subsection 203-9.

205-3.04 Compacting and Finishing. The top 6 inches (*150 millimeters*) of the subgrade shall be compacted to a density not less than 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer except that when asphaltic concrete is to be placed directly on subgrade, the required density shall be 100 percent.

The surface of the subgrade shall be finished to a reasonably smooth and uniform surface and in reasonably close conformity to the lines, grades, dimensions and cross section shown on the project plans or established by the Engineer. The finished surface of the subgrade shall not vary by more than 0.04 foot (*12 millimeters*) above or below the grade established by the Engineer

except when asphaltic concrete pavement or portland cement concrete pavement are to be placed directly on the subgrade, the finished surface of the subgrade shall not vary by more than 0.02 foot (*6 millimeters*) above or that 0.04 foot (*12 millimeters*) below the established grade.

205-4 METHOD OF MEASUREMENT

Measurement of roadway grading will be made by the square yard (*square meter*) of the area prepared and subsequently covered with subbase, base, asphaltic concrete or portland cement concrete; however, when raised median islands are constructed, the area occupied by these islands will be included in the area measured for payment. No direct measurement shall be made for placing, grading, shaping, and compacting material in areas behind the roadway curbing. This work shall be considered as incidental with the cost being considered as included in the cost of contract items. Where the new pavement is not bounded by curb and gutter and additional shoulder work is necessary to construct the typical section shown on the project plans, such work shall be considered as incidental and the cost will be considered as included in the cost of this contract bid item.

205-5 BASIS OF PAYMENT

The accepted quantities of roadway grading measured as provided above, will be paid for at the contract unit price per square yard (*square meter*), including any borrow or necessary saw cutting of existing pavement as specified herein.

SECTION 206

FURNISH WATER SUPPLY

206-1 DESCRIPTION

The work under this section shall consist of either developing or obtaining an adequate water supply and furnishing all water required for the work.

206-2 MATERIALS (None Specified)

206-3 CONSTRUCTION DETAILS

The use of pressure pumps and spray bars on all sprinkling equipment used on the roadway will be required. The use of gravity flow spray bars and splash plates will not be permitted.

Material may be watered either at the source or on the roadway, at the option of the contractor.

If the contractor elects to apply water to materials at the source, and these materials will subsequently be measured and paid for on the basis of weight, he shall give the Engineer ample notice of his intentions.

Pre-moistened soil shall be measured in accordance with the requirements of Subsection 203-8.04(2).

206-4 METHOD OF MEASUREMENT

No measurement will be made under this Section for furnishing a water supply.

206-5 BASIS OF PAYMENT

The cost of furnishing, developing or obtaining a water supply; the cost of providing a water distribution system; the cost of delivering the water; and the cost of applying the water as a dust palliative or to aid the compaction of the materials will not be paid for directly but will be considered as included in the prices paid for the various contract items requiring water.

SECTION 207

DUST PALLIATIVE

207-1 DESCRIPTION

The work under this section shall consist of applying all water required for the control of dust as considered necessary for the safety and convenience of the traveling public, for the reduction of the dust nuisance to adjacent property, for the allaying of dust in crusher and pit operations and on roads used to haul materials, all in accordance with the requirements of the Pima County Code, Title 17.

207-2 MATERIALS (None Specified)

207-3 CONSTRUCTION DETAILS

The use of pressure pumps and spray bars on all sprinkling equipment used for the application of dust palliative will be required. The use of gravity flow spray bars and splash plates will not be permitted.

207-4 METHOD OF MEASUREMENT

No measurement will be made under this section for water used as dust palliative, used in compacting of materials, used in wet collectors in conjunction with hot plants, used in and around commercial plants or borrow sources for the sole convenience of the contractor, or for any other purpose not specifically authorized. Water utilized for dust control purposes shall be that quantity required to assure conformance with the Pima County Code, Title 17 as administered by the Pima County Department of Environmental Quality. When the Engineer directs the contractor to apply water in excess of that needed to satisfy compliance with Title 17, payment for this additional water shall be made in accordance with the requirements found in Section 104.

207-5 BASIS OF PAYMENT

No direct payment will be made for Dust Palliative, its cost being considered incidental to and included in the cost of those items of work for which it is required.

SECTION 208

SEPARATION GEOTEXTILE FABRIC

208-1 DESCRIPTION

The work under this section shall consist of furnishing and placing a permeable separation geotextile fabric. The fabric shall be placed in accordance with the details shown on the project plans and the requirements of these specifications.

208-2 MATERIALS

208-2.01 Geotextile Fabric. The separation geotextile fabric shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-4. Special attention shall be given to the required survivability of the fabric material which will be as called out in the special provisions or as shown on the plans.

208-2.02 Fabric Packaging, Handling, and Storage. The identification, packaging, handling, and storage of the geotextile fabric shall be in accordance with ASTM D4873. Fabric rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Rolls will be stored on the site or at another identified storage location in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof, light colored, opaque cover. At no time, shall the fabric be exposed to sunlight for a period exceeding 14 days.

208-3 CONSTRUCTION DETAILS

208-3.01 Weather Limitations. Separation geotextile fabric shall not be placed when weather conditions, in the opinion of the Engineer, are not suitable to allow placement or installation in accordance with the manufacturer's or supplier's requirements and instructions.

208-3.02 Equipment. Mechanical or manual laydown equipment shall be capable of handling full rolls of fabric, and laying the fabric smoothly, without wrinkles or folds. The equipment shall be in accordance with the fabric manufacturer's recommendations or as approved by the Engineer.

208-3.03 Surface Preparation. The surface upon which the separation fabric will be placed shall be compacted and finished according to the requirements of the Standard Specifications.

208-3.04 Fabric Placement. The separation geotextile fabric shall be unrolled on the finished surface and laid smooth without wrinkles. The placement of fabric by dragging across the finished surface will not be allowed. The geotextile fabric shall be

overlapped a minimum 24 inches (*600 millimeters*) for longitudinal and transverse joints. The center of a longitudinal overlapped joint shall be located in the same manner as a longitudinal pavement joint according to Subsection 406-3.07. Transverse overlaps shall be in the direction of aggregate placement.

208-3.05 Placement and Compaction of Aggregate. Aggregate materials shall be placed by back dumping the aggregate in a manner which does not damage the fabric and then spreading the aggregate material onto the geotextile fabric in a constant forward direction. Traffic or construction equipment shall not be permitted directly on the geotextile unless approved by the Engineer for emergency purposes. Pins or piles of aggregate can be used to hold the geotextile in place while being covered.

Overstressing the subgrade soil shall be avoided by utilizing equipment in spreading and dumping that exerts only moderate pressures on the soil. If ruts of 2 inches (*50 millimeters*) or greater occur in the aggregate, the contractor shall use lighter equipment which transmit less ground pressure. Any ruts which develop during spreading or compacting aggregate shall be filled with additional aggregate rather than bladed from adjacent areas so that the final design aggregate thickness is maintained. Construction equipment shall not be allowed to turn or stop suddenly on the aggregate placed over the geotextile fabric.

Aggregate base shall be compacted as specified in Subsection 303-3.02. Aggregate base material shall not be mixed or processed on the separation geotextile fabric. The aggregate base material shall be premixed at the stockpile area or at another location in a manner approved by the Engineer. Aggregate base materials will be sampled for acceptance after premixing and prior to placement on the separation fabric. Contamination and segregation of aggregate base materials prior to or during placement shall be minimized.

Any damage to the fabric occurring during placement of the aggregate must be repaired immediately. The aggregate shall be removed from the damaged area to allow placement of a fabric patch extending 3 feet (*0.9 meters*) on all *s*ides beyond the damaged area, followed by replacement of the aggregate.

208-4 METHOD OF MEASUREMENT

Separation geotextile fabric will be measured by the square yard (*square meter*) in-place. Measurement will be to the nearest square yard (*square meter*). No allowance will be made for material in laps.

208-5 BASIS OF PAYMENT

The accepted quantity of separation geotextile fabric, measured as provided above, will be paid for at the contract unit price per square yard (*square meter*), which price shall be full compensation for furnishing all labor, materials, and equipment, and performing all operations in connection with placing the separation

geotextile fabric as shown on the project Plans. No payment will be made for separation geotextile fabric rejected, or patches which are necessary, due to either contamination or damage due to either the fault or negligence of the contractor.

SECTION 301

LIME TREATED SUBGRADE

301-1 DESCRIPTION

The work under this section shall consist of preparing the roadbed for lime treatment, furnishing and applying a lime slurry, spreading and mixing lime slurry with in-place material, and, compacting and curing the mixture to the lines, grades and dimensions shown on the project plans and in accordance with the requirements of these specifications.

301-2 MATERIALS

301-2.01 Soil or Subgrade Material. The soil or subgrade material shall consist of native or imported material or embankment. The material shall be free of roots, sod, weeds and stones larger than 3 inches (*75 millimeters*).

301-2.02 Lime. Lime shall be either a commercial dry hydrated lime or a commercial granular or pelletized quick lime, conforming to the requirements of ASTM C 977. When sampled on delivery, the sample of lime shall conform to the following gradations:

	Percent Passing	
Sieve Size	Hydrated Lime	Quicklime
3/4 inch (*19.0 mm*)	100	100
No. 30 (*600 μm*)	95-100	
No. 100 (*150 μm*)		0- 30
No. 200 (*75 μm*)	75-100	
Test Method	ASTM C 110	ASTM C 136 (dry sieving only)

Hydrated lime shall contain not less than 85 percent calcium hydroxide, $Ca(OH)_2$, as determined by ASTM C 25.

Hydrated lime that has slaked prior to mixing, for any reason, shall not be incorporated in the work. The contractor is cautioned to obtain only freshly manufactured hydrated lime and to store it after delivery under conditions which will prevent moisture absorption and slaking.

Quicklime shall contain not less than 94 percent total available calcium oxide and magnesium oxide (CaO+MgO), and not less than 90 percent total available calcium oxide (CaO), as determined by ASTM C 25.

Lime shall only be used in the production of a lime slurry. The direct use of dry hydrated lime or quicklime to the soil or subgrade material is strictly prohibited.

Lime from more than one source or more than one type may be used on the same project, but the different lime shall not be mixed. If lime from more than one source is used, a mix design shall be submitted for each source. The mix design shall be approved by the Engineer prior to its use on the project.

Lime shall be protected from exposure to moisture until used and shall be sufficiently dry to flow freely when handled.

301-2.03 Lime Slurry. Commercial lime slurry shall be a pumpable suspension of solids in water. The solids portion of the mixture, when considered on the basis of solids content, shall consist principally of hydrated lime meeting the requirements specified in Subsection 301-2.02.

The percent by weight of residue retained in the solids content of lime slurry shall conform to the following requirements;

Residue retained on the No. 6 (*3.35 millimeter*) sieve Maximum 0.2%
Residue retained on the No. 30 (*600 micrometer*) sieve Maximum 4.0%

Lime slurry shall be applied at the mix design rate for the depth of subgrade stabilization shown on the plans or as directed by the Engineer.

Before commencing lime treatment work, the contractor shall submit for approval by the Engineer, a proposed mix design. The proposed mix design shall be prepared by a testing laboratory under the direction and control of a Professional Engineer registered in the State of Arizona. The mix design shall be determined using the soils or subgrade material to be stabilized and lime from the proposed source and shall consist of the following:

Percent of lime and rate of application of lime slurry in the treated soil or subgrade material.

Optimum water content during mixing, curing and compaction.

Gradation of in-situ mixture after treatment.

Additional mixing or equipment requirements.

Mellowing time requirements, if needed.

The mix design shall comply with the following requirements:

pH: Minimum 12.4 after compaction of initial mixing with lime slurry at ambient temperature, in accordance with Eades-Grimm pH test method (ASTM C 977 Appendix).

Plasticity Index: Less than 3, per AASHTO T89 & T90.

Swell Potential: One (1) percent or less vertical expansion of an air dried solid when inundated with water and allowed to swell at a confined pressure of 60 psi (*414 kilopascals*).

Hydrated Lime Content: Minimum 5.0 percent by dry weight of the combined lime soil mixture, per ASTM D 3155.

Unconfined Compressive Strength: Minimum 160 psi (1103 kilopascals) in five days curing at 100° F (*37.8 °C*) when tested in accordance with ASTM D 1633 Method A.

At final compaction, the lime and water content for each course of subgrade treatment shall conform to the approved mix design with the following tolerance:

Material	**Tolerance**
Lime	+0.5% of design, (ASTM C 114)
Water	+4%, -0% of optimum, (ASTM D 698)

A Certificate of Compliance, conforming to the requirements of Subsection 106-5(B), and a certified copy of the shipping weight shall be submitted to the Engineer with each delivery of lime.

301-2.04 Water. Water shall conform to the requirements of Subsection 1006-2.02.

301-2.05 Bituminous Material for Curing Seal. Bituminous material for curing seal shall be Liquid Asphalt, Grade SS-1 or CSS-1 conforming to the requirements found in Section 1005.

301-3 CONSTRUCTION DETAILS

301-3.01 Equipment. No work will be permitted until all necessary equipment is on hand and has been found to be in satisfactory working condition. All equipment shall be subject to the approval of the Engineer.

301-3.02 Preparation of Roadbed. In-place material to be lime treated shall be scarified and thoroughly broken up to the full roadway width. The material to be treated shall not contain any material retained on a 3 inch (*75 millimeters*) sieve, exclusive of random stones up to six 6 inches (*150 millimeters*) in diameter. The depth to be scarified shall be such that when the lime slurry and in-place material are mixed and compacted, the treated subgrade will be in close conformity to the specified thickness.

The subgrade material shall be shaped to the required line, grade and cross section before application of lime slurry and mixing.

301-3.03 Application of Lime. The direct use of dry hydrated lime or quicklime to the soil shall be strictly prohibited.

Lime slurry shall be added to the material to be treated at a rate not varying more than ten percent from the rate specified in the Special Provisions. The equipment used to distribute the lime slurry shall be approved by the Engineer and it shall be capable of uniformly distributing the required amount of lime slurry for the full width of the pass. Gravity feed spreaders shall not be permitted. When using dry hydrated lime to make slurry, agitators are mandatory in distributor trucks.

Lime slurry or lime treated material shall not be spread or mixed when the soil is frozen, when the air temperature is less than 40° F (*5 °C*) in the shade, or when conditions indicate that the temperature may fall below 40° F (*5 °C*) within 24 hours.

Lime slurry shall be mixed in a portable mixing unit and spread with trucks equipped with a distribution system approved for slurry applications. Commercial lime slurry shall be applied with a lime percentage not less than specified. The distribution of a lime slurry shall be attained by successive passes over a measured section of subgrade until the proper amount of lime has been spread as determined in the mix design. The rate of application shall be verified using methods outlined in ASTM D 3155.

The thickness of the lime slurry treated subgrade shall be determined by visual inspection and/or by depth tests taken at intervals such that each test shall represent no more than 1000 square yards (*835 square meters*) per layer. If more than one layer, the method used to remove material to determine the depth of lime treatment may be by shovel and/or pick, coring or other method approved by the Engineer. The contractor shall replace, at no additional cost to the Agency, the material where depth tests are taken. Phenolphthalein solution shall be used to detect the presence of lime.

The area upon which lime slurry may be spread ahead of the mixing operation shall be limited to that which the contractor may thoroughly mix by the end of the working day.

No traffic other than water trucks and the mixing equipment shall be allowed to pass over the spread lime until after completion of mixing.

301-3.04 Mixing. Mixing shall be accomplished by a traveling pugmill or a single or multiple transverse shaft mixer and shall be approved by the Engineer. The mixer shall be equipped with a system capable of introducing water at a controlled rate during mixing in order to produce a completed mixture with a uniform moisture content two percentage points above of the optimum moisture content of the material being treated. The optimum moisture content will be determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Mixing or remixing operations shall continue until the material is uniformly mixed, free of streaks or pockets of lime slurry. The final mixture shall not contain more than 5 percent of untreated dirt clods larger than 1 inch (*25 millimeters*) in diameter.

After mixing and prior to compaction, 100 percent of the clay lumps in the mixture shall pass the 1 1/2 inch (*37.5 millimeter*) sieve and 60 percent shall pass a No. 4 (*4.75 millimeter*) sieve.

301-3.05 Compaction and Finishing. The uniformily processed treated mixture shall be spread and compacted to the required width, grade and cross section.

The thickness of a compacted layer shall not exceed 8 inches (*200 millimeters*). Where the required thickness is more than 8 inches (*200 millimeters*), the mixture shall be spread and compacted in two or more approximately equal lifts. The moisture content shall be maintained to achieve compaction. Unless specified otherwise in the Special Provisions, the lime treated material shall be compacted to a density of at least 100 percent of the maximum density as determined in accordance with the requirements of the applicable test method of the ADOT Materials Testing Manual, as directed and approved by the Engineer. Optimum moisture and maximum density determinations may be adjusted at anytime to accommodate changes in the composition of the in-place material.

Initial compaction shall be by means of sheep's-foot or grid rollers. Final compaction shall be by means of steel wheel or pneumatic tired rollers. Areas inaccessible to rollers shall be compacted to the required density by other means satisfactory to the Engineer.

The lime treated subgrade shall be finished to a reasonably smooth and uniform surface and in reasonably close conformity to the lines, grades, dimensions, and cross sections shown on the project plans or established by the Engineer; however, when portland cement concrete pavement or asphaltic concrete pavement is to be placed directly on subgrade, the surface of the treated subgrade shall not vary by more than 0.02 of a foot (*6 millimeters*) above or below the grade established by the Engineer.

The thickness of the lime treated subgrade will be determined from measurements made in test holes located at random intervals not to exceed 500 feet (*150 meters*). The measured thickness shall not be deficient by more than 1/2 inch (*13 millimeters*) from the thickness as shown on the plans or specified by the Engineer. Thickness deficiencies exceeding this value shall be subject to a unit price adjustment or reconstruction in accordance with the provisions of Subsection 110-4.02. When the grade deficiency exceeds 1/2 inch (*13 millimeters*), the contractor shall correct the area in a manner satisfactory to the Engineer.

Any damage to the lime treated subgrade which occurs as a result of the contractor's construction operations, shall be promptly repaired by the contractor at no expense to the Agency, when such repairs are directed by the Engineer.

301-3.06 Curing. The surface of each compacted layer of lime slurry treated material shall be kept moist until covered by a subsequent layer of lime slurry treated material, aggregate base course, or if required by the Special Provisions, until a bituminous curing seal is applied.

When the project plans call for 4 inches (*100 millimeters*) or more of aggregate base over the lime treated subgrade, the aggregate base may be used as the curing seal. The surface of the lime treated subgrade shall be kept moist until covered by the aggregate base. The aggregate base shall be placed within 48 hours of final compaction of the lime treated subgrade. The aggregate base shall be kept moist 72 hours after placement. Once the aggregate base has been placed and compacted, the roadway may be opened to traffic.

Should a bituminous curing seal be specified, it shall be applied uniformly at an approximate rate of 0.20 gallon per square yard (*0.9 liters per square meter*) of surface, the exact rate to be determined by the Engineer in accordance with the requirements of Subsection 404-3.05. The bituminous curing seal shall be applied as soon as possible after the completion of final compaction and before the temperature falls below 40° F (*5 °C*).

No equipment or traffic will be permitted on lime treated subbase for three days after a bituminous curing seal is applied, unless otherwise permitted by the Engineer. Subsequent subbase, base or pavement course(s) shall be placed within ten calendar days after application of the curing seal.

Any damage to the bituminous curing seal during the curing period of the lime treated subgrade shall be promptly repaired by the contractor at his expense and as directed by the Engineer, until a subsequent subbase, base or pavement course is placed over the lime treated subgrade.

301-3.07 Safety Program. The contractor shall provide to the Engineer for review a detailed safety program for the protection of the workers and public, covering precautions to be exercised and emergency treatment to be available on the project site. The program shall include protective equipment for eye, mouth, nose, and skin protection; and a first aid kit with a portable eye socket wash. Said protective equipment shall be available on the project site during spreading and mixing operations. This program shall be provided and agreed upon before the lime slurry application begins. Acceptance of the contractor's safety program shall in no way, relieve the contractor of his responsibility for insuring protection of workers, the public and adjacent properties from lime dust created by the lime application and mixing operation. The contractor shall actively enforce the program for the protection of his work force and others in the construction area. Adequate care must be taken to avoid quicklime contact during spreading and slaking operations.

301-4 METHOD OF MEASUREMENT

Hydrated lime or quicklime will be measured by the ton (*metric ton*).

Subgrade treatment will be measured by the square yard (*square meter*) of subgrade treated. The area will be determined from horizontal measurements of the surface area treated, excluding any side slopes of the treated section.

Bituminous curing seal when specified by the Special Provisions, will be measured by the ton (*metric ton*) in accordance with the requirements of Section 109.

301-5 BASIS OF PAYMENT

The accepted quantities of lime and subgrade treatment, measured as provided above, will be paid for at the contract unit price per ton (*metric ton*) for hydrated lime or quicklime, and per square yard (*square meter*) for subgrade treatment, complete-in-place.

Payment for bituminous material will be made at the contract unit price per ton (*metric ton*).

Payment for lime will include furnishing and application of lime.

SECTION 302

CEMENT TREATED SUBGRADE

302-1 DESCRIPTION

The work under this section shall consist of preparing the roadbed for cement treatment, furnishing and applying portland cement; mixing cement and water with in-place material; and spreading, compacting, and curing the mixture to the lines, grades and cross-section shown on the project plans and in accordance with the requirements of these specifications.

302-2 MATERIALS

302-2.01 In-Place Material. In-place material on the roadbed shall be the native material or embankment.

302-2.02 Portland Cement. Portland cement shall conform to the requirements of ASTM C 150 Type II.

302-2.03 Fly Ash. Fly ash shall conform to the requirements of Subsection 1006-2.04(D).

302-2.04 Water. Water shall conform to the requirements of Subsection 1006-2.02.

302-2.05 Bituminous Material for Curing Seal. Bituminous material for curing seal shall be Liquid Asphalt, Grade SS-1 conforming to the requirements found in Section 1005.

302-3 CONSTRUCTION DETAILS

302-3.01 Equipment. No work under this item will be permitted until all equipment and facilities required are in place, inspected and approved by the Engineer.

The materials shall be mixed in a central twin-shaft, continuous flow or batch-type mixing plant or mixed on the roadbed by a traveling pugmill, whichever equipment the contractor elects to use. Traveling pugmill mixing equipment shall not be operated at speeds greater than those recommended by the manufacturer for the depth of treatment and quantity of materials to be mixed.

Where the materials are mixed in a central twin-shaft, continuous flow type mixing plant, the area of the mixing chamber shall extend at least 4 feet (*1.2 meters*) beyond the last point where the soil, cement, or water are fed into the mixer, so that all materials will be completely and thoroughly mixed in the chamber for a distance of at least 4 feet (*1.2 meters*). Where a batch type mixing plant is used, tests shall be conducted, prior to commencing full scale soil cement production, to determine the mixing time required to obtain a homogeneous, intimate, uniform mixture of soil, portland cement and water.

Where the materials are mixed at a central twin-shaft mixing plant, a hydraulically or mechanically operated discharge holding bin, having a minimum capacity of 20 tons (*18 metric tons*), shall be provided. Sufficient clearance for a dump truck shall be provided underneath the holding bin.

The central mixer shall be either a continuous or batch type mixing chamber and shall be designed to accurately proportion the mix either by volume or by weight. The central mixer shall be provided with weighing, volumetric or other gaging equipment, which shall be capable of providing accurate control at all times of the amount of soil and cement entering the mixer per time interval. In the production of the soil-cement, the percent of cement and the percent of fly ash (if utilized) shall not vary by more than $\pm$ 0.5 percent of that specified by the mix design or as otherwise directed by the Engineer. The mixer shall be equipped with a method of mechanically inter-locking the cement feed with the soil feed so that uniformity of the mixture will be assured at all times.

Compaction equipment shall be in good operating condition and shall be of a type specifically designed for the purpose. The minimum number of passes of the compaction equipment shall be such as to produce the specified minimum density for the full depth of the course. Cleated or tracked equipment will not be permitted on the soil-cement course. In areas inaccessible to rollers or pneumatic tired compactors, or where maneuvering space is limited, impact rammers and/or vibratory equipment may be used provided the required density is obtained.

Equipment suitable for storing, handling, weighing, measuring, proportioning controlling, and applying or spreading the cement shall be used.

Equipment suitable for accurately controlling and applying the water shall be used. If a traveling pugmill is used, all necessary water for mixing shall be added in the pugmill. If a rotary mixer is permitted and used, water for mixing shall be added through a spray bar in the mixing chamber.

302-3.02 Stockpiling, Sampling, and Testing. When a central mixing plant is used, the soil material shall be stockpiled and sampled before mixing in accordance with the requirements found in Section 106.

302-3.03 Preparation of Foundation. Before cement treatment operations are begun, the area upon which the cement treated course is to be placed shall be graded, shaped, and compacted as required in conformance with the grades, lines, thicknesses, and typical sections shown on the plans or as ordered by the Engineer.

The subgrade and any preceding course shall be compact and suitable to support the construction and compaction equipment.

No cement treatment shall be commenced unless the air temperature in the shade is 40° F (*5 °C*) and rising.

302-3.04 Application of Cement. Unless otherwise specified in the project plans or special provisions, portland cement shall be added uniformly to the soil material in order to attain a minimum compressive strength of 500 pounds per square inch (*3.5 megapascals*) at 7 days.

The percentage of moisture in the soil, at the time of cement application, shall not exceed the quantity that will permit a uniform mixture of soil and cement during mixing operations.

Where a traveling pugmill mixer is used, cement that has been displaced or removed from the windrow regardless of cause, shall be replaced before mixing is started, at the contractor's expense.

302-3.05 Application of Fly Ash. At the contractor's option, fly ash may be used to replace 15% of the total weight of portland cement when mixing is conducted in a central, twin shaft, continuous flow mixing plant or a batch type mixing plant and is approved by the Engineer. Should fly ash be incorporated into the mix design, an additional scale shall be required conforming to the requirements found in Subsection 302-3.01 Equipment. The replacement of portland cement with fly ash shall be based on the ratio of 1 pound (*1 kilogram*) of fly ash added for each 1 pound (*1 kilogram*) of portland cement removed.

302-3.06 Mixing and Spreading. Soil shall be graded from coarse to fine, free of topsoil, organic matter, and substances deleterious to the normal hardening of the soil/cement mixture. Soils shall not contain any material retained on a 3 inch (*75 millimeter*) sieve, exclusive of random stones up to 6 inches (*150 millimeter*) in diameter. Immediately, prior to mixing, the soil shall have a minimum temperature of 40° F (*5 °C*). Cement shall be uniformly spread by mechanical equipment which can be accurately calibrated in order to achieve the required cement content. After the cement has been applied to the soil, it shall be immediately mixed with the soil. Mixing shall continue until the cement has been thoroughly blended with the soil to prevent the formation of cement balls when the water is applied. Immediately after the soil and cement have been thoroughly mixed, the full amount of water shall be applied uniformly and mixing shall be continued until an intimate and homogeneous blend of soil, cement, and water has been obtained. Traveling mixers shall have provisions for introducing water at the time of mixing, through a metering device or by other approved methods. Leakage of water from equipment, or application of excessive amounts of water shall be corrected before proceeding further with the work.

When water application and mixing have been completed, the percentage of moisture in the mixture, based on test results, shall be such as to achieve the compressive strength and compaction requirements specified herein.

If traveling equipment is used that requires more than one pass of the mixer, at least one pass shall be made prior to water being introduced to the material.

The optimum moisture content and density of the mixture shall be determined in the field by a moisture-density test conducted in accordance with the applicable test methods of the ADOT materials Testing Manual, as directed and approved by the Engineer, on representative samples of the cement treated mixture obtained from the area being processed.

When traveling mixing equipment is used, not more than two hours shall elapse between the time water is added to the subgrade and cement and the time of completion of the initial compaction prior to trimming. Not more than 2-1/2 hours shall elapse between the time water is added to the subgrade and cement and the completion of final compaction after trimming, unless otherwise approved by the Engineer.

The cement treated mixture shall be spread immediately after mixing. If mixed in a central plant, approved mechanical spreading equipment shall be used and not more than 60 minutes shall elapse between the time that water is added to the soil-cement mixture and the start of the compaction operation. Not more than 2-1/2 hours shall elapse between the time water is added to the soil-cement mixture and the time of completion of final compaction.

In case of rain between the time of adding cement and final finishing, the Engineer shall be the sole judge of what areas involved are satisfactory and what areas are not acceptable. Areas not acceptable to the Engineer shall be removed, as directed by the Engineer, to the full depth of the cement treated course and properly replaced at no additional cost to the Agency.

Materials shall be mixed and/or spread either by one or several traveling mixers or spreaders operating in a staggered position across the subgrade, unless traffic conditions require that less than two lanes be spread. If two lanes cannot be spread, no more than 2 hours shall elapse between the time of placing the material in adjacent lanes to result in a 2 lane width. However, if conditions preclude placement of the cement treated mixture in adjacent lanes within two hours, the Engineer may authorize such longer times as may be necessary. Cement placed on areas inaccessible to mechanical mixing/spreading equipment may be mixed and spread by other methods as approved by the Engineer.

302-3.07 Compaction. Prior to the beginning of compaction the mixture shall be in a loose condition for its full depth on the subbase course. As an immediate continuation of mixing operations, and after an initial breakdown pass, the loose mixture then shall be uniformly compacted to the specified density. All areas and portions of this course shall be thoroughly and uniformly compacted for the full thickness of the course to a

density of 100 percent of the maximum density in accordance with the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer. During compaction, water shall be applied to the surface to maintain the moisture content required for satisfactory compaction finish and strength.

302-3.08 Finishing. During the compaction operations, shaping will be required to obtain the required surface and cross section. During shaping operations it may be necessary to lightly scarify and broom-drag the surface in order to remove ridges or depressions in excess of the permitted tolerance. The resulting surface shall then be rolled to provide a dense smooth finished surface. Several applications of water may be required to keep the surface at the proper moisture content during the finishing operation. Water shall be applied by the pressure spray bar method. Compaction and finishing shall be done in such a manner as to produce, in not longer than 2 hours after completion of mixing, a smooth, dense surface, free of surface compaction planes, cracks, ridges, or loose material. Immediately after rolling, the surface of the course shall be tested for trueness, transversely and longitudinally. The finished surface of the course shall not vary by more than 0.02 of a foot (6 millimeters) above or below the grade established by the Engineer.

Any portion of this course which has a density less than that specified shall be corrected or removed and replaced to its full depth to meet these specifications, at no additional cost to the Agency.

302-3.09 Construction Joints. At the end of each day's construction, and when placement operations are delayed for more than 2 hours, a straight transverse and/or longitudinal construction joint shall be formed by cutting back into the completed work to form a true vertical face, which shall be properly maintained until the abutting section is completed.

Where the cement treated mixture has been finally compacted more than one hour, longitudinal joints shall be constructed by cutting vertically into the existing edge of the course for approximately 3 inches (*75 millimeters*). The material cut away shall be disposed of outside the roadway surface area. Prior to placing adjacent cement treated material the face of the joint shall be moistened.

302-3.10 Curing and Surface Treatment. After the cement treated course has been finished as specified herein, it shall be protected against drying by the application of water, until covered by a subsequent layer of aggregate base course or, if required by the special provisions, until a bituminous curing seal is applied.

When the project plans call for 4 inches (*100 millimeters*) or more of aggregate base over the cement treated subgrade, the aggregate base shall be used as the curing seal. The aggregate base shall be kept moist for 72 hours after placement. The section may be opened to traffic immediately after placement and compaction of the aggregate base.

Should a bituminous curing seal be specified, it shall be applied on the same day that final compaction is performed and as soon after said compaction as practicable. The bituminous curing seal shall be liquid asphalt SS-1 conforming to the requirements found in Section 1005.

At the time the bituminous curing seal is applied, the surface of the cement treated subgrade shall be dense and free of all loose and extraneous material. Water shall be applied in sufficient quantity to fill the surface voids of the cement treated course immediately before the bituminous seal is applied. The bituminous curing seal shall be uniformly applied to the surface of the completed cement treated course at the rate of approximately 0.15 gallon per square yard (*0.7 liters per square meter*) with heating and distributing equipment specifically designed for this purpose. No traffic, nor placement of an overlaying course, will be permitted over the cement treated course for a period of at least three days from the application of the bituminous curing seal. Subsequent subbase, base, or pavement course shall be placed within ten days after application of the bituminous curing seal.

Where this course is utilized for maintaining traffic, between the no traffic period after application of the bituminous curing seal and the placement of a subsequent subbase, base or pavement course, the application of the bituminous material shall be immediately followed by the application of approved cover aggregate at the rate of approximately 20 to 30 pounds per square yard (*10 to 15 kilograms per square meter*). The aggregate will be broomed and rolled as ordered by the Engineer. Damage to the curing seal shall be promptly repaired by the contractor at his expense and as directed by the Engineer.

When the air temperature may be expected to reach the freezing point, sufficient protection from freezing shall be given the cement treated course for seven days after its construction and until it has hardened to the satisfaction of the Engineer.

302-3.11 Traffic. No traffic or hauling equipment other than that necessary for sealing, chipping, or for placing the next course will be permitted over the cement treated course, unless specifically permitted, in writing, by the Engineer.

302-3.12 Maintenance. The contractor shall be required, within the limits of his contract, to maintain the cement treated subgrade in good condition and in a manner satisfactory to the Engineer from the time he first starts work until all work has been completed and accepted. Maintenance by the contractor shall

include immediate repairs of any defects, regardless of cause, that may occur. This work shall be done by the contractor at no additional cost to the Agency, and repeated as often as may be necessary to keep the course continuously intact. Repairs are to be made in a manner to insure restoration of a uniform surface and durability of the part repaired. Faulty or damaged work, regardless of cause, shall be replaced for the full depth of the course by the contractor at no additional cost to the Agency.

302-3.13 Inspection and Testing. The Engineer, with the assistance and cooperation of the contractor, shall make such observations and tests as he deems necessary to ensure the conformance of the work to the plans and specifications. These observations and tests may include, but shall not be limited to, (1) the taking of test samples of the cement treated subgrade and its individual components at all stages of processing and after completion, and (2) the close observation of the operation of all equipment used on the work.

All testing of cement treated subgrade and its individual components, unless otherwise provided for specifically in the plans or specifications, shall be in accordance with the latest applicable ASTM or Arizona test methods in effect as of the date of advertisement for bids on the project.

Testing for proper compaction shall be done at any location chosen by the testing personnel. If the lift being tested does not pass the minimum 100% density requirements, it must be reworked as required until it does pass or be removed at the contractor's expense.

The compressive strength of the cement treated subgrade shall be tested in accordance with the requirements of Subsection 110-4.03.

The initial acceptance of material shall in no way preclude further examination and testing at any time the Engineer suspects that the material is no longer properly represented by the accepted sample. The acceptance at any time of any material shall not bar its future rejection if it is subsequently found to be defective in quality or uniformity.

302-4 METHOD OF MEASUREMENT

The quantity to be paid for under this item will be the number of square yards (*square meters*) of cement treated subgrade computed in its final compacted position within the payment lines shown on the plans or otherwise directed by the Engineer, and completed in accordance with the plans and specifications. Side slopes of treated sections shall be excluded from measurement. The thickness of the surface treatment will not be included in the measurement for payment. Cement treated subgrade placed in excess of the planned thickness will not be paid for.

Cementitious material (i.e., portland cement or a combination of portland cement and fly ash) for cement treated subgrade will be measured by the ton (*metric ton*).

When, in the opinion of the Engineer, there is reason to believe that the cement treated subgrade is deficient in thickness, cores will be taken at random locations in accordance with Subsection 110-4.02

When the cement treated subgrade is deficient in thickness the provisions of Subsection 110-4.02 shall apply.

Bituminous curing seal, when specified by the special provisions, will be measured by the ton (*metric ton*) in accordance with the requirements of Section 109.

302-5 BASIS OF PAYMENT

The accepted quantities of cementitious material (i.e., portland cement or portland cement and fly ash), measured as provided above, will be paid for at the contract unit price per ton (*metric ton*) of cementitious material furnished and incorporated into the work.

Payment for bituminous material will be made at the contract unit price per ton (*metric ton*).

An adjustment will be made to the unit price of cement treated subgrade, inclusive of the unit price of cementitious material contained therein, for any lot represented by the mean value of 7-day compressive strength falling below the specified strength required. Unit price adjustments shall conform to Table 110-11.

The accepted quantity of cement treated subgrade, measured as provided above, will be paid for at the unit price per square yard (*square meter*) of subgrade treatment, complete-in-place.

The unit bid price per square yard (*square meter*) for this item will include the cost of furnishing all labor, equipment and materials necessary to complete the work, including furnishing and applying water.

No direct payment will be made for any maintenance, repairs and replacements made before acceptance, nor for any losses of material which may result from shrinkage, compaction, foundation settlement, waste, overflow, erosion, trimming, leakage or any other causes, the cost of such will be included in the price bid for this item.

SECTION 303

AGGREGATE BASE COURSE

303-1 DESCRIPTION

The work under this section shall consist of furnishing, placing and compacting an aggregate base course in accordance with the details shown on the project plans and the requirements of these specifications.

303-2 MATERIALS

Aggregate for aggregate base shall consist of stone, gravel, recycled asphalt pavement (RAP) or other approved inert material of similar characteristics, and shall be clean and free from vegetable matter and other deleterious substances.

The following test methods shall be applicable under this section:

AASHTO	T2	Sampling Aggregates
Ariz.	201	Dry Preparation and the Sieving of Coarse and Fine Soils and Aggregates
AASHTO	T89	Test for Liquid Limit of Soils
AASHTO	T90	Test for Plastic Limit and Plasticity Index of Soils
AASHTO	T96	Test for Resistance to Abrasion of Small Size Course Aggregate by Use of the Los Angeles Machine
Ariz.	212	Percent of Crushed Particles in Cover Material or Mineral Aggregate.
SHRP Protocol	P46	Resilient Modulus Testing

Aggregate base shall conform to the following gradation requirements unless otherwise specified in the Special Provisions:

Sieve Size	Percent Passing
1 inch (*25 mm*)	100
3/4 inch (*19.0 mm*)	90 - 100
1/4 inch (*6.3 mm*)	45 - 75
No. 200 (*75 μm*)	0 - 10

The plasticity index for aggregate base material shall not exceed 5.

At least 30 percent by weight of the aggregate material retained on the No. 8 (*2.36 millimeter*) sieve shall have at least one rough and angular surface which has been produced by crushing.

Resistance to abrasion shall be in accordance with the following requirements:

Maximum loss of 9 percent at 100 revolutions.
Maximum loss of 40 percent at 500 revolutions.

Recycled asphalt pavement (RAP) shall comply with all of the provisions of this Subsection.

303-3 CONSTRUCTION DETAILS

303-3.01 Placement. Aggregate base material shall have water added to it and shall be mixed and processed to produce a uniform blend of material before final placement. After processing, the material shall be placed and spread on the approved subgrade, subbase or base in a uniform layer or layers not exceeding 6 inches (*150 millimeters*) in compacted depth, unless otherwise approved, in writing, by the Engineer. The method of dumping or spreading shall be determined by the contractor. Uncontrolled spreading from piles dumped on the grade which result in segregation will not be permitted. The course shall not be placed in excess of 500 linear feet (*150 linear meters*) without being compacted.

303-3.02 Compaction. Each layer of aggregate base shall be compacted to a density of not less than 100 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Material Testing Manual, as directed and approved by the Engineer.

303-3.03 Traffic and Contamination. The movement of highway traffic over the final surface of the aggregate base course may be permitted at locations designated by, and under such restrictions as ordered by the Engineer, provided such movements take place prior to the final finishing of this course to the specified tolerance. The movement of construction equipment on this course may be permitted, at locations designated by and under such restrictions, as ordered by the Engineer. At locations where permission is granted for such movement, the temporary surface of the course, upon which the construction traffic is running, shall be placed and maintained at least 2 inches (*50 millimeters*) above the final surface of the course. Just prior to paving and after all construction traffic, not required for the removal, has ceased, the 2 inch (*50 millimeter*) protective layer shall be removed, and the exposed surface of the course prepared and compacted to the specified tolerance. No payment will be made for furnishing, placing, maintaining, removing and disposing of the 2 inch (*50 millimeter*) thick protective layer; the cost thereof shall be included in the price bid for the aggregate base.

Should the aggregate base become mixed with the subgrade or any other material, through any cause whatsoever, the contractor shall, as his expense, remove such mixture and replace it with the appropriate base material.

303-3.04 Finishing. The final layer of aggregate base shall be finished with equipment capable of shaping and grading the surface within the tolerance specified herein.

The finished surface of aggregate base shall not vary from the grades established by the Engineer by more than 0.02 feet (*6 millimeters*).

The compacted layers of aggregate base shall be maintained in a condition satisfactory to receive any subsequent surfacing material or traffic, when so permitted.

Areas not within the allowable tolerance shall be corrected by scarifying, placing additional material, remixing, reshaping and recompacting to the specified density and surface tolerance.

303-4 METHOD OF MEASUREMENT

Aggregate base shall be measured by the cubic yard (*cubic meter*), placed and compacted in its final position, computed from payment lines shown on the plans or, where changes have been ordered, from payment lines established by the Engineer.

303-5 BASIS OF PAYMENT

The accepted quantities of aggregate base, measured as provided above, will be paid at the contract unit price per cubic yard (*cubic meter*) complete in place. The unit price shall be inclusive of the cost of furnishing all labor, material and equipment necessary to complete the work as well as the cost of adding water for compaction. No direct payment will be made for losses of material resulting from compaction, foundation settlement, erosion or any other cause. The cost of such losses shall be considered as included in the price bid for aggregate base. No deductions shall be made for the volumes occupied by manholes, catch basins, or other such objects.

SECTION 304

CEMENT TREATED BASE

304-1 DESCRIPTION

The work under this section shall consist of furnishing and mixing aggregate, Portland cement and water, and spreading and compacting the mixture in accordance with the details shown on the project plans and the requirements of these specifications.

304-2 MATERIALS

304-2.01 Aggregate. Aggregate shall conform to the requirements of Subsection 303-2, unless otherwise specified in the Special Provisions.

304-2.02 Portland Cement. Portland cement shall conform to the requirements of ASTM C 150.

304-2.03 Fly Ash. Fly ash shall conform to the requirements of Subsection 1006-2.04(D).

304-2.04 Water. Water shall conform to the requirements of Subsection 1006-2.02.

304-2.05 Bituminous Material for Curing Seal. Bituminous material for curing seal shall be Liquid Asphalt, Grade SS-1 conforming to the requirements found in Section 1005.

304-2.06 Mix Design. The contractor shall determine the mix proportions and shall furnish cement treated base conforming to the requirements specified herein. The job-mix design with the supporting test results shall be submitted to the Engineer and the Engineer's approval shall be obtained prior to incorporating any of the material into the work. The brand of cement, fly ash (if utilized) and the location of the aggregate source shall be included with the job mix design data. A new mix design shall be submitted for approval any time the contractor requests a change in materials or proportioning of the materials from that given in the approved mix designs.

When the option to incorporate fly ash into the cementitious portion of the mix is used, fly ash shall replace portland cement based on a ratio of 1 pound (*1 kilogram*) of fly ash added for each 1 pound (*1* kilogram) of portland cement removed, up to a maximum replacement of 20 percent by weight.

Unless otherwise specified in the plans or Special Provisions, cement treated base shall attain a minimum compressive strength of 500 pounds per square inch (*3.5 megapascals*) at seven days.

304-3 CONSTRUCTION DETAILS

304-3.01 Equipment. No work under this item will be permitted until all equipment and facilities required are in place, inspected and approved by the Engineer.

304-3.02 Preparation of Subgrade. Cement treated base shall be placed on a prepared subgrade which shall have been constructed in accordance with the surface finish and grade tolerance requirements specified for the subgrade material involved.

The subgrade shall be free of loose or extraneous material and maintained in an acceptable condition throughout the treatment operation. Any soft or yielding areas of the subgrade shall be corrected prior to placement of cement treated base.

304-3.03 Mixing.

(A) General Requirements. Aggregate, cement, and fly ash (if utilized) for cement treated base shall be proportioned and mixed in a central mixing plant, unless otherwise specified. The plant shall be either the batch-mixing type using revolving blades or rotary drum mixers, or the continuous mixing type.

The central mixing plant shall be equipped with screening, feeding and metering devices that will add the soil, cement, and water into the mixer in the specified quantities. In the production of the soil cement, the percent of cement content and the percent of fly ash content (if utilized) shall not vary by more than ± 0.5 percent of the contents specified by the mix design. The plant shall also be equipped with a hydraulically or mechanically operated discharge holding bin having a minimum capacity of 20 tons (*18 metric tons*).

The moisture content of the completed mixture shall be uniform throughout. The optimum moisture content will be determined in accordance with the requirements of AASHTO T 134.

The cement shall be added in such a manner that it is uniformly distributed throughout the aggregate during the mixing operation. There shall be safe, convenient facilities for sampling the cement and fly ash (if utilized) in the supply line to the weight hopper or pugmill.

The charge in the batch mixer or the rate of feed to the continuous mixer shall not exceed that which will permit complete mixing of all of the mix material.

The mixing time shall be sufficient to secure a homogeneous, intimate, uniform mixture of the soil, cement, fly ash (if utilized) and water and to prevent the formation of cement balls.

(B) Batch Mixing: The mixer shall be equipped with a sufficient number of paddles of a type and arrangement which will produce a uniformly mixed batch.

The mixer shall be equipped with an accurate timing device which will indicate, by a definite audible or visual signal, the expiration of the mixing period.

The time of mixing a batch shall begin after all ingredients are in the mixer and shall end when the mixer is half emptied. Mixing shall continue until a homogeneous mixture of uniformly distributed aggregate of unchanging appearance is produced. The time of the mixing shall not be less than 30 seconds.

The batch-mixing plant shall be equipped with sampling facilities as approved by the Engineer. The sampling facilities shall allow for the easy and safe collection of representative samples of aggregate and cement treated base mixture.

(C) Continuous Mixing: Aggregate shall be drawn from the storage facility by a feeder or feeders which will continuously supply the correct amount of aggregate in proportion to the cement and fly ash (if utilized).

A control system shall be provided that will automatically close down the plant when the material in any storage facility approaches the strike-off capacity of the feed gate. The plant will not be permitted to operate unless this automatic control system is in good working condition.

The feeder for the aggregate shall be mechanically or electrically driven.

Continuous mix plants shall be equipped with sampling facilities approved by the Engineer. The sampling facilities shall allow for the easy and safe collection of representative samples of aggregate and cement treated base mixture.

Scales are required at the cement feed, fly ash feed (if utilized) and, either the soil or total mix feed locations. Each scale shall record the weight of the material and have a digital read out, such that the total discharged weight per hour is displayed. Scales shall be calibrated and certified by the contractor, and approved by the Engineer at least forty-eight (48) hours prior to the start of production. Each scale shall be calibrated to an accuracy of plus/minus 2.0%.

(D) Spreading: Mixed material shall be transported from the plant to the roadway in approved vehicles and spread on a moistened subgrade in a uniform layer for the full width of the base under construction. Mixed material may be placed in partial widths as approved by the Engineer. Spreading shall be accomplished with approved spreader boxes or finishing machines or motor graders. If the Engineer approves the use of one spreader operating alternatively on two or more lanes, not more than 2 hours shall elapse between the time of placing the material in adjacent lanes at any location. The material shall be spread full depth in one pass unless otherwise specified.

Cement treated base shall not be mixed or placed while the air temperature is below 40° F (*5 °C*) in the shade or when conditions indicate that the temperature may fall below 40° F (*5 °C*) within 24 hours. Cement treated base shall not be placed on frozen subgrade or mixed when the aggregate is frozen.

304-3.04 Compacting and Finishing: Initial compaction shall begin immediately after spreading. Successive passes of compacting equipment shall overlap the previous adjacent pass by at least 25 percent of its width. Following initial compaction and before final compaction, the treated material shall be trimmed by blading with a motor grader or a planing machine to obtain a surface in reasonably close conformity with the lines, grades and cross sections established or shown on the project plans.

Extreme care shall be exercised by the contractor during the trimming operation so that no more material than is necessary is disturbed and so that the trimming operation can be completed as quickly as possible. Trimmed material shall be wasted. Compaction shall proceed without interruption, except as stated above, to achieve at least 100 percent of maximum density as determined in accordance with the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

The finished surface of cement treated base shall be uniform and shall not deviate at any point more than 0.02 foot (*6 millimeters*) from the bottom of a 10-foot (*3 meter*) straightedge laid in any direction.

The surface of the finished cement treated base shall not vary more than 0.02 foot (*6 millimeters*) from the grade established by the Engineer.

The surface shall be kept moist at all times until the curing seal is applied.

304-3.05 Operation Time Requirement. Not more than 60 minutes shall elapse between the time water is added to the aggregate and cement, and the start of compaction. Not more than 2-1/2 hours shall elapse between the time water is added to the aggregate and cement and the time of completion of final compaction.

304-3.06 Construction Joints. At the end of each day's work or when cement treated base operations are delayed or stopped for more than two hours, a construction joint shall be made in the thoroughly compacted material. The joint shall be normal to the center line of the roadbed and have a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

When partial-width construction of cement treated base is specified in the special provisions or approved by the Engineer and when the material has been finally compacted more than one hour, a longitudinal joint shall be constructed by cutting back into the previously placed material to a point where it meets the proper line and grade, and trimmed to a true vertical face which is free of any loose or shattered material. Trimmed material shall be disposed of.

The face of transverse and longitudinal construction joints shall be moistened prior to placement of the adjacent base material.

304-3.07 Curing After the cement treated base has been finished as specified herein, it shall be protected against drying by the application of water until covered by a subsequent layer of aggregate base course or, if required by the Special Provisions, until a bituminous curing seal is applied.

When the project plans call for 4 inches (*100 millimeters*) or more of aggregate base over the cement treated base, the aggregate base shall be used as the curing seal. The aggregate base shall be kept moist for 72 hours after placement. The section may be opened to traffic immediately after placement and compaction of the aggregate base.

Should a bituminous curing seal be specified, it shall be applied on the same day that final compaction is performed and as soon after said compaction as practicable.

After the curing seal has been applied, the cement treated base shall be kept free of traffic for a period of at least 3 days. Subsequent subbase, base, or pavement course shall be placed within 10 days after application of the bituminous curing seal.

Any damage to the curing seal or the cement treated base shall be promptly repaired by the contractor, at his expense and as directed by the Engineer.

304-4 METHOD OF MEASUREMENT

Cement treated base will be measured by the square yard (*square meter*), placed to the lines and grades specified on the plans or as directed by the Engineer.

Bituminous curing seal, when specified in the Special Provisions will be measured by the ton (*metric ton*) in accordance with the requirements of Section 109.

304-5 BASIS OF PAYMENT

The accepted quantities of cement treated base, measured as provided above, will be paid for at the contract unit price per square yard (*square meter*) for the cement treated base mixture, complete in place, including cement and fly ash (if utilized).

Payment for bituminous material will be made at the contract unit price per ton (*metric ton*).

An adjustment will be made to the unit price of cement treated base, inclusive of the unit price of cementitious material contained therein, for any lot represented by the mean value of 7-day compressive strength falling below the specified strength required. Unit price adjustments shall conform to Table 110-11.

The unit bid price per square yard (*square meter*) for this item will include the cost of furnishing all labor, equipment and materials necessary to complete the work, including the aggregate and furnishing and applying water.

No direct payment will be made for any maintenance, repairs, and replacements made before acceptance, nor for any losses of material which may result from shrinkage, compaction, foundation settlement, waste, overflow, erosion, trimming, leakage, or any other causes, the cost of such will be included in the price bid for this item.

SECTION 306

GEOGRID BASE REINFORCEMENT

306-1 DESCRIPTION

The work under this section shall consist of furnishing and placing a geogrid material within or below the aggregate base as shown on the project plans.

306-2 MATERIALS

306-2.01 Geogrid Materials: The geogrid material shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-3.

306-2.02 Geogrid Packaging, Handling, and Storage: The identification, packaging, handling, and storage of the geogrid material shall be in accordance with ASTM D4873. Geogrid rolls shall be furnished with suitable wrapping for protection from the elements, primarily ultraviolet exposure, prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacturer, shipping date, and the project number and name to which it is assigned. Rolls will be stored on the site or at another identified storage location in a manner which protects them from the elements, and any other factor which may cause damage to the material. Care should be taken to prevent mud, wet cement, epoxy, and other contaminating materials which may permanently affix themselves to the grid material, from coming into contact with the geogrid. If stored outdoors, geogrid rolls shall be elevated and protected with a light colored, opaque, waterproof cover. At no time shall the geogrid material be exposed to ultraviolet light for a period exceeding 14 days or stored in temperatures below 0° F (*-18 °C*) or in extreme heat. Torn, damaged, or defective geogrid will be rejected.

306-3 CONSTRUCTION DETAILS

306-3.01 Weather Limitations: The geogrid shall be placed in accordance with the manufacturer's or supplier's recommendations and instructions.

306-3.02 Equipment: Mechanical or manual laydown equipment shall be capable of laying the geogrid properly and smoothly, according to the manufacturer's recommendations.

306-3.03 Surface Preparation: If the geogrid material is to be placed directly on the subgrade, the subgrade surface shall be compacted and finished according to Subsections 203-3.03, 203-9.03 or 205-3.04 prior to placement of the geogrid. If the geogrid material is to be placed within the aggregate base materials, the aggregate base surface upon which the geogrid will be placed, shall be compacted according to Subsection 303-3.02 and finished according to Subsection 303-3.04 before placement of the geogrid.

306-3.04 Geogrid Placement: The geogrid shall be rolled out along the alignment in the direction of advancing construction. All wrinkles and folds shall be removed.

A 12 inch (*300 millimeter*) minimum overlap with securing pins is required at all joints (both transverse and longitudinal). Longitudinal joints shall be located according to the requirements shown in Subsection 406-3.07 for pavement joints unless otherwise approved by the Engineer. At transverse joints, the preceding roll shall overlap the following roll in the direction that the aggregate base will be placed. Securing pins shall be 3/16 inch (*5 millimeter*) steel bars, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 1.5 inches (*40 millimeters*). U-shaped pins shall be another option as approved by the Engineer.

The length of the securing pins shall be 4 inches (*100 millimeters*) minimum. The geogrid shall be tensioned by hand and anchored to the ground at the edges, including overlaps, and in the center of the roll at 30 foot (*9 meter*) intervals along the roll length, at the corners if applicable, or as directed by the Engineer. The use of securing pins may be reduced or eliminated by the Engineer if it can be shown that by careful installation the geogrid is adequately tensioned by hand and anchored by the placed aggregate in a progressive installation process as recommended by the manufacturer's representative.

Care shall be taken to ensure that geogrid sections do not separate at overlaps during construction. Placement of geogrid around corners will require cutting of the geogrid product and diagonal overlapping of the same to make sure that excessive buckling of geogrid material does not occur.

306-3.05 Placing and Compacting Aggregate Fill: The aggregate shall be back dumped and spread in a uniform lift maintaining the design aggregate thickness at all times. The aggregate material shall be bladed onto the geogrid in such a manner that the aggregate rolls onto the grid ahead, by gradually raising the dozer blade while moving ahead.

If the underlying material is capable of supporting rubber tire trucks (end and belly dumps) they may drive over the grid at speeds less than 5 mph (*8 kilometers per hour*), and dump aggregate as they go. Sudden stops and turning by trucks shall be avoided while on the grid. No tracked vehicles shall be allowed on the grid until there is a minimum of 6 inches (*150 millimeters*) of material between the tracks and the grid.

Any ruts which might develop during spreading or compacting the aggregate shall be filled with additional aggregate rather than bladed from surrounding areas. Placing additional aggregate into the rutted areas insures that the design aggregate thickness is maintained.

Geogrid damaged after or during construction will be repaired in accordance with the manufacturer's recommended procedure.

Aggregate base shall be compacted as specified in Subsection 303-3.02. Aggregate base material shall not be mixed or processed on the geogrid. The aggregate base material shall be premixed at the stockpile area or another location in a manner approved by the Engineer. Aggregate base materials will be sampled for acceptance after premixing and prior to placement on the geogrid material. Contamination and segregation of aggregate base materials prior to or during placement shall be minimized.

306-4 METHOD OF MEASUREMENT

Geogrid base reinforcement will be measured by the square yard (*square meter*) in-place. Measurement will be to the nearest square yard (*square meter*). No allowance will be made for material in laps.

306-5 BASIS OF PAYMENT

The accepted quantity of geogrid base reinforcement, measured as provided above, will be paid for at the contract unit price per square yard (*square meter*), which price shall be full compensation for furnishing all labor, material, and equipment, and performing all operations in connection with placing the geogrid as shown on the project plans. No payment will be made for geogrid base reinforcement rejected due to either contamination or damage due to either the fault or negligence of the contractor.

SECTION 307

GEOCOMPOSITE EDGE DRAIN

307-1 DESCRIPTION

The work under this section shall consist of furnishing all labor, equipment, and materials to install a pavement edge drain system. The drainage system shall be installed in accordance with the specifications, plans, and manufacturer's recommendations. The purpose of the geocomposite edge drain is to provide drainage for the pavement base course while restricting loss of fines.

307-2 MATERIALS

307-2.01 Geocomposite Edge Drain: The geocomposite edge drain material shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-7.

307-2.02 Geocomposite Packaging, Handling, and Storage: The identification, packaging, handling, and storage of the geocomposite edge drain material shall be in accordance with ASTM D 4873. Geocomposite edge drain shall be furnished in rolls, or in another acceptable manner, wrapped with a suitable protective covering to protect the fabric from mud, dirt, dust, debris, or harmful ultraviolet light. The edge drain material shall be free of defects or flaws which significantly affect its physical properties at the time of delivery and installation. Each roll or package shall be labeled or tagged to provide product identifications sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Geocomposite edge drain materials shall be stored on the site or at another location approved by the Engineer in a manner which protects them from the elements. If stored outdoors, the materials shall be elevated and protected with a light colored, opaque, waterproof cover. At no time shall the edge drain material be exposed to direct sun light for a period exceeding 14 days.

307-3 CONSTRUCTION DETAILS

307-3.01 Weather Limitations: The geocomposite edge shall be placed in accordance with the manufacturer's or supplier's recommendations and instructions.

307-3.02 Equipment: Trenching equipment shall be capable of excavating the necessary trenches for the edge drain and lateral outlet pipes. Mechanical or manual equipment shall be capable of properly installing the edge drain and lateral outlet pipes, and backfilling according to the specifications, plans, and manufacturer's recommendations.

307-3.03 General: The contractor will not be allowed to begin installation of the edge drain system unless a representative of the edge drain manufacturer or supplier is present. The edge drain is to be placed in accordance with the manufacturer's recommendations in a trench having the dimensions as shown on the Plans or as required by the manufacturer and approved by the Engineer.

307-3.04 Construction Method: The trenches for the edge drain and necessary lateral outlet pipes shall be neatly cut through existing materials to the lines and dimensions shown on the plans or as recommended by the manufacturer and approved by the Engineer. The trenching method shall normally be by use of wheel cutter trenching equipment although an alternative method may be approved by the Engineer. The edge drain material including lateral outlet pipes, shall be placed in accordance with the plans and the manufacturer's recommendations. The edge drain shall be placed so that the fabric on one side is in intimate contact with the aggregate base materials. It may be necessary to use spacers or blocks to keep the edge drain up against the aggregate base during backfilling. The trench with the edge drain in place may be backfilled with minus 2 inch (*50 millimeters*) material that was excavated from the trench, provided that sharp rocks or other material which, in the opinion of the Engineer may damage the fabric, are removed.

The soil backfill shall be placed in lifts not to exceed 6 inches (*150 millimeters*) of compacted depth with the backfill compacted to a density not less than 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual as directed and approved by the Engineer. Care shall be taken during compaction to prevent damage to the edge drain material or lateral pipes. The final 2 inches (*50 millimeters*) of the edge drain trench shall be filled with hot asphaltic concrete, meeting the material requirements specified in the Special Provisions, and compacted. The amount of trench excavated at any time shall not exceed the amount of pavement edge drain system which can be installed and the backfill completed in one working day. Backfill must be placed to the top of the edge drain trench if the asphaltic concrete will not be placed in the same working day.

All necessary splices and connections are to be made with kits furnished by the manufacturer and in accordance with the manufacturer's specifications and directions.

307-3.05 Damage to Pavement: The contractor shall not damage the adjacent existing pavement during the excavation and placement operation. Any damage done to the pavement shall be repaired, at the contractor's expense, in a method approved by the Engineer.

307-4 METHOD OF MEASUREMENT

Geocomposite edge drain will be measured by the linear foot (*meter*) in-place. Measurement will be to the nearest foot (*one-half meter*). No allowance will be made for laps or lateral pipes.

307-5 BASIS OF PAYMENT

The accepted quantity of geocomposite edge drain, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), which price shall be full compensation for furnishing all labor, material, and equipment, and performing all operations in connection with installing the geocomposite edge drain as shown on the project plans. No payment will be made for geocomposite edge drain rejected due to either the fault or negligence of the contractor.

Lateral outlet pipes, pavement cutting and removal, subgrade preparation and subbase and pavement replacement shall be measured and paid for under their respective bid items.

SECTION 308

LIGNIN SULFONATE TREATED SUBGRADE

308-1 DESCRIPTION

The work under this section shall consist of furnishing all plant, labor, equipment and materials, and performing all operations including water dilution, excavating, placing, and compacting a course of lignin sulfonate treated subgrade in accordance with the lines, grades and cross sections shown on the plans, as indicated in these specifications or as may be ordered by the Engineer. Included in the work will be scarifying, mixing, shaping and compacting the subgrade area as necessary.

308-2 MATERIALS

Ammonium lignin sulfonate shall conform to the following specifications:

Oven Dried Solids	50% minimum
pH (10% solution)	4.5
Sugars expressed as glucose	24% maximum
Specific gravity at 70° F (*21°C*)	1.237
Weight	10.30 pounds/gallon (*1.23 kilograms per liter*)
Viscosity at 70° F (*21°C*)	200 centipoise minimum 1500 centipoise maximum
Toxicity	Non-toxic
Flash Point	Will not flash at boiling point

Product alternates equivalent to ammonium lignin sulfonate, which are found acceptable by the Agency, will be considered.

An analysis of the lignin material herein specified shall be provided by the contractor. The analysis shall be certified by a laboratory acceptable to the Agency.

308-3 CONSTRUCTION DETAILS

Construction operations will be permitted only during favorable weather, when the subgrade is not saturated and the temperature of both the subgrade material and the air temperature in the shade is above 40° F(*5 °C*) and less than 95° F (*35 °C*), or as may otherwise be designated by the Engineer.

308-3.01 Application. The lignin sulfonate shall be diluted with water at a rate of 2 gallons (*7.6 liters)* of water for every 1 gallon (*3.8 liter*) of lignin sulfonate or as directed by the Engineer. The water used for dilution and compaction shall meet

the requirements found in Subsection 1006-2.02. The rate of application of diluted lignin sulfonate shall be 1-1/2 gallons per square yard (*6.8 liters per square meter*) and shall not be varied unless approved by the Engineer.

308-3.02 Mixing. The existing in-place subgrade material shall be treated with diluted lignin sulfonate to the depth and width specified on the plans or as otherwise directed by the Engineer.

The diluted lignin sulfonate shall be accurately applied and mixed in place at the rate specified herein by one of the following methods:

(A) Equipment. A traveling pugmill, or equal, capable of providing a homogeneous mixture to the depth required, may be used. A minimum of two passes of the mixing machine will be required. The mixer shall be equipped with accurate metering devices capable of providing adequate control of lignin sulfonate and water application.

(B) Mixing. Mixing may be performed by scarifying, windrowing, and processing material with a road grader until a homogeneous mixture is accomplished. Lignin is to be applied in three approximately equal portions, each application followed by a "pass" of the road grader through the entire length of the segment to spread windrowed material across the width of the roadway. The distributor shall be equipped with accurate metering devices capable of providing adequate control of lignin sulfonate and water applications.

The contractor shall be responsible for the addition of water to the mix to bring the stabilized mixture to an optimum moisture content.

The supplier of the lignin sulfonate shall have a qualified representative available if needed during application, mixing, shaping, and compaction operations to provide technical assistance.

308-3.03 Shaping and Compaction. Following mixing in place, the stabilized subgrade shall be uniformly spread and compacted to the limits and grades specified on the plans or as directed by the Engineer. Spreading and compaction shall be performed in thicknesses approved by the Engineer. Placement and compaction shall be accomplished with construction equipment specifically designed for the purpose. Rolling shall continue until the minimum specified compaction is achieved and the surface is true to grade and cross section. The lignin sulfonate stabilized subgrade shall have a density of not less than 100 percent of the maximum dry density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual as directed and approved by the Engineer.

308-3.04 Finishing. At completion of stabilization of each section, the contractor will apply a surface dressing of lignin sulfonate diluted with water at a rate of 1 gallon (*3.8 liters*) of

water for every 1 gallon (*3.8 liters*) of lignin. The rate of application of diluted lignin sulfonate shall be 0.1 gallon per square yard (*0.5 liters per square meter*) and shall not be varied unless approved by the Engineer.

308-3.05 Curing. Within 24 hours of the completion of the surface dressing of the lignin sulfonate treated subgrade it shall be cured by the application of water. At a minimum, water shall be applied at a rate of 0.7 gallon per square yard (*3.2 liters per square meter*) at least twice per day. Curing shall continue for fourteen calendar days.

Should weather or other conditions influence a change in the curing procedure such change shall be approved by the Engineer.

308-4 MEASUREMENT

Measurement shall be on the basis of gallons (*liters*) of undiluted lignin sulfonate satisfactorily placed in the roadway. Quantities of materials for this work will be paid at the applicable contract price per unit of measurement with no allowance for waste.

308-5 PAYMENT

The accepted quantities of lignin sulfonate treated sub-grade, measured as provided above will be paid for at the contract unit price per gallon (liter) of undiluted lignin sulfonate furnished and applied and shall be considered compensation in full for furnishing all materials, labor, tools, equipment, and appurtenances necessary to complete the work in a satisfactory manner as specified.

SECTION 404

BITUMINOUS TREATMENTS

404-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing or applying a single or multiple course bituminous treatment in accordance with the requirements of these specifications and in reasonably close conformity with the lines shown on the project plans or established by the Engineer.

The kind of bituminous treatment may consist of one or a combination of the following:

Prime Coat
Tack Coat
Fog Coat
Slurry Seal Coat
Chip Seal Coat

404-2 MATERIALS

404-2.01 Bituminous Materials. The bituminous material shall be of the type and grade specified in the special provisions and shall conform to the requirements found in Section 1005.

Application temperature of bituminous materials shall conform to the requirements found in Table 1005-5.

Bituminous material for slurry seal shall be an anionic quick setting asphaltic emulsion conforming to the requirements for QS-h grade meeting the following requirements:

Viscosity at 77° F (*25 °C*), Saybolt-Furol, Sec.	20-100
Residue by distillation, %	57 Min.
Sieve Test, retained on 20 mesh, %	0.10 Max.
Particle charge - electroplate	Negative
Tests on residue from distillation:	
Penetration at 77° F (*25 °C*), 100g., 5 Sec.	40-110
Solubility in Trichloroethylene, Wt. %	97.5 Min.
Ductility at 77° F (*25 °C*), Cm.	40 Min.
Mix Properties	
Slurry Seal Mixing Test, 70-85° F (*20-30 °C*), Sec.	84120 Min.
Slurry Seal Setting Test, 70-85° F (*20-30 ° C*), (1 Hour Cure)	No brown stain
Slurry Seal Water Resistance Test (70-85° F (*20-30 °C*), 30 minute cure)	No more than slight dis-colorization

404-2.02 Aggregate Materials.

(A) General. The contractor shall provide aggregate material for the work.

Aggregate material will be sampled for acceptance in the final stockpile before incorporation into the work. The aggregate material will be deemed to be acceptable when the test values for each specified aggregate characteristic are within the specified limits.

(B) Blotter Material. Blotter material shall be a natural sand, crushed sand, volcanic cinders, or other approved material and shall be free of deleterious amounts of foreign substances.

The grading shall meet the following requirements when tested in accordance with the requirements of Arizona Test Method 201.

Sieve Size		Percent Passing
1/8 Inch	(*3.2 mm*)	100
No. 4	(*4.75 mm*)	80-100
No. 16	(*1.18 mm*)	45-80
No. 200	(*75 μm*)	0- 5.0

(C) Cover Materials. Aggregate for cover material shall be clean sand, gravel or crushed rock and shall be free from lumps or balls of clay and shall not contain calcareous or clay coatings, caliche, synthetic materials, organic matter or foreign substances.

The grading shall meet the following requirements when tested in accordance with the requirements of Arizona Test Method 201.

Sieve Size		Percent Passing
3/8 Inch	(*9.5 mm*)	100
No. 4	(*4.75 mm*)	0-25
No. 8	(*2.36 mm*)	0-5
No. 200	(*75 μm*)	0-2.0

A representative portion of the cover material will be taken and tested.

The loss on abrasion will be determined in accordance with the requirements of AASHTO T 96 and shall meet the following requirements:

Maximum loss of 9 percent at 100 revolutions.
Maximum loss of 40 percent at 500 revolutions.

The percent of carbonates in aggregate shall be a maximum of 30 when tested in accordance with the requirements of Arizona Test Method 238.

The percent of crushed faces shall be a minimum of 70 when tested in accordance with the requirements of Arizona Test Method 212.

The Flakiness Index shall be a maximum of 25 when tested in accordance with the requirements of Arizona Test Method 233.

The Bulk Oven Dry Specific Gravity shall range from 2.30 to 2.85 when tested in accordance with the requirements of AASHTO T 85.

(D)Aggregate Slurry Seal Coat. Aggregate shall conform to the International Slurry Seal Association (ISSA) Guide Specification A-105 for Type II mineral aggregate. The percentage composition by weight of the aggregate shall conform to the following gradation:

Sieve Size		Percentage Passing
1/8"	(*9.5 mm*)	100
#4	(*4.75 mm*)	90 - 100
#8	(*2.36 mm*)	65 - 90
#16	(*1.18 mm*)	45 - 70
#30	(*0.60 mm*)	30 - 50
#50	(*300 μm*)	18 - 30
#100	(*150 μm*)	10 - 21
#200	(*75 μm*)	5 - 15

Ninety percent of the aggregate retained on the No. 50 (*300 μm*) sieve shall have at least one fractured face produced by crushing. Material passing the No. 50 (*300 μm*) sieve shall be non-plastic when tested in accordance with ASTM D-424. The sand equivalent shall be not less than 45.

404-2.03 Water. Water shall be of such quality that the asphalt will not separate from the emulsion before the slurry seal is placed.

404-2.04 Admixtures for Slurry Seal Coat.

(A)Accelerator. Accelerator shall be portland cement, Type I. The quantity of portland cement added to the slurry mix will range between 0.25 percent and 1.5 percent by weight. The exact percentage will be determined by the Engineer, in the field, so as to insure that the in-place slurry mix has cured adequately to support vehicular traffic within sixty minutes of application.

(B)Mineral Fillers. Mineral fillers such as hydrated lime, limestone dust, fly ash, etc., shall be used only if required to improve the workability or stripping characteristics of the aggregate-emulsion mixture and then only in the minimum amounts necessary. Mineral fillers shall conform to the requirements of ASTM D 242 and shall be considered as part of the blended aggregate.

404-2.05 Slurry Seal Coat Mix Design. Trial mixes shall be prepared by the contractor to determine the proportions to be used in the project. The quantity of bituminous material required in the mix can be initially approximated by use of the following formula:

$$P = .03a + .06b + .5c$$

Where P = Percentage of residual asphalt by weight

a = Percentage aggregate retained on No. 8 (*2.36 mm*) sieve
b = Percentage aggregate passing No. 8 (*2.36 mm*) sieve and retained on No. 200 (*75 μm*) sieve
c = Percent of aggregate passing No. 200 (*75 μm*) sieve

The mix design shall be prepared using the material components to be used by the contractor on the project site.

Testing shall be conducted in accordance with AASHTO T 59, Standard Methods of Testing Emulsified Asphalts and shall consist of the following:

(A) Slurry Seal Mixing Test. To 200 grams of aggregate, inclusive of portland cement, and conforming to the gradation requirements of Subsection 404-2.02, add nine percent water, by dry weight of aggregate. To the moistened aggregate add 10 percent, by weight, of quick-setting emulsified asphalt at 70 to 85° F (*20-30 °C*). To be acceptable, the mixture thus obtained shall form a free flowing, smooth, creamy, homogenous slurry with no segregation that is capable of being stirred by hand, using a spoon or spatula, without balling or stiffening for a minimum period of two minutes at 70 to 85 degrees Fahrenheit (*20-30° C*).

(B) Slurry Seal Setting Test. Using approximately three-quarters of the mixture produced in the Slurry Seal Mixing Test, spread the mixture on a section of asphalt-saturated roofing felt to a thickness of 1/4 inch (6 millimeters) and cure for one hour at 70 to 80° F (*20-30 °C*) and 40 to 60 percent relative humidity. After this period, a piece of white paper towel shall be pressed lightly on the surface of the slurry. The mixture will be deemed acceptable if no brown stain, exclusive of black asphalt particles, is observed.

(C) Slurry Seal Resistance Test. Using one-quarter of the slurry mixture prepared during the Slurry Seal Mixing Test, spread the mixture on a section of asphalt-saturated roofing felt to a thickness of 1/4 inch and cured for 30 minutes at 70 to 85 degrees Fahrenheit (*20-30° C*) and 40 to 60 percent relative humidity. The cured specimen shall be sprayed with tap water in accordance with ASTM D 244. The mixture will be deemed acceptable if the runoff water shows no more than a slight discoloration.

(D) Wet Track Abrasion Test. Testing shall be in accordance with the procedures of the International Slurry Seal Association. The maximum wear loss after testing shall be 75 grams per square foot.

404-3 CONSTRUCTION DETAILS

404-3.01 Weather Limitations. Bituminous material used in chip seal coats shall be applied to an existing bituminous surface only when the existing bituminous surface is dry and the ambient temperature is at least 70° F (*20° C*) and rising. The application shall cease when the temperature is 75° F (*25 °C*) and falling.

Bituminous material used in prime coats shall normally be applied to an existing aggregate surface only when the ambient air temperature in the shade is at least 70° F (*20 °C*) and when the existing aggregate surface is slightly damp.

The slurry seal coat shall be applied only when the existing surface is free from puddles of water. Slurry seal shall not be applied when the pavement is wet and shall be applied only when the atmospheric temperature is at least 45° F (*7 °C*) and rising, unless otherwise directed.

Despite the required minimum surface temperature and surface condition, the Engineer, at any time, may require that work cease or that the work day be reduced in the event of weather conditions either existing or expected which would have an adverse effect upon the bituminous treatment.

404-3.02 Equipment.

(A) Distributor Truck. Distributor trucks shall be so designed, equipped, maintained and operated that bituminous material at even heat may be applied uniformly on variable widths of surface up to 15 feet (*4.5 meters*) at readily determined and controlled rates from 0.03 to 1.0 gallons per square yard (*0.15 to 4.5 liters per square meter*), with uniform pressure, and with an allowable transverse variation from any specified rate not to exceed ten percent or 0.02 gallon per square yard (*0.10 liter per square meter*), whichever is less. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of the tank contents. Distributors shall be equipped with a power unit for the pump, and a spray bar~~s~~ which is adjustable laterally and vertically. The distributor shall provide for continuous circulation of the bituminous material through the tank and spray bar.

Prior to the spreading of bituminous material, all distributor trucks proposed for use shall have been tested within one year from the date of spreading to determine the rate of the transverse spread. The contractor shall furnish the Engineer with evidence that the distributor provides continuous circulation of the bituminous material through the tank and spray bar, and that the transverse spread of the distributor trucks, when the trucks were approved for use, was as uniform as practicable and under no

conditions was there a variance on any of the test pads greater than the allowable transverse variation; however, the Engineer may require that each distributor truck be tested to determine the rate of the transverse spread.

The rate of transverse spread shall be determined in accordance with the requirements of Arizona Test Method 411.

(B) Sweepers. Power brooms shall be of the rotary type equipped, maintained and operated so that the bristles are of reasonably uniform length and capable of cleaning without gouging or tearing the surface. Pick-up sweepers are also acceptable for use.

(C) Rollers. Rollers shall be of the oscillating type having a width of not less than 4 feet (*1.2 meters*) with pneumatic tires of equal size and diameter and with treads satisfactory to the Engineer. Wobblewheel rollers will not be permitted. The tires shall be spaced so that the gaps between adjacent tires will be covered by the following tires. The tires shall be inflated to 90 pounds per square inch (*620 kilopascals*), or such lower pressure as designated by the Engineer, and maintained so that the air pressure will not vary more than 5 pounds per square inch (*35 kilopascals*) from the designated pressure. Pneumatic tired rollers shall be constructed so that the total weight of the compactor can be varied to produce an operating weight per tire of not less than 2,000 pounds (*900 kg*). The total operating weight of the roller shall be varied as directed by the Engineer.

For slurry seal coats, steel wheel rollers may be used to supplement pneumatic tired rollers with the approval of the Engineer.

(D) Aggregate Spreaders. Aggregate spreaders shall be self-propelled continuous feed units supported by at least four wheels equipped with pneumatic tires mounted on two axles.

Aggregate spreaders shall be equipped with positive controls so that the required amount of material will be deposited uniformly over the full width of the bituminous material. Aggregate application rates are expected to vary from 4 to 40 pounds per square yard (*2 to 22 kilograms per square meter*), depending on the type of construction.

Where it is necessary to apply aggregate at a rate less than 4 pounds per square yard (*2 kilograms per square meter*), other means such as a sand slinger may be used with the approval of the Engineer.

(E) Slurry Seal Mixer. The slurry mixing machine shall be a continuous flow mixing unit and be capable of delivering accurately a predetermined proportion of aggregate, water, and asphalt emulsion to the mixing chamber and to discharge the thoroughly mixed product on a continuous basis. The aggregate shall be prewetted immediately prior to mixing with the emulsion.

The mixing unit of the mixing chamber shall be capable of thoroughly blending all ingredients together. No excessive mixing shall be permitted.

The mixing machine shall be equipped with an approved fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer at the same time and location that the aggregate is fed. The fines feeder shall be used whenever added mineral filler is a part of the aggregate blend.

The mixing machine shall be equipped with a water pressure system and fog type spray bar adequate for complete water fogging of the surface preceding spreading equipment with an application of 0.05 to 0.10 gallon per square yard (*0.25 to 0.45 liters per square meter*). A calibrated control for both aggregate and asphalt emulsion shall be provided and capable of accurately proportioning these materials.

Sufficient machine storage capacity to properly mix and apply a minimum of 5 tons (*4500 kg*) of the slurry shall be provided. Proportioning devices shall be calibrated prior to placing slurry seal.

The mixer shall be capable of rapid discharge of the mixed materials into a spreader.

(F) Slurry Seal Spreading Equipment. Attached to the mixer machine shall be a mechanical type squeegee distributor equipped with flexible material in contact with the surface to prevent loss of slurry from the distributor. It shall be maintained to prevent loss of slurry on varying grades and crown by adjustments and baffles to assure uniform spread. The equipment shall be capable of a minimum speed of 60 feet per minute (*18 meters per minute*) and shall not exceed 180 feet per minute (*55 meters per minute*) while placing slurry. There shall be a lateral control device and a flexible strike off. The spreader box shall have an adjustable width. The box shall be kept clean, and built-up asphalt and aggregate on the box shall not be permitted. The use of burlap drags or other drags may be approved by the Engineer.

Squeegees, shovels and other hand equipment shall be available.

404-3.03 Traffic Control. In the construction or application of a bituminous treatment, the treated roadway surface shall not be used by the contractor, its agents, or others until it has been definitely established to the satisfaction of the Engineer that it will not be damaged or marred under the action of the traffic. No traffic of any description shall be allowed on any bituminous application until approved by the Engineer. The contractor shall erect and maintain approved barricades, signs and other traffic control devices and shall use every possible means to protect the work and to exclude traffic from the roadway surface for as long a time as may be required. Traffic shall be handled in the manner most convenient to the traveling public. When traffic is handled on a one-way basis, the contractor shall provide such flagmen and

pilot trucks as deemed necessary to insure adequate protection for the roadway surface. Traffic may be detoured around the work, provided that detours are constructed and maintained in a satisfactory manner and properly signed. When it is necessary to provide for traffic across a bituminous treated surface, the crossing shall be blotted with material, as directed, before the crossing is opened to traffic.

404-3.04 Preparation of the Surface. The surface to be treated shall be thoroughly cleaned and patched as required by the plans, the Special Provisions, or as directed by the Engineer prior to applying the bituminous material or slurry seal coat. The contractor shall inspect the surface to be treated and shall satisfy himself as to the extent of the cleaning work required and the type of equipment that will be necessary to clean the surface.

When the work consists of a chip seal coat or when blotter material is applied, self-propelled rotary power brooms or pick-up sweepers along with hand brooms, if necessary, shall be used immediately in advance of applying the bituminous material.

When a bituminous treatment is to be applied to an existing aggregate surface, the surface shall be uniformly smooth, firm and reasonably true to grades and cross sections as shown on the project plans, and shall be so maintained throughout the placing of the bituminous treatment. In no event shall a bituminous treatment be placed on a soft, uneven base. Any holes, depressions or irregularities shall be repaired. All loose and unsuitable material shall be removed and replaced by suitable material, which shall be compacted to produce a dense surface conforming to the adjacent area. Uniformity of surface texture is of the utmost importance.

When required, the existing aggregate surface on which the bituminous treatment is to be placed shall be lightly bladed, watered and compacted immediately prior to the application of bituminous material. In extremely dry areas, additional light applications of water may be required prior to the application of the bituminous material to facilitate penetration of the bituminous material.

404-3.05 Application of Bituminous Material. For each kind of bituminous treatment, the type and grade of bituminous material will be specified in the special provisions.

For each kind of bituminous treatment, the approximate rate of bituminous material to be applied will be specified in the special provisions; however, the Engineer will specify the exact rate based on the surface to be treated and the characteristics of the aggregate material. The rate to be applied for each kind of bituminous treatment may vary substantially because of different surface conditions within the project limits.

The bituminous material shall be uniformly applied to the prepared surface at the rate specified by the Engineer and in one application.

Bituminous materials shall be heated by a retort or steam coils in such a manner that steam will not be introduced directly into the bituminous material.

The various types or grades of bituminous materials shall be mixed with materials or applied at temperatures within the limits given in Section 1005 and at no time shall the contractor increase the temperature of the bituminous material above the higher limit specified.

In order to obtain a uniform coat, the application shall be promptly started or stopped at the junction of a previously placed coat in a manner that will not result in overlaps or gaps in the applications. If required by the Engineer, a strip of building paper, at least 3 feet (*1 meter*) in width and with a length equal to that of the spray bar of the distributor plus 1 foot (*0.3 meter*), shall be used at the beginning of each application. The paper shall be removed and disposed of in a satisfactory manner.

Application of bituminous material shall be promptly cut off prior to a decrease in uniform flow caused by the distributor tank becoming empty, when there is a decrease in uniform flow due to any reason whatever, or when the forward movement of the distributor slows down or stops.

In the event that any spots are missed in the application or any areas develop that do not have a uniform spread or penetration, such areas shall be remedied without unnecessary delay as directed. The length of spread of bituminous material shall not be in excess of that which a truck loaded with cover material can immediately place or which can be satisfactorily compacted.

Manhole covers, catch basins, water valves, survey monuments and any other structure within the roadway areas shall be protected against the application of bituminous materials.

Care shall be taken to prevent the spraying or splattering of bituminous material on adjacent pavements, structures, curb, guard rail, trees and shrubbery or any other object outside of the area designated for spraying. The distributor, when not in use, shall be parked so that the spray bar or mechanism will not drip bituminous material on the surface of the roadway.

Unused bituminous material shall not be disposed of within the right-of-way lines.

404-3.06 Application of Cover Material. The approximate amount of cover material, when required as part of a bituminous treatment, will be specified in the Special Provisions; however, the contractor will recommend and the Engineer will approve the exact rate to be applied based on the characteristics of the aggregate material and the surface to be treated.

Cover material shall be immediately and uniformly spread over the freshly applied bituminous material by means of a self-propelled, continuous feed aggregate spreader. Any oversize aggregate or foreign material picked up during stockpiling or loading operations shall be eliminated before entering the aggregate spreader hopper. Supplemental spreading and smoothing shall be done by hand methods where necessary.

Spreading shall be accomplished in such a manner that the tires of the trucks or aggregate spreader at no time contact the uncovered and newly applied bituminous material.

When emulsified asphalt is used, the cover material shall be wet but free of running water at the time of spreading. When bituminous material other than emulsified asphalt is used, the cover material, at the time of spreading shall be at least as dry as material dried to a saturated surface dry condition in accordance with the requirements of AASHTO T 85.

404-3.07 Mixing of Slurry. The mixing shall be sufficient to produce a uniform mixture, but it shall not continue for more than 4 minutes. If breaking, hardening, segregation, balling, or lumping occurs during the mixing process, the batch shall be discarded.

404-3.08 Application of Slurry Seal. No slurry mix shall be spread if there is a possibility of rain before the mix has dried, or during periods of abnormally high humidity.

The surface shall be fogged with water directly preceding the spreader. The slurry mixture shall be of the desired consistency when deposited on the surface and no additional elements shall be added. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that complete coverage is obtained.

No segregation of the emulsion and aggregate fines from the coarse aggregate will be permitted. No streaks such as caused by oversized aggregate will be left in the finished pavement. No excessive build-up nor unsightly appearance shall be permitted on longitudinal or transverse joints. Approved squeegees shall be used to spread slurry in areas inaccessible to the slurry mixer. Care shall be exercised in leaving no unsightly appearance from hand work. Treated areas will be allowed to cure until such time as the inspector in charge permits their opening to traffic.

The beginning and end of the slurry application shall present a straight line perpendicular to the centerline of the existing pavement.

404-3.09 Rolling Cover Material. Following the spreading of cover material, the surface shall be promptly rolled with self-propelled pneumatic tired compactors. A sufficient number of compactors shall be provided to cover the full width of the material spread in one pass of the compactors and this rolling shall continue until a minimum of three passes has been completed.

404-3.10 Rolling Slurry Seal Coat. As soon as the asphalt slurry has set sufficiently to prevent any material being picked up, it shall be rolled by a minimum of 4 complete coverages, as directed. Rolling shall continue until all ridges have been ironed out and a uniformly smooth surface is obtained. The slurry seal shall be protected from traffic by barricades and markers until it has dried adequately to prevent marring from traffic.

404-3.11 Removing of Loose Cover Material. All loose cover material shall be removed from the paved surface by brooming in not less than 4 hours nor more than 36 hours after application; however, if because of weather conditions, temperature or other reasons, the Engineer determines that conditions are not conducive to obtaining the best results, brooming shall be discontinued until the Engineer has considered all conditions and has determined the best time for the removal of the cover material. The cover material shall be removed by means of a power broom which shall be in good condition and of a design suitable for the work. The action of the broom shall be such that particles which are stuck to the bituminous material will not be dislodged.

404-3.12 Application of Blotter Material. The approximate amount of blotter material, when required as a part of a bituminous treatment, will be specified in the special provisions; however, the Engineer will specify the exact rate to be applied based on the characteristics of the bituminous treated surface.

Blotter material, at the time of spreading, shall be at least as dry as material dried to a saturated surface dry condition in accordance with the requirements of Arizona Test Method 211.

Blotter material shall be uniformly spread by means of a sand slinger or other equipment approved by the Engineer. Any oversize aggregate or foreign material picked up during stockpiling or loading operations shall be eliminated before entering the spreader. Supplemental spreading or smoothing shall be done by hand methods where necessary.

Prior to final acceptance and when ordered by the Engineer, the contractor shall remove and dispose of any excess blotter material. The method of removal and the disposal of any excess blotter material shall be the contractor's responsibility.

404-3.13 Joints. Transverse joints shall be made with the preceding work, at intersections and at all existing pavements and structures. Transverse joints shall be made by any method approved by the Engineer prior to the start of the work.

Longitudinal joints shall be butt joints.

Joints shall be cleaned as deemed necessary by the Engineer prior to the application of bituminous material in the adjacent strip.

Regardless of the width of the roadway to be sealed, the number of longitudinal joints shall be kept to a minimum and shall be located to the greatest degree possible so that they will coincide with painted lines between traffic lanes.

404-3.14 Prime Coat. When the type and grade of bituminous material is not specified, the contractor shall furnish liquid asphalt, grade MC-250.

The approximate application rate for the prime coat is 0.20 gallons per square yard (*0.9 liters per square meter*).

When it is deemed necessary, areas having excess bituminous material shall be blotted with material as directed.

When so directed, the surface of the completed prime coat shall be rolled with a pneumatic tired roller.

The integrity of the prime coat shall be maintained at all times until the next course is placed or until final acceptance. In the event traffic has caused holes or breaks in the surface, such holes or breaks shall be satisfactorily repaired by the contractor.

404-3.15 Tack Coat. Tack coat shall be applied to a primed surface, to an existing bituminous surface or to the surface between layers of bituminous mixed materials.

Unless otherwise stated in the Special Provisions, the contractor shall furnish liquid asphalt, Type CSS-1, CSS-1h, SS-1 or SS1h conforming to the requirements of Section 1005 for tack coat. The tack coat shall be uniformily applied at an appropriate rate as approved by the Engineer.

If emulsified asphalt of any designation or type is used it shall have broken before asphaltic concrete is placed. If held over night, the emulsified asphalt shall be reheated and agitated prior to further application.

The Engineer may either reduce the rate to be applied or eliminate the use of tack coat in any part of the work if, in his judgment, the bituminous mixed material to be placed will be effectively bonded to the underlying surface.

Bituminous material shall be applied only as far in advance of the placement of the bituminous mixed materials as is necessary to obtain the proper condition of tackiness. In no event shall more bituminous material be applied in one day than will be covered by bituminous mixed materials during that same day.

404-3.16 Chip Seal Coat. When the type and grade of bituminous material is not specified, the contractor shall furnish cationic rapid set emulsified asphalt, Type CRS-2. Unless otherwise specified in the special provisions, or adjusted by the Engineer, bituminous material shall be applied at the following rate:

Single Application	0.42 gal/SY (*1.9 L/m²*)
Double Application (on primed Aggregate base course)	0.30 gal/SY (*1.4 L/m²*)

When asphaltic-rubber material is to be applied, the rate of application and other requirements shall be in accordance with the Special Provisions.

Cover material shall be applied at the rate of approximately 0.01 cubic yard per square yard (*0.009 cubic meters per square meter*) however, the Engineer will specify the exact rate to be applied based on the characteristics of the aggregate material and the surface to be treated.

The contractor shall submit a minimum 75 pound (*35 kilogram*) sample of cover material to the Engineer at least ten calendar days prior to beginning application of the cover material for testing.

Chip seal coat shall not be placed from March 15 to May 31 and September 1 to November 15 unless otherwise specified in the Special Provisions or approved, in writing, by the Engineer.

The minimum traffic free period for a newly applied chip seal coat shall be three hours; however, the contractor's hauling equipment may use the new seal coat during the traffic free period at a speed not to exceed 15 miles per hour (*25 kilometers per hour*). After the traffic free period, yet prior to removing the loose material, all traffic allowed by the Engineer shall be limited to a speed not to exceed 25 miles per hour (*40 kilometers per hour*).

404-3.17 Fog Coat. When the types and grade of bituminous material are not specified, the contractor shall furnish emulsified recycling agent, designation ERA 25. The material shall be diluted with one part water to one part emulsified recycling agent.

Blotter material shall be applied to the treated surface at a time specified by the Engineer and before opening to traffic.

404-4 METHOD OF MEASUREMENT

Bituminous treatments will be measured by the ton (*metric ton*) of bituminous material and by the ton (*metric ton*) of aggregate material, if specified. Measurement for payment will be made only of the quantity of bituminous material and of the quantity of aggregate material, if specified, used in accordance with the requirements of these specifications.

Bituminous material that is required to be diluted prior to application will be measured by the ton (*metric ton*) of diluted material.

Cover material will be measured by the ton (*metric ton*) of aggregate material. The weight of all moisture contained in the cover material will be deducted.

The specific gravity of cover material varies from one source to another. It will be the responsibility of the contractor to determine the amount of cover material that will be required to complete the work from the source or sources from which the cover material is obtained.

No direct measurement shall be made for admixtures for slurry seal coats, as specified in Subsection 404-2.04.

404-5 BASIS OF PAYMENT

The accepted quantities of bituminous treatments, complete in place, measured as provided above, will be paid for at the contract unit price, except that adjustments in the contract unit price, in accordance with the provisions of Tables 110-3 and 110-4, will be made for the quantity of material represented by test samples whose test results fall within the deviation ranges shown in Tables 110-3 and 110-4.

For emulsified bituminous materials which have a specified minimum percent residue, the emulsified product incorporated into the work which does not meet this minimum will be subject to an adjustment, to the nearest cent, in the contract unit price. The adjusted unit price for material which does not meet this minimum will be determined by multiplying the contract unit price by the value, to the nearest hundredth, obtained by dividing the residue obtained by testing by the specified minimum residue.

The accepted quantities of bituminous treatment of the kind specified, measured as provided above, will be paid for at the contract unit prices of the applicable pay items, complete in place.

Payment for all measures necessary to direct and escort traffic through the area being bituminous treated will be made as specified under Section 701.

No measurement or direct payment will be made for rolling.

No measurement or direct payment will be made for furnishing, applying and removing blotter material, furnished in conjunction with the application of a prime coat.

No measurement or direct payment will be made for the maintenance or repair of a prime coat surface.

No measurement or direct payment will be made for admixtures used in slurry seal coats.

The unit price bid for bituminous tack coat is deemed to be the cost to furnish, transport, store and apply emulsified asphalt of any designation at the project location. Payment for bituminous tack coat will be made at the contract unit price.

The bidding schedule quantity for bituminous tack coat is based on an estimated application rate of 0.06 gallon per square yard (*0.27 liters per square meter*).

Should the items of prime coat or tack coat be eliminated, they will be eliminated in accordance with the requirements of Subsection 109.05; however, no reimbursement will be made for any costs which the contractor may have incurred in anticipation of their use.

SECTION 406

ASPHALTIC CONCRETE

406-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, mixing at a plant, hauling, placing and compacting a mixture of aggregate, asphalt cement and approved mineral admixture to form a pavement course or for other purposes as specified and in accordance with the details shown on the project plans and the requirements of these specifications.

The Marshall Mix Design Method shall be the basic design for all proposed mix designs and testing procedures.

Asphaltic concrete shall be produced in a batch mixing plant, a continuous pugmill mixing plant or a drum drier mixing plant. Proportioning shall be either by hot-feed control or cold-feed control.

406-2 MATERIALS

406-2.01 General. The contractor shall obtain Agency approval of materials before any material is mixed at any plants. Approval of coarse and fine mineral aggregates shall be in accordance with Section 1001 - Material Source of the Standard Specifications.

406-2.02 Composition of Asphaltic Concrete Mixtures. The asphaltic concrete mix shall generally be composed of a mixture of aggregate, mineral admixture, and asphalt cement.

For any asphaltic concrete mix required by the plans or special provisions, the contractor shall develop and submit to the Agency, a job mix formula that satisfies the general criteria listed herein.

The optimum asphalt cement content for the gradation proposed shall be determined by the contractor using the Marshall Mix Design Method.

The resultant mixture shall meet the following properties:

TABLE 406-1

MIX DESIGN PROPERTIES

Arizona Mix Property	Mix Criteria	Test Method
Compaction (number of blows each end of specimen)	75	---
Wet Strength, psi (*Mpa*), min	150 (*1.00*)	802
Index of Retained Strength, percent, min,	60	802
Stability, lb. (*kN*), min.	2000 (*9.0*)	815
Flow, 0.01 in. (*mm*)	8 - 16 (*2 - 4*)	815
Effective Voids, %	Note 1	815
VMA, %	15.5 - 18.5	815
Absorbed Asphalt, %	0 - 1.0	815

NOTE 1: Effective air voids shall be 5.5 ± 0.2% for all arterial, collector and major street designations and 4.0 ± 0.2% for local streets.

406-2.03 Mineral Aggregate. Coarse mineral aggregate shall consist of crushed gravel, crushed rock, or other approved inert material with similar characteristics, or a combination thereof, conforming to the requirements of these specifications.

Fine mineral aggregate or blend material shall consist of natural sand or sand prepared from rock, or other approved inert materials, or a combination thereof, conforming to either the requirements of these specifications or as may otherwise be approved by the Engineer.

Mineral aggregate furnished for mix designs shall be representative of the source(s) and sampled from the materials stockpiles to be utilized in asphaltic concrete production. Mix designs shall be performed utilizing mineral aggregate which conforms to the grading limits in Table 406-2 or in the case of batch type plants, from bin samples if authorized by the Engineer.

TABLE 406-2

COMPOSITION OF ASPHALTIC CONCRETE MIXTURES

Mix Designation	Percent Passing		
	No. 1	No. 2	No. 3
Sieve Size			
1" (*25 mm*)	100	--	--
3/4" (*19 mm*)	90-100	100	--
1/2" (*12.5 mm*)	72-90	90-100	100
3/8" (*9.5 mm*)	60-76	70-85	85-100
#4 (*4.75 mm*)	48-62	54-68	55-75
#8 (*2.36 mm*)	40-52 (Note 1)	44-52 (Note 1)	38-50 (Note 2)
#40 (*425 μm*)	12-24	13-23	16-26
#100 (*150 μm*)	--	--	--
#200 (*75 μm*) (Note 3)	3-7	3-8	3-8

Notes:

1. A minimum of 50 percent, by weight, of the material retained on the No. 8 (*2.36 millimeters*) sieve shall have at least one rough, angular surface, produced by crushing when tested in accordance with the requirements of Arizona Test Method 212a.

2. A minimum of 70 percent, by weight, of the material retained on the No. 8 (*2.36 millimeter*) sieve shall have at least one rough, angular surface produced by crushing when tested in accordance with the requirements of Arizona Test Method 212a.

3. The percent passing the No. 200 (*75 micrometer*) sieve shall include the amount of mineral admixture.

Mineral aggregate shall conform to the requirements found in Table 406-3 when tested in accordance with the applicable test methods.

TABLE 406-3

MINERAL AGGREGATE CHARACTERISTICS

Characteristic	Test Method	Requirement
Combined Bulk Specific Gravity	AASHTO T 85, Arizona Test Method 211	2.35 to 2.85
Combined Water Absorption	AASHTO T 85, Arizona Test Method 211	0.00 to 2.50
Sand Equivalent	AASHTO T 176	Minimum 50
Crushed Faces	Arizona Test Method 212	Minimum Values per Table 406-2
Abrasion (Note 1)	AASHTO T 96	100 Rev., Max. 9% 500 Rev., Max. 40%

Note: (1) Abrasion shall be run on samples from each source of mineral aggregate.

Tests on aggregates outlined in Table 406-3 shall be performed on materials furnished for mix design purposes and composited to the mix design gradation.

Mineral aggregate from a source or combination of sources which does not meet the requirements, according to the contractor's mix design proposal, for combined bulk specific gravity and/or combined water absorption up to a maximum of 3.0 percent, but meets the other requirements of Table 406-3 will be further considered for acceptance by the Engineer if: a) the total estimated cost of all asphaltic concrete components, using the mix design unit weight, asphalt cement content and mineral admixture percentage, does not exceed the total amount bid for these items by more than 5.0 percent; or b) a supplemental agreement is executed adjusting the unit prices of asphaltic concrete components such that the total estimated cost does not exceed the total amount bid by more than 5.0 percent.

406-2.04 Mineral Admixture. The mix design shall include a mineral admixture. The amount of mineral admixture used shall be a minimum of 0.5 percent, by weight, of the mineral aggregate, with the exact amount to be specified in the mix design. A maximum of 2.0 percent admixture will be permitted. Mineral admixture shall be either portland cement, blended hydraulic cement or hydrated lime conforming to the requirements of Table 406-4.

SECTION 406

TABLE 406-4

MINERAL ADMIXTURE

Material	Requirement
Portland Cement, Type I or II	ASTM C 150
Blended Hydraulic Cement, Type IP	ASTM C 595
Lime	ASTM C 1097

A Certificate of Analysis, conforming to the requirements of Subsection 106-5, shall be submitted to the Engineer.

406-2.05 Bituminous Material. Unless otherwise specified in the Special Provisions, the bituminous material shall be an asphalt binder performance grade PG 70-10 when tested in accordance with the requirements of AASHTO Provisional Standard MP1. The pressure aging temperature shall be 100 °C.

A Certificate of Analysis conforming to the requirements of Subsection 106-5 shall be submitted and duplicate samples per shift shall be taken. In addition, the supplier shall determine the mixing and the compaction temperature ranges for each PG asphalt binder used for mix design purposes. The mixing temperature range is defined as the range of temperatures where the unaged asphalt binder has a rotational viscosity 0.17 ± 0.02 pascal seconds measured in accordance with ASTM D 4402. The compaction temperature range is defined as the range of temperatures where the unaged asphalt binder has a rotational viscosity 0.28 ± 0.03 pascal seconds measured in accordance with ASTM D 4402. The testing required by ASTM D 4402 shall be performed at 135 °C and 175 °C, and the results plotted on a semi-log graph with viscosity (logarithmic scale) versus temperature (arithmic scale). PG asphalt binders that are polymer modified shall have mixing and compaction temperature ranges based on the manufacturer's recommendations if the mixing temperature range exceeds 163 °C and/or the compaction temperature range exceeds 149 °C as determined by the ASTM D 4402 procedure.

If it is determined by testing that bituminous materials used in asphaltic concrete production fails to meet the requirements of the AASHTO Provisional Standard MP1 for the specified grade, the contract unit price of the asphaltic concrete will be adjusted by the dollar amount per ton (*metric ton*) shown in Table 110-4, when the asphaltic concrete is allowed to remain in place. Should the bituminous material be in reject status, the Contractor shall, upon request by the Engineer, supply an engineering analysis of the expected performance of the material in which the bituminous material is incorporated. The engineering analysis shall detail any proposed corrective action and anticipated effect of such corrective action on the performance. Asphaltic concrete not allowed to remain in place shall be removed at no additional cost to the Agency and replaced with asphaltic concrete meeting the requirements of these specifications.

406-2.06 Mix Design Proposal.

(A) New Mix Designs. Utilizing mineral aggregate which has been crushed, processed, separated and stockpiled, a mix design proposal shall be formulated and submitted by the contractor to the Engineer.

The proposal shall be based on the mix design criteria and other requirements herein specified, utilizing asphalt cement and mineral admixture of the type and from the sources proposed for use in the production of asphaltic concrete.

Marshall specimens shall be prepared and mix properties determined in accordance with Arizona Test Method 815 and Arizona Test Method 802. The mix design shall be prepared under the direct supervision of a Professional Engineer experienced in the development of asphaltic concrete mix designs and mix design testing.

The mix design proposal shall contain as a minimum:

(1) The name and address of the testing organization and the individual responsible for the mix design development and testing.

(2) The specific location(s) of the source(s) of mineral aggregate.

(3) The supplier, refinery, and type of asphalt cement, and the source and type of mineral admixture, and the percentage of each to be used.

(4) The anticipated mineral aggregate gradation in each stockpile.

(5) Mix design gradation. The mix design shall contain the gradation of the mineral aggregate as well as the mix gradation with the mineral admixture if it is used.

(6) The results of all testing, determinations, etc., such as: specific gravity of each component, water absorption, sand equivalent, loss on abrasion, crushed faces, uncompacted void content, immersion compression results (Index of Retained Strength, wet and dry strengths), Marshall stability and flow, asphalt absorption, percent air voids, voids in mineral aggregate, and bulk density. Historical abrasion values may be supplied on existing sources.

(7) The Viscosity-Temperature curve together with the laboratory mixing and compaction temperature ranges.

The mix design proposal shall be submitted and signed by a person authorized by the contractor to act in such matters on his/her behalf. The mix design proposal shall be submitted to the Agency a minimum of three weeks prior to the scheduled start of production.

The Engineer will review the mix design proposal to assure that it contains all required information. If it does not, it will be returned, within three working days, for further action and resubmission by the contractor.

(B) Previously Utilized Mix Designs. The contractor may propose to use an established mix design from a previously utilized source or a combination of sources. The previous mix design will be accepted upon request, within three working days, if acceptable evidence is provided with the request that the materials to be incorporated have not been changed and the mix design had been approved by the Agency within the last twelve month period.

Evidence shall consist of analyses of stockpile gradations, sand equivalents and crushed faces and certification that crushing, screening or other processing methods are unchanged, that the asphalt cement is of the same source and type, and mineral admixture, if required, is of the same type. Such evidence and certification shall be considered as a complete mix design proposal in lieu of the requirements of Subsection 406-2.06 (A).

If the Engineer questions the evidence provided, he may require that samples be obtained of the various stockpiles sufficient for testing to verify the above information. Should such testing indicate results not meeting the requirements outlined in Table 406-6, Items 1 through 10, the Engineer will inform the contractor within three working days of receipt of the samples, and a new mix design proposal conforming to the requirements of Subsection 406-2.06 (A) will then be required.

406-2.07 Mix Design. Following submission of a complete mix design proposal by the contractor, samples of the produced mineral aggregate stockpiles, including any blend material, shall be obtained by the contractor and witnessed by the Engineer so that both parties are satisfied that samples are representative of the mineral aggregates to be utilized in the asphaltic concrete production.

Samples shall consist of approximately 600 pounds (*275 kilograms*) of mineral aggregate in proportion to the proposed stockpile usage, along with five 1 gallon (*4 liter*) cans of the proposed asphalt cement. Mineral admixture of the type to be used in the mix shall also be furnished by the contractor. These samples shall be placed in sample sacks in the presence of the Engineer and fully identified, and shall then be transported, by the contractor, to the Agency's laboratory where they will be split and one-half set aside for a period of 30 calendar days for possible referee testing, after which they will be discarded.

Utilizing the samples, the laboratory will determine if the proposed mix design meets the requirements of Subsection 406-2.08. If the proposed mix design meets all the requirements, it will be the approved mix design.

If the proposed mix design fails to meet all the requirements necessary, it will be disapproved by the Engineer. The contractor, upon notification that the proposal is disapproved, shall prepare, and submit for approval, a new mix design proposal; however, should the contractor wish to protest the Engineer's decision, on the basis of a written request from said contractor, the samples set aside will be provided by the Agency to an independent, approved laboratory, selected from a list of three Arizona Department of Transportation certified laboratories named by the contractor in his written request, for referee verification testing within two working days of the contractor's request. The results of such testing shall be binding upon the Agency and the contractor. Testing will be paid for by the contractor; however, should such testing prove the proposal to be satisfactory, the Agency will approve the mix design proposal, reimburse the contractor for the private laboratory costs and issue an extension of the contract time for the time required for such testing.

The approved mix design shall specify a single percent of material passing each required sieve; the approximate percent of material to be used from each source; the type, source and percent of asphalt cement; the percent effective voids; the type and percent of any mineral admixture; the laboratory bulk density and any special treatment.

If approval of the mix design is contingent upon the use of a minimum or maximum percentage of special materials such as washed or imported aggregates, the approved mix design will also contain such stipulation.

406-2.08 Verification Testing. Mineral aggregate samples submitted for verification testing will be combined in the proportions specified in the contractor's proposed mix design. The resultant composite gradation will be compared to the proposed mix design gradation and the percentage deviations determined. The required action is determined from Table 406-5.

TABLE 406-5

ALLOWABLE DEVIATIONS FROM PROPOSED TARGETS

Sieve Size	Proceed	Adjust	Reject
3/8 inch (*9.5 mm*) or larger	±3	> ±3 to ±8	> ±8
No. 4* (*4.75 mm*) (Note 1)	±2	> ±2 to ±6	> ±6
No. 8 and No. 40 (*2.36 mm and 425 μm*)	±2	> ±2 to ±6	> ±6
No. 200 (*75 μm*)	±0.5	> ±0.5 to ±3	> ±3

*Note 1: No. 4 (*4.75 mm*) sieve size criteria is applicable to Mix No. 3 (Table 406-2) only.

If the deviations are such that they fall into the adjust column of Table 406-5, the contractor has the option to request artificial grading of the samples in accordance with the requirements of Arizona Test Method 244 or to resample the material. In lieu of resampling, the contractor may elect to submit new stockpile percentages.

When the final composite is determined, tests will be performed in accordance with Arizona Test Method 827 for conformance to the criteria of Table 406-6.

TABLE 406-6

VERIFICATION CRITERIA

Property	Allowable Deviation From Proposal Targets	Values
1) Sand Equivalent	-10 (Note 1)	50 Min.
2) Crushed Faces, Percent	-----	(Note 2)
3) Abrasion 100 Revolutions	-----	9 Max.
500 Revolutions	-----	40 Max.
4) VMA, Percent	± 1.5	14.5 Min.
5) Effective Voids, Percent	± 1.5	3.8 Min.
6) Stability, Pounds (*kN*)	-----	1,750 Min. (*8.0 Min*)
7) Flow, 0.01-Inch (*mm*)	-----	7-17 (*1.8-4.3*)
8) Index of Retained Strength, Percent	-----	60 Min.
9) Wet strength, psi (*MPa*)	-----	140 Min. (*0.95 Min*)
10) Absorbed Asphalt Percent	-----	1.0 Max.

Note 1: In verifying previously used mix designs only.
Note 2: Refer to Table 406-2.

Results of testing will be verbally furnished to the contractor within fifteen working days following the date of receipt of both an acceptable mix design proposal and the samples in the Agency laboratory. If the contractor elects to artificially adjust the gradation, then an additional two working days will be required for verification testing. The contractor will be verbally notified of failing test results within one working day of failure.

406-2.09 Mix Design Revisions. The contractor shall not significantly change his methods of crushing, screening, or stockpiling from that used during production of material used for mix design purposes without approval of the Engineer or submitting

for approval, a new mix design proposal in accordance with Subsections 406-2.06 (A) and 406-2.07. Significant changes may include changes in the amount or type of materials rejected or wasted, changes in the amount of materials crushed, or reductions in the amount of crushed fines.

During production of asphaltic concrete, the Engineer shall independently test samples of the mineral aggregate. The mineral aggregate samples shall be obtained and tested in accordance with the requirements of Subsection 406-2.03 and Table 406-3. Should the results of the testing indicate values that fall outside the allowable deviation from the mineral aggregate characteristics specified in Table 406-6, Items 1 through 10, paving operations shall cease until a new mix design proposal, addressing the deficiencies and conforming to the requirements of Subsection 406-2.06 (A), is approved.

At any time after a mix design has been approved, the contractor may submit a new mix design proposal to the Engineer in accordance with Subsections 406-2.06 (A) and 406-2.07. If the revised mix design proposal is determined to meet all the requirements, the Engineer will approve the proposal and it shall be the approved mix design.

During the production of asphaltic concrete, the contractor, on the basis of field test results, may request a change to the approved mix design Target Values. The Engineer will evaluate the proposed changes and notify the contractor verbally of his decision within three working days of the receipt of the request. This verbal notification will be promptly verified, in writing, by the Engineer. If approved, the revised Target Values will be applied to the samples immediately following the request for Target Value changes. If the Engineer determines that the test results indicate that the asphaltic concrete previously sampled will perform satisfactorily, the Engineer may apply the revised Target Values to samples taken prior to the request for the Target Value change(s).

If, at any time, changes are made in the source of asphalt cement, source(s) of mineral aggregate, or proportional changes, in violation of approved mix design stipulations, production shall cease until the contractor has approval for a new mix design or complies with the approved mix design.

406-2.10 Time and Cost for Mix Designs and Verification Testing. The number of working days established for completion of the work includes fifteen days for the required verification of the first mix design proposal. Should this proposal be disapproved, the contract time shall be extended, if requested, for no more than 15 working days for formulating one new mix design proposal and verification testing by the Agency. Additional contract time will not be granted for subsequent mix design proposals and associated verification testing.

Once a mix design proposal has been verified and approved by the Engineer, the costs associated with verification testing for subsequent mix design proposals requested by the contractor shall be borne by the contractor.

406-2.11 Acceptance of Materials.

(A) General. The contractor's attention is directed to the requirements of the Standard Specifications in Subsection 105-12 under Removal of Unacceptable and Unauthorized Work and Section 110, Corrective Requirements For Deficiencies. The Agency reserves the right to suspend the work should the following occur:

(1) Three or more consecutive Mixture Property or Compaction sample test results that are subject to pay adjustment(s).

(2) Five or more Mixture Property or Compaction sample test results that are subject to pay adjustments within any ten consecutive samples.

If the Agency elects to suspend the work for any of these conditions, the contractor shall either submit a revised mix design in accordance with Subsection 406-2.06, or submit an engineering analysis. The engineering analysis shall detail the course of action necessary to correct deficiencies in the contractor's present production methods such that further production can be accomplished without penalties. If approved by the Engineer, the revised mix design or course of action proposed in the engineering analysis, shall be implemented, and the work may continue. Costs or delays due to the provisions of this subsection are not compensable.

The acceptance of the mineral aggregate gradation, the asphalt cement content and the effective voids shall be determined on the basis of the tests specified herein. The Engineer will determine the variance from the stated values of each mix characteristic based on the measured value of each characteristic. The Engineer shall use this variance to determine the appropriate monetary pay adjustment, or action, from Section 110, to be applied to the deficient mix quantity.

The Engineer, at any time, may increase the frequency of sampling and testing.

(B) Mineral Aggregate Gradation in Asphaltic Concrete. For each 500 tons (*450 metric tons*) or portion thereof of asphaltic concrete, at least one sample of mineral aggregate will be taken. The Engineer will split the sample in half, saving one half of the sample for 15 days. Samples will be taken in accordance with the requirements of Arizona Test Method 105 on a random basis, just prior to the addition of asphalt cement, by means of a sampling device which is capable of producing samples which are

representative of the mineral aggregate. The device, which shall be approved by the Engineer, shall be furnished by the contractor. In any shift that the production of asphaltic concrete is less than 500 tons (*450 metric tons*), at least one sample will be taken.

Samples will be tested for conformance with the mix design gradation target values in accordance with the requirements of Arizona Test Method 201. When mineral admixture is required, gradation results will be adjusted to reflect this addition.

The sand equivalent will be determined by the Engineer in accordance with the requirements of AASHTO T 176. The percent of crushed faces will be determined in accordance with Arizona Test Method 212.

(C) Asphalt Cement Content and Effective Voids. For each 500 tons (*450 metric tons*) or portion thereof of asphaltic concrete, at least one sample of the asphaltic concrete will be taken on a random basis. The Engineer will split the sample in half, saving one half for 15 days. Samples will be taken in accordance with the requirements of Arizona Test Method 104, Section 2, or ASTM 3665 current on the date of bid award.

The asphalt cement content will be determined in accordance with the requirements of Arizona Test Method 421 or Interim Arizona Test Method 427, using an ignition furnace. The asphalt cement content obtained will be compared to the mix design target value.

Marshall density and maximum theoretical density shall be tested in accordance with the requirements of Arizona Test Method 416. Effective voids shall be determined in accordance with the requirements of Arizona Test Method 424, Section 2.

(D) Referee Testing. In the event the contractor elects to question the results obtained for a particular sample, the contractor may make a written request for additional testing of the sample within 15 days after the sample was obtained. The contractor may request additional testing for either the mineral aggregate gradation of the aggregate sample or the asphalt cement content and effective voids of the hot mix sample, or both. The additional testing shall be performed in an independent approved laboratory designated by the Engineer. The testing of the samples will be performed by the independent laboratory without knowledge of the specific project conditions such as the identity of the contractor or mix design laboratory, the test results obtained by the Agency or the mix design targets. The samples previously saved will be tested as specified in Subsection 406-2.11 (B) and (C). A new Total Pay Adjustment Amount will be determined for the sample. The results of the additional testing will be binding on both the contractor and the Agency. The Agency will pay for the testing;

however, if the dollar pay adjustment amount of the sample does not improve or is reduced, or the sample remains in reject, payment to the contractor for asphaltic concrete, after the application of all penalties shall be reduced by an amount equivalent to the cost of the testing.

406-3 CONSTRUCTION DETAILS

406-3.01 Quality Control. Quality control shall be the responsibility of the contractor. The Engineer reserves the right to obtain samples of any portion of any material at any point of the operations for testing.

406-3.02 Stockpiling. The contractor will not be allowed to feed the hot plant from stockpiles containing less than two full days of production, unless only two days production or less remain to be done or special conditions exist where the Engineer deems this requirement waived.

Mineral aggregate shall be separated and stockpiled so that segregation is minimized. Construction of stock piles shall conform to the requirements of Subsection 1006-2.06 (A) (1), (3) and (4).

406-3.03 Proportioning. Mixing plants shall conform to the requirements of AASHTO M 156, except as modified herein. The contractor shall provide documentation by calibration charts or other approved means that the mineral aggregate, asphalt cement and mineral admixture is being proportioned in accordance with the approved mix design.

If a mineral admixture is necessary to produce asphaltic concrete that meets the design criteria, the mineral admixture shall be mechanically mixed with the mineral aggregate prior to combining the mineral aggregate and asphalt cement. The Engineer may direct a spray of water be applied either to control the loss of the mineral admixture or to comply with any mix design requirements for set mixing of aggregate and admixture.

If a drum mix plant is used, the mineral admixture shall be added and thoroughly mixed by means of a mechanical mixing device prior to the mixture entering the drum drier. The mineral mixture shall be weighed across a weigh belt or an approved alternative weighing system, with a weigh totalizer prior to entry into the mechanical mixing device. The mechanical mixing device shall be a pugmill type mixer consisting of at least two motorized shafts with mixing paddles. The mixing device shall be designed such that the mixture of aggregate and admixture is moved in a near horizontal direction by the mixing paddles without the aid of conveyor belts for a distance of at least 3 feet (*1 meter*). Mixing devices which permit the aggregate to fall through mixing blades onto a belt or chute are not acceptable. The mixing device's rated capacity in tons per hour shall not be exceeded by the rate of aggregate feed to the mixer. The mixer shall be constructed to prevent the leakage of the contents. The mixer shall be situated in the aggregate delivery system at a location where the mixed material

can be readily inspected on a belt prior to entry into the drum. The mixing device shall be capable of effective mixing in the full range of asphaltic concrete production rates. If a batch plant is used, the mineral admixture shall be added and thoroughly mixed in the pugmill prior to adding asphalt cement.

The contractor shall furnish daily documentation to the Engineer that the required amount of mineral admixture has been incorporated into the asphaltic concrete.

A positive signal system and a limit switch device shall be installed in drum drier plants at the point of introduction of the admixture. The positive signal system shall be placed between the metering device and the drum drier, and utilized during production whereby the mixing shall automatically be stopped if the admixture is not being introduced into the mixture.

Unless specified in the mix design approved for the project, no fine material which has been collected in the dust collection system shall be returned to the mixture unless the Engineer, on the basis of tests, determines that all or a portion of the collected fines can be utilized. If the Engineer so determines, he will authorize, in writing, the utilization of a specific proportion of the fines; however, authorization will not be granted unless the collected fines are uniformly metered into the mixture.

Mineral aggregate, mineral admixture, and asphalt cement shall be proportioned by volume, by weight, or by a combination of volume and weight.

When mineral aggregate, mineral admixture, and asphalt cement are proportioned by weight, all boxes, hoppers, buckets or similar receptacles used for weighing materials, together with scales of any kind used in batching materials, shall be insulated against the vibration or movement of the rest of the plant due to the operation of any equipment so that the error in weighing with the entire plant operating shall not exceed two percent for any setting nor one and on-half percent for any batch. Bituminous material shall be weighed in a heated, insulated bucket suspended from a springless dial scale system.

When mineral aggregate, mineral admixture, and asphalt cement are proportioned by volume, the correct portion of each mineral aggregate size introduced into the mixture shall be drawn from the storage bins by an approved type of continuous feeder which will supply the correct amount of mineral aggregate in proportion to the asphalt cement and so arranged that the proportion of each mineral aggregate size can be separately adjusted. The continuous feeder for the mineral aggregate shall be mechanically or electrically actuated.

406-3.04 Drying and Heating. A recording pyrometer or other approved recording thermometric instrument sensitive to a rate of temperature change not less than 10° F (*-12 °C*) per minute shall be placed at the discharge chute of the drier so as to record automatically the temperature of the asphaltic concrete or mineral aggregate. A copy of the recording shall be available to the Engineer at the end of each shift.

The moisture content of the asphaltic concrete immediately behind the paver shall not exceed one percent. The moisture content will be determined in accordance with Arizona Test Method 406. Drying and heating shall be accomplished in such a manner as to preclude the mineral aggregate from becoming coated with fuel oil or carbon.

406-3.05 Mixing. The production of the plant shall be governed by the rate required to obtain a thorough and uniform mixture of the materials. Mixing shall continue until the uniformity of coating, when tested in accordance with the requirements of AASHTO T 195, is at least 95 percent.

A positive signal system shall be provided to indicate the low level of mineral aggregate in the bins. The plant will not be permitted to operate unless this signal system is in good working condition. Each bin shall have an overflow chute or a divider to prevent material from spilling into adjacent bins.

The temperature of asphaltic concrete upon discharge from the mixer shall not exceed 325° F (*165 °C*). If the asphaltic concrete is discharged from the mixer into a hopper, the hopper shall be constructed so that segregation of the asphaltic concrete will be minimized.

406-3.06 Placing and Finishing.

(A) General Requirements. The handling of asphaltic concrete shall at all times be such as to minimize segregation. Any asphaltic concrete which displays segregation shall be removed and replaced.

All wheels and tires of compactors and other equipment shall be wiped, when necessary, with an approved product in order to prevent the picking up of the asphaltic concrete.

Before asphaltic concrete is placed, the surface to be paved shall be cleaned of objectionable material, and a bituminous tack coast shall be applied, if directed by the Engineer.

A light coat of bituminous material shall be applied as directed to edges or vertical surfaces against which asphaltic concrete is to be placed.

The base or subgrade upon which the asphaltic concrete is to be placed shall be prepared in accordance with the applicable requirements for the material involved and maintained in a smooth and firm condition until placement. Asphaltic concrete shall not be placed on a frozen or excessively wet base or subgrade.

At any time, the Engineer may require that the work cease or that the work day be reduced in the event of weather conditions which would have an adverse effect upon the asphaltic concrete.

All asphaltic concrete shall be placed either as a leveling course or as a surfacing course. Leveling courses are defined as courses placed for the primary purpose of raising an existing paved or unpaved surface to a smooth plane. Surfacing courses are defined as courses placed to serve either as the traffic surface or as a surface upon which a finishing course or seal coat is to be placed.

The thickness of leveling and surfacing courses will be shown on the project plans. No change in thickness will be allowed without the written approval of the Engineer. When the plans indicate a leveling course or surfacing course thickness greater than 4 inches (*100 millimeters*), that course shall be placed in multiple lifts of equal thickness with no single lift having a compacted thickness of more than 4 inches (*100 millimeters*).

The contractor shall furnish a delivery ticket for each type of asphalt concrete used in the construction of any project. The minimum information to be shown on each delivery ticket shall be the ticket number, date, project name, truck number, truck tare weight, truck gross weight, net tons, time of loading, and type of mix by name. Contractor product code numbers will not preclude or be an acceptable substitute for this information. An authorized representative of the contractor shall be responsible for each delivery ticket and shall sign each delivery ticket accepting the contractor's responsibility for the asphaltic concrete. The contractor shall furnish the delivery ticket to the Engineer at the time of placement.

(B) Hauling Equipment. The mixture shall be transported from mixing plants to the work site in tight vehicles having clean, smooth beds.

The inside surface of the vehicles used for the transportation of plant mixes shall be lightly coated, just before the vehicles are loaded, with either a whitewash of lime and water, soap solutions or detergents, as approved by the Engineer.

After application, excess fluid shall be drained from the truck bodies.

(C) Loading Asphaltic Concrete into the Paving Machine. If the asphaltic concrete is dumped from the hauling vehicles directly into the paving machine from trucks, care shall be taken to avoid

jarring the machine or moving it out of alignment. No vertical load shall be exerted on the paving machines by the trucks. Trucks, while dumping, shall be securely attached to the paving machine.

If the asphaltic concrete is dumped upon the surface being paved and subsequently loaded into the paving machine, the loading equipment shall be self-supporting and shall not exert any vertical load on the paving machine. Substantially all of the asphaltic concrete shall be picked up and loaded into the paving machine.

(D) Placing and Finishing Asphaltic Concrete by Means of Self-Propelled Paving Machines. All courses of asphaltic concrete shall be placed and finished by means of self-propelled paving machines except under certain conditions or at certain locations where the Engineer deems the use of self-propelled paving machines impracticable.

In order to achieve, as far as practicable, a continuous operation, the speed of the paving machine shall be coordinated with the production of the plant.

Self propelled paving machines shall be provided with an activated screed or strike-off assembly. The machine shall be capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thicknesses shown on the plans. When screed extensions are permitted by the Engineer for placement of mainline pavement, such extensions shall be of the same design as the main screed. The screed or strike-off assembly shall be heated as necessary to produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture. When laying mixtures, the paver shall be capable of operating at forward speeds consistent with satisfactory placement of the mixtures.

Screeds shall include any strike-off device operated by tamping or vibrating action which is effective without tearing, shoving or gouging the mixture and which produces a course with a uniform texture and density for the full width being paved. Screeds shall be adjustable as to height and crown and shall be equipped with a controlled heating device for use when required.

Tapered sections not exceeding 8 feet (*2.4 meters*) in width, or widened sections not exceeding 4 feet (*1.2 meters*) in width may be placed and finished by other means as approved by the Engineer.

The mixture shall be laid upon an approved clean, dry surface, spread and struck off to the established grade and elevation. Approved bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable. Bituminous pavers shall be in the charge of an experienced operator.

If there are areas to be paved which are small and scattered, a paver may be dispensed with and the course spread by hand methods if approved by the Engineer. For such areas, the mixture shall be dumped, spread and leveled to give the required section and compacted thickness.

Before any rolling is started, the loose mat shall be checked, any irregularities adjusted, and all unsatisfactory material shall be removed and replaced.

(E)Automatically Actuated Control System. Except under certain conditions or at certain locations where the Engineer deems the use of automatic controls impracticable or unnecessary, all courses of asphaltic concrete shall be placed and finished by means of self-propelled paving machines equipped with an automatically actuated control system.

The system shall control the elevation of the screed at each end by controlling the elevation of one end directly and the other end indirectly, either through controlling the transverse slope or alternately, when directed, by controlling the elevation of each end independently.

The controls shall automatically adjust the screed and increase or decrease the mat thickness to compensate for irregularities that are in the surface being paved. The controls shall be capable of maintaining the proper transverse slope and be readily adjustable so transitions and super-elevated curves can be satisfactorily paved. The controls shall operate from suitable fixed or moving references as prescribed herein.

The transverse slope and longitudinal grade screed controls of the bituminous paver may be manually adjusted, where permitted by the Engineer, and according to the requirements specified herein.

The paving machine(s) shall be at the job site or locally available sufficiently ahead of the start of paving operations to allow for examination by the Engineer. Any paving machine found worn or defective either before or during its use shall be immediately repaired to the satisfaction of the Engineer or replaced.

The control system shall be capable of working with the following devices:

Ski-type device at least 30 feet (*9 meters*) in length, supported throughout its entire length.

Short ski.

500 feet (*150 meters*) of control line.

Joint matcher shoe.

When the control line is used it shall be set and maintained taut by the contractor to the grade and alignment established by the Engineer.

Failure of the control system to function properly shall be cause for the suspension of the asphaltic concrete operations if so directed by the Engineer.

406-3.07 Joints. The finished pavement at all joints shall comply with the surface smoothness requirements, specified in Subsection 406-3.10, when tested with a straightedge placed across the joint, and exhibit the same uniformity of texture and compaction as other sections of the course.

The placement of successive courses shall be such that all joints are offset at least 6 inches (*150 millimeters*) from the joint of the lower pavement course, unless otherwise approved by the Engineer.

(A) Transverse. The placement of the courses shall be as continuous as possible to limit the number of transverse joints. The transverse joints in adjacent lanes shall be staggered a minimum of 10 feet (*3 meters*). The transverse joint shall be formed by cutting back on the previous run to expose the full depth of the course. The exposed edge of the existing course that will become part of the joint shall be the full thickness of the course, straight and vertical. The joint shall be formed by using a power driven saw or other approved apparatus to cut, in a neat line, the cold existing pavement course to its full thickness to expose a fresh face.

(B) Longitudinal. Placement of the surface course shall be carefully planned to assure that the longitudinal joints in the surface course will correspond with the edges of proposed traffic lanes. Other joint arrangements will require approval of the Engineer. When traffic is maintained on the roadway during paving operations, the mixture shall be laid such that no more than 100 feet (*30 meters*) of the pavement edge will be exposed at the end of the working day. The Engineer may permit an exposed edge of this type in excess of 100 feet (*30 meters*) providing that the edge is adequately protected against damage by vehicles and equipment.

Joints shall be vertical, formed by a slope shoe or hot lapped, and shall be compacted while the mixture is still hot.

The placement of longitudinal joints in successive courses shall be such that joints are offset at least one foot (*300 millimeters*) from the joint of the immediate underlying pavement course, unless otherwise approved by the Engineer.

406-3.08 Compaction.

(A) Temperature Requirements. Asphaltic concrete placed in nominal thicknesses of 1-1/2 inch (*38 millimeters*) or less shall be placed only when the temperature of the surface on which the

asphaltic concrete is to be placed is at least 65° F (*18 °C*). Asphaltic concrete immediately behind the laydown machine shall be a minimum of 250° F (*120 °C*).

Asphaltic concrete placed in nominal thicknesses greater than 1-1/2 inches (*38 millimeters*) shall be placed only when the ambient temperature is at least 40° F (*5 °C*) and rising. Placement shall be stopped when the ambient temperature is below 45° F (*7 °C*) and falling. Asphaltic concrete immediately behind the laydown machine shall be a minimum of 250° F (*120 °C*).

(B)Equipment. Compacting and smoothing shall be accomplished by the use of self-propelled equipment. Compactors shall be pneumatic tired and/or steel wheel.

The rollers shall be in good mechanical condition, and capable of operating at speeds slow enough to avoid displacement of the mixture. The number and weight of rollers shall be sufficient to satisfactorily compact the mixture while it is still in a workable condition. The use of equipment which results in excessive crushing of aggregate will not be permitted. Vibratory rollers shall be of a type that are specifically designed for the compaction of bituminous concrete.

Compactors shall be operated in accordance with the manufacturer's recommendations. Compactors shall be designed and properly maintained so that they are capable of accomplishing the required compaction.

Static steel wheel compactors used on mainline paving shall weigh not less than eight tons (*7.25 metric tons*).

Pneumatic tired compactors shall be the oscillating type with at least seven pneumatic tires of equal size and diameter. Wobble-wheel compactors will not be permitted. The tires shall be spaced so that the gaps between adjacent tires will be covered by the following tires. The tires shall be capable of being inflated to 90 pounds per square inch (*620 kilopascals*) and maintained so that the air pressure will not vary more than five pounds per square inch (*35 kilopascals*) from the designated pressure. Pneumatic tired compactors shall be constructed so that the total weight of the compactor will be varied to produce an operating weight per tire of not less than 5,000 pounds (*2270 kilograms*). Pneumatic tired compactors shall be equipped with skirt-type devices mounted around the tires so that the temperature of the tires will be maintained during the compaction process.

(C)General Requirements. Immediately after the bituminous mixture has been spread, struck off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. The surface shall be rolled when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking or shoving. When the compaction procedure used by the contractor fails to produce results acceptable to the Engineer,

the procedure shall be adjusted to obtain the desired results. Rollers shall move at a slow and uniform speed in accordance with the manufacturers recommendations.

Any displacement occurring as a result of the reversing of the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture as required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture. To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with small quantities of detergent or other approved material, but in no case shall a solvent having any affect upon the bituminous pavement be used.

Along forms, curbs, headers, walls and other areas not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers as directed by the Engineer.

Suitable means shall be provided to keep pavers and other equipment and tools free from bituminous accumulations. The surface of the pavement shall be protected from drippings of oil, kerosene, or other materials used in paving and cleaning operations.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh hot mixture which shall be compacted to conform with the surrounding area. Any area showing the excess of deficiency of bituminous material shall be corrected to the satisfaction of the Engineer.

(D)Rolling Method Procedure. For courses of 1-1/2 inches (*38 millimeters*) or less in nominal thickness, compaction shall consist of an established sequence of coverage using specified types of compactors. A pass shall be defined as one movement of a compactor in either direction. Coverage shall be the number of passes necessary to cover the entire width being paved.

The rolling sequence, the type of compactor to be used and the number of coverages required shall be as follows:

Rolling Sequence	Type of Compactor Option		No. of Coverages Option	
	No. 1	No. 2	No. 1	No. 2
Initial	Static Steel	Vibrating Steel	1	1
Intermediate	Pneumatic Tired	Vibrating Steel	4	2-4*
Finish	Static Steel	Static Steel	1-3	1-3

* Based on the roller pattern which exhibits the best performance.

The Engineer shall select the option for compaction and, when pneumatic tired compactors are used, will verify, the tire pressure is in accordance with the manufacturer's recommendations.

When option No. 1 is used, one pneumatic tired roller shall be furnished for each 300 tons (*275 metric tons*) of asphaltic concrete placed per hour.

Steel wheel compactors shall not be used in the vibratory mode for courses of 1 inch (*25 millimeters*) or less in nominal thickness nor when the temperature of the asphaltic concrete falls below 180° F (*80 °C*).

Initial and intermediate compaction shall be completed before the temperature of the asphaltic concrete falls below 200° F (*95 °C*). All edges shall be rolled by a method approved by the Engineer.

Compaction will be deemed to be acceptable on the condition that the asphaltic concrete is compacted using the type of compactors specified, ballasted and operated as specified and with the number of coverages of the compactors as specified.

(E)Compaction Control. Compaction control for courses greater than 1 1/2 inches (*38 millimeters*) in nominal thickness shall be defined as the responsibility of the contractor, and shall be based on the anticipated rate of production and placement to determine the number and types of compactors and the sequence and manner in which they are to be used to achieve the specified density.

Responsibility for compaction control shall rest solely with the contractor.

Compaction shall be determined from samples taken utilizing mechanical coring equipment in accordance with the requirements of Arizona Test Method 104, Section 3. Cores shall be a minimum of four inches in diameter. The core samples shall be tested for acceptance in accordance with the requirements of Arizona Test Method 415. Compaction of a course shall continue until the compacted density of the Asphaltic Concrete achieves a minimum of 95 percent of the laboratory compacted density as determined by Arizona Test Method 410a. The laboratory density shall be the average of the laboratory densities determined from samples taken from the same days production.

Compaction, other than finish rolling, shall be completed before the temperature of the asphaltic concrete falls below 200° F (*95 °C*). All edges shall be rolled by a method approved by the Engineer.

406-3.09 Compacting Miscellaneous Items and Surfaces. Asphaltic concrete used in the construction of curbs, spillways, and spillway inlets, ditches, catch basin entrances, median strips, sidewalks or other similar miscellaneous items or surfaces shall

be compacted using compactors, hot hand tampers, smoothing irons, mechanical vibrating hand tampers or with other devices to the extent considered necessary by the Engineer.

406-3.10 Surface Requirements and Tolerances. All courses of asphaltic concrete shall be compacted as required, smooth and reasonably true to the required lines, grades, and dimensions.

Leveling course surfaces shall not vary more than 1/4 inch (*6 millimeters*) from the lower edge of a 10 foot (*3 meter*) straightedge when the straightedge is placed parallel to the center line of the roadway.

Surfacing course surfaces shall not vary more than 1/8 inch (*3 millimeters*) from the lower edge of a 10 foot (*3 meters*) straightedge when the straightedge is placed parallel to the center line of the roadway, nor shall the surface vary more than 1/4 inch (*6 millimeters*) on any portion of the pavement surface when a 10 foot (*3.0 meters*) straightedge is placed transverse to the center line.

406-4 METHOD OF MEASUREMENT

Asphaltic concrete will be measured by the ton (m*etric ton*) for mainline paving and by either the ton (*metric ton*) or the square yard (*square meter*) for miscellaneous areas of paving as noted in the bidding schedule, for the specific use listed therein. When measured on the basis of tonnage (*metric tonnage*), such measurement will be for asphaltic concrete actually used, complete-in-place, and shall include the weight of mineral aggregate, asphalt cement, and approved admixtures.

Measurement, as provided above, will include asphaltic concrete used in the construction of intersections, turnouts, driveways, median strips, sidewalks, bike paths or other miscellaneous items or surfaces.

406-5 BASIS OF PAYMENT

The accepted quantities of asphaltic concrete, measured as provided above, will be paid for under the appropriate bid items at the contract unit price, complete-in-place.

Should testing determine the asphalt cement deficient in meeting the requirements specified in Section 1005 of the Standard Specifications, the asphaltic concrete, representing the half-shift or half-shifts in which such a deficient material was utilized, shall be evaluated as to acceptance in accordance with the requirements of Subsection 110-2.03.

Deficiencies in mineral aggregate gradation, asphalt cement content, asphaltic concrete thickness or compaction will be evaluated in accordance with the criteria established in Subsection 110-2.

SECTION 410

ASPHALT-RUBBER STRESS-ABSORBING MEMBRANE

410-1 DESCRIPTION

The work under this section shall consist of furnishing asphalt-rubber (vulcanized) or asphalt-rubber (reclaimed high natural), tack coat and cover material and applying the materials in accordance with the details shown on the project plans and the requirements of these specifications.

410-2 MATERIALS

410-2.01 Tack Coat. Asphalt for tack coat shall be either Asphalt Cement or Emulsified Asphalt, Grade CRS-2.

Asphalt cement shall conform to the requirements of Table 1005-1 for either Asphalt Cement PG 70-10 or the same grade specified for the asphalt-rubber membrane.

Emulsified Asphalt, Grade CRS-2 shall conform to the requirements of Table 1005-2.

410-2.02 Asphalt-Rubber. Asphalt-Rubber shall conform to the requirements of Section 1009.

410-2.03 Cover Material. Cover material shall conform to the requirements of Subsection 404-2.02 (C) and the bulk specific gravity shall be a maximum of 2.9 as determined in accordance with the requirements of AASHTO T 85.

410-3 CONSTRUCTION DETAILS

410-3.01 General. All equipment used to mix and apply asphalt-rubber material shall meet the requirements specified under Subsection 404-3.02 (A) of the specifications. The equipment shall also be capable of maintaining a uniform, homogeneous mixture throughout the operation.

Equipment used to combine asphalt-rubber, extender oil, and kerosene shall be so designed and accessible that the Engineer can readily determine the percentage, by weight, of each of the materials being incorporated into the mixture.

410-3.02 Asphalt-Rubber (Vulcanized). The proportions of asphalt and rubber, by weight, shall be 78 percent plus or minus percent asphalt and 22 percent plus or minus 1 percent rubber.

The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semi-fluid material. The temperature of the asphalt at the time rubber is added shall be between 350° F (*175 °C*) and 450° F (*235 °C*). The necessary reaction time required to achieve this semi-fluid state is a time-temperature relationship.

The use of kerosene or other solvents to obtain optimum spraying and wetting viscosity is not permitted unless otherwise approved by the Engineer.

410-3.03 Application of the Asphalt-Rubber Stress-Absorbing Membrane. The existing pavement shall be cleaned in accordance with the requirements of Subsection 404-3.04.

After cleaning and prior to the application of the membrane, the existing pavement surface shall be treated with a tack coat as hereinbefore specified.

Placement of the asphalt-rubber membrane shall be made only when all of the following conditions are met:

(1) The ambient air temperature is above 65° F (*18 °C*).

(2) The pavement is absolutely dry, and

(3) The wind conditions are such that a satisfactory membrane can be achieved.

(4) All construction equipment such as asphalt rubber distributor, aggregate spreader, haul trucks with cover material, and rollers are in position and ready to commence placement operations.

The distributor shall be capable of spreading the asphalt-rubber mixture in accordance with the tolerances specified in Subsection 404-3.02 (A) except that the maximum deviation from the specified rate shall not exceed 0.05 gallon per square yard (*0.25 liters per square meter*).

After reaching the proper consistency, application of the material shall proceed immediately and in no case shall the material be held at a temperature over 350° F (*175 °C*) for vulcanized or 400° F (*205 °C*) for reclaimed high natural for more than three hours after reaching the proper consistency.

The hot asphalt-rubber mixture shall be applied at the rate of approximately 0.55 plus or minus 0.05 gallon per square yard (*2.5 ± 0.25 liters per square meter*) (based on a unit weight of 7-1/2 pounds per hot gallon (*0.9 kilograms per liter*); however, the Engineer will specify the exact rate based on existing surface conditions.

All transverse joints shall be made by placing building paper over the end of the previous application, and the joining application shall start on the building paper. Once the application process has progressed beyond the paper, the paper shall be disposed of as directed by the Engineer.

All longitudinal joints shall be lapped approximately 4 inches (*100 millimeters*).

Traffic shall not be permitted on the asphalt-rubber membrane prior to the application of cover material.

410-3.04 Application of Cover Material. Cover material shall be applied in accordance with the requirements of Subsection 404-3.06.

Cover material shall be immediately and uniformly spread over the freshly applied asphalt-rubber at the rate of approximately 0.014 cubic yard per square yard (*0.013 cubic meters per square meter*); however, the actual rate of application will be determined by the Engineer.

Cover material shall be precoated with 0.40 percent to 0.60 percent PG 64-10, by weight, and have a minimum temperature of 250° F (*120 °C*) when delivered to the job site. The end result shall be a thoroughly and uniformly coated, dust free material.

410-3.05 Rolling. At least three pneumatic rollers conforming to the requirements of Subsection 406-3.08(B) shall be provided to accomplish the required rolling, except that the minimum air pressure in each tire shall be 100 pounds per square inch (*690 kilopascals*).

A sufficient number of rollers shall be furnished to cover the width of the spread on the first pass. It is imperative that the first pass be made immediately behind the spreader and if the spreading is stopped for any reason, the spreader shall be moved ahead so that all cover material may be immediately rolled. The rolling shall continue until a minimum of four complete coverages have been made. Final rolling shall be completed in accordance with the following criteria:

Existing Pavement Temperature	**Complete Rolling Within**
100° F (*38 °C*) and above	1 Hour
between 65° and 100° F (*18-38 °C*)	30 Minutes
65° F (*18 °C*) and below	15 Minutes

410-3.06 Traffic. Traffic of all types shall be kept off the stressabsorbing membrane until it has had time to set properly. The minimum traffic free period shall not be less than three hours. However, when it is absolutely necessary that hauling equipment or piloted traffic travel on the newly applied membrane, the speed shall not exceed 15 mph (*25 kilometers per hour*). Stress-absorbing membrane operations shall be scheduled so that the normal flow of traffic will be resumed before sunset.

410-3.07 Removing Loose Cover Material. Loose cover material shall be removed in accordance with the requirements of Subsection 404-3.11. Sweeping shall be completed and all excess cover material removed prior to the placement of any subsequent layers of asphaltic concrete.

410-3.08 Placement of Asphaltic Concrete. If the asphalt-rubber membrane has been subjected to traffic, a tack coat, as hereinbefore specified, shall be applied at the rate of approximately 0.06 gallon per square yard (*0.25 liters per square meter*) prior to placement of the asphaltic concrete.

410-4 METHOD OF MEASUREMENT

Asphalt rubber will be measured by the ton (*metric ton*) of asphalt-rubber mixture placed in accordance with the requirements of these specifications.

Cover material will be measured by the cubic yard (*cubic meter*). Cover material will be weighed and the amount in tons (*metric tons*) of dry material will be converted to cubic yards (*cubic meters*). The weight per cubic foot (*cubic meter*) will be determined in accordance with the requirements of AASHTO T 19, Shoveling Procedure. The weight of all moisture contained in the cover material will be deducted prior to the conversion of the weight in tons (*metric tons*) to the volume in cubic yards (*cubic meters*).

Bituminous tack coat will be measured in accordance with the requirements of Section 404.

410-5 BASIS OF PAYMENT

The accepted quantity of asphalt-rubber, measured as provided above, will be paid for at the contract unit price for the asphalt-rubber mixture complete-in-place, including asphalt cement, rubber, and required extender oil, kerosene or calcium carbonate.

The accepted quantity of cover material, measured as provided above, will be paid for at the contract unit price, complete-in-place, including rolling and removal and disposal of loose cover material.

The accepted quantities of bituminous tack coat will be paid for in accordance with the requirements of Section 404.

The bidding schedule reflects a quantity of bituminous tack coat based on two applications of Emulsified Asphalt, Grade CRS-2 at the specified rate. No adjustment in the contract unit prices will be made because of a variation in the quantities actually required to complete the work.

SECTION 412

PAVEMENT FABRIC INTERLAYER

412-1 DESCRIPTION

The work under this section shall consist of furnishing and placing a pavement fabric and applying an asphaltic binder coat between pavement layers or beneath a pavement overlay to provide a waterproof and stress relieving membrane within the pavement structure, in accordance with the details shown on the project plans and the requirements of these specifications.

412-2 MATERIALS

412-2.01 Pavement Fabric. The pavement fabric shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-2.

412-2.02 Asphalt Binder Coat. The asphalt binder coat is used to bond or tack the fabric to the pavement and perform a sealant function, providing a barrier to moisture infiltration. The bituminous material for the binder coat shall be an asphalt cement conforming to the requirements of Section 1005. The grade to be used shall be PG 64-16 or PG 70-10 as directed by the Engineer. The use of cutback or emulsion asphalts will not be allowed.

412-2.03 Blotter Material. Blotter material shall meet the requirements of Section 404-2.02(B).

412-2.04 Fabric Packaging, Handling and Storing. The identification, packaging, handling and storing of the geotextile fabric shall be in accordance with ASTM D 4873. Fabric rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Rolls will be stored on the site or at another identified storage location in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. At no time, shall the fabric be exposed to ultraviolet light for a period exceeding 7 days.

412-3 CONSTRUCTION REQUIREMENTS

412-3.01 Weather Limitations. Neither the asphalt binder coat nor fabric shall be placed when weather conditions, in the opinion of the Engineer, are not suitable. For placement of the asphalt binder coat, the minimum air and pavement temperature shall be 50° F (*10 °C*) and rising. Air and pavement temperature shall also be sufficient to allow the asphalt binder coat to hold the fabric in place.

412-3.02 Equipment.

(A) Asphalt Distributor Truck. The asphalt distributor truck shall meet the minimum requirements of Section 404-3.02(A). The asphalt distributor truck shall be capable of spraying the asphalt binder coat at the application rate as approved by the Engineer. No streaking, skipping or dripping will be permitted. The distributor truck shall also be equipped with a hand spray attachment having a single nozzle and positive shut-off valve.

(B) Fabric Handling Equipment. Mechanical or manual laydown equipment shall be capable of laying the fabric smoothly.

(C) Miscellaneous Equipment. Stiff bristle brooms or squeegees to smooth the fabric, scissors or blades to cut the fabric, and brushes for applying asphalt at fabric overlaps shall be provided. Pneumatic rolling equipment to smooth the fabric into the asphalt binder, sanding equipment to apply a blotter sand, and brooming equipment may be required by the Engineer to improve the installation procedure. Refer to Sections 404-3.02(B), (C), and (D) for equipment requirements.

412-3.03 Surface Preparation. The pavement surface on which the fabric is to be placed shall be cleaned to remove all dirt, water, oil and vegetation or debris.

412-3.04 Application of Asphalt Binder Coat. The asphalt binder coat shall be uniformly spray applied to the prepared dry pavement surface by means of the asphalt distributor truck at the rate of 0.25 gallons per square yard (*1.15 liters per square meter*) or as recommended by the fabric manufacturer and as approved by the Engineer. Some underlying surfaces may require a higher or lower application rate. A test strip may be necessary to determine the proper application rate.

Application of the asphalt binder coat shall be primarily by the distributor truck spray bar with hand spraying kept to a minimum. Temperature of the asphalt binder coat shall be sufficiently high to permit a uniform spray pattern. The minimum temperature of asphalt in the distributor tank shall be 290° F (*145 °C*). However, to avoid damage to the fabric, the asphalt temperature in the tank shall not exceed 325° F (*165 °C*).

The target width of the asphalt binder application shall be the width of the pavement fabric plus 6 inches (*150 millimeters*). The asphalt binder shall be applied only as far in advance of the fabric installation as is appropriate to insure a tacky binder surface at the time of the fabric placement. Fabric shall be placed the same workshift as the asphalt binder coat is applied. Traffic shall not be allowed on the asphalt binder coat. Excess asphalt or spills shall be cleaned from the road surface to avoid flushing and fabric movement.

412-3.05 Fabric Placement. The fabric shall be placed, with the heat bonded side up, on the asphalt binder coat using mechanical or manual laydown equipment capable of providing a smooth installation of the fabric with a minimum amount of wrinkling or folding. Placement of the fabric will take place prior to the time when the asphalt binder coat has cooled enough to start losing its tackiness. Wrinkles or folds which remain in the fabric and are large enough to be folded over 1/2 inch (*13 mm*) or more shall be slit and laid flat into the binder coat. Slit folds or wrinkles shall be shingle-lapped in the direction of the paving operation. Brooming and/or pneumatic rolling will be required to maximize fabric contact with underlying pavement surface.

Overlap of fabric joints shall be a minimum of 3 inches (*75 mm*) to insure full closure of the joint, but shall not exceed 6 inches (*150 mm*). Transverse joints shall be lapped in the direction of paving to prevent edge pickup by the paver. Longitudinal joints shall be located in the same manner as normal pavement joints according to Subsection 406-3.07. A second application of hand-placed asphalt binder may be required at laps and repairs as determined by the Engineer to ensure proper binding of the narrow double fabric layer.

All areas with fabric placed shall be paved the same workshift. No vehicles or equipment except necessary construction equipment as approved by the Engineer and emergency vehicles will be allowed to drive on the fabric.

Removal and replacement of any fabric that is damaged will be the responsibility of the contractor.

412-3.06 Application of Blotter Materials. Blotter material may be spread over asphalt-saturated fabric, if approved by the Engineer, to facilitate movement of equipment during construction or to prevent tearing or delamination of the fabric. If blotter sand is applied, excess quantities shall be removed from the fabric prior to placing the asphaltic concrete.

412-3.07 Placement of Asphalt Concrete. All areas where fabric has been placed shall be paved with asphaltic concrete during the same workshift. Placement of the asphaltic concrete shall closely follow fabric lay down. The temperature of the asphaltic concrete when delivered shall not exceed 325° F (*165 °C*). In the event that asphalt binder coat bleeds through the fabric causing construction problems before the overlay is placed, the affected areas shall be blotted by spreading blotter sand. Excess sand shall be removed before beginning the paving operation. In the event of a rainfall on the fabric prior to the placement of asphaltic concrete, the fabric must be allowed to dry completely before the asphalt concrete is placed. To avoid movement or damage to the fabric during the paving operation, the turning of the paver and other vehicles shall be gradual and kept to a minimum.

412-4 METHOD OF MEASUREMENT. The pavement fabric interlayer will be measured by the square yard (*square meter*) in-place.

Bituminous material that is required for the asphalt binder coat will be measured by the ton (*metric ton*).

Time to apply the asphalt binder coat is defined as the hours within a workshift that an approved distributor truck containing the specified bituminous material is required by the Engineer to be at the work site.

The time which is required to apply the asphalt binder coat will be measured to the nearest hour for the actual number of hours required in any one workshift; however, when the time required is less than four hours in any work day, the time will be measured as four hours.

412-5 BASIS OF PAYMENT. The accepted quantities of pavement fabric, measured as provided above, will be paid for at the contract unit price per square yard (*square meter*) which price shall be full compensation for furnishing all labor, materials, and equipment, and preforming all operations in connection with placing the pavement fabric interlayer as shown on the project plans and as specified and described herein.

The accepted quantities of bituminous material for the asphalt binder coat complete-in-place, measured as provided above, will be paid for at the contract unit price per ton (*metric ton*), except that adjustments in the contract unit price, in accordance with the provisions of Table 110-3, will be made for the quantity of material represented by test samples whose test results fall within the deviation ranges shown in Table 110-3.

Payment for all measures necessary to direct and escort traffic through the area where the pavement fabric is being placed will be made as specified under Section 701.

No measurement or direct payment will be made for pneumatic rolling or brooming which is required or directed by the Engineer.

No measurement or direct payment will be made for furnishing, applying and removing sand blotter material which may be required by the Engineer.

The accepted quantity of time to apply the asphalt binder coat, measured as provided above, will be paid for at the contract unit price per hour, which payment shall be full compensation for applying the asphalt binder coat.

SECTION 501

DRAINAGE PIPE

501-1 DESCRIPTION

The work under this Section shall consist of furnishing and installing drainage pipe and all other materials required for the installation of drainage pipe, including excavating, and furnishing, placing and compacting backfill material, all in accordance with the details shown on the plans and the requirements of these specifications.

Drainage pipe is comprised of pipe culverts and storm drain pipe.

At each location where a pipe is to be installed, the project plans will specify the size and approximate length along with the requirements for each approved option at that location, such as wall thickness, corrugation configuration, coatings, lining, class and strength.

The contractor shall furnish and install the pipe specified at each such location. When the plans provide for an option, only one kind and material, selected from the options shown, shall be used. All contiguous pipe and all metal pipe in close proximity shall be of the same kind and material. Special sections, fittings, elbows, branch connections, tapered inlets, end sections, connectors, coupling, and other such items shall be of the same material and coating as the pipe to which they are attached.

All trenching shall comply with Occupational Safety and Health Administration (OSHA) regulations. The contractor shall submit, in writing to the Engineer, a detailed description of the proposed trenching operations, including shoring methods, prior to the commencement of construction.

Bedding material and shading material shall conform to the requirements of these specifications. Placement and compaction requirements for bedding material and shading material shall conform to the requirements of this Section unless otherwise noted on the plans or in the Special Provisions.

501-2 MATERIALS

501-2.01 Drainage Pipe.

(A) All Drainage Pipe Except Nonreinforced, Cast-In-Place. Except for nonreinforced, cast-in-place concrete pipe, materials for drainage pipe shall conform to the requirements of Subsection 1010-2.

(B) Nonreinforced, Cast-In-Place Drainage Pipe. Concrete for constructing cast-in-place concrete drainage pipe shall conform to the requirements of Section 1006 for Class S concrete, except as specified herein.

Class S concrete shall have a minimum compressive strength of 3000 pounds per square inch (20.68 *mega pascals*) at 28 days.

The proposed slump in the mix design furnished by the contractor shall be the minimum required to permit proper placement of the concrete without harmful segregation, bleeding or incomplete consolidation.

The maximum size of the coarse aggregate for pipe 48 inches (*1220 millimeters*) or less in diameter shall be 1 inch (*25 millimeters*) and for pipes larger than 48 inches (*1220 millimeters*) in diameter shall be 1-1/2 inches (*38 millimeters*).

(C) Other Pipe Types and Materials. Materials for drainage pipe types and uses other than those noted above shall be as specified in the Special Provisions or as noted on the plans.

(D) Filter Material. Filter material shall conform to the gradation requirements for fine aggregate in Section 1006.

501-2.02 Concrete for Pipe Encasement. Portland cement concrete for pipe encasement shall conform to the requirements found in Section 1006 for Class B concrete.

501-2.03 Controlled Low Strength Material (CLSM). Materials comprising the controlled low strength material shall conform to the requirements of Section 1006. CLSM mix designs shall be in accordance with Table 501-1 unless otherwise designated on the plans, in the Special Provisions or directed by the Engineer.

TABLE 501-1

Mix Proportions For Controlled Low Strength Material

	CLSM No.1	CLSM No.2	CLSM No.3
Compressive Strength, 28 day psi (*megapascals*)	50 (*0.34*)	500 (*3.4*)	1000 (*6.9*)
Portland Cement, pounds (*kilograms*)	60 (*27.2*)	190 (*86.2*)	280 (*127.0*)
Water, pounds (*kilograms*)	475 (*215.5*)	460 (*208.6*)	440 (*199.6*)
Fly Ash, pounds (*kilograms*)	290 (*131.5*)	300 (*136.0*)	300 (*136.0*)
Fine Aggregate, pounds (*kilograms*)	2,770 (*1256.5*)	2,680 (*1215.6*)	2,650 (*1202.0*)

501-2.04 Bedding Material. Aggregate for bedding material shall conform to the following gradation requirements:

Sieve Size	Percent Passing
1½ inch (*37.5 mm*)	100
1 inch (*25.0 mm*)	90-100
No. 8 (*2.36 mm*)	35-80
No. 200 (*75 μm*)	0- 8

The plasticity index shall not exceed 8 when tested in accordance with the requirements of AASHTO T 90.

Bedding material used for pipes, pipe-arches or arches made of metal shall have a value of resistivity not less than 2000 ohm-cm or the value shown on the project plans, whichever is less. When resistivity is not shown on the plans, the bedding material shall have a resistivity not less than that of the existing in-place material or 2000 ohm-cm, whichever is less.

Bedding material shall have a pH value between 6.0 and 10.0, inclusive, for all metal pipe installations except aluminum. Bedding material for aluminum pipe installations shall have a pH value between 6.0 and 9.0 inclusive.

Bedding material shall have a pH value between 6.0 and 12.0, inclusive for all concrete or plastic pipe installations. Tests for pH and resistivity shall be in accordance with the requirements of Arizona Test Method 236.

501-2.05 Shading Material. Aggregate for shading material shall conform to the following gradation requirements:

Sieve Size	Percent Passing
3 inch (*75 mm*)	100
3/4 inch (*19.0 mm*)	60-100
No. 8 (*2.36 mm*)	35-80
No. 200 (*75 μm*)	*

* The total sum of the percent passing the No. 200 sieve and the plasticity index (P.I.) shall not exceed 25.

Shading to be used for pipes, pipe-arches or arches made of metal shall have a value of resistivity not less than 2000 ohm-cm or the value shown on the project plans. Shading shall have a pH value between 6.0 and 9.0, inclusive for all metal pipe installations. Shading shall have a pH value between 6.0 and 12.0 for all concrete or plastic pipe installations. Tests for pH and resistivity shall be in accordance with the requirements of Arizona Test Method 236.

501-2.06 Trench Backfill Material. Trench backfill material for drainage pipe shall not contain organic material, rubbish, debris and other deleterious material and shall not contain solid material which exceeds 8 inches (*200 millimeters*) in greatest dimension and shall be soil selected from excavation or from a source selected by the contractor.

501-3 CONSTRUCTION DETAILS

501-3.01 Preparation of Foundations, Trenches, and Embankments. Trenches for drainage pipe installations shall be in conformance with the Standard Details unless otherwise noted on the plans or in the Special Provisions.

A trench condition is defined as a trench which has vertical slopes to a point at least 1 foot (*300 millimeters*) above the top of the pipe and its maximum width is as detailed on the standard details or contract plans.

Unless specified otherwise, the contractor may install drainage pipe in either a nontrench condition or a trench condition in natural ground or in embankment.

Where rock, hardpan, or other unyielding material is encountered, such material shall be removed below the vertical limits as shown on the plans. The depth to be removed shall be at least 12 inches (*300 millimeters*) or as designated by the Engineer. The width to be removed shall depend on whether a trench or nontrench condition exists. If a trench condition exists, the width of the trench, as shown on the standard details or project plans, shall be maintained throughout the additional depth. If a nontrench condition exists, the width of the removal shall be a minimum of the outside diameter of the pipe plus 2 feet (*600 millimeters*) for pipe under 4 feet (*1220 millimeters*) in diameter, or a minimum of the outside diameter of the pipe plus 3 feet (*900 millimeters*) for pipe of 4 feet (*1220 millimeter*) or more in diameter. The over excavated area shall be backfilled with structure backfill material as designated in subsection 203-5.02 and compacted in layers not exceeding 6 inches (*150 millimeters*) in depth.

When a firm foundation is not encountered at the bottom of the vertical limits as shown on the plans due to soft, spongy, or other unstable soil, such unstable soil shall be removed for a width of at least the horizontal outside dimension of the pipe on each side of the pipe and to the depth specified by the Engineer. The unstable soil removed shall be replaced with structure backfill material as designated in Subsection 203-5.02 and compacted in layers not exceeding 6 inches (*150 millimeter*) in depth.

The completed foundation shall be firm for its full length and width. When specified on the project plans, the foundation shall have longitudinal camber of the magnitude specified.

The maximum length of open trench for all installations, except nonreinforced, cast-in-place pipe, shall be 500 lineal feet (*150 meters*) or the contractor's daily installation length, whichever is greater.

501-3.02 Bedding.

(A) Placement of Bedding Material. All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the area into which bedding material is to be placed.

Bedding material shall be placed in uniform horizontal layers not exceeding 8 inches (*200 millimeters*) in depth before compaction.

Bedding material shall be placed under and around the pipe to the elevation at the point of maximum width of the pipe (springline), as shown on the plans or as noted on the Standard Details. At the contractor's option, bedding material may be placed above the springline of the pipe.

Bedding material shall be placed in a manner which will prevent distortion, damage to, or displacement of the pipe from its intended location. Bedding material shall also be placed so that adequate support will be provided in the haunch support areas for the pipe. Voids or loose soils which are found to occur due to improper placement or compaction of bedding materials will result in rejection of that portion of the pipe installation. Replacement of the pipe will be at the contractor's expense.

(B) Compaction of Bedding Material. Bedding material shall be compacted to at least 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Compaction of bedding material shall be performed without damage to the pipe and surrounding in-place material. Special care shall be taken in placing, shaping and compacting all bedding material under haunches of pipe to prevent moving the pipe or raising it from its bedding.

Water jetting shall not be allowed for the compaction of bedding material.

501-3.03 Installation of Drainage Pipe.

(A) General. Drainage pipe shall be handled carefully. Proper facilities shall be provided for handling and lowering the sections of pipe. All pipe which show defects due to negligence or rough handling shall be removed and replaced if so ordered by the Engineer. If damaged galvanized steel pipe is not replaced it shall be repaired in accordance with the requirements of AASHTO M 36/M 36M. Damage to the coating of bituminous coated pipe shall be repaired using material conforming to the requirements of AASHTO M 190.

Drainage pipe shall be installed in reasonably close conformity with the lines, grades and dimensions shown on the project plans or specified by the Engineer.

Prior to staking of pipe culverts, an assessment of the typical flow of the drainage shall be made. The results of this assessment may require a change in the length, alignment or location of the pipe as approved by the Engineer to attain the optimum placement of the pipe. Pipe profiles shall be approved by the Engineer prior to installation.

Unless otherwise permitted by the Engineer, the installing of drainage pipe shall begin at the downstream end and progress upstream.

Pipe joints and joint materials shall conform to these specifications, the recommendation of the manufacturer for the type of pipe specified, or shall be approved by the Engineer as providing a secure and/or waterproof joint.

Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream.

Helical corrugated pipe shall be installed with the separate sections firmly joined together with the corrugations in alignment.

Where there is restricted cover, the bolts of the bands connecting flexible pipe shall be advanced so that the tops of the bolts will be in line with or below the top of the pipe.

When aluminum alloys come in contact with concrete, the contacting surfaces shall be coated either with asphalt mastic conforming to the requirements of AASHTO M 243 or with aluminum-impregnated caulking compound.

When specified on the project plans, the vertical diameter of round, flexible conduit shall be increased five percent by shop elongation.

Any drainage pipe which is not in true alignment or which shows undue settlement after laying or is damaged shall be removed. The trench shall be prepared as hereinbefore specified and the pipe shall be installed again. Any pipe which, in the opinion of the Engineer, is damaged so that it cannot be used shall be replaced.

Field strutting of corrugated metal pipe and structural plate pipe may be done at the contractor's option and expense to afford added protection from construction equipment and other loads during installation, backfilling and filling above the pipe. The method and scheduling of installation and removal of strutting, however, shall be conducted as approved by the Engineer.

Field strutting shall constitute installation of structurally sound timber sills, compression caps and struts.

Paved or partially lined flexible pipe shall be installed so that the longitudinal center line of the paved segment coincides with the flow line. Elliptical and elliptically reinforced rigid pipe shall be installed with the minor axis within five degrees of a vertical plane through the longitudinal axis of the pipe.

The interior of all drainage pipes shall be free of dirt and foreign material as the work progresses and all pipes shall be left clean at the time of final acceptance.

Connections to new or existing drainage pipes or structures shall be made in accordance with the details shown on the project plans or as may be ordered by the Engineer in order to complete the work specified.

Where existing pipes are to be extended, the ends of the existing pipe shall be in such condition that the new pipe can be firmly joined to form an acceptable joint. All existing pipe ends that are damaged or are out of shape such that they cannot be joined in an acceptable manner shall be repaired.

Damaged galvanized coating shall be cleaned by a wire brush and the end painted with at least one full coat of zinc paint conforming to the requirements of Subsection 1002-2.02. If the Engineer determines that the end of an existing pipe is damaged to the extent that it cannot be joined properly to the new pipe, he will order the contractor to remove the damaged portion.

Where prefabricated pipe fittings are to be installed in existing pipes, a portion of the existing pipe shall be removed in order to accommodate the fitting.

(B) Full Circle Corrugated Metal Pipe. Field joints for each type of corrugated metal pipe shall provide circumferential and longitudinal strength to maintain the pipe alignment, prevent separation of the pipe, prevent infiltration of side fill material, and prevent leakage of water into the surrounding soil.

Corrugations in the coupling bands shall have the same dimensions as the corrugations in the pipe being connected. The use of bands with projections (dimples) shall be limited to end sections, pipe with dissimilar ends, and pipe laid on grades under 10 percent.

Pipe fabricated with helical corrugations shall have the ends re-rolled to circumferential corrugations to facilitate coupling to other corrugated pipe, except for the end of an existing in-place helical pipe which is to be extended.

Where bands with projections (dimples) are used to join pipe, the projections shall conform substantially to the shape and depth of the pipe corrugations and shall be in circumferential rows with one projection for each corrugation of helically corrugated pipe. Bands with projections for pipe diameters to 72 inches (*1830 millimeters*), inclusive, shall be at least 10-1/2 inches (*265*

millimeters) wide and shall have two circumferential rows of projections. Rows of projections shall be spaced to provide equal contact on each side of the pipe being joined.

When bands with projections (dimples) are used, the joints shall be sealed with a continuous sponge rubber strip. When bands without projections are used, the joints shall be sealed with a resilient sealant material, a continuous sponge rubber strip or a rubber "O"-ring gasket. The strip shall conform to the minimum requirements of ASTM D1056, Grade 2A1 and shall be at least 7 inches (*180 millimeters*) wide and 1/2 half inch (*13 millimeters*) thick. The rubber "O"-ring gaskets shall be installed one on each side of the joints and shall conform to AASHTO M198 with diameters according to AASHTO M36/M 36M, Section 7 for depth of corrugation.

Watertight joints shall be provided for syphon and irrigation pipe installation and when specified in the Special Provisions, Standard Details, or shown on the project plans. Watertight joints, unless otherwise specified, will not be required for storm drains, culverts, or other drainage pipe, however, joints for these pipes shall be water resistant.

Watertight and water resistant joints shall conform to the requirements of Subsection 1010-2.01(A) of the Specifications. When watertight joints are shown on the project plans or specified in the Special Provisions, the assembled joint shall pass a performance test, as specified herein or as approved by the Engineer, without significant leakage at the joint:

(1) Hydrostatic Pressure Test. A hydrostatic pressure test on a joint shall be made on an assembly of two sections of pipe, properly connected in accordance with the joint design. At the option of the contractor, suitable bulkheads shall be provided within the pipe adjacent to and on either side of the joint, or the outer ends of the two joined pipe sections shall be bulkheaded. No mortar or concrete coatings, fillings, or packings in addition to that normally required for the joint shall be placed prior to watertightness tests. After the pipe sections are fitted together with the gasket or gaskets in place, the assembly shall be subjected to a pressure resulting from a head of 10 feet (*3 meters*) of water above the crown of the pipe for 10 minutes. Moisture or beads of water appearing on the surface of the joint will not be considered as leakage. The tests on individual joints may be performed at the fabricator's facility or at the job site.

The joint watertightness test shall be performed on pipe sections in straight alignment and on pipe sections deflected from straight alignment. When testing pipe sections not on straight alignment, the pipe sections shall be positioned to create a gap on one side of the outside perimeter of the pipe that is 1/2 inch (*13 millimeters*) wider than the gap for pipe sections in straight alignment. When coupling bands are used to test pipe sections not on straight alignment and the maximum

gap on one side of the outside perimeter of the pipe is less than 1/2 inch (*13 millimeters*) wider than that for pipe sections in straight alignment, said coupling band pipe sections shall be positioned to provide maximum gap.

(2) Joints. Joints, other than watertight joints, which employ rubber gaskets, whether flat or "O"-rings, will be considered water resistant. No testing will be required to establish that condition.

The contractor shall furnish to the Engineer a Certificate of Compliance, in accordance with the provisions in Subsection 106-5 of the specifications, that the material being furnished conforms to the joint property requirements as described herein. Field tests may be required by the Engineer whenever there is a question regarding compliance with these requirements.

(C) Slotted Pipe. Slotted pipe shall be joined with coupling bands as shown on the project plans and the joint shall be made water resistant. Prior to attaching the coupling band, sealant material shall be placed between the coupling band and the periphery of the pipe section ends.

Prior to backfilling and paving operations, the slot shall be covered to prevent infiltration of material into the pipe. Heavy tape, roofing paper, timber or other material may be used. Coverings shall be removed when the paving operations have been completed.

Slotted pipe shall be backfilled with grout in accordance with the details shown on the project plans. The grout shall conform to the requirements of Subsection 913-2.04.

Grout shall not be placed when a descending air temperature falls below 40° F (*5 °C*) nor until an ascending air temperature exceeds 35° F (*2 °C*). Temperatures shall be taken in the shade and away from artificial heat. The grout shall be cured in accordance with the requirements of Subsection 912-3.11.

(D) Spiral Rib Corrugated Metal Pipe: Spiral rib corrugated metal pipe shall be installed in accordance with the requirements specified in Subsection 501-3.03(A) for full circle corrugated metal pipe, except as otherwise specified herein. Special care shall be taken during placement of the pipe and backfilling to avoid damage to the pipe.

Lateral field connections between metal pipes shall be welded and any galvanizing damaged by welding shall be repaired in accordance with the requirements of Subsection 1010-. Coupling bands shall be supplied in accordance with Section 1010-2.03(A).

The coupling bands used to connect spiral rib pipe sections shall be hugger-type bands, made from the same material as the pipe, or other approved design, and shall be fitted with gaskets or "O"-rings fabricated from neoprene or butyl rubber or other durable,

resilient material approved by the Engineer, and assembled in such a manner as to form a sealed joint. "O"-ring gaskets required for watertight joints shall be composed of rubber as specified in ASTM C 361, Section 6.9, and shall be compressed by tightening the coupling band, in accordance with the manufacturer's installation instructions.

(E) Concrete-lined Corrugated Metal Pipe: Concrete-lined corrugated metal pipe shall be installed in accordance with the requirements specified in Subsection 501-3.03(A) for full circle corrugated metal pipe, except as otherwise specified herein.

Pipe shall be joined with hugger-type bands which are 0.064 inches (*1.63 millimeters*) in thickness, of the same material as the pipe, and shall be two-piece for pipe greater than 48 (*1220 millimeters*) inches in diameter.

Coupling bands, in addition to the requirements specified in Subsection 1010-2.03, shall be a minimum of 10-1/2 inches (*265 millimeters*) wide, formed with two corrugations that are spaced to provide nesting in the second corrugation of each pipe end and shall be drawn together by a minimum of two galvanized bolts, one 1/2 inch (*13 millimeters*) in diameter, inserted in a bar held in place by a strap welded to the pipe. Bands drawn together by other connection arrangements, such as angles, shall not be allowed. "O"-ring gaskets required for watertight joints shall be composed of rubber as specified in ASTM C361M, Section 6.9, and shall be placed in the first corrugation of each pipe end and shall be compressed by tightening the coupling bands in accordance with the manufacturer's installation instructions.

(F) Corrugated High Density Polyethylene Pipe: Corrugated high density polyethylene pipe shall be assembled in accordance with the manufacturer's recommendations. Installation shall conform to the requirements of Subsection 501-3 and 1010-2.09 of these Specifications and Standard Detail 108.

Water tight and water resistant joints shall conform to the requirements of Subsection 1010-2.09 of these Specifications.

A 6 inch (*150 millimeters*) by 18 inch (*450 millimeter*) strip of magnetic tape shall be placed in the trench over the centerline of each full length of installed pipe.

Shading material shall have a pH value between 1.5 and 14 with no specified minimum value for resistivity.

Special care shall be taken in the handling and installation of polyethylene pipe to prevent damage and to assure that proper line and grade are maintained through the backfilling operation.

(G) Metal Arches: The assembly and erecting of metal arches shall generally conform to the requirements specified under Section 502.

(H) Precast Concrete Pipe. Pipe sections shall be jointed such that the inner surfaces are reasonably flush and even, and the ends are centered as required.

Unless a particular type of joint is specified on the project plans, joints shall be made with portland cement mortar, portland cement grout, rubber gaskets, plastic sealing compound, or any other type approved by the Engineer.

"Self-centering" tongue and groove mortar joints shall be finished smooth on the inside. For diapered joints, diapers shall be used to retain the poured grout. Joints shall be thoroughly wetted before mortar or grout is applied.

When portland cement mixtures are used, the completed joints shall be protected against rapid drying by means of an approved curing method. No joint shall be grouted until the following two sections of pipe are laid.

Flexible watertight gasketed joints when required, shall be installed on the pipe in accordance with the requirements of AASHTO M 198, Paragraph 5.1.

(I) Non-reinforced, Cast-In-Place Concrete Pipe.

(1) General Requirements. Nonreinforced, cast-in-place concrete pipe (CIP pipe) shall be cast monolithically in a prepared trench at the locations and in accordance with the details shown on the plans and the requirements of these specifications.

The cast-in-place pipe shall be constructed with equipment specifically designed for constructing CIP, monolithic concrete pipe. The equipment shall be acceptable to the Engineer and the contractor and may be required to furnish evidence of successful operation of the equipment on other prior work. Equipment not suitable to produce the quality of work required for the pipeline will not be permitted to operate on the work.

Cast-in-place pipe shall be constructed in trenches which have been excavated in either native soil or compacted fill. The trench walls shall be stable so as to maintain its formed shape without sloughing. The minimum inside diameter of the pipe, measured in any direction, shall be at least 98 percent of the nominal pipe size. The minimum wall thickness will be specified on the plans for each pipe size.

(2) Excavation. The trench shall be excavated to the lines and grades shown on the project plans. Laser guided alignment instruments shall be used to control the grade and alignment of the trench. Departure from and return to the established grade for the finished trench shall not exceed 1 inch (*25 millimeters*) for any linear section of 10 foot (*3 meters*). Departure from and return to specified alignment for the trench shall not exceed 2 inches (*50 millimeters*) per a 10 foot (*3 foot*) linear distance, with a total departure not to exceed 4

inches (100 millimeters). The bottom of the trench shall be shaped in accordance with the details shown on the plans and prepared to provide full, firm and uniform support over the bottom 210 degrees of the pipe to be constructed.

The length of trench permitted to remain open at any one time shall not exceed 1,600 linear feet (*490 meters*), unless otherwise specified in the Special Provisions or as may be permitted by the Engineer.

The bottom of the trench must consist of either undisturbed native soil or compacted backfill. When soft, spongy or other unsuitable material is encountered in the bottom of the trench, such material shall be removed to the depth and width directed by the Engineer.

The resulting excavated area shall be backfilled with material conforming to the requirements hereinbefore specified under pipe backfill. The backfill shall be compacted to not less than 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer. This backfill shall then be excavated as specified above.

When boulders or rock ledges are encountered in the bottom or side walls of the trench, such material shall be removed to a distance of at least 6 inches (*150 millimeters*) from the nearest surface of the pipe, and the space then backfilled, compacted, and reshaped as required above for unsuitable material.

The trench walls, from a point 1 foot (*300 millimeters*) above the top of the pipe to the top of the trench, may be sloped as required by soil conditions to provide more stability in the trench and safer working conditions in accordance with the provisions found in Subsection 107-7. The steepness of the side slopes shall be limited to the degree of stability considered necessary for safety, unless an approved shoring system is used.

(3) Concrete Placement. At the time of concrete placement, all surfaces in the trench which will be in contact with the pipe shall be thoroughly moistened so that moisture will not be drawn from the freshly placed concrete; however, the trench shall be free of standing water, mud and debris.

When daytime ambient temperatures are expected to exceed 105° F (*41 °C*) and when directed by the Engineer, concrete shall be placed only between the hours of 8:00 p.m. and 8:00 a.m. Concrete shall not be placed when the temperature of the concrete exceeds 90° F (*32 °C*) or less than 50° F (*10 °C*). The soil adjacent to the trench shall be at a temperature above 32° F (*0 °C*).

The concrete shall be placed around the full circumference of the pipe in one operation. When metal forms are used, they shall be of sufficient strength to withstand vibrating or tamping the concrete.

The concrete shall be vibrated, rammed, tamped or worked with suitable devices until the concrete has been thoroughly consolidated and completely fills the formed space.

Laser guided alignment instruments shall be used to control the grade and alignment of the pipe. Departure from and return to the established grade for the invert of the installed pipe shall not exceed 1 inch (25 millimeters) for any linear section of 10 feet (3 meters). The surface of the invert shall not vary by more than 1-1/4 inches (30 millimeters) when tested with a 10 foot (3 meter) straight edge. Departures from and return to specified alignment for the pipe shall not exceed 2 inches (*50 millimeters*) per a 10 foot (*3 meters*) linear distance, with a total departure not to exceed 4 inches (*100 millimeters*).

When placing operations stop for such a time that initial set of the concrete is likely to occur before placement resumes, a construction joint shall be made by leaving the end of the pipe rough with a slope of approximately 45 degrees and inserting 24 inch (*610 millimeters*) No. 4 (No. 13) dowels 1 foot (*300 millimeters*) into the pipe wall at approximately 18 inch (*450 millimeters*) intervals.

Collars may be used in lieu of doweled joints. An excavation shall be made along the sides and bottom of the construction joint to permit casting of a concrete collar around the outside of the joint. The collar shall have a minimum thickness 1-1/4 times the pipe wall thickness and shall lap the entire joint by at least two times the wall thickness.

Immediately before resuming concrete placement, the joint shall be cleaned of all laitance, loose or defective concrete, coatings and other deleterious materials, thoroughly wetted and coated with a layer of bonding mortar approximately 1/4 inch (*6 millimeters*) thick and conforming to the requirements found in Subsection 1010-2.07.

Construction joints used for connections to another pipe or at junction structures shall be made by squaring off the end of the pipe. An excavation along the sides and bottom of the pipe to permit casting of the concrete collar shall be made as previously specified.

After the removal of forms, the inside of the pipe will be inspected for rock pockets, voids, cracks, form indention and excessive form lap. Any necessary repairs shall be made promptly and to the satisfaction of the Engineer.

The flow line grade of the finished pipe shall not vary by more than 0.10 foot (*3 millimeters*) from the grade line established by the Engineer. The invert shall not vary more than 0.10 feet (*30 millimeters*) when tested with a 10 foot (*3 meters*) straight edge.

(4) Finishing. The interior surface of the pipe shall be as smooth as a wood-float finish and shall be essentially free of fractures, cracks and roughness.

(5) Curing. Immediately after the cast-in-place pipe is cast, the concrete forming the exposed top portion of the pipe shall be cured by one of the following methods:

The cast-in-place pipe shall be sprayed with a liquid membrane-forming compound conforming to the requirements found in Subsection 1006-2.05.

The cast-in-place pipe shall be covered with a polyethylene film conforming to the requirements of AASHTO M 171 except that the nominal thickness shall be 0.0015 inches (*38 μm*). The film shall be white opaque or clear and shall be held in place to assure continuous contact. The loose soil shall not be greater than 6 inches (*150 millimeters*) in depth at any point, and shall conform to the requirements hereinbefore specified under pipe backfill.

During the curing period, the inside of the pipeline shall be kept in a humid condition for at least seven days following placement of the concrete. To prevent air drafts from drying the fresh concrete all openings in the pipeline shall be covered during the seven day period, except at locations where work on the pipe is required and only during the time that such work is actually in progress.

(6) Backfilling. Backfilling shall not start until the concrete has developed a compressive strength of at least 2,000 pounds per square inch (*13.8 mega pascals*).

The type of backfill material, the placement of pipe and trench backfill material and compaction shall conform to the requirements of Subsection 501-3.04.

(7) Pipe Repair. Transverse cracks 3/64 inch (1.3 millimeters) or more in width that can be penetrated by more than 1/4 inch (*6 millimeters*) with a standard machinist gauge leaf designated in AASHTO T 280 and are more than 1 foot (*300 millimeters*) in length shall be repaired by injection of an approved elastomeric compound or another method approved by the Engineer.

Longitudinal cracks 3/64 inch (*1.3 millimeters*) or more in width that can be penetrated by more than 1/4 inch (*6 millimeters*) with a standard machinist gauge leaf designated in AASHTO T 280, are more than 1 foot (*300 millimeters*) in length, and within 45 degrees of either side of the crown or invert

will be cause for rejection. At the sole discretion of the Engineer, these cracks may be structurally repaired by epoxy pressure grouting.

Longitudinal cracks 3/32 inch (*2.5 millimeters*) or more in width that can be penetrated by more than 1/4 inch (*6 millimeters*) with a standard machinist gauge leaf designated in AASHTO T 280, and are more than 1 foot (*300 millimeters*) in length, and within 45 degrees of either side of the spring line will be cause for rejection. At the sole discretion of the Engineer, these cracks may be structurally repaired by epoxy pressure grouting.

A longitudinal crack shall be defined as one which is generally oriented within 30 degrees of the alignment of the pipe.

Any section of pipe rejected by the Engineer shall be removed and replaced at no additional cost to the Agency.

(8) Cast-In-Place Pipe Wall Thickness. A primary unit of pipe shall be defined as the length of each size of cast-in-place pipe placed each day.

A secondary unit of cast-in-place pipe shall be defined as one-third of the length of each size placed as a primary unit.

For the purpose of determining acceptability for wall thickness, a hole shall be drilled within each secondary unit. The wall thickness will be measured for acceptance. If the wall thickness is less than the specified thickness, a core shall be drilled adjacent to the drilled hole. If the length of that core is not deficient in thickness by more than 0.10 inch (*2.5 millimeter*), that secondary unit will be accepted.

All holes shall have a minimum diameter of 3/4 inch (*19 millimeters*).

All cores shall have a minimum diameter of 3 inches (*75 millimeters*).

All holes and cores shall be drilled at locations specified by the Engineer.

The length of the cores shall be determined in accordance with the requirements of AASHTO T 148, except that the nine measurements will be read to the nearest 0.001 of an inch (*0.025 millimeters*). The average of the nine measurements will be reported to the nearest 0.01 of an inch (*0.25 millimeters*).

In calculating the average length, cores which have a length in excess of the thickness specified on the project plans by more than 0.10 inch (*0.25 millimeter*) will be deemed to have a length of the specified thickness plus 0.10 inch (*0.25 millimeter*). Field length measurements will be acceptable in lieu of average length measurements in accordance with the requirements of AASHTO T 148, provided that the original core

in any secondary unit meets or exceeds the specified thickness. Measurements in accordance with the requirements of AASHTO T 148 will be required on any questionable thickness measurements and on the three cores used to determine the average length for acceptance, regardless of length.

If the length of the first core drilled in the secondary unit is deficient by 0.10 inch (*2.5 millimeter*) or more, that core will not be used in determining the average thickness of that secondary unit. Additional cores shall be taken at intervals not to exceed 10 feet (*3 meters*) in each direction from the deficient core until one core is obtained in each direction which is not deficient by 0.10 inch (*2.5 millimeters*) or more. The cast-in-place pipe between these two cores will be rejected. This pipe section shall be removed and replaced with pipe of the specified thickness at the contractor's expense. One additional core shall be taken in the secondary unit to represent the quantity of concrete in that unit after deducting the limits of the deficient area. This additional core shall conform to the requirements contained herein and will be considered to be the original core.

At all locations where cores or drill holes have been made, the resulting holes shall be filled by the contractor, with concrete, in a manner satisfactory to the Engineer.

501-3.04 Backfilling and Compacting.

(A) Backfill. Drainage pipe backfill shall consist of shading material and trench backfill material. Shading shall be placed over and around the pipe from the springline to one foot (*300 millimeters*) above the top of the pipe. Trench backfill shall be placed from one foot (*300 millimeters*) above the top of pipe to the subgrade elevation of the roadway or to existing ground when the installation is outside the roadway prism. Shading shall be selected from excavation or from a source selected by the contractor. It shall not contain frozen lumps, stones larger than 3 inches (*75 millimeters*) in diameter, chunks of clay or other objectionable material. Shading material shall conform to the requirements of Subsection 501-2.05. Trench backfill shall conform to the requirements of Subsection 501-2.06 with the exception that, within the roadway prism, trench backfill material shall conform to the requirements of shading material as specified in Subsection 501-2.05. However, when shading material is used for trench backfill, 100% of the material shall pass the 6 inch (*150 millimeters*) sieve. At the contractor's option, shading material may be used in place of backfill material in areas outside the roadway prism.

(B) Placement of Backfill. All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the areas to be backfilled before backfill material is placed.

Shading or trench backfill, compacted by pneumatic or mechanical tamping devices, shall be placed in layers not more than 8 inches (*200 millimeters*) in depth before compaction.

Shading, or bedding material, shall be brought up evenly on both sides of the pipe to an elevation 1 foot (*300 millimeters*) above the top of the pipe.

Backfill material shall be placed around and over arches in accordance with the requirements of Section 502.

(C) Compaction of Backfill. Shading and trench backfill material shall be compacted to at least 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Water jetting shall not be allowed for the compaction of shading or trench backfill.

(D) Filter Material. When shown on the project plans or specified in the Special Provisions, filter material shall be carefully placed around perforated pipe.

Filter material be placed in accordance with the details shown on the project plans.

(E) Encasement of Pipe. When shown on the project plans, or specified in the special provisions, pipe shall be encased in Class B concrete conforming to the requirements of Subsection 501-2.03 or controlled low strength material (CLSM) conforming to the requirements of Subsection 501-2.04. CLSM may also be used in lieu of trench backfill material if approved by the Engineer.

501-4 METHOD OF MEASUREMENT

Drainage pipe will be measured by the linear foot (*meter*) parallel to the central axis of the pipeline, and shall include the length of all fittings and connections.

Tees, wyes and other branches will be measured as pipe along the central axis of the pipes to the point of intersection of said central axis. Pipe reducers will be measured as pipe of the larger diameter along the central axis.

The end of pipe in closed structures will be considered to be at the intersection of the central axis and the inside face of the wall and for masonry and concrete headwalls it will be considered to be at the intersection of the central axis and the face of the headwall.

Flared end sections will be measured by the number of units installed.

501-5 BASIS OF PAYMENT

Except as hereinafter specified, no separate measurement or payment will be made for excavating trenches, dewatering compacting subgrade and for furnishing, placing and compacting

bedding and backfill material as described and specified herein and on the project plans, the cost thereof being considered as included in the contract unit price per foot of drainage pipe or sanitary sewer pipe.

Payment for the removal of rock, hard pan, other unyielding material, or soft, spongy or other unstable soil below the vertical limits as shown on the plans, and the backfilling and compaction of these overexcavated areas, as specified herein and as directed by the Engineer, will be paid for in accordance with the requirements of Subsection 104-2.

When an embankment is constructed prior to the digging of a trench, and the installation of a pipe, payment for the construction of the embankment will be made under the appropriate item, such as Roadway Excavation or Borrow. Removal of rock, hardpan, other unyielding material, or soft, spongy or other unstable material from the trench within the embankment will not be considered for payment.

The accepted quantities of drainage pipe, measured as provided above, will be paid for at the contract unit price complete-in-place.

The repairing of the damage to existing pipe ends to which new pipe is to be joined and which cannot be seen in order to be assessed and the removal of any portion of a damage pipe, as specified under Subsection 501-3.03(B) will be paid for in accordance with the provisions of Subsection 104-2.

No measurement or direct payment will be made for furnishing and placing filter material, plating material, fittings, collars, bands and the joining of new and existing pipe.

SECTION 502

STRUCTURAL PLATE PIPE, PIPE-ARCHES, AND ARCHES

502-1 DESCRIPTION

The work under this section shall consist of furnishing and erecting structural plate pipe, pipe-arches, and arches of the sizes, thicknesses, and dimensions shown on the project plans. They shall be installed at the locations specified on the project plans or as directed by the Engineer and shall be in reasonably close conformity to the lines and grades shown on the project plans or as established by the Engineer and the requirements of these specification.

502-2 MATERIALS

502-2.01 General. Materials shall conform to the requirements of Section 1010, unless otherwise specified.

Plates shall be fabricated in accordance with the requirements of either AASHTO M 167, AASHTO M 219 or Federal Specifications WW-P-405.

502-2.02 Concrete. Concrete shall conform to the requirements of Section 1006 for Class B concrete unless otherwise noted on the plans or in the Special Provisions.

502-2.03 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 1003.

502-3 CONSTRUCTION DETAILS

Excavating, bedding and backfilling for the structural plate pipe, pipe arches, and arches shall be performed as specified under Section 501 and as specified herein and on the project plans. Excavating and backfilling for the concrete footings shall be performed as specified under Subsection 203-5. Placement of reinforcing steel and structural concrete shall conform to the requirements of Sections 605 and 601, respectively.

When backfill material is placed around and over arches prior to headwalls being in place, the backfill material shall first be placed midway between the ends of the arch, forming as narrow a ramp as possible, until the top of the arch is reached. The ramp shall be constructed evenly from both sides and the material shall be compacted as it is placed. After the two ramps have been constructed to the top of the arch, the remainder of the material shall be placed from the top of the arch both ways from the center to the ends and as evenly as possible on both sides of the arch.

When the headwalls are constructed before any backfill material is placed around and over the arch, the material shall first be placed adjacent to one headwall until the top of the arch is reached after which it shall be dumped from the top of the arch toward the other headwall and as evenly as possible on both sides of the arch.

In multiple installations, extreme care shall be taken so that the backfill material is brought up evenly on each side of each arch so that unequal pressures will be avoided.

Plates shall be installed to provide lap joints with the upstream plate lapping over the downstream plate. The bolt holes shall be so punched that all plates having like dimensions, curvature, and the same number of bolts per foot (*meter*) of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross-sectional dimensions of the finished structure will be as indicated on the project plans.

Plates for forming skewed or sloped ends shall be cut to give the angle of skew or slope specified. Burned edges shall be free from oxide and burrs, and shall present a workmanlike finish. Legible identification numerals shall be placed on each plate to designate its proper position in the finished structure.

Steel plates shall be punched so that bolt holes along those edges of the plates that will form longitudinal seams in the finished structure will be staggered in rows 2 inches (*50 millimeters*) apart, with one row in the valley and one on the crest of the corrugation. Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12 inches (*300 millimeters*). The minimum distance from center of hole to edge of plate shall be not less than 1.75 times the diameter of the bolt. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than 1/8 inch (*3 millimeters*).

Aluminum plates shall be punched so that bolt holes along those edges of the plates that will form longitudinal seams in the finished structure will be on a double row with a center to center dimension of 1-3/4 inch (*44 millimeters*). In all structures the longitudinal seam shall be comprised of two bolts in each valley and crest of each corrugation. The standard center to center dimensions of bolt holes that will form the circumferential seam in the finished structure shall be 9-5/8 inches (*245 millimeters*). The minimum distance from the center of the hole to the edge of the plate shall not be less than 1.75 times the diameter of the bolt.

Tolerance of all hole diameters and spacing shall be as indicated on the project plans or in the special provisions.

Plates shall be erected in their final position by connecting the plates with bolts at longitudinal and circumferential seams. Drift pins may be used to facilitate matching of holes. All plates shall be placed in the order recommended by the manufacturer with joints staggered so that not more than three plates come together at any one point. All bolts shall be drawn tight, without overstress, before beginning the backfill.

Steel bolts for structural-plate sections shall be torqued during installation to a minimum of 100 foot-pounds (*135 newton meters*) and a maximum of 300 foot-pounds (*405 newton meters*).

For power-driven tools, the hold-on period may vary from two to five seconds. The bolts for aluminum structural-plate sections shall be torqued during installation to a minimum of 100 foot-pounds (*135 newton meters*) and a maximum of 200 foot-pounds (*270 newton meters*). Bolts shall be of sufficient length to provide a full nut.

After structural plate pipe has been erected, all spots where damage has occurred to the protective coating shall be given two coats of an approved hot asphalt paint, or shall be wire brushed and given two coats of Paint No. 4, as directed by the Engineer.

502-4 METHOD OF MEASUREMENT

Structural plate pipe, pipe-arches, and arches will be measured by the linear foot (*meter*), or by the lump sum for each structure, installed in place, complete and accepted.

If measurement is made by the linear foot (*meter*), measurement will be made along the invert center line for pipe and pipe-arches and the average of the spring line lengths for arches.

Structural concrete and reinforcing steel used for headwalls and footings will be measured by the cubic yard (*cubic meter*) and by the pound (*kilogram*), respectively.

Structural excavation and structure backfill for footings will be measured in accordance with the requirements of Subsection 203-5.04.

502-5 BASIS OF PAYMENT

The acceptance of quantities of work under this section, measured as provided above, will be paid for at the contract lump sum price or the contract unit price per linear foot (*meter*) different sizes and thickness of structural plate pipe, pipe arches and structural plate arches designated in the bidding schedule, complete in place, including excavating and furnishing, placing and compacting backfill material.

Payment for structural concrete used in footings and headwalls will be made as provided in Section 601. Payment for reinforcing steel used in footings and headwalls will be made as provided in Section 605. Payment for structural excavation and structure backfill for footings will be made as provided in Subsection 203-5.

SECTION 503

CONCRETE CATCH BASINS

503-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing or reconstructing concrete catch basins, including excavation, concrete removal and backfill. Work shall be done at the locations designated on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

503-2 MATERIALS

503-2.01 Concrete. Materials furnished for portland cement concrete shall conform to the requirements of Section 1006. Concrete shall conform to the requirements of Section 1006 for Class B concrete.

503-2.02 Reinforcing Steel. Reinforcing steel bars or mesh shall conform to the requirements of Section 1003.

503-2.03 Masonry Mortar. Masonry mortar shall be composed by volume of one part portland cement, two parts fine aggregate, one-fifth part hydrated lime and sufficient water to provide a plastic mixture. The lime shall be considered as an addition to and not as replacing any cement.

Fine aggregate shall conform to the requirements of ASTM C 144. Portland cement and water shall conform to the requirements of Section 1006. Hydrated lime shall conform to the requirements of ASTM C 207, Type N.

Mortar that has been mixed more than one hour shall not be used. Retempering of mortar will not be permitted.

503-2.04 Structural Steel. Structural steel parts shall conform to the requirements of Section 1004. Grating units and frames shall be fabricated from ASTM A 36 steel.

503-3 CONSTRUCTION REQUIREMENTS

503-3.01 Catch Basins. Excavation for catch basins shall be in accordance with the requirements of Subsection 203-5.

Catch basins shall be cast-in-place or, at the option of the contractor, may be precast units.

Cast-in-place catch basins shall be constructed in accordance with the requirements of Section 601 and reinforced where called for on the plans in accordance with the requirements of Section 605 and in reasonably close conformity to the lines and grades shown on the plans and shall meet adjacent sidewalk, curb, or gutter surfaces with no appreciable offsets.

Joints for precast concrete catch basin sections shall be made with portland cement mortar, rubber gaskets, mastic joint fillers or by a combination of these types, or other approved type. A completed mortar joint shall be formed with a bead on the outside and finished smooth on the inside of the sections and suitably cured. Rubber gaskets shall be installed so as to form a flexible watertight seal. Mastic joint filler shall conform to the requirements of AASHTO M 198 and shall be applied in accordance with the manufacturers recommendations so as to form a water tight seal.

Proper equipment shall be provided for lowering precast sections into position. The tongue end of the section shall be placed in contact with the base structure unless otherwise directed. Not more than two holes shall be cast or drilled in the shell of each section for the purpose of handling and placing and if such holes are provided, they shall be filled and finished with mortar after placing. Immediately before joining precast sections, mortar shall be placed continuously around the circumference of the receiving section's contact surface. Any precast section damaged during handling or placing shall be repaired or replaced at the option of the Engineer and at no additional cost to the Agency.

When specified on the project plans, aprons shall be constructed in accordance with the details shown on the plans. Aprons shall be constructed from portland cement concrete or from asphaltic concrete.

When specified on the project plans or ordered by the Engineer, corrugated metal pipe shall be installed as a temporary drain for the roadway. These drains shall be subsequently filled with concrete.

Backfilling of the completed structure shall be in accordance with the requirements of Subsection 203-5.

Preformed bituminous joint filler shall be installed where the catch basin concrete will meet new or existing concrete curb or pavement.

Grating units shall have continuous, full, and uniform bearing contact with their frames and shall be non-rocking when in place and under the influence of traffic or other loads. For installation where grating units are placed transversely across the roadway in series, the grates shall be securely welded or bolted to the frame. However, when grates are welded, every fifth unit shall be secured by bolts to provide access for cleaning and maintenance. All welding shall be in accordance with American Welding Society Standards. The completed assembly shall be given one shop coat of paint No. 1 meeting the requirements of Subsection 1002-3.01.

Grating units and frames shall be installed true to line and grade.

503-3.02 Reconstruct Catch Basins. Catch basins shall be reconstructed in reasonably close conformity to the lines and grades shown on the plans. The existing frame and grate shall be carefully removed and cleaned. After removal of the frame, the top of the catch basin shall be trimmed to provide a suitable foundation for the new material. Frames and grates shall then be reinstalled according to the requirements of Subsection 503-3.01.

Where reconstruction of a catch basin requires partial removal of concrete, sufficient concrete shall be removed to permit new reinforcing steel to be spliced to existing reinforcing steel in accordance with the requirements found in Section 605. Existing reinforcing incorporated into the new work shall be protected from damage and shall be thoroughly cleaned of all adhering material before being embedded in new concrete. New concrete shall be placed according to the requirements of Section 601 and the frames and grates reinstalled as specified herein.

503-3.03 Frame and Grate. Where an existing frame and grate for a catch basin is unfit for further use, a new frame and cover shall be furnished and installed as specified under Subsection 503-3.01.

Where an existing frame and grate is suitable for reuse and is lost or damaged by the contractor's operations to the extent that it is unacceptable for reuse, it shall be replaced at no additional cost to the Agency.

503-4 METHOD OF MEASUREMENT

Catch basins will be measured as a unit for each catch basin, including frame and grate; for each catch basin reconstructed; or for each frame and grate furnished.

503-5 BASIS OF PAYMENT

The accepted quantities of catch basins, of reconstruct catch basin, and of frame and grate for catch basin, measured as provided above, will be paid for at the contract unit price each, complete in place, including aprons, temporary construction drains, excavation and backfill.

The removal of unsuitable material below the required depth and the furnishing and placing of material in the voids thus created will be paid for in accordance with the provisions found in Subsection 104-2.

SECTION 505

STORM DRAIN AND UTILITY MANHOLES

505-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing or adjusting manholes for storm drainage and utility systems including frames and covers; furnishing and installing manhole frames and covers; or removing and resetting existing manhole frames and covers or furnishing prefabricated adjustment rings at the locations designated on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

505-2 MATERIALS

505-2.01 Concrete. Materials furnished for portland cement concrete shall conform to the requirements of Section 1006.

Concrete shall be Class B, except precast manholes. Precast manholes shall conform to the requirements of AASHTO M 199 (*M 199/M*) except that the compressive strength of each unit will be determined and accepted in accordance with Subsection 1006-7.

505-2.02 Reinforcing Steel. Materials furnished for reinforcing steel shall conform to the requirements of Section 1003.

505-2.03 Brick. Brick shall conform to the requirements of AASHTO M 91.

505-2.04 Mortar. Mortar shall conform to the requirements of Subsection 503-2.03.

505-2.05 Water. Water shall conform to the requirements of Subsection 1006-2.02.

505-2.06 Frames, Covers and Prefabricated Adjustments Rings. The top surface of each storm drain cover shall be cast with a studded pattern, including lettering in accordance with the standard details. Covers, with the exception of waterproof covers, shall be provided with ventilating holes conforming to the requirements of the Standard Details.

Frames and covers shall conform to the requirements of Subsection 1004-6 for drainage structure castings. Prefabricated adjustment rings shall conform to the requirements for gray iron castings, found in Subsection 1004-6. The bearing face of the frame or adjustment ring shall be machined so that the cover will lie flat in any position in the ring and have a uniform bearing throughout its entire circumference. Before leaving the foundry, the frames and covers shall be thoroughly cleaned.

505-3 CONSTRUCTION DETAILS

505-3.01 General. Excavation for manholes shall be in accordance with the requirements of Subsection 203-5.

All connections for lateral pipes will be considered a part of the manhole. The invert channel may be lined with split pipe.

Manhole side-walls shall be constructed of cast-in-place concrete or precast concrete or brick, as shown on the project plans. The base of all manholes shall be cast-in-place concrete.

Precast units shall be approved by the Engineer prior to delivery to the job site. Precast manhole sections shall be subject to rejection for any of the following deficiencies:

- Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
- Defects that indicate imperfect proportioning, mixing, and molding.
- Surface defects indicating honeycombed or open texture.
- Damaged or cracked ends, where such damage would prevent making a satisfactory joint.
- Any continuous crack having a surface width of 0.01 inch (0.25 millimeters) or more and extending for a length of 12 inches (300 millimeters) or more, regardless of position in the section wall.

Proper equipment shall be provided for lowering the precast sections into position. The tongue end of the section shall be placed in contact with the base structure unless otherwise directed. Not more than two holes shall be cast or drilled in the shell of each section for the purpose of handling and placing and if such holes are provided, they shall be filled and finished with mortar after placing. Immediately before joining precast sections, mortar shall be placed continuously around the circumference of the receiving section's contact surface. Any precast section damaged during handling or placing shall be repaired or replaced at the option of the Engineer and at the contractor's expense.

Cast-in-place concrete shall be placed in accordance with the requirements of Section 601.

Bricks for side-walls shall be wetted before being used and shall be laid in full mortar beds. Mortar that has been mixed for more than one hour shall not be used. Retempering of mortar will not be permitted.

Backfilling of the completed structure shall be with satisfactory material thoroughly compacted in accordance with the requirements of Subsection 203-5.

Where frames and covers for manholes are to be set in new bituminous mix or asphaltic concrete surfaces, they shall be set after placement of the finish or surface course of asphaltic concrete. Steel plates of a size approved by the Engineer shall

be placed over the manhole prior to placing courses of asphaltic concrete. After placement of all courses of asphaltic concrete are completed the steel plates shall be removed. The asphaltic concrete shall be cut and removed in a manner such that a concentric circle is formed about the center of the manhole and the excavated face of the area remaining is vertical. The frames and covers shall be set in concrete at the proper elevation so that the cover will be flush with the adjacent finish or surface course. Care shall be taken that the base and surfacing materials are not disturbed beyond the edges of the plate and that debris is kept from falling into the manhole. Concrete and reinforcing steel shall be placed around the frame as detailed on the plans. The concrete shall be protected during the curing period.

All castings shall be true to pattern in form and dimension and free from pouring faults, sponginess, cracks, blowholes, or other defects in locations effecting their strength for the service intended. Castings shall be filleted boldly at angles, and the risers shall be sharp and true. Before the castings are removed from the foundry, they shall be thoroughly cleaned and the parting lines, gates and risers ground flush. No plugging or other stopping of holes will be allowed. The castings shall be thoroughly cleaned of all lumps and subject to a careful hammer test.

Upon completion each manhole shall be thoroughly cleaned and kept clean until final acceptance of the work.

The contractor shall observe all pertinent requirements regarding the manhole construction. Streets shall be kept open for passage of traffic and protection for the public shall be provided when the manhole excavation is exposed. The manhole construction work shall be completely and adequately covered when no work is being done. Every precaution shall be taken to prevent water pumped from storm drain manholes from flooding streets, alleys, sidewalks and private property.

505-3.02 Manholes. Joints for precast concrete manhole sections shall be made with portland cement mortar, rubber gaskets, mastic joint fillers or by a combination of these types, or other approved type. The completed mortar joint shall be formed with a bead on the outside and finished smooth on the inside of the sections and suitably cured. The rubber ring gaskets shall be installed so as to form a flexible watertight seal. The mastic joint filler shall conform to the requirements of AASHTO M 198 and shall be applied in accordance with the manufacturers recommendations so as to form a watertight seal.

Steps shall be placed at equal intervals of 12 to 15 inches. The lower step shall not be more than 18 inches from the top of the manhole bench, and the upper step shall not be more than 24 inches below the top of the frame. Steps shall be located above a solid bench.

505-3.03 Testing Storm Drain Manholes. The Engineer may require testing to verify that the stormdrain manhole is watertight. This test shall be carried out by filling the manhole with water to an elevation 1 foot above the beginning of the cone section, but to a maximum depth of 20 feet. The water shall stand in the manhole for a minimum of 1 hour to allow the concrete to reach maximum absorption. After 1 hour, the contractor shall refill the manhole to the original depth, and the drop in the water surface shall be recorded after a period of 2 minutes for each foot of depth. The maximum allowable drop in water surface for the period of testing shall be 1/2 inch for each 15 minutes of testing.

In lieu of the foregoing, manholes may be vacuum tested in accordance with ASTM C 1244.

Repairs shall be made as directed by the Engineer whenever leakage exceeds the test limit.

505-3.04 Frame and Cover for Manhole. Where an existing frame and cover for a manhole is unfit for further use, a new frame and cover shall be furnished and installed as specified under Subsection 505-2.06. Where necessary, existing side-walls shall be adjusted to the required grade by removing portions of, or adding to, the existing walls. Such adjustments shall conform to the details of the existing manhole unless otherwise noted on the project plans. Replacement frame(s) and cover(s) shall either be provided by the appropriate utility or provided by the contract with payment being made in accordance with Subsection 109-5.

505-3.05 Reset Manhole Frame and Cover. Existing frames and covers to be reset shall be carefully removed and reset to the required grade in accordance with the requirements of Subsection 505-3.02; however, at the contractor's option and with approval of the Engineer, adjustable extension rings, of the type which do not require the removal of the existing frame, may be used. The extension device shall provide positive locking action with the existing frame and shall permit adjustment in height to conform to the new finished pavement surface. The material for the extension device shall be compatible with the existing frame and conform to the requirements of the respective section of these specifications.

Manhole frames and covers to be reset which are lost or damaged due to the contractor's operations to the extent that they are unacceptable for reuse shall be replaced at the contractor's expense.

505-4 METHOD OF MEASUREMENT

New manholes will be measured as a unit for each manhole constructed inclusive of frame and cover.

Existing manholes requiring adjustment to accommodate changes in the finished elevation of the roadway of 1 foot (*300 millimeters*) or less, will be measured as a unit for each manhole adjusted.

Existing manholes requiring an adjustment of greater than 1 foot (*300 millimeters*) to accommodate changes in the finished elevation of the roadway shall be designated as a reconstruction and will be measured by the foot (*millimeters*), to the nearest one-half foot (15*0 millimeters*) of elevation change between the existing rim elevation of the manhole and the new rim elevation.

505-5 BASIS OF PAYMENT

The accepted quantities of new manholes and manhole adjustments, measured as provided above, will be paid for at the contract unit price each, complete-in-place, including excavation, backfill, frame and cover.

The accepted quantities of reconstructed manholes, measured as provided above, will be paid for at the contract unit price per foot (*millimeters*), including excavation, backfill, frame and cover.

The removal of unsuitable material below the required depth and the furnishing and placing of material in the voids thus created will be paid for in accordance with the provisions found in Subsection 109-4.

SECTION 506

UNDERDRAINS

506-1 DESCRIPTION

The work under this section shall consist of furnishing all labor, equipment, and materials to construct an underdrain system in accordance with the details shown on the project plans and as directed by the Engineer.

When more than one type of pipe is allowed to be installed at underdrain installations, the underdrain will be designated as alternative pipe underdrain on the plans and in the bidding schedule. The type of pipe to be installed shall be selected by the contractor from the allowable types of pipe shown on the plans.

506-2 MATERIALS

506-2.01 Pipe Materials. Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted for all pipe materials.

(A) Perforated Clay Pipe. Perforated clay pipe shall conform to the requirements for extra-strength perforated clay pipe as specified in AASHTO M 65, except that plain end pipe complying in all other respects with the stated AASHTO M 65 specification may be used.

Design modifications to the bell socket end of the pipe which will facilitate positioning of the perforations or placement of the pipe may be made, provided that such modifications are approved by the Engineer prior to use. Pipe so modified shall conform to all performance requirements and tests specified in AASHTO M 65.

If plain end pipe is used, couplers which are capable of holding the pipe in alignment shall be used to join the pipe.

(B) Perforated Steel Pipe. Perforated steel pipe and coupling bands shall conform to the requirements of AASHTO M 36 (M 36M) and M 218 (M 218M), with the following modifications: The pipe shall conform to any one of the full circle types specified in AASHTO M 36 and perforations in the pipe shall be either drilled or punched. The perforations shall be located either in the inside crests or in the flat tangent portion of all corrugations, but not in both locations in a given length of pipe.

(C) Perforated Aluminum Pipe. Aluminum underdrain pipe and fittings shall conform to the requirements of AASHTO M 196 with the following modifications: The pipe shall conform to Type III pipe according to AASHTO M 196 (M 196M). Perforations in the pipe shall be either drilled or punched. The minimum thickness of sheet shall be 1/16 inch (*1.5 millimeters*).

(D) Perforated Plastic Pipe. Perforated plastic pipe shall be either smooth-wall polyvinyl chloride plastic pipe, corrugated polyvinyl chloride plastic pipe with a smooth interior surface, or corrugated polyethylene plastic tubing.

Smooth-wall polyvinyl chloride plastic pipe shall conform to the requirements of AASHTO M 278.

Corrugated polyvinyl chloride plastic pipe with a smooth interior surface shall conform to the material and structural requirements of AASHTO M 278. The pipe shall have perforations located in the bottom half of the pipe and the perforations shall consist of slots meeting the size and opening area requirements listed in AASHTO M 252. The inside diameter and diameter tolerances shall conform to the requirements of either AASHTO M 252 or M 278.

Corrugated polyethylene plastic tubing shall conform to the requirements of AASHTO M 252 or M 294.

Polyvinyl chloride pipe shall be connected with belled ends, or with sleeve-type or stop-type couplings conforming to the requirements of AASHTO M 278. Polyethylene tubing shall be connected with snap-on, screw-on, or wrap-around fittings and couplings conforming to the requirements of AASHTO M 252 or M 294. Solvent cementing of joints will not be required.

506-2.02 Underdrain Outlets and Risers. Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted for all underdrain outlet and riser materials.

Underdrain outlets and underdrain terminal risers, vertical risers, and 45-degree risers, consisting of covers, pipes, band couplers, pipe elbows, tees and wyes shall be furnished and installed in accordance with the details shown on the plans and as specified in these specifications.

Underdrain outlets and risers shall be fabricated of the same material as the underdrain pipe or of corrugated metal pipe. Except for covers and coupling band fastening hardware, aluminum and steel shall not be mixed in any installation. Outlet and riser pipe and fittings shall not be perforated.

The welded metal cover for risers shall conform to the details shown on the plans. Welded steel covers shall be galvanized after fabrication, in accordance with the provision in Subsection 604-3.05, “Galvanizing.”

Welding shall be in accordance with the requirements in Subsection 604-3.06, “Welding.”

Covers shall be fitted and bolted into the riser pipe or elbow. The covers shall seat uniformly and shall not be subject to rocking.

506-2.03 Drain Aggregate. The drain aggregate shall conform to the following gradation when tested in accordance with the requirements of Arizona Test Method 201.

Sieve Size	Percent Passing
1-1/2 in (*37.5 mm*)	100
1 in (*25.0 mm*)	95 – 100
1/2 in (*12.5 mm*)	25 – 60
No. 4 (*4.75 mm*)	0 – 10
No. 8 (*2.36 mm*)	0 – 5
No. 10 (*2.00 mm*)	0 – 2

For underdrains within the roadway prism, the percent of fractured particles for material retained on the No. 4 (*4.75 mm*) sieve shall be at least 70 when tested in accordance with the requirements of Arizona Test Method 212, unless otherwise approved by the Engineer.

The combined bulk specific gravity range for the aggregate shall be 2.35 to 2.85.

The combined water absorption range for the aggregate shall be 0 to 2.5.

Resistance to abrasion for aggregate will be determined in accordance with the requirements of AASHTO T 96 and shall meet the following requirements:

Maximum loss of 9 percent at 100 revolutions.

Maximum loss of 40 percent at 500 revolutions.

506-2.04 Drainage Geotextile Fabric. The drainage geotextile fabric shall be as specified in Subsection 1014-9.

506-3 CONSTRUCTION REQUIREMENTS

506-3.01 General. The trench for the underdrain shall be excavated to the lines and grades shown on the project plans. The bottom of the trench shall be shaped in accordance with the details shown on the plans and prepared to provide full, firm and uniform support for the drainage geotextile fabric, aggregate, and perforated pipe.

506-3.02 Weather Limitations. Drainage fabric placement and underdrain installation shall not be done when weather conditions, in the opinion of the Engineer, are not suitable to allow placement or installation.

Exposure of geotextiles to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

506-3.03 Fabric Placement. Surfaces to receive drainage fabric, immediately prior to placing, shall be free of loose or extraneous material and sharp objects that may damage the fabric during installation. The fabric shall be aligned and placed in a wrinkle-free manner. Successive sheets or rolls of fabric shall

be overlapped a minimum of 1 foot (*300 millimeters*) in the direction of water flow. The drain aggregate shall also be placed in the trench in the direction of water flow, if possible. Should the fabric be damaged during placing, the torn or punctured section shall be either completely replaced or shall be repaired by placing a piece of fabric that is large enough to cover the damaged area and to meet the overlap requirement. Damage to the fabric resulting from the contractor's vehicles, equipment or operations shall be replaced or repaired by the contractor at no additional cost to the Agency.

506-3.04 Underdrain Construction Details. Aggregate materials shall be placed with great care in a manner which does not damage the fabric. Pins or piles of aggregate can be used to hold the drainage fabric in place while aggregate is being placed. Aggregate materials shall be compacted in 6 inch (*150 millimeter*) maximum lifts with a minimum of three passes of a vibratory plate type compactor.

Perforated pipes shall be laid with the perforations down.

Outlets, riser pipes, and associated fittings shall be constructed in accordance with the details shown on the plans and specifications and as directed by the Engineer.

The outlet for each underdrain shall be clean at the time of installation and shall be free of obstructions after installation. Pipes that are found to be plugged shall be replaced by the contractor, including replacement of aggregate materials, surfacing and backfill materials, at no additional cost to the Agency.

After placing the drain aggregate, the geotextile drainage fabric shall be folded over the top of the drain aggregate to produce a minimum overlap of 1 foot (*300 millimeters*) for trenches greater than 1 foot (*300 millimeters*) wide. In trenches less than 1 foot (*300 millimeters*) in width, the overlap shall be equal to the width of the trench. The geotextile drainage fabric shall then be covered with the subsequent course.

506-4 METHOD OF MEASUREMENT

Underdrains pipe will be measured by the linear foot (*meter*) parallel to the central axis of the pipe and shall include the length of all fittings and connections.

Elbows, wyes, tees, risers, outlets, and other branches will be measured by the linear foot (*meter*) as pipe along the central axis of the pipes to the point of intersection of said central axis for the size and type of underdrain pipe they are connected to.

The total linear feet (*meters*) measured of each type and size of underdrain pipe shall be the sum of the above measured quantities.

506-5 BASIS OF PAYMENT

The accepted quantities of each type and size of underdrain measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), complete in place. The contract price shall be full compensation for furnishing all labor, materials, tools, equipment, and incidentals involved in installing perforated pipe, drainage fabric, and aggregate material as specified in the plans and specifications, and as directed by the Engineer. The contract unit price shall also include connecting outlets to drainage facilities, welded metal covers, and any necessary excavation and backfill.

SECTION 508

SANITARY SEWER PIPE

508-1 DESCRIPTION

The work under this section shall consist of furnishing and installing sanitary sewer pipe and all other appurtenant materials required including excavation and the furnishing, placing and compacting of backfill material, all in accordance with the details shown on the plans and the requirements of these specifications.

The contractor shall furnish and install sanitary sewer pipe, as specified on the plans at each location. Special sections, fittings, elbows, branch connections, tapered inlets, connectors, coupling, and other such items shall be of the same material and coating as the pipe to which they are attached.

508-2 MATERIALS

508-2.01 General. At each location where a pipe is to be installed, the project plans will specify the pipe-type and size and approximate length along with the requirements for each approved option at that location, such as wall thickness, coatings, lining, class and strength.

508-2.02 Sanitary Sewer Pipe. Sanitary sewer pipe materials for both gravity flow sewers and pressure sewers shall conform to the requirements of Subsection 1010-3.

508-2.03 Concrete for Pipe Encasement. Portland cement concrete for pipe encasement shall conform to the requirements found in Section 1006 for Class B concrete.

508-2.04 Controlled Low Strength Material (CLSM). Materials comprising controlled low strength material shall conform to the requirements of Section 1006. CLSM mix designs shall be in accordance with Subsection 501-2.03, Table 501-1 unless otherwise designated on the plans, in the Special Provisions or directed by the Engineer.

508-2.05 Bedding Material. Aggregate for bedding material shall conform to the gradation requirements for rigid and flexible sanitary sewer pipe found on Standard Detail WWM 104 and WWM 105 respectively.

Bedding material for all concrete or plastic pipe installations shall have a pH value between 6.0 and 12.0, inclusive. Tests for pH and resistively shall be in accordance with the requirements of Arizona Test Method 236.

508-2.06 Shading Material. Aggregate for shading material shall conform to the gradation requirements for rigid and flexible sanitary sewer pipe found on Standard Detail WM 104 and WM 105 respectively.

Shading shall have a pH value between 6.0 and 12.0 for all concrete or plastic pipe installations. Tests for pH and resistively shall be in accordance with the requirements of Arizona Test Method 236.

508-2.07 Trench Backfill Material. Trench backfill material for sanitary sewer pipe shall not contain organic material, rubbish, debris and other deleterious material and shall not contain solid material which exceeds 8 inches (*200 millimeters*) in greatest dimension and shall be soil selected from excavation or from a source selected by the contractor and approved by the Engineer.

Trench backfill material for sanitary sewer pipe within the roadway prism shall also conform to the gradation requirements of the agency in whose right-of-way the pipe is to be installed.

508-3 CONSTRUCTION DETAILS

508-3.01 Preparation of Foundations, Trenches, and Embankments. Trenches for sanitary sewer pipe installations shall be in conformance with the Standard Details unless otherwise noted on the plans or in the Special Provisions.

A trench condition is defined as a trench which has vertical slopes to a point at least 1 foot (*300 millimeter*) above the top of the pipe and its maximum width is as detailed on the Standard Details or project plans.

The contractor shall comply with all Occupational Safety and Health Administration (OSHA) regulations pertaining to trenching operations.

Where rock, hardpan, or other unyielding material is encountered, such material shall be removed below the vertical limits as shown on the plans. The depth to be removed shall be at least 12 inches (*300 millimeters*) or as designated by the Engineer. The width to be removed shall be the width of the trench, as shown on the Standard Details or project plans. This width shall be maintained throughout the additional depth. The over excavated area shall be backfilled with structure backfill material as designated in subsection 203-5.02 and compacted in layers not exceeding 6 inches (*150 millimeters*) in depth.

When a firm foundation is not encountered at the bottom of the vertical limits as shown on the plans due to soft, spongy, or other unstable soil, such unstable soil shall be removed for a width of at least the horizontal outside dimension of the pipe on each side of the pipe and to the depth specified by the Engineer. The unstable soil removed shall be replaced with structure backfill material as designated in Subsection 203-5.02 and compacted in layers not exceeding 8 inches (*200 millimeters*) in depth.

The completed foundation shall be firm for its full length and width. When specified on the project plans, the foundation shall have longitudinal camber of the magnitude specified.

Unless otherwise approved, in writing, by the Engineer, the maximum length of open trench for all installations shall be 500 lineal feet (*150 meters*) or the contractor's daily installation length, whichever is greater.

508-3.02 Bedding.

(A) Placement of Bedding Material. All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the area into which bedding material is to be placed.

Bedding material shall be placed in uniform horizontal layers not exceeding 8 inches (*200 millimeters*) in depth before compaction.

Bedding material shall be placed under and around the pipe to the elevation at the point of maximum width of the pipe (springline), as shown on the plans or as noted on the Standard Details. At the contractor's option, bedding material may be placed above the springline of the pipe.

Bedding material shall be placed in a manner which will prevent distortion, damage to, or displacement of the pipe from its intended location. Bedding material shall also be placed so that adequate support will be provided in the haunch support areas of the pipe. Voids or loose soils which are found to occur due to improper placement or compaction of bedding materials will result in rejection of that portion of the pipe installation. Replacement of the pipe will be at the contractor's expense.

(B) Compaction of Bedding Material. Unless otherwise specified in the Standard Details, bedding material shall be compacted to at least 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Compaction of bedding material shall be performed without damage to the pipe and surrounding in-place material. Special care shall be taken in placing, shaping and compacting all bedding material under haunches of pipe to prevent moving the pipe or raising it from its bedding.

508-3.03 Installation of Sanitary Sewer Pipe

(A) General. Only those materials specified shall be utilized to construct public sanitary sewerage system facilities. Other materials shall be utilized only upon approval by the Engineer.

Sanitary sewer pipe and appurtenances shall be handled in such a manner as to insure delivery to the trench in sound and undamaged condition. Sanitary sewer pipe shall be unloaded opposite or near the location at which it will be installed. The sanitary sewer

pipe shall not be stored along a residential street for more than ten days or along a business street for more than three days. The interior of the pipe shall be thoroughly cleaned of foreign material before being lowered into the trench.

Repairs shall be allowed only when approved by the Engineer. Repairs shall be made in conformance with the requirements specific to the pipe material as herein noted.

Laying of sanitary sewer pipe shall be in finished trenches free from water and debris. Installation of sanitary sewer pipe shall be commenced at the lowest point of the system with the spigot ends pointing in the direction of the flow. Each pipe shall be laid true to line and grade, with uniform support under the full length of the pipe barrel.

Pipe sections shall be laid and joined in such a manner that the offset of the inside of the pipe at any joint will be held to a minimum at the invert. The maximum offset at the invert of pipe shall be one percent of the inside diameter of the pipe, or 3/8 inch (*10 millimeters*), whichever is smaller.

Upon installation, the meeting surfaces shall be wiped clean of dirt and foreign matter, then an approved lubricant shall be applied at the joint surfaces. The spigot shall be positioned inside the socket and the installation completed.

Any adjustment of line and grade shall be made by excavating or filling under the pipe. Wedging or blocking under the pipe ends is prohibited.

Fittings shall correspond in all respects with the requirements specified for pipe of the corresponding size.

Fittings shall be made to such lengths as will accommodate the joining system provided. Tee and wye fittings shall be furnished with spurs of the size specified, securely and completely fastened to the barrel of the fitting in the process of manufacture.

The spurs of tee fittings shall have their axes perpendicular to the longitudinal axis of the fitting. The spur of the wye fittings shall have their axes at angles of approximately 45 degrees to the longitudinal axis of the fitting, measured from the socket or bell end of the fitting. The barrel of each spur shall be of sufficient length to permit making a proper joint.

Spurs shall not project inside the inner surface of the barrel. The barrel of each spur shall be of sufficient length to permit making a proper joint with the connecting pipe.

Plugs shall be furnished and installed in all branch spurs that are left unconnected and at the upper end of each house connection sewer. The plugs shall be strong enough to sustain all applied earth and hydrostatic loads including those due to field hydrostatic tests or air tests.

Plugs for branch pipes having flexible compression joints may be either clay discs with flexible compression joints, factory applied, that will mate with the branch joint; or a resilient material of controlled design and dimensions for mating with the branch pipe to which it is to be applied; or of other material approved by the Engineer. Plugs shall not be adversely affected when exposed to chemical and bacteriological environments. When installed and braced in place in branch spurs, plugs shall withstand a hydrostatic pressure test of 10 psi (*70 kilopascals*) with no leakage.

Whenever work is not in progress, open pipe ends shall be securely closed so that no water, earth or other substance will enter the pipe or fittings. If, prior to testing, any debris is found in the pipe, the pipe shall be cleaned by propelling with water a snug-fitting inflated ball through the pipe or by using other adequate methods.

(B)Vitrified Clay Pipe (VCP). Vitrified clay pipe shall conform to the requirements of Subsection 1010-3.02.

The inside diameter of vitrified clay pipe shall not vary from a true circle by more than three percent of its nominal diameter. The average inside diameter shall be determined by taking any two 90 degree opposing measurements and averaging the readings.

Vitrified clay pipe shall not deviate from a straight line by more than 1/16 inch per foot (*5 millimeters per meter*) of length when the offset is measured from the concave side of the pipe. Measurement shall be taken by placing a straightedge of the concave side of the pipe's full length of the barrel, being sure not to include spigot joint material or socket, and measuring the maximum distance between the straightedge along concave side of pipe.

Vitrified clay pipe of nominal inside diameters from 3 to 18 inches (*75 to 450 millimeters*) shall have no blister with a dimension exceeding 3 inches (*75 millimeters*) and no blister or pimple shall project more than 1/8 inch (*3 millimeters*) above the surface of the pipe. Pipe of nominal sizes over 18 inches (*450 millimeters*) shall have no blister exceeding 2 inches per foot (*167 millimeters per meter*) of internal diameter, and no blister or pimple shall project above the surface of the pipe more than 1/8 inch per foot (*10 millimeters per meter*) of internal diameter. The pipe shall have no broken blisters.

There shall be no fractures or cracks passing through the barrel or socket, except that a single crack at the spigot end of the pipe not exceeding 75 percent of the depth of the socket, or a single fracture in the socket not exceeding 3 inches (*75 millimeters*) around the circumference nor 2 inches (*50 millimeters*) lengthwise, may be permitted. Chips or fractures on the interior of the pipe shall not exceed 2 inches (*50 millimeters*) in length, 1 inch (*25 millimeters*) in width, and a depth of one fourth of the thickness of the barrel. A single pipe shall contain no more than two such defects.

Prior to installation, vitrified clay pipe larger than 15 inches in diameter which is structurally sound may be repaired. These repairs include the cleaning out of cracks, the preparation of chipped surfaces, and the application of repair material.

Longitudinal cracks parallel to the pipe axis and as described below may be repaired, provided they were caused by shrinkage or drying and are not more than 1/32 inch (*1 millimeter*) wide:

Cracks on the exterior of the spigot that do not penetrate the entire barrel thickness and do not exceed 50 percent of the depth of the socket in length.

Cracks in the socket of the pipe that do not penetrate the entire thickness, and do not exceed 75 percent of the depth of the socket in length.

Cracks in the socket of the pipe that penetrate the entire thickness of the socket and do not exceed 50 percent of the depth of the socket in length.

Cracks in the interior of the socket and in the shoulder on the exterior of the socket which do not exceed three inches in length, and do not penetrate more than 20 percent of the wall thickness.

Surface chips located on the exterior of the spigot, the interior or exterior of the socket, or on the shoulder of the socket may be repaired provided:

The length of the chip as measured along its arc does not exceed twice the barrel thickness.

The width is not greater than 50 percent of the socket depth measured parallel to the axis.

The depth is not greater than 25 percent of the wall thickness measured perpendicular to the axis.

Full-depth chips located on the socket may be repaired provided the length of the chip does not exceed twice the barrel thickness or the width does not exceed 25 percent of the socket depth.

Repairs of any type at the spigot or socket or repairs to fittings shall be in accordance with the requirements specified in Subsection 1010-3.02.

Pipe having unauthorized repairs will be rejected. The Engineer may require retesting of any repaired pipe to demonstrate its soundness. The Engineer will supervise all repairs and inspections required in accordance with Subsection 1010-3.02. The Agency shall be reimbursed for all costs incurred for inspection and testing of the repaired pipe.

Joints for VCP shall be bell and spigot or plain end, and shall meet the requirements of ASTM C 425. The bell and spigot shall not vary from a true circle more than three percent of its nominal diameter when measured in accordance with the procedure outlined in this Section. The bell shall be concentric with the barrel of the pipe. Sealing components shall resist attack by chemicals (including a 10% by weight sulfuric acid solution) or combinations of chemicals normally present in domestic and industrial sewage, and shall resist bacterial attack.

Compression couplings shall incorporate continuous and internally positioned corrosion resistant shear rings. Coupling components shall be made of stainless steel of the following type:

Clamps: 300 Series, Type 316
Bolts: 300 Series, Type 305
Nuts: 300 Series, Type 305

The clamps at both ends of the couplings shall be the "field take-up" type.

Fittings and stoppers shall meet the hydrostatic pressure testing requirements of the ASTM C 700 using the testing procedures of ASTM C 301. Joints shall not leak when subjected to the deflection, shear, and displacement tests as described in ASTM C 425.

(C) Ductile Iron Pipe (DIP). Ductile iron pipe shall conform to the requirements of Subsection 1010-3.02.

The pipe manufacturer shall certify that the pipe and the lining meet the requirements of these specifications. The certification shall state specifically the following:

All ductile iron pipe and fittings shall have an internal lining comprised of either a polyethylene (PE) or a combination of polyethylene and fusion bonded epoxy (PE/FBE) or a hybrid novolac epoxy, as appropriate. The internal lining thickness shall be 40 mils (*1 millimeter*) nominal (35 mils (*.90 millimeters*) minimum) in the barrel area, 10 mils (*0.25 millimeters*) minimum in the bell area and 10 mils (*0.25 millimeters*) minimum on the exterior of the spigot end.

Each piece of pipe and each fitting have been checked for holidays utilizing a testing voltage of 7500 volts with a dry conductive probe in the barrel area and a testing voltage of 67-1/2 volts with a wet sponge in both the bell area and the exterior of the spigot end, and that no holidays were found.

The PE, PE/FBE or hybrid novolac epoxy lining shall extend from the bottom of the gasket socket in the bell to a point on the exterior of the spigot end of the pipe where the next pipe gasket would overlap the lining.

All PE, PE/FBE and hybrid novolac epoxies shall comply with the requirements of Subsection 1010-3.02(A) and (B).

A maximum lining thickness of 15 mils (*0.38 millimeters*) has been applied to both the gasket seat groove in the bell area and the exterior of the spigot end.

The Engineer may require the use of novolac epoxy caulking or other approved material during the assembly of all ductile iron pipe when deemed appropriate. The caulking or other approved material must be applied in sufficient quantity and at the proper location so that when the spigot end of the pipe is inserted into the bell end of another pipe, an impermeable seal is developed between the spigot end of one pipe section and the barrel to bell transition point of the other pipe section.

If the contractor makes a field cut of PE, PE/FBE or hybrid novolac epoxy lined pipe, the contractor shall comply with the recommendations of both the pipe and coating manufacturer in applying a hybrid novolac epoxy coating to the pipe end and in allowing proper drying time before pipe assembly. In all cases, a minimum, a 10 mil (*0.25 millimeters*) coating of hybrid novolac epoxy shall be applied to the pipe end and shall overlap the PE, PE/FBE or hybrid novolac epoxy lining by 4 inches (*100 millimeters*) and extend around the end of the pipe and along the outside of the pipe a minimum of 10 inches (*250 millimeters*) and shall also be allowed to dry before pipe assembly. In addition, the overlapped surface of the PE, PE/FBE or hybrid novolac epoxy lining shall be roughened to produce a 3 to 5 mil (*75 to 125 micrometer*) profile over the entire surface in order to insure proper adhesion for the hybrid novolac epoxy.

Holiday testing may be required by the Agency after pipe assembly when deemed appropriate. The testing and repair requirements shall follow the procedures called for in these specifications.

Repair of damaged sections of the PE, PE/FBE or hybrid novolac epoxy lining shall be in accordance with the lining manufacturer's recommendations or as specified below so that the repaired area is equal to the undamaged lined area in all respects. All damaged lined areas and holidays shall be repaired immediately.

There are no other provisions for repair of ductile iron pipe.

The requirements of ANSI/AWWA C105/A 21.5 for materials and installation procedures for polyethylene encasement of underground installations of ductile iron pipe shall be met. Clear polyethylene wrap shall be used. The clear polyethylene wrap shall be marked in accordance with the requirements of ANSI/AWWA C105/A 21.5.

Polyethylene wrap in tube or sheet form for piping encasement shall be manufactured from virgin polyethylene material conforming to the requirements of ANSI/ASTM Standard Specification D 4976. The specified minimum thickness is 0.008 inches (*8 mils*).

(D) Reinforced Concrete Pipe (RCP). Reinforced concrete pipe (RCP) shall conform to the requirements of Subsection 1010-3.03.

Prior to the start of manufacture of RCP, the contractor shall submit to the Engineer detailed shop drawings of the pipe, joints, reinforcement cage assemblies, pipe specials, and the pipe-laying diagrams. The laying diagram shall show the location, length, design designation, and number designation of each pipe section.

The D-Loads specified in the plans and specifications are those to produce a 0.01 inch (*0.25 millimeter*) crack at least 12 inches (*300 millimeters*) in length at the interior pipe surface.

All pipe shall be manufactured, handled, loaded, and shipped in such a manner that it will be delivered to the job site undamaged in sound condition and conforming in all respects to these Specifications.

Reinforced concrete pipe may be rejected for any of the following:

Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

Defects that indicate imperfect proportioning, mixing, and molding.

Surface defects indicating honeycombed or open texture.

Damaged or cracked ends where such damage would prevent the making of a satisfactory joint.

Any continuous crack having a surface width of 0.01 inches (*0.25 millimeters*) or more and extending for a length of 12 inches (*300 millimeters*) or more, regardless of position in the wall of the pipe.

Any crack showing two visible lines of separation for a continuous length of 2 feet (*610 millimeters*) or more, or an interrupted length of 3 feet (*915 millimeters*) or more inside or outside. When required by the Engineer, any crack which is 0.01 inch (*0.25 millimeters*) wide or wider and is not a cause for rejection, shall be filled with neat cement grout composed of cement mixed with water to a fluid consistency.

Any crack that penetrates completely through the pipe wall.

Shattering or flaking of concrete at a crack.

Bubble voids on the pipe surface exceeding 1/4 inch (*6 millimeters*) in depth (unless pointed with mortar).

Blisters at pipe joints involving more than 1/4 the interior surface area, and any un-repaired blister.

A piece broken from the end projections of the pipe which has circumferential length exceeding 60 degrees of the circle, or extends into the gasket contact surfaces of gasketed joint pipe for a circumferential length in excess of 6 inches (*150 millimeters*) (measured at the midpoint of the gasket contact surface on the bell end and at the inner shoulder of the gasket groove at the spigot end). If two or more pieces are broken from an end projection, the total length of such broken pieces on any end shall not exceed 90 degrees of the circle and there shall be a distance of at least 9 inches (*230 millimeters*) of sound concrete between breaks. The total length of broken pieces that extends into the gasket contact surfaces of gasketed joint pipe shall not exceed a circumferential length of 6 inches (*150 millimeters*). If less than 9 inches (*150 millimeters*) of sound concrete exists between two individual breaks, the two breaks shall be considered as one continuous break. Repair of such defects not exceeding the above limitations shall be made as described below. Unsound portions of end projections shall be removed and, if the pieces removed do not exceed the above limits, the pipe may be similarly repaired.

Reinforced concrete pipe may be repaired if approved, in writing, by the Engineer.

Unsound or imperfect concrete shall be removed by chipping. The edges shall be beveled. The area to be repaired shall be kept dry. Loose material and concrete dust remaining after the chipping operation shall be removed by means of an air jet. All concrete repair work shall be trimmed or ground smooth for a neat appearance on the surface.

Epoxy resins previously approved for such use by the Engineer shall be used in the manner prescribed by the Engineer. The prepared area shall be primed with epoxy resin compound, care being taken to ensure intimate contact with the base material. No other materials used in repair of imperfections or damaged pipe are acceptable and shall be rejected regardless of place and nature of repair. An approved epoxy resin shall be equal to "Thiopoxy 63-Grout" as made by Grace and Company, 62 Whittemore Avenue, Cambridge, Massachusetts (Horm Products).

Joints for reinforced concrete pipe shall be rubber-gasket type. The ends of the pipe shall be so formed that, when the pipes are joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface. Each joint shall contain a solid gasket of EPDM, or other material approved by the Engineer, which shall be the sole element for water tightness of the joint. The joint shall not leak when pulled one inch from normal closure for full circumference. The slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees. The rubber gaskets shall conform to the requirements of ASTM C 443. Gaskets shall be stored in a cool place and not exposed to the direct rays of the sun.

Installation of liner plate, including the welding of all joints, shall be done in accordance with the manufacturer's recommendations. Nailing through the plate is not acceptable. Liner plate shall be installed with locking extensions parallel with the longitudinal axis of the sewer unless otherwise shown on the plans. Liner plate shall be held snugly in place against inner forms by means of light gauge steel wire, light steel banding straps, or other suitable means. If steel banding straps are used, they shall be applied in strap channels provided for this purpose.

Locking extensions (T-shaped) shall be integrally extruded to all lower, terminal, or longitudinal edges of liner plate as applied to concrete pipe. If banding straps are used, a steel rod 1/4 inch (*6 millimeters*) in diameter may be inserted in each locking extension along the longitudinal edges of each sheet of liner plate. If approved, either method for holding the lower edge of the liner plate snugly against the form may be provided.

Concrete poured against liner plate shall be compacted in a careful manner so as to protect the liner plate and to produce a dense, homogeneous concrete securely anchoring the lock extensions into the concrete. In removing forms, care shall be taken to protect liner plate from damage. Sharp instruments shall not be used to pry forms from lined surfaces. All holes and cut, torn, or seriously abraded areas in the liner plate shall be repaired. Patches shall be limited to those which can be made with a single weld strip. Parallel, overlapping or adjoining weld strips will not be allowed. Patches made entirely with welding strip shall be fused to the liner plate over the entire patch. Larger patches may consist of smooth liner plate applied over the damaged area with adhesive. All edges must be covered with welding strip fused to the patch and the sound liner plate adjoining the damaged area.

Prior to placing the spigot into the bell of the reinforced concrete pipe previously installed, the spigot groove, the rubber gasket and the bell shall be lubricated with a soft, vegetable soap compound.

The gasket, after lubrication, shall be uniformly stretched or relieved when placing it in the spigot grove so that the rubber is distributed uniformly around the circumference.

After the joint is assembled, a thin metal feeler gauge shall be inserted between the bell and the spigot, and the position of the rubber gasket inspected for the complete circumference of the pipe. If the gasket is not in the proper position, the pipe shall be withdrawn, the gasket inspected to insure that it is not cut or damaged, the pipe reinstalled, and the gasket position again checked. All elliptical pipe shall be joined such that the "T" is at the top and the ends of the plastic liner match in a continuous straight line. Pipe not placed in this manner shall be removed and reinstalled.

The contractor shall take all necessary precautions to prevent damage to installed liner plate from equipment and materials used in or taken through the work. The applied lining shall be free from bubbles due to poor workmanship. The contractor shall cut out bubbled areas and weld a similar sheet in its place unless otherwise directed by the Engineer.

Liner plate shall be set flush with the inner edge of the bell or groove end of a pipe section and shall extend to the spigot or tongue end or to approximately 3 inches (*75 millimeters*) beyond the tongue end, depending upon the type of liner plate to be made with the adjoining concrete pipe. Wherever liner plate protected concrete pipe joins structures not so lined; such as brick structures, concrete pipe cast-in place structures, or clay pipe; the liner plate shall be extended over and around the end of the pipe and back into the structure for not less than 4 inches (*100 millimeters*). Where a pipe spur not of plastic-lined concrete is installed through lined concrete pipe, the liner plate shall be returned 4 inches (*100 millimeters*) at the surface of contact. The seal between the liner plate and the spur shall be made using a method recommended by the manufacturer of the sheet and approved by the Engineer.

If the joint space is too wide or the joint space surface too rough to allow satisfactory sealing with this method, the joint space shall be filled with 2 inches (*50 millimeters*) of densely-caulked lead wool or other approved caulking material. Lined concrete pipe may be cured by standard curing methods. Care shall be exercised in handling, transporting, and placing lined pipe to prevent damage to the liner plate. No interior hooks or slings shall be used in lifting pipe. All handling operations shall be done with an exterior sling or with a suitable fork lift. Pipe with damaged lining shall not be accepted until the damage has been repaired to the satisfaction of the Engineer.

The contractor shall obtain the services of qualified personnel to weld the liner plate field joints. Qualified personnel shall mean the person doing the welding has attended a training school for welding PVC T-rib lined material, been certified by the PVC T-rib manufacturer and has worked for at least 160 hours during the past 12 months welding PVC T-rib lining material. If the individual has not worked the required hours during the previous 12 months, they must attend the training school again, and be re-certified by the PVC T-rib manufacturer. However, if the Engineer finds that, in his opinion, a welder is not providing proper welds, the welder shall be removed from the project even though he has met the training and work experience requirements noted and another qualified welder shall be brought in by the contractor to complete the welding work.

Pipe joints must be dry before the liner plate joints are made. All mortar and other foreign material shall be removed from liner plate surfaces adjacent to the pipe joint, leaving them clean and dry. No liner plate joints shall be made until the trench has been backfilled and the pipe has been tested for leaks.

Field joints in the liner plate at pipe joints shall be Type P-1.

Type P-1 joints shall be made with a separate 4 inch (*100 millimeters*) joint strip and two welding strips. The 4 inch (*100 millimeters*) strip shall be centered over the joint, secured to the liner plate by an approved method, and welded along each edge to adjacent liner plate with a 1 inch (*25 millimeters*) weld strip. The width of the space between adjacent liner plate sheets shall be a minimum of 1/2 inch (*13 millimeters*). The 4 inch (*100 millimeters*) joint strip shall lap over each liner plate a minimum of 1/2 inch (*13 millimeters*).

After the pipe is installed in the trench, all surfaces covered with liner plate shall be tested with an approved electrical Holiday or flaw detector set at a minimum of 20,000 volts. All welds shall be physically tested by a non-destructive probing method. All patches over nail and form tie holes and repairs to the liner plate shall be done in conformance with the instructions and recommendations of the liner plate manufacturer.

Factory certification is required for PVC t-rib lined reinforced concrete pipe. The certification must state that the PVC liner was checked at the factory for holidays at the voltage and testing conditions described in the special provisions and these standard specifications, and that the pipe tested holiday free before shipment.

The contractor, in the presence of and at the direction of the Engineer, shall perform random checks on deliveries of RCP pipe at the site according to the voltage and testing conditions described in the special provisions and these standard specifications.

If an average of one holiday per 1 linear foot (*0.3 linear meter*) in any piece of pipe are found, which average includes any holiday patches already made at the factory, the Engineer reserves the right to reject the delivery of pipe and return it to the manufacturer for replacement. Such pipe rejection is not automatic and would only occur if the Engineer exercises his right to do so.

The factory certification and onsite holiday random spot checking does not remove the requirement for the final holiday testing after the pipe is installed .

The contractor shall also provide to the Engineer a written certification or manifest from the manufacturer of the PVC weld strips and joints strips that lists the quantity, size and number of containers for both the weld strip material and the joint strip

material supplied on the project. The contractor shall require the supplier of PVC joint and weld strip material to label the exterior of all the boxes before arrival on site so that both joint strip containers and weld strip containers can be readily distinguished.

Each transverse welding strip which extends to a lower edge of the liner plate shall be tested. The welding strips shall extend below the liner plate, providing a tab. A 10 pound (*5 kilograms*) pull shall be applied normal to the face of the pipe by means of a spring balance. Liner plate adjoining the welding strip shall be held against the concrete during application of the force. If a weld failure develops The 10 pound (*5 kilograms*) pull shall be maintained until no further separation occurs. Defective welds shall be re-tested after repairs have been made. Tabs shall be trimmed away neatly after the weld strip has passed inspection. The contractor shall provide all equipment required to test liner plate in the manner recommended by the manufacturer and as described above. The contractor shall also provide personnel qualified to perform the testing. Testing shall be performed in the presence of a representative of the Agency.

(E) Polyvinyl Chloride (PVC) Pipe (Gravity Installations). Polyvinyl chloride (PVC) pipe shall conform to the requirements of Subsection 1010-3.05(A).

Standard laying lengths for gravity flow PVC pipe shall be 12.5 feet *(3.8 meters)* or 14 feet (4.3 *meters*). The requirements for pipe diameter and wall thickness are set forth in ASTM D 3034 for nominal pipe diameters of 4 inches through 15 inches (*100 to 400 millimeters*) and ASTM F 679 for nominal pipe diameters of 18 inch (*450 millimeters*) and larger.

Any imperfections which, in the opinion of the Engineer, may adversely affect the performance of the pipe or joints shall be cause for rejection of PVC pipe.

Polyvinyl chloride pipe shall be delivered to the job site and stored in pelletized units less than 40 inches high (*1000 millimeters*). Care shall be taken during the transportation of the pipe to insure that the tie-down methods do not damage or deflect the pipe.

PVC pipe stored at the job site shall be covered with an opaque material to protect it from the ultraviolet radiation. Air circulation shall be provided under the covering. PVC pipe shall not be removed from the pallet or laid out along the ditch more than 24 hours prior to installation in the trench.

Polyvinyl chloride pipe (PVC) pipe shall be installed in accordance with ASTM 2321 as modified by the standard details or these specifications.

In addition to the requirements for pipe installation contained in these specifications, the following provisions shall pertain to gravity PVC pipe installation:

The trench shall not be wheel loaded until 3 feet (*900 millimeters*) of cover is placed over the top of the pipe.

A clamp gasket or approved equivalent method shall be provided at manhole entry or connection to reduce infiltration and exfiltration.

In addition to the tests at the manufacturer's plant, the Engineer may require that tests be performed on pipe specimens selected at random at the point of delivery or at the job site. The Agency shall bear the costs of such tests, which shall be in accordance with ASTM D 2412 and D 2444.

Prior to leaving the job storage area, the pipe may, at the option of the Engineer, be subjected to a deflection test using a mandrel with an outside diameter equal to 98 percent of the internal diameter of the pipe. The mandrel shall pass through the pipe without obstruction or binding.

Prior to final acceptance of the project, but not less than seven days after compaction has been completed, the PVC pipe shall be tested for vertical deflection using a mandrel. Deflections exceeding five percent of the internal diameter shall be cause for rejection of the pipe.

There are no provisions for repair of PVC.

Joints for PVC gravity pipe shall meet the minimum requirements specified in accordance with ASTM D 3212. All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made. All surfaces of the joint, upon which the gasket may bear, shall be smooth and free of any imperfection which could adversely affect sealability. Elastomeric seals (gaskets) shall meet the minimum requirements specified in accordance with ASTM F 477, the gasket shall be an integral part of the joint such that when assembled, the gasket inside the bell shall be compressed radially on the pipe spigot to form a water-tight seal.

Fittings and stoppers shall meet the testing requirements for PVC pipe. Joints shall be capable of passing all tests specified in ASTM D 3212.

(F)High Density Polyethylene (HDPE) Pipe. High density polyethylene (HDPE) pipe shall conform to the requirements of Subsection 1010-3.05.

Prior to the delivery of pipe to the site, the contractor shall submit shop drawings to the Engineer for review and approval. The shop drawings shall provide the following information:

Detailed procedures to be used in joining and installing the piping system including manufacturer's recommendations.

Interface of piping system to equipment and appurtenances.

Bill of materials, indicating material composition of pipe, pressure rating, nominal size with wall dimensions, and its locations on the piping installation drawing.

Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted. Certificates shall specify conformance with the requirements of ASTM D 1248, ASTM D 3350 and that testing of the pipe material was undertaken in accordance with ASTM F 1473, for >100 hours, without failure.

HDPE pipe and fitting joints shall be heat fused by a qualified technician trained by an approved manufacture's representative, in accordance with the manufacturer's recommended fusion procedures. Training shall have occurred in the previous 12 months or submittals verifying field installation experience within the previous 12 months for all technicians performing heat fusion on polyethylene pipe and fittings shall be submitted prior to the start of installation.

All necessary precautions shall be taken to prevent damage or contamination to pipe and other incidental materials during shipment and delivery. All materials shall be securely fastened to truck or rail car to prevent movement or damage during shipment. The contractor shall examine all materials before unloading.

All pipe materials shall be handled so as to prevent damage. HDPE pipe shall not be dropped, rolled or pushed off from any height on delivery storage or installation.

All pipe materials shall be stored off the ground in a dry location. Pipe shall be stored to prevent sagging or bending. Stored pipe shall be protected from exposure to ultraviolet light.

The design pressure rating of the pipe shall be defined in accordance with ASTM D 3035 and F 714. The HDPE pipe shall have a controlled outside diameter and have been manufactured to the SDR/DR rating specified by the plans or Special Provisions.

Fittings shall be manufactured using the same pressure rating as the designed piping system. The fitting shall have a controlled outside diameter and the SDR/DR rating for the pressure specified by the plans or Special Provisions. Fittings shall be specifically manufactured to standardized dimensions noted on the plans.

Butt fusion fittings shall be manufactured from the same material as the extruded pipe, shall be rated for a pressure service at least equal to that of the system pipe, and shall have outlets manufactured to the same DR as the system pipe. Molded fittings shall be manufactured in accordance with ASTM D 3261 and socket fittings shall comply with ASTM D 2683.

All piping shall be inspected to assure that it is free from defects in material and workmanship. The compatibility of all pipe and fittings shall be verified.

Pipe, fittings and accessories that are cracked, damaged, not identified or in poor condition shall be rejected. Pipe sections or fittings containing significant scratches, dents or marks, that are not in conformance with the manufacturer's criteria for such blemishes, may be cause for rejection at the sole discretion of the Engineer.

The Engineer shall have free access to all joints, including test joints for determining the suitability of the joining procedure. Where construction restrictions limit inspection of joints the Engineer may direct the individual joining the pipe and/or fittings to perform a test joint in a manner that it can be clearly and easily observed. The Engineer shall select the method of testing from either visual examination, bent strap testing or ultra-sonic testing. Ultra-sonic testing shall conform to the requirement of the U S Department of Transportation as found in the Code of Federal Regulations 49, Part 192.285 (b) (ii) or (b) (iii).

HDPE pipe and fittings shall be heat fused together creating a homogeneous joint. Joining shall be in accordance with the manufacturer's heat fusion recommendations. Joints shall not be of the solvent weld type.

Personnel responsible for heat fusing the joints shall demonstrate proficiency by fusing trial joints and testing the trial fusion by bent strap testing or ultra-sonic testing. Trial joints shall be allowed to cool completely before testing and shall not fail at the joint. During construction, the first fusion of the day shall be a trial fusion which shall be allowed to cool, and destructively bent strap tested or ultrasonically tested. If the trial fusion fails, additional trial fusion's shall be made and tested until successful fusion's are completed. The procedure used to join the trial fusion shall be used for the balance of the day's work, provided the procedure is in compliance with that recommended by the manufacturer. The Engineer shall provide written notice to the contractor of the unacceptability of any installer whose work is deemed deficient in satisfactorily completing the heat fusion of polyethylene pipe. Any individual deemed unacceptable by the Engineer shall not be utilized by the contractor unless the individual undergoes additional training and meets the requirements specified herein.

All HDPE pipe shall be installed so as to minimize shear or tensile stresses. Pipe shall be installed in a trench as specified by the plans or Special Provisions. The minimum burial depth shall also be as specified in the plans or Special Provisions.

Pipe bedding and shading shall conform to the requirements of Standards Detail WM 105. Backfill shall comply with the provisions of Subsection 508-2.07.

508-3.04 Shading and Trench Backfill.

(A) Backfill. Sanitary sewer pipe backfill shall consist of shading material and trench backfill material.

Shading shall be placed over and around the pipe from the top of the bedding material to 1 foot (*300 millimeters*) above the top of the pipe. Shading shall be selected from excavation or from a source selected by the contractor. It shall not contain frozen lumps, stones larger than 3 inches (*75 millimeter*) in diameter, chunks of clay or other objectionable material. Shading material shall conform to the requirements of Subsection 508-2.06. At the contractor's option, shading material may be used in place of backfill material in areas outside the roadway prism.

Trench backfill shall be placed from 1 foot (*300 millimeters*) above the top of pipe to the subgrade elevation of the roadway or to existing ground when the installation is outside the roadway prism.

Trench backfill shall conform to the requirements of Subsection 508-2.07 with the exception that, within the roadway prism, trench backfill material shall conform to the requirements of shading material as specified in Subsection 508-2.06. However, when shading material is used for trench backfill, 100% of the material shall pass the 6 inch (*150 millimeter*) sieve instead of the 1 inch (*25 millimeter*) sieve.

(B) Placement of Shading and Trench Backfill. All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the areas to be backfilled before backfill material is placed.

Shading or trench backfill, compacted by pneumatic or mechanical tamping devices, shall be placed in layers not more than 8 inches (*200 millimeters*) in depth before compaction.

Shading, or bedding material, shall be brought up evenly on both sides of the pipe to an elevation 12 inches (*300 millimeters*) above the top of the pipe.

(C) Compaction of Shading and Trench Backfill. Shading and trench backfill material shall be compacted to at least 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manuel, as directed and approved by the Engineer.

Jetting shall not be used to compact shading or trench backfill.

(D) Encasement of Pipe. When shown on the project plans, or specified in the Special Provisions, pipe shall be encased in Class B concrete conforming to the requirements of Subsection 501-2.02 or controlled low strength material (CLSM) conforming to the requirements of Subsection 501-2.03. CLSM may also be used in lieu of trench backfill material if approved by the Engineer.

508-3.05 Testing. Sanitary sewer pipelines shall be tested for leakage or infiltration following the placement of the trench backfill material and final compaction.

Gravity sanitary sewer installations shall comply with the testing requirements of Arizona Administrative Code R18-9-E301.

The contractor shall test all pipe as specified above. Pipe greater than 48 inches (*1.2 meters*) in diameter shall also be tested using the Joint Test method described in Subsection 508-3.05(G) when directed by the Engineer.

In the case of new sewer lines with house connections included as an integral part of the project, the test shall be performed after the house connections and stubs have been completed and backfilled. In the case of replacement sewer lines, the test shall be as specified in the Special Provisions.

(A) Air Test. Testing shall be done in accordance with either ASTM F 1417 (plastic pipe), ASTM C 924 (concrete pipe) or ASTM C 828 (vitreous clay pipe). The test procedure shall match the type of pipe material. If the material type of the pipe to be installed does not fall under one of the noted categories, the Engineer will direct which test should be conducted to verify the pipe's water tightness. The basic test procedure is as follows:

(1) Determine the test time for the section of line to be tested - see procedure noted in Subsection 508-3.05(E).

(2) Plug all openings in the test section.

(3) Add air until the internal pressure of the line is raised to approximately 4.0 pounds per square inch (*27.5 kilopascals*). After this pressure is reached, allow the pressure to stabilize. The pressure will normally drop as the air temperature stabilizes. This usually takes 2 to 5 minutes, depending on the pipe size. The pressure may be reduced to 3.5 psi (*24 kilopascals*) before starting the test.

(4) When the pressure has stabilized and is at or above the minimum required starting test pressure of 3.5 psi (*24 kilopascals*), start the test. If the pressure drops more than 1.0 psi (*7.0 kilopascals*) during the test time, the line is presumed to have failed the test. If a 1.0 psi (*7.0 kilopascals*) drop does not occur within the test time, the line is considered to have passed the test.

(B) Air Test - Time Determination Procedure

(1) Table 508-1, or Table 508-2 indicates the required test time, T, in minutes/100 feet (*minutes per 30 meters*) or other distances for pipe of each nominal size. Test times are for a 1.0 psi (*7.0 kilopascal*) pressure drop from 3.5 to 2.5 psi (*24 kilopascals to 17 kilopascals*).

(2) If the section of line to be tested includes more than one pipe size, calculate the test time for each size and add the test time to arrive at the total test time for the section.

(3) It is not necessary to hold the test for the whole period when it is clearly evident that the rate of air loss is greater than allowable.

TABLE 508-1

Minimum Test Time for Various Pipe Sizes
(Vitreous Clay Pipe and Concrete Pipe)

Nominal Pipe Size, Inches (*millimeters*)	Time Minutes/100 ft. (*minutes/30 meters*)	Nominal Pipe Size Inches (*millimeters*)	Time Minutes/100 ft. (*minutes/30 meters*)
3 (*75*)	0.2	24 (*600*)	3.6
4 (*100*)	0.3	27 (*675*)	4.2
6 (*150*)	0.7	30 (*750*)	4.8
8 (*200*)	1.2	33 (*825*)	5.4
10 (*250*)	1.5	36 (*900*)	6.0
12 (*300*)	1.8	39 (*975*)	6.6
15 (*375*)	2.1	42 (*1050*)	7.3
18 (*450*)	2.4	48 (*1220*)	8.5
21 (*525*)	3.0		

Table 508-2

Minimum Test Time for Various PVC Pipe Sizes (Plastic Pipe)

(Time Required for a 1.0 psig Pressure Drop for Size and Length of Pipe Indicated for Q = 0.0015)

Note 1: Refer to Uni-Bell PVC Pipe Association Standard UNI-B-6-90, "Recommended Practice for Low Pressure Testing of Installed Sewer Pipe"

Note 2: Consult with pipe and appurtenance manufacturer for maximum test pressure for pipe size greater than 30 in. diameter.

Pipe Diameter, in. (*mm*)	Minimum Time, min. s	Length For Minimum Time, ft (*m*)	Time For Longer Length, s	Specification Time for Length (L) Shown, min, s							
				100 ft (*30.5m*)	150 ft (*45.7m*)	200 ft (*61m*)	250 ft (*76.2m*)	300 ft (*91.5m*)	350 ft (*106.7m*)	400 ft (*121.9*)	450 ft (*137.1m*)
4 (*100*)	3:46	597 (*182.0*)	0.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6 (*150*)	5:40	398 (*121.3*)	0.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8 (*200*)	7:34	298 (*90.8*)	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10 (*250*)	9:26	239 (*72.8*)	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12 (*300*)	11:20	199 (*60.6*)	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15 (*380*)	14:10	159 (*48.4*)	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18 (*460*)	17:00	133 (*40.5*)	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21 (*530*)	19:50	114 (*34.7*)	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24 (*610*)	22:40	99 (*30.2*)	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27 (*685*)	25:30	88 (*26.8*)	17.306 L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30 (*760*)	28:20	80 (*24.4*)	21.366 L	35.37	53.25	71:13	89:02	106:50	124:38	142:26	160:15
33 (*835*)	31:10	72 (*22.0*)	25.852 L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36 (*910*)	34:00	66 (*20.1*)	30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

(C) Pressure Test. All pipe for use as a force main shall be hydrostatically tested for leakage. Care shall be taken to insure that all air vents are open during filling. After the piping is completely filled, it shall be allowed to stand under a slight pressure for sufficient time, at least 48 hours, to allow the escape of air from any air pockets. During this period, bulkheads, valves, and connections shall be examined for leaks. If any are found, they shall be repaired prior to final pressure testing. The final test shall consist of holding 150 psi (*1035 kilopascals*) for a period of 4 hours with leakage less than 15 gallons per inch of diameter per mile of pipe per 24 hours (*1.4 liters per day per kilometer per millimeter of internal diameter of pipe*).

(D) Joint Test. For pipe greater than 48 inches (*1.2 meters*) in diameter, the joint test method shall be used in addition to the air test previously described in this Subsection when so directed by the Engineer.

(1) Equipment. The contractor shall provide all materials, labor, and equipment necessary for joint testing.

(a) Joint Tester Frame - The joint tester frame assembly is to be constructed of heavy gauge metal that can be broken down easily into small sections for ease of handling and installation/removal from sewer manholes.

(b) Bladder(s) - The joint tester shall have either single or double bladder construction.

Single Bladder Tester: The bladder shall be of a one-piece construction within an outer layer of a soft, natural rubber, between the pipe and tester.

Double Bladder Tester: The joint tester shall have two inflatable tubes (bladders) constructed of rugged heavy-duty elastomer. The bladders shall be stretched and positioned onto the joint tester frame assembly so they can be aligned over the joint to be tested. When inflated, the bladders shall create an air-tight seal against the pipe wall.

(c) Control Panel - The joint tester control panel shall provide a reliable means of controlling and monitoring bladder and center cavity pressures from a single component. The control panel shall be conveniently mounted onto the joint tester frame assembly requiring only input air from the compressor.

(d) Wheel Assemblies - Each wheel assembly shall be mounted to the inside surface of the joint tester frame assembly. The contractor will provide an easy way of transporting the Joint Tester from one joint to the next, as well as providing height adjustment and centering of the joint tester over pipe joints.

(e) Interconnect Hoses - Hoses shall be provided to route air from the control panel to the air reservoir and from the air reservoir to the center cavity chamber.

(f) Air Reservoir – An air reservoir shall be included in the joint test system. The air reservoir shall have a maximum volume of 2.5 cubic feet (*0.07 cubic meters*).

(2) Air Testing Procedure.

Determine test pressure. Test pressure for large diameter reinforced concrete pipe (RCP) shall be 3.5 psi (*24 kilopascals*).

Position the joint tester so the bladder(s) are properly located over the joint to be tested. Inflate the bladder(s) to 50 psi (*345 kilopascals*) or in accordance with testing equipment and manufacturer's instructions.

Pressurize the center cavity with air to test pressure in Step 1 above. Allow pressure to stabilize (approximately 10-15 seconds) and turn off pressure source.

If the pressure in the cavity holds or drops less than 1 psi (*7 kilopascals*) in 5 seconds, the pipe joint shall be found to be acceptable. If the pressure drops over 1 psi (*7 kilopascals*), the joint is defective and should be repaired and retested.

When the joint test is completed, all pressure must be exhausted from center cavity to 0 psi (*0 kilopascals*) and then from the bladder(s) to 0 psi (*0 kilopascals*). The joint tester can then be transported and positioned on the next joint to be tested.

(3) Joint Sealing. The contractor may seal the joint to make sure that it is water tight if the Engineer approves this method instead of a joint test. The sealing method shall consist of:

(a) Priming the sides of the concrete joint according to the primer manufacturer's instructions.

(b) Installing backer rod of a certain size in the bottom of the joint so as to leave a 1/2 inch (*13 millimeters*) to 5/8 inch (*16 millimeters*) depth for the flexible sealant.

(c) Installing a nonsagging, 2 component elastomeric sealant in accordance with the sealant manufacturer's instructions.

(E)Alignment Verification. The contractor shall provide sufficient checking and verification of the grade and alignment during the progress of the construction to ensure that the installed sanitary sewer pipe is constructed within the allowable tolerances noted in this Subsection. Unless otherwise approved by the Engineer, the method of verification shall include the use of grade stakes. Grade stakes, when used, shall be placed at intervals not exceeding 50 feet (*15 meters*) along the entire length of the sewer line to be installed. The grade stake(s) shall indicate the offset distance to the centerline of the pipe and the cut or fill value, to specified elevations. When grade stakes are used, the contractor shall provide a grade sheet to the Engineer describing the type of stake, offset dimension or line indication, station, cut or fill value to invert or other specified elevation and any other special information. The contractor shall provide access to the trench and installed pipe to allow for periodic inspections of the alignment and grade by the Engineer.

The pipe shall be visually inspected by directing a beacon of light, from a flashlight, mirror, or other source, into the pipe. If the illuminated interior, or moon, of the pipe indicates improper alignment or any other deficiency, the condition shall be either corrected at the contractor's sole cost, or, upon approval

of the Engineer based on the degree of the deficiency, the contractor may be given the option of accepting a reduction in payment as a penalty for the Agency allowing the deficient work to remain in place.

Penalty schedules are as noted in Subsection 110-5.

The percentage of pipe illumination noted in Table 110-13 is based on the area of that portion of the full "moon" that is visible during the visual inspection.

Pipe sections installed at a reverse grade shall be removed and reinstalled to the correct grade at the contractor's sole expense.

508-4 METHOD OF MEASUREMENT

Sanitary sewer pipe less than 36 inches (*900 millimeters*) in diameter shall be measured by the linear foot (*meter*) parallel to the central axis of the pipeline, from manhole center to manhole center, and from manhole center to the end of plugged pipe; and shall include the length of all fittings and connections.

Sanitary sewer pipe 36 inches (*900 millimeters*) and greater in diameter shall be measured by the linear foot (*meter*) from inside face of wall to inside face of wall.

Tees, wyes and other branches will be measured as pipe along the central axis of the pipes to the point of intersection of said central axis. Pipe reducers will be measured as pipe of the larger diameter along the central axis.

The end of pipe in closed structures will be considered to be at the intersection of the central axis and the inside face of the wall.

Unless otherwise provided in the special provisions, no measurement shall be made for the following items of work. The cost of these items shall be included in the unit price for sanitary sewer pipe.

All testing except those tests specifically herein as being paid for by the Agency.

Shoring and sheetpiling, except that sheetpiling, directed by the Engineer to be cut off and left in place.

Dewatering.

Maintenance and operation of existing sewers during construction.

508-5 BASIS OF PAYMENT

Except as hereinafter specified, no separate measurement or payment will be made for excavating trenches, dewatering compacting subgrade and for furnishing, placing and compacting bedding and backfill material as described and specified herein and on the project plans, the cost thereof being considered as included in the contract unit price per foot (*meter*) of sanitary sewer pipe.

Payment for the removal of rock, hard pan, other unyielding material, or soft, spongy or other unstable soil below the vertical limits as shown on the plans, and the backfilling and compaction of these overexcavated areas, as specified herein and as directed by the Engineer, will be paid for in accordance with the requirements of Subsection 104-2.

The accepted quantity of sanitary sewer pipe, measured as provided above, shall be paid for at the contract unit price complete-in-place for all pipe diameters specified.

The respective unit prices specified to be paid per linear foot (*meter*) of pipe shall be compensation in full for furnishing all pipe, sewer fittings and other materials required for building pipelines, for excavating and for laying, setting, and jointing of all pipes and fittings, for all testing, including leakage tests, all shoring, sheeting and bracing, de-watering by any and all methods, all backfill, excavation and recompaction of existing sub-grade, all bedding, all clean up, all labor, tools and construction equipment, and for all other work and incidental expenses. Payment includes all costs for maintaining the operation of the existing sewers during construction and for removing or abandoning existing sanitary sewers.

SECTION 509

SANITARY MANHOLES

509-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing or adjusting manholes or other structures comprising the sanitary sewer conveyance system including frames and covers; furnishing and installing frames and covers; or removing and resetting existing frames and covers or furnishing prefabricated adjustment rings at the locations designated on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

509-2 MATERIALS

509-2.01 Concrete. Materials furnished for portland cement concrete shall conform to the requirements of Section 1006.

Unless otherwise specified on the plans or Special Provisions, sanitary sewer manholes shall be precast units conforming to the requirements of ASTM C 478.

When specified on the plans or in the Special Provisions, sanitary sewer manholes and structures may be cast-in-place. Class S concrete, having a compressive strength after 28 days of 3,000 psi shall be required for manhole bases, inverts, channels, and bench areas. Class S concrete, having a minimum compressive strength after 28 days of 4,000 psi shall be required for manhole walls. Class B concrete shall be used for all other portions of the manhole. Portland cement shall conform to the requirements of ASTM C 150 for Type II unless the construction plans or Special Provisions state otherwise.

509-2.02 Reinforcing Steel. Materials furnished for reinforcing steel shall conform to the requirements of Section 1003.

509-2.03 Brick. Brick shall be 2-1/4 x 3-5/8 x 7-5/8 inches (*57 x 90 x 190 millimeters*) in size and shall conform to the requirements of ASTM C32, Grade MS.

509-2.04 Mortar. Mortar shall conform to the requirements of Subsection 503-2.03.

509-2.05 Water. Water shall conform to the requirements of Subsection 1006-2.02.

509-2.06 Frames, Covers and Prefabricated Adjustment Rings. The top surface of each sanitary sewer cover shall be cast with a studded pattern, including lettering in accordance with the standard details. Covers, with the exception of waterproof covers, shall be provided with ventilating holes conforming to the requirements of the standard details.

Frames and covers shall be manufactured in accordance with the Standard Details and shall be manufactured from gray iron, conforming to the requirements of ASTM A 48, Class 35B. Frames and covers shall be designed for H-20 loading inclusive of the proof load requirements outlined in Section 7 of the American Association of State Highway and Transportation Officials (AASHTO) Standard Specification for Drainage Structure Castings, ASSHTO Designation M 306.

Frames and covers shall be cast from ferrous materials using a minimum of 75% post consumer waste. The basic design, initial sample castings and first article inspection, also known as the first proof load test, shall be pre-approved by the Agency prior to delivery. All lettering on the covers shall comply with that shown on the Standard Details.

Certificates of Compliance conforming to the requirements of Subsection 106.5(B) shall be submitted.

The bearing surfaces of the frames and covers shall be machine finished so that the covers will seat themselves firmly onto the frame. There shall be no movement of the frame from traffic. A 1/8 inch (*3 millimeter*) annular clearance shall be provided between frame and cover.

509-2.07 Steps. Steps for manholes and structures shall be polypropylene plastic-coated Number 3 (*metric No. 10*) deformed bars conforming to the requirements of ASTM C 478. Steps for pre-cast concrete manholes and for brick manholes shall conform to the Standard Details.

509-2.08 T-Lock Lining. Where indicated on the plans, the interior concrete walls and ceiling surfaces of manholes and structures shall be sealed with a protective lining installed by the Contractor or Pre-fabrication Supplier. The material used in the liner plate shall be a combination of inert, synthetic resins, pigments, and plasticizers, compounded to make permanently flexible sheets.

The liner plate shall be resistant to oxidizing agents; sulfuric, phosphoric, nitric, chromic, oleic, and stearic acids; sodium and calcium hydroxides; ammonia; sodium, calcium, magnesium and ferric chlorides; ferric sulfate; petroleum oils and greases; vegetable and animal oils; fats; greases' and soaps. The liner plate shall be impermeable to sewage gases and liquids, and shall be nonconducive to bacterial and fungus growth. All liner plates shall be factory checked with a high-voltage electrical Holiday detector set to a minimum of 20,000 volts to insure freedom from any porosity. The lining shall have good impact resistance, shall be flexible, and shall have an elongation sufficient to bridge up to a 1/8 inch (*3 millimeters*) setting crack without damage. Once cast into the structure, the lining shall be permanently and physically (not adhesively) attached by the T-LOCK mechanism. The lining shall withstand a 40 psi (*275 kilopascals*) hydrostatic back-pressure applied to the under surface of the lining without losing anchorage or without rupture or leakage.

The liner plate shall not be less than 0.065 inches (*2 millimeters*) in thickness. Locking extensions shall be of the same material as the liner and shall be integrally extended with the sheets. If steel bands are used to secure the liner plate to the forms transversely, strap channels shall be integrally molded into the sheet.

The liner plate shall be supplied as wall-size sheets fabricated by shop welding together the basic size sheets. Any joint straps shall be 4.0 ± 0.25 inches (*100 ± 6 millimeters*) in width and shall have the edges beveled at the time of manufacture.

509-2.09 Coatings.

(A) All exposed metal shall receive an SSPC-SP5 White Metal Blast Cleaning and the following coatings:

(1) One or more coats of HYBRID NOVOLAC EPOXY COATING, or other approved coating shall be applied in accordance with the manufacturer's recommendations. The total dry film coating thickness shall be 16 to 20 mils (*400 to 500 micrometers*) in dry film thickness. The color of the final coat shall be charcoal gray, white or other approved color. After all coats have been applied, the area where the HYBRID NOVOLAC EPOXY COATING or other approved coating was applied shall be checked for holidays utilizing a testing voltage of 67 1/2 volts with a wet sponge and a certification issued stating that there are none.

(B) The HYBRID NOVOLAC EPOXY COATING, or other approved coatings shall be applied by an applicator who specializes in applying coatings and is qualified to apply the coating in accordance with the manufacturer's specifications.

(1) The coating applicator must have a minimum of five (5) years experience in applying either the specified coating or an equivalent coating. The applicator shall submit a performance history for the application of either the specified coating or a similar coating in the wastewater industry or equivalent for the previous five (5) years.

(2) The coating applicator shall be an Arizona licensed contractor with an AE license or approved equivalent.

(3) The coating applicator shall submit a manufacturer's certification to apply the coating specified herein.

(4) The coating applicator shall submit three (3) references relating to the quality of workmanship performed on other projects using the same coating being proposed or an equivalent coating.

(5) The coating applicator shall warrant the work for five years from the date of acceptance of the work. The warranty shall include a bond or approved equivalent for the coating in an amount that is approved by the Engineer. The warranty shall cover the coating that is applied to any part of the manhole except for the manhole cover and frame. This bond will be payable to the Agency that will own, use and maintain the manholes. No bond or warranty will be required for the coating that is to be applied to the manhole frame and cover. The bond or approved alternate shall cover both the material costs and the labor costs associated with installing the approved coating. The bond or approved alternate shall be unconditional in nature covering any type of failure in the coating and agreeing to repair or replace it at no cost to the Agency that will own, use and maintain the manhole(s), at any point during this five year period. The coating applicator shall also supply a warranty from the coating manufacturer addressed to the bonding company and the Agency that will own, use and maintain the manholes. This warranty shall state, at a minimum, that if the coating is applied in accordance with the manufacturer's recommendations, that the coating will not fail for a period of five years while the coating is immersed in either an acidic or an alkaline solution that is maintained at a temperature of 85° F *(30 °C)*. The acidic solution shall be considered a 10% by weight concentration of sulfuric acid and the alkaline solution shall be considered a 25% by weight concentration of sodium hydroxide. The definition of a coating failure is blistering, cracking, brittleness or softening of the coating.

(C) The joint between the manhole frame and the manhole walls and the joint between the manhole walls and the bench shall be caulked using an approved Hybrid Novolac Epoxy Caulk, or other approved caulking material. All applications shall be conducted in accordance with the manufacturer's recommendations.

(D) Manhole steps shall be caulked to seal any crack that exists between the manhole step and the manhole wall. Caulking shall be approved by the Engineer prior to being used by the contractor.

(E) Dry abrasive brush-off blasting and dry abrasive blasting of metal shall be conducted in the presence of the Engineer. Dry abrasive blasting shall use only copper slag.

(F) All new manhole walls, channels and bench areas that are constructed over a new or existing sewer line shall be cleaned and coated to resist corrosion. Coating of the manhole walls, channels and manhole bench areas shall be accomplished with a 3/16 inch (5 millimeter) minimum dry film thickness coating of Hybrid Novolac Epoxy Coating, or other approved coating after an approved underlayment has been used to fill all cracks or voids and to provide a smooth surface. The Hybrid Novolac Epoxy Coating, or other approved coatings and underlayments are to be applied in accordance with the manufacturer's recommendations using a trowel. The final coating applied to the bench shall not be backrolled to

retain the rougher surface. The trowel marks and other minor surface irregularities shall be removed (except for the bench area) by using a short nap mohair paint roller. The short nap mohair roller should be dampened with water and the excess water shaken off prior to use. All concrete surfaces that have been cured with conventional curing compounds or could be contaminated with oils, grease, or other substances must be scarified (and if needed, chemically cleaned) to remove the contaminants prior to beginning the specified surface preparation. All new concrete on the wall, in the manhole bench area and channel shall receive a dry abrasive brush-off blasting using a minimum pressure of 90 p.s.i. *(620 kilopascals)* to lightly abrade the surface and open up subsurface holes and voids and etch the surface sufficiently (to approximately a 60 grit sandpaper texture) to allow the coating to bond satisfactorily. Finally, spray application of coatings will be allowed if the spray equipment complies with the coating manufacturer's recommendations. After the Hybrid Novolac Epoxy Coating, or other approved coating has been applied to all specified areas, the areas shall be checked for holidays utilizing a minimum testing voltage of 17,000 volts with a dry conductive probe. Once the testing has been completed with no deficiencies noted, a certification shall be submitted to the Engineer to that effect.

(G) All new manholes or extensions to manholes with existing PVC t-rib lining shall have one of the previously specified coatings applied to both the concrete and the steel surfaces of the new manhole or the extension to the new manhole. For the purpose of this note, a diversion structure will be considered a manhole.

(H) All existing manholes that must be extended and do not have an existing PVC t-rib lining shall have a Hybrid Novolac Epoxy Coating or other approved coating applied to both the concrete and the steel surfaces of the extension and the existing part of the manhole.

(I) An epoxy primer/sealer coat shall be applied to all new and existing concrete surfaces before any other coating is applied. The existing concrete surfaces that shall receive the epoxy primer/sealer are those which have a difference in temperature of 15° F (8 °C) or more between the concrete surface at the top of the manhole and the concrete surface at the bottom of the manhole. The epoxy primer/sealer shall be applied in accordance with the manufacturer's instructions.

(J) Existing manholes shall be cleaned and rehabilitated to resist corrosion by coating the manhole walls, manhole channels and manhole bench areas with a 3/16 inch (*5 millimeters*) minimum dry film thickness Hybrid Novolac Epoxy Coating, or other approved coating after an approved underlayment has been used to fill all cracks or voids and to provide a smooth concrete surface. The Hybrid Novolac Epoxy Coating, or other approved coatings and underlayments are to be applied in accordance with the manufacturer's recommendations using a trowel. The final coating that will be applied to the bench shall not be backrolled to

retain the rougher surface. The trowel marks and other minor surface irregularities shall be removed (except for the bench area) by using a short nap mohair paint roller. The short nap mohair roller should be dampened with water and the excess water shaken off prior to use. After the Hybrid Novolac Epoxy Coating, or other approved coating has been applied to all specified areas, the areas shall be checked for holidays utilizing a minimum testing voltage of 17,000 volts with a dry conductive probe. Once the testing has been completed with no deficiencies noted, a certification shall be submitted to the Engineer to that effect. All concrete surfaces that have been cured with conventional curing compounds or could be contaminated with oils, grease, or other substances must be scarified (and if needed, chemically cleaned) to remove the contaminants prior to beginning the surface preparation. New concrete in the manhole bench area and channel shall receive a dry abrasive brush-off blasting using a minimum pressure of 90 p.s.i. (*620 kilopascals*) in order to lightly abrade the surface, open up subsurface holes and voids and etch the surface sufficiently (to approximately a 60 grit sandpaper texture) to allow the coating to bond satisfactorily. All existing concrete surfaces on the walls, manhole bench area and in the channel shall first receive a wet abrasive blasting using a minimum water pressure of 5,000 p.s.i. (*34.5 megapascals*) until all loose and deteriorated concrete has been removed. When the wet abrasive blasting has been completed, all concrete surfaces in the area where this blasting has occurred shall be flushed with water at a minimum water pressure of 5,000 p.s.i. (*34.5 megapascals)* to remove any residual sand from the abrasive blasting operation. Only silica sand and water may be used in the wet abrasive brush-off blasting. Following the wet abrasive blasting, a dry abrasive blasting using only copper slag at a minimum pressure of 90 p.s.i. (*620 kilopascals)* shall be done to remove any remaining deteriorated concrete. The channel area of the sewer shall be covered when there is a chance of falling debris entering the sewer. The channel cover, together with any debris, shall be removed prior to acceptance of the work by the Engineer.

A spray application of the coating will also be allowed if the spray equipment being proposed complies with the coating manufacturer's recommendations.

509-3 CONSTRUCTION DETAILS

509-3.01 General. All Hybrid Novolac Epoxy coatings used for manhole applications shall meet Pima County Wastewater Management standards current at the time of bid advertisement.

Excavation for manholes shall be in accordance with the requirements of Subsection 203-5.

All connections for lateral pipes will be considered a part of the manhole. The invert channel may be lined with split pipe.

SECTION 509

Manhole side-walls shall be constructed of cast-in-place concrete or precast concrete or brick, as shown on the project plans. The base of all manholes shall be cast-in-place concrete.

Backfilling of the completed structure shall be with satisfactory material thoroughly compacted in accordance with the requirements of Subsection 203-5.

Where frames and covers for manholes are to be set in new bituminous mix or asphaltic concrete surfaces, they shall be set after placement of the finish or surface course of asphaltic concrete. Steel plates of a size approved by the Engineer shall be placed over the manhole prior to placing courses of asphaltic concrete. After placement of all courses of asphaltic concrete are completed, the steel plates shall be removed. The asphaltic concrete shall be cut and removed in a manner such that a concentric circle is formed about the center of the manhole and the excavated face of the area removed is vertical. The frames and covers shall be set in concrete at the proper elevation so that the cover will be flush with the adjacent finish or surface course. Care shall be taken that the base and surfacing materials are not disturbed beyond the edges of the plate and that debris is kept from falling into the manhole. Concrete and reinforcing steel shall be placed around the frame as noted on the Standard Details. The concrete shall be protected during the curing period.

All castings shall be true to pattern in form and dimension and free from pouring faults, sponginess, cracks, blowholes, or other defects in locations affecting their strength for the service intended. Castings shall be filleted boldly at angles, and the risers shall be sharp and true. Before the castings are removed from the foundry, they shall be thoroughly cleaned and the parting lines, gates and risers ground flush. No plugging or other stopping of holes will be allowed. The castings shall be thoroughly cleaned of all lumps and subject to a careful hammer test.

Prior to setting, both new and existing frames and covers shall be thoroughly cleaned of all grease, oils, asphaltic materials, portland cement concrete or other deleterious materials. Cleaning shall include obstructions to handling holes, pick holes, vent holes and bolt holes.

Frames and/or covers that are damaged by other than the contractor or that cannot be cleaned to the satisfaction of the Engineer shall be replaced. Payment for replacement frames and/or covers shall be made in accordance with Subsection 104-3.

Upon completion each manhole shall be thoroughly cleaned and kept clean until final acceptance of the work.

The contractor shall observe all pertinent requirements regarding the manhole construction. Streets shall be kept open for passage of traffic and protection for the public shall be provided when the manhole excavation is exposed. The manhole construction work shall be completely and adequately covered when no work is being done. Flow management of wastewater from sanitary sewers shall be accomplished by pumping to an adjacent "live" manhole or tank truck for proper disposal.

509-3.02 Sanitary Sewer Manholes and Structures. Prior to commencing work on any sanitary sewer manhole or structure, a Construction Permit shall be secured from the Agency that owns and operates the sanitary sewer system. The contractor shall be responsible for payment of all applicable inspection fees associated with said permit.

Manholes shall be located so as to be positioned beneath the paved portions of public roads, streets, avenues, alleys and public rights-of-way, or within dedicated public sewer easements under paved private streets, to the maximum degree viable; to maximize visual access and to maximize unrestricted 24-hour maintenance vehicle access over and to the public sanitary sewerage facilities. See the standard details for more information in this regard.

(A) New Construction.

(1) Manhole Base. An unreinforced manhole base may be used for sewer lines equal to or less than 21 inches (*525 millimeters*) in diameter which are also less than 20' *(6 meters)* deep from invert to top of cover. A reinforced base shall be used for sewer lines greater than 21 inches (*525 millimeters*) in diameter and may be used for lines up to 36 inches (*900 millimeters*).

The manhole base shall be a circular slab of Class S concrete poured against undisturbed soil or approved bedding. The base, including the flow channel and connections to pipe and barrel section, shall be made in one monolithic pour.

Forms shall be checked and approved for accuracy of dimension and relative smoothness prior to pouring the base. The base shall be shaped with a wood float and receive a hand, steel-trowel finish prior to concrete setting.

If additional mortar is needed after the initial set, the surface to receive the mortar shall be primed and the mortar mixed with an approved adhesive in order to secure as chip-proof a surface as possible. The base shall be set a minimum of 72 hours before the manhole construction is continued.

A precast manhole base may be used if approved, in writing, by the Engineer.

(2) Precast Barrel and Cone Sections. Precast units shall be approved by the Engineer prior to delivery to the job site. Precast manhole sections shall be subject to rejection for any of the following deficiencies:

Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

Defects that indicate imperfect proportioning, mixing, and molding.

Surface defects indicating honeycombed or open texture.

Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

Any continuous crack having a surface width of 0.01 inch *(25 micrometers)* or more and extending for a length of 12 inches *(300 millimeters)* or more, regardless of position in the section wall.

Proper equipment shall be provided for lowering the precast sections into position. The tongue end of the section shall be placed in contact with the base structure unless otherwise directed. Not more than two holes shall be cast or drilled in the shell of each section for the purpose of handling and placing and if such holes are provided, they shall be filled and finished with mortar after placing. Immediately before joining precast sections, mortar shall be placed continuously around the circumference of the receiving section's contact surface. Any precast section damaged during handling or placing shall be repaired or replaced at the option of the Engineer and at the contractor's expense.

Barrel and cone sections of various heights conforming to ASTM C 478 and the standard details shall be used in order to bring the top of the manhole to the designated elevation.

The precast manhole sections shall be sealed to each other with a preformed flexible gasket conforming to the following requirements:

The flexible plastic gasket shall conform to Federal Specifications SS-S-00210, "Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints."

The plastic sealing compound shall be packaged in an extruded pre-formed rope-like shape of proper size to completely fill the joint when fully compressed. The material shall be protected by a suitable, removable wrapper. The sealing compound shall be impermeable to water, have high immediate bonding strength to the primed concrete surface and shall maintain permanent plasticity, resistance to water, acids, and alkalies.

All surfaces of the tongue and groove joint of the manhole barrel shall be clean prior to the installation of the sealing compound. The application of the sealing compound shall be accomplished in strict conformance with the manufacturer's instructions as to the method of application, quantity of material, the grade of the materials, and the application temperatures.

All lifting holes shall be sealed with the plastic sealing compound on the exterior side of the hole and hydraulic cement a minimum of 1/2 inch *(13 millimeters)* deep on the interior side of the hole.

(3) Brick Manholes. Brick work shall not be laid upon a concrete foundation less than 24 hours after such foundation has been poured. No brick work shall be laid in water, nor, except as prescribed for curing, shall water be allowed to stand or run on any brickwork until the mortar has thoroughly set. Where new work is joined to existing unfinished work, the contact surfaces of the latter shall be thoroughly cleaned and moistened.

Bricks shall be thoroughly moistened prior to placing and shall be laid in full cement mortar beds. The horizontal cross section of the manhole shall be circular unless otherwise called for on the plans or standard details. An oval or egg-shaped section will not be permitted. A double row-lock of brick in the manhole wall shall be arched over the top half of the circumference of all inlet and outlet pipes.

Brick manholes shall be plastered outside with 1/2 inch (*13 millimeters*) of cement mortar as shown on the standard details. The plaster coat shall be cured with a liquid membrane-forming compound immediately after plaster has been placed and finished. Inside, the brick wall shall be neatly pointed.

(4) Cast-In-Place Manholes. Cast-in-place concrete shall be placed in accordance with the requirements of Section 601.

The location of concrete placement shall conform to the requirements of the plans and these specifications and be approved by the Engineer before placement of concrete may begin.

All absorptive surfaces against which concrete is to be placed shall be moistened sufficiently to minimize moisture loss from the freshly-placed concrete.

The trench or excavated area must be free of water, dirt, mud, and debris before the concrete is placed.

Floor slabs in the area of their juncture with walls shall be washed free of sawdust, chips, and other debris after wall forms are built and immediately before the concrete placement. Should the form work confine sawdust, chips, and other loose matter in such a manner that it is impossible to remove them by

flushing with water, a vacuum cleaner shall be used for their removal, after which the cleaned surfaces shall be flushed with water.

Before placing concrete, the forms shall be coated with a non-staining lubricant to prevent adherence of concrete. All forms and form lumber, once used, shall be thoroughly cleaned and contact surfaces re-coated before being used again.

Forms may be either metal or wood, and shall be built true to shape, line and grade, mortar-tight, and sufficiently rigid to prevent displacement or sagging between supports. No form shall be used which is not clean. Deformed, broken, or defective forms shall be removed from the job site.

Contact surfaces for exposed concrete surfaces shall be of plywood, metal, or non-warping fiberboard. The pieces used shall be as large as the form layout permits. Small pieces shall not be patched together.

For unexposed surfaces and rough work, square-edge lumber may be used for forms. Unexposed surfaces mean any concrete surface not exposed to view on completion of the project.

All form work shall be provided with adequate cleanout openings to permit inspection and easy cleaning after all reinforcement has been placed.

Form ties shall be such that when the forms are removed, no metal remains within 3/4 inch (*19 millimeters*) of the surface of the concrete nor shall there be any holes larger than 7/8 inch (*22 millimeters*) in the surface of the concrete. Wire ties will not be permitted.

All external angles of beams, columns, edges of concrete structures and sides of walls shall be given a 3/4 inch (*19 millimeters*) chamfer unless otherwise indicated on the plans.

(5) Manhole Lining. If the plans call for a protective lining, the lining material shall comply with the requirements of Subsection 509-2.08 or Subsection 509-2.09. The protective lining shall be white if it is PVC.

The installation of PVC liner plate, including the welding of all joints, lap strips, flaps, etc., shall be done in accordance with the manufacturer's recommendations. Nailing through the plate shall not be allowed. Liner plate shall be held snugly in-place against inner forms by means of light gauge steel wire, light steel banding straps, or other suitable means. If steel banding straps are used, they shall be applied in strap channels provided for this purpose.

Locking extensions (T-Shaped) shall be integrally extruded to all lower, terminal, or longitudinal edges of the PVC liner plate as applied to the wall. If banding straps are used, a steel rod 1/4 inch (*6 millimeters*) in diameter may be inserted

in each locking extension along the longitudinal edges of each sheet of liner plate. If approved, either method for holding the lower edge of the liner plate snugly against the form may be provided.

Concrete poured against the PVC liner plate shall be consolidated in a careful manner so as to protect the liner plate and to produce a dense, homogeneous concrete securely anchoring the lock extensions into the concrete. In removing forms, care shall be taken to protect liner plate from damage. Sharp instruments shall not be used to pry forms from lined surfaces. All holes and cut, torn or seriously abraded areas in the liner plate shall be repaired. Patches shall be limited to those which can be made with a single weld strip. Parallel, overlapping or adjoining weld strips shall not be allowed. Patches made entirely with welding strip shall be fused to the liner plate over the entire patch. Larger patches may consist of smooth liner place applied over the damaged area with adhesive. All edges must be covered with welding strip fused to the patch and the sound liner plate adjoining and damaged area.

The contractor shall take all necessary precautions to prevent damage to installed PVC liner plate from equipment and materials used in or taken through the work. The applied lining shall be free from bubbles due to poor workmanship. The contractor shall cut out bubbled areas and weld a similar sheet in its place unless otherwise directed by the Engineer.

The contractor shall obtain the services of qualified personnel to weld the PVC liner plate field joints. Refer to Subsection 508-3.03(D) for information regarding the required qualifications. Manhole joints must be dry before the PVC liner plate joints are made. All mortar and other foreign material shall be removed from PVC liner plate surfaces adjacent to the manhole joint, leaving them clean and dry. No PVC liner plate joints shall be made until the trench has been backfilled and the manhole has been tested for leaks.

The field joint used for PVC manhole lining shall be Type C-1:

Type C-1 joints shall be made with a separate 4 inch (*100 millimeters*) joint strip and two welding strips. The 4 inch (*100 millimeters*) joint strip shall be centered over the joint, heat-sealed to the liner, then welded along each edge to adjacent liner plate with a 1 inch (*25 millimeters*) weld strip. The width of the space between adjacent liner plate sheets shall not exceed 2 inches (*50 millimeters*). The 4 inch (*100 millimeters*) joint strip shall lap over each liner plate a minimum of 1/2 inch (*13 millimeters*). It may be used at any transverse or longitudinal joint.

All welding and testing of joints are to be in strict conformance with the PVC liner plate manufacturer's specifications.

(6) Specialty Manholes.

(a) Drop Manholes. Drop manholes are not an acceptable specialty manhole.

(b) Flat Top Manholes. Flat top manholes shall conform to standard details.

(B) Existing Facilities. Raising and lowering of existing manholes shall be done in accordance with the applicable standard details.

The following procedures shall be followed when connecting a new sewer line to an existing manhole that has no stub-out or block-out:

Concrete core manhole riser to accommodate new pipe.

After the new main is laid, the opening through the wall around the new main shall be sealed off with material compatible with existing manhole wall components.

The existing bench shall be broken out to a minimum depth of 1 inch *(25 millimeters)* and thoroughly cleaned.

The new bench and channel shall be formed from mortar of Class S concrete with an epoxy additive to assure adequate bonding to the existing bench.

All surfaces shall be steel-troweled to a smooth, dense surface.

(C) Inverts. Invert channels shall be troweled to a smooth, dense surface and a semi-circular shape conforming to the inside diameter of adjacent sewer sections. The invert channel shall be formed of concrete, using a template if necessary. It may also be half-tile laid in concrete; or it may be constructed by laying a full section of sewer pipe through the manhole and cutting out the top half after the surrounding concrete has hardened.

A cut-out shall take place, under the inspection of the Engineer, by using a saw-cutter to remove the top portion of the pipe. Care shall be taken to prevent cuttings from entering the sewer, and the Engineer may require balling of the line if an excessive amount of cuttings have fallen into the pipe. After a cut-out, the edges of the pipe shall be filled and smoothed with mortar.

The bench of the base shall be brush or broom-finished, and shall slope toward the channels at 1 to 2 percent grade. The bench elevation shall be higher than the highest pipe crown in the manhole.

(D) Pipe Connections. Where designated as a provision for future lateral extensions, block-outs, or, if approved, stub-outs shall be built into the manhole. Flow channels shall be formed in the base for each block or stub-out. Stub-outs shall be plugged with an approved watertight stopper.

Stub-outs are made by extending a section of pipe with the bell flush with the outside of the manhole base. The pipe shall be sealed with an approved, prefabricated plug or cap.

(E) Frames and Covers. The elevations at which frames and covers are to be set shall conform to the requirement set forth on the plans, but in all cases shall be governed by the Engineer in the field. Where the cover is in existing pavement or in the traveled way of the existing road shoulder, it is to be placed flush with the existing surface. Where the structure is outside the limits of the traveled shoulder or pavement, it should be placed 1/10 foot (*30 millimeters*) or more above the existing ground surface. Manhole frames shall be set at the required grade and shall be securely attached to the top pre-cast manhole shaft unit with a grout bed and filled as shown on the standard details. After the frames are securely set in the place provided herein, covers shall be installed and all necessary cleaning and scraping of foreign materials from the frames and covers shall be accomplished to ensure a satisfactory fit.

(F) Steps. Steps shall be placed at equal intervals of 12 to 15 inches (*300 to 375 millimeters*). The lower step shall not be more than 18 inches (*450 millimeters*) from the top of the manhole bench, and the upper step shall not be more than 24 inches (*600 millimeters*) below the top of the frame. Steps shall be located above a solid bench.

(G) Testing Manholes. The Engineer may require testing to verify that the manhole is watertight. Testing shall be conducted after the trench around the manhole has been backfilled. The negative air pressure test, as specified in ASTM C 1244, or a water test as specified in Arizona Administrative Code R18-9-E301 shall be used to test all manholes.

Repairs shall be made as directed by the Engineer whenever leakage exceeds the test limit.

509-3.03 Frame and Cover for Manhole or Structure. Where an existing frame and cover for a manhole or structure is unfit for further use, a new frame and cover shall be furnished and installed as specified under Subsection 509-2.06. Where necessary, existing side-walls shall be adjusted to the required grade by removing portions of, or adding to, the existing walls. Such adjustments shall conform to the details of the existing manhole unless otherwise noted on the project plans.

Unless provided by the appropriate utility, payment for replacement frames and covers shall be in accordance with Subsection 109-5.

509-3.04 Reset Frame and Cover. Existing frames and covers to be reset shall be carefully removed and reset to the required grade in accordance with the requirements of Subsection 509-3.01; however, at the contractor's option and with approval of the Engineer, adjustable extension rings, of the type which do not

require the removal of the existing frame, may be used. The extension device shall provide positive locking action with the existing frame and shall permit adjustment in height to conform to the new finished pavement surface. The material for the extension device shall be compatible with the existing frame and conform to the requirements of the respective section of these specifications.

Once reset, manhole frames and covers shall be free of all dirt, mud, concrete, asphaltic paving materials and other deliturious substances and shall have all vent holes unobstructed.

Manhole frames and covers to be reset which are lost or damaged due to the contractor's operations to the extent that they are unacceptable for reuse shall be replaced at no additional cost to the Agency.

509-4 METHOD OF MEASUREMENT

New sanitary manholes and structures will be measured as a unit for each manhole or structure constructed inclusive of frame and cover.

Existing manholes or structures requiring adjustment to accommodate changes in the finished elevation of the roadway of 12 inches (*300 millimeters*) or less, will be measured as a unit for each manhole (*300 millimeters*) adjusted.

Existing manholes or structures requiring an adjustment of greater than 12 inches (*300 millimeters*) to accommodate changes in the finished elevation of the roadway shall be designated as a reconstruction and will be measured by the foot (*millimeter*), to the nearest one-half foot (*150 millimeters*) of elevation change between the existing rim elevation of the manhole or structure and the new rim elevation.

509-5 BASIS OF PAYMENT

The accepted quantities of new manholes or structures and manhole adjustments, measured as provided above, will be paid for at the contract unit price each, complete-in-place, including excavation, backfill, concrete, reinforcing steel, brick, frame, cover and testing.

The accepted quantities of reconstructed manholes or structures, measured as provided above, will be paid for at the contract unit price per foot (*meter*), including excavation, backfill, frame and cover.

The removal of unsuitable material below the required depth and the furnishing and placing of material in the voids thus created will be paid for in accordance with the provisions found in Subsection 109-4.

SECTION 510

POTABLE WATER SYSTEMS

510-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, equipment, tools, and labor necessary to install a complete and functioning potable water distribution system, inclusive of all service connections and appurtenances and installing the pipe including excavation and furnishing, placing and compacting backfill material, in accordance with the details shown on the project plans and the requirements of these specifications.

At each location where a pipe is to be installed, the project plans will specify the size and approximate length along with the requirements for each approved option at that location, such as wall thickness, coatings, class and strength.

The contractor shall furnish and install the pipe specified at each such location. Special sections, fittings, elbows, branch connections, tapered inlets, connectors, coupling, and other such items shall be of the same material and coating as the pipe to which they are attached.

The contractor shall furnish and install such system and service appurtenances and materials specified on the project plans at each location noted.

Bedding material and trench backfill material shall conform to the requirements of these specifications. Placement and compaction requirements for bedding material and trench backfill material shall conform to the requirements of this Section unless otherwise noted on the plans or in the Special Provisions.

510-2 MATERIALS

510-2.01 Potable Water Pipe. Potable water pipe materials shall conform to the requirements as specified herein.

510-2.02 Concrete for Pipe Encasement. Portland cement concrete for pipe encasement shall conform to the requirements found in Section 1006 for Class B concrete.

510-2.03 Controlled Low Strength Material (CLSM). Materials comprising the controlled low strength material shall conform to the requirements of Section 1006. CLSM mix designs shall be in accordance with the provisions of Subsection 501-2.03, Table 501-1 for water system installations within the roadway prism. CLSM mix designs for all other areas shall be as designated on the plans, in the Special Provisions or directed by the Engineer.

510-2.04 Bedding Material. Aggregate for bedding material shall conform to the following gradation requirements:

Sieve Size	Percent Passing
1/2 inch (*13 millimeters*)	100
No. 8 (*2.36 millimeters*)	30 – 85
No. 200 (*75 μm*)	0 –15

The plasticity index shall not exceed 5 when tested in accordance with the requirements of AASHTO T 90. The sum of the percent passing the No. 200 sieve and the plasticity index shall not exceed 15.

Bedding material for all concrete or plastic pipe installations shall have a pH value between 6.0 and 12.0, inclusive. Tests for pH and resistively shall be in accordance with the requirements of Arizona Test Method 236.

Bedding material shall be approved by the Engineer prior to start of construction and must remain consistent throughout the project.

All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the area into which bedding material is to be placed.

510-2.05 Trench Backfill Material. Trench backfill material for potable water pipe shall not contain organic material, rubbish, debris, and other deleterious material and shall not contain solid material which exceeds 6 inches (*150 millimeters*) in greatest dimension and shall be soil selected from excavation or imported from a source selected by the contractor and approved by the Engineer. Milled asphaltic concrete pavement material may be used for trench backfill except within the roadway prism.

510-3 CONSTRUCTION DETAILS

510-3.01 Preparation of Trenches. Trenches for potable water pipe installations shall be in conformance with the Standard Details unless otherwise noted on the plans or in the Special Provisions.

Trench excavation shall be conducted such that existing roadway facilities, utilities, railroad tracks, and other non-roadway facilities will not be damaged beyond the limits of the excavation. The contractor, at no additional cost to the Agency, shall furnish and install sheet piping, shoring or other means, as necessary, to adequately support material underlying such facilities or to support the facilities themselves and shall maintain such supports until they are no longer needed. Temporary pavements, facilities, utilities, and installations shall also be protected until they are no longer required. When temporary supports and other protective means are no longer required, they shall be removed and disposed of by the contractor at no additional cost to the Agency.

All suitable material removed from excavated areas may be used instead of borrow for backfill of trenches, construction fill and in other designated areas if approved by the Engineer.

The contractor shall provide and maintain earthwork operations to insure satisfactory surface drainage at all times. Ditches and other drainage facilities necessary to remove ponded water shall be constructed as soon as practical to have the work area dry during the progression of work. All existing culverts and drainage systems shall be maintained in satisfactory operating condition throughout the course of the work. If it is necessary to interrupt existing surface drainage, sewers, culverts or under-drainage, then temporary drainage facilities shall be provided until the permanent drainage work is complete.

A trench condition is defined as a trench which has vertical slopes to a point at least 1 foot (*0.3 meters*) above the top of the pipe and its maximum width is as detailed on the Standard Details or project plans.

All excavation shall be finished to a smooth and uniform surface, and be in reasonable close conformity to the grade established, and shall be in close conformity to the lines, grades, and dimensions shown on the project plans or established by the Engineer.

Where rock, hardpan, or other unyielding material is encountered, such material shall be removed below the vertical limits as shown on the plans. The depth to be removed shall be at least 12 inches (*300 millimeters*) or as designated by the Engineer. The width to be removed shall be the width of the trench, as shown on the Standard Details or project plans. This width shall be maintained throughout the additional depth. The over excavated area shall be backfilled with structure backfill material as designated in subsection 203-5.02 and compacted in layers not exceeding 6 inches (*150 millimeters*) in depth.

When a firm foundation is not encountered at the bottom of the vertical limits as shown on the plans due to soft, spongy, or other unstable soil, such unstable soil shall be removed for a width of at least the horizontal outside dimension of the pipe on each side of the pipe and to the depth specified by the Engineer. The unstable soil removed shall be replaced with structure backfill material as designated in Subsection 203-5.02 and compacted in layers not exceeding 8 inches (*200 millimeters*) in depth.

The completed foundation shall be firm for its full length and width. When specified on the project plans, the foundation shall have longitudinal camber of the magnitude specified.

Unless otherwise approved, in writing, by the Engineer, the maximum length of open trench for all installations shall be 500 lineal feet (*150 meters*) or the contractor's daily installation length, whichever is greater.

Material excavated from the trench may be windrowed along the side of the trench in such a location that no collapsing soil loads are transmitted to the trench walls, and no hazard to traffic, motorist, or pedestrian is created. Excavated material shall not, in any manner, inhibit access to or the use of fire hydrants.

Water tables shall be kept below final trench grade. Trenches shall be kept free of water during the time period beginning prior to excavation and ending when the trench backfill is above the water table existing prior to construction. The contractor shall construct and maintain the necessary facilities; such as pumps, wells, drains, dams, and channels; to keep the trench free of water. If pumps are used, a minimum of one standby pump shall be on the job site. If well points are used, the contractor must obtain the necessary dewatering permit from Arizona Department of Water Resources.

Water removed from the site shall be conducted to drainage facilities without causing damage or disturbance to adjacent property. The contractor shall be responsible for and shall repair, at his expense, any damage caused by water or protective works. Water levels shall be changed slowly and uniformly so as not to impair the stability of slopes and soil properties. No direct payment shall be made for dewatering unless otherwise specified in the Special Provisions.

510-3.02 Abandonment or Removal of Existing Water Pipe and Appurtenances. The contractor shall remove, wholly or in part, and satisfactorily dispose of or salvage, all potable water pipe and appurtenances, as noted on the plans. The contractor shall dispose of all structures and obstructions, within rights-of-way or easements, as necessary in order to complete the work as noted on the plans.

Water pipe shall be abandoned in accordance with the requirements of Standard Detail W-350 or as directed by the Engineer.

Non-hazardous materials removed and designated not to be salvaged or incorporated into the work shall become the property of the contractor, removed from the project, and properly disposed of.

All valves, valve boxes, fire hydrants, and fittings removed by the contractor from the abandoned water system shall be delivered to the water utility in accordance with the provisions of Standard Detail W-105 and as directed by the Engineer.

Holes, cavities, trenches and depressions within the construction area resulting from the removal of water pipe, appurtenances or obstructions, except in areas to be excavated, shall be backfilled with suitable material and compacted to a density of not less than 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

All removed water pipe to be salvaged shall be cleaned of all earth and other deleterious material from both inside and outside prior delivery. Pipe to be salvaged shall be stored, when necessary, so as to avoid damage or loss before delivery.

When necessary, water pipe shall be cut with straight and smooth edges on a plane perpendicular to the centerline of the pipe.

Handling and disposal of cement asbestos pipe shall comply with all requirements of the Pima County Department of Environmental Quality pertaining to the handling and disposal of asbestos materials.

The contractor shall be responsible for the proper removal, handling, storage, and disposal of all cement asbestos pipe materials encountered during the course of the work. Removal, handling and disposal of cement asbestos pipe shall be in accordance with the provisions of Section 940 and shall comply with all ordinances, laws, procedures, and policies regarding the handling and disposal of cement asbestos pipe as adopted by the jurisdiction in which the work is being conducted as well as the jurisdiction through whose limits the material must be hauled and/or disposed of. The contractor shall be responsible for all civil and/or criminal penalties which may be levied for the improper handling or disposal of the cement asbestos material.

Disposal of cement asbestos pipe material shall occur only at approved asbestos disposal sites.

The contractor shall direct all questions regarding asbestos disposal to the agency having jurisdiction over the approved disposal site.

The contractor shall notify the Engineer and the approved disposal site a minimum of 24 hours prior to the contractor's intent to dispose of cement asbestos pipe material. The contractor shall have obtained and completed all applicable forms and permits prior to disposing of cement asbestos pipe materials.

The contractor shall provide the Engineer with a copy of all executed forms and permits which shall serve as verification of proper disposal at an approved asbestos disposal site.

510-3.03 Bedding.

(A) Placement of Bedding Material. All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the area into which bedding material is to be placed.

Pipe with an inside diameter of 12 inches (*300 millimeters*) or less shall be installed on a minimum 4 inch (*100 millimeter*) thickness of bedding material. Pipe in excess of 12 inches (*300 millimeters*) in diameter shall be installed on a minimum 6 inch (*150 millimeter*) thickness of bedding material. Bedding thickness shall be measured after installation of pipe.

Bedding material shall be placed in uniform horizontal layers not exceeding 12 inches (*300 millimeters*) in depth before compaction. For pipe diameters 24 inches (*610 millimeters*) or greater, lift thicknesses shall be determined by the method of compaction and approved by Engineer.

Bedding material shall be placed under, around, and over the pipe to an elevation 1 foot (0.*3 meters*) above the top of the pipe after compaction.

Bedding material shall be placed in a manner which will prevent distortion, damage to, or displacement of the pipe from its intended location. Bedding material shall also be placed so that adequate support will be provided in the haunch support areas of the pipe. Voids or loose soils which are found to occur due to improper placement or compaction of bedding materials will result in rejection of that portion of the pipe installation. Replacement of the pipe will be at the contractor's expense.

(B) Compaction of Bedding Material. Bedding material shall be compacted to at least 90 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Compaction of bedding material shall be performed without damage to the pipe and surrounding in-place material. Special care shall be taken in placing, shaping and compacting all bedding material under haunches of pipe to prevent moving the pipe or raising it from its bedding.

Water jetting of bedding material is the preferred method of installation and consolidation for water system piping only. If field conditions preclude the use of water jetting, the contractor shall submit, in writing, an alternate placement and compaction method for approval by the water utility.

510-3.04 Potable Water Pipe and Valves.

(A) General. Only those materials specified shall be utilized to construct public potable water system facilities. Other materials shall be utilized only upon approval by the Engineer.

Prior to the delivery of water pipe or appurtenances to the site, the contractor shall submit:

(1) Shop drawings to the Engineer for review and approval. The shop drawings shall provide the following information:

Detailed procedures to be used in joining and installing the piping system including manufacturer’s recommendations.

Interface of piping system to equipment and appurtenances.

(2) A bill of materials, indicating material composition of pipe, pressure rating, nominal size with wall dimensions, and its locations on the piping installation drawing shall be provided at the time of delivery of all pipe and fitting.

(3) Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall also be provided for all pipe material and appurtenances.

All submittals shall reference the approved water plan number.

Pipe ends shall be covered during transport to prevent exhaust fumes from entering the pipe. Pipe ends shall remain covered while stored. Pipe materials and water system appurtenances shall be delivered to the site, stored and handled in accordance with the manufacturer's instructions except as may be modified by the plans, Special Provisions, or as directed by the Engineer. Materials shall be sorted and stored neatly and shall insure ease of accessibility. Materials shall be protected from the elements in accordance with the recommendations of the manufacturer. Materials which, in the judgment of the Engineer, have been improperly stored or shipped shall not be eligible for the partial payment or installation.

For pipe 24 inch (*600 millimeter*) diameter or larger, the sequence of installation shall be submitted by the contractor prior to the start of work. The sequence shall conform to the contract time and comply with all required phasing noted on the project plans. The sequence shall also minimize inconvenience to the traveling public.

Two working days prior to commencement of excavation, the contractor shall contact Blue Stake to verify the location of all existing utilities in the vicinity of the work.

All personnel of the contractor or their subcontractors shall be skilled and knowledgeable with regard to the installation procedures for the specific pipe, fittings and appurtenances being installed.

Potable water pipe and appurtenances shall be handled in such a manner as to ensure delivery to the trench in sound and undamaged condition. Pipe shall be unloaded opposite or near the location at which it will be installed. Pipe shall not be stored along a residential street for more than ten days or along a business street for more than three days. The interior of the pipe shall be thoroughly cleaned of foreign material before being lowered into the trench.

Repairs shall be allowed only when approved by the Engineer. Repairs shall be made in conformance with the requirements specific to the pipe material as herein noted.

Pipe and pipe appurtenances shall be carefully lowered into the trench by means of slings, pipe tongs or other acceptable means. Waterline materials shall not be dropped or dumped into the trench. Care shall be taken to avoid abrasion of the pipe coating or lining.

Laying of potable water pipe shall be in finished trenches free from water and debris. Each pipe shall be laid true to line and grade, with uniform support under the full length of the pipe barrel.

Upon installation, the meeting surfaces shall be wiped clean of dirt and foreign matter, then an approved lubricant shall be applied at the joint surfaces. The spigot shall be positioned inside the socket and the installation completed.

Any adjustment of line and grade shall be made by excavating or filling under the pipe. Wedging or blocking under the pipe ends is prohibited.

Fittings shall correspond in all respects with the requirements specified for pipe of the corresponding size.

Fittings shall be made to accommodate the joining system provided.

All valves and metallic fittings, flexible couplings, and repair clamps which are to be buried shall be encased with 10 mil (*250 micrometer*) polyethylene in accordance with AWWA C 105, Method C.

Pipe marking and detecting tape, complying with the requirements of Subsection 510-3.05, shall be installed in the trench in accordance with Subsection 510-3.05.

The ends of all pipe shall be plugged at the end of each work day, or when work is not in progress, to prevent contamination.

The method of plugging the ends of pipe shall be approved by the Engineer.

(B) Water Shutoffs. Should construction require shutoff of the water system, the contractor shall notify the Engineer a minimum of 48 hours prior to the planned system shutoff. The contractor may be required to operate the necessary valves under the direction of the representative from the water utility. When operating valves under the direction of the water utility's representative, the contractor assumes no liability for normal operation.

The contractor shall be responsible for assisting the water utility in notifying all affected water users of the time and duration of the system shutoff in accordance with the requirements of Standard Detail W-110. Shutoff shall not be made to any lines

serving businesses dependent on water services during business hours unless other arrangements have been approved by the Engineer. Work may be required at night or on weekends. The Engineer, upon request, will provide valve and service maps of the existing water system to the contractor.

(C) Utility Separation. Water pipe construction shall conform to the following separation requirements with regard to other existing utility lines:

(1) Electric. Potable water pipes shall not be installed within a 5 foot (*1.5 meter*) horizontal distance to parallel electric duct or conduits. The minimum vertical separation between electric duct or conduits and the water pipe, at any location, shall be 12 inches (*300 millimeters*). Water services and fire hydrants shall not be installed at the same property corners as electrical pedestals or transformers and shall be separated by a minimum horizontal distance of 10 feet (*3 meters*).

When electric, telephone, cable, fiber optic, or gas facilities parallel water facilities, they shall not be installed with less than 5 feet (*1.5 meter*) horizontal clearance from the water pipe unless the system has been approved by the Engineer.

(2) Storm Drain Culvert. The minimum vertical separation between the potable water pipe and storm drain culvert shall be 12 inches (*300 millimeters*) minimum, either over or under the culvert. The separation shall be measured from the outside wall of the water pipe to the outside wall of the storm drain culvert or pipe. In all cases however, the minimum cover of the water pipe shall be 44 inches (*1.1 meters*) from finish road grade as well as providing for a minimum of 36 inches (*910 millimeters*) of cover to the bottom of any excavation.

(3) Sanitary Sewer. Potable water pipes installed in the vicinity of sanitary sewer mains shall comply with Standard Detail WWM-108.

(4) Reclaimed Water. Potable water pipes installed in the vicinity of reclaimed water pipes shall comply with the separation criteria established for pressure sanitary sewer lines.

(D) Pipe Materials and Installation. All pipe, pipe fittings, valves, and other appurtenances shall be carefully examined for damage or other defects immediately prior to installation. Defective materials shall be legibly marked. The contractor may initiate repairs upon approval of the Engineer. However, should the Engineer determine that repairs will not satisfactorily correct the damage or defect, the material in question shall be replaced, at no additional expense to the Agency.

During laying operations no debris, tools, clothing, or other items shall be placed in the pipe.

Pipe shall be laid in reasonably close conformity with lines, grades and dimensions shown on the project plans or as directed by the Engineer.

Pipe shall not be laid in water or when trench conditions are unsuitable for the work as determined by the Engineer. When work is not in progress, open ends of pipe, fittings, and valves shall be securely plugged to eliminate water, earth, or other foreign material from entering the opening. Plugs shall be approved by the Engineer prior to their use.

Pipe that has had the grade or joint disturbed after laying shall be removed and relaid.

(1) Ductile Iron Pipe (DIP). Ductile iron pipe shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

The pipe manufacturer shall certify that the pipe and the lining provided for the project meet the requirements of the applicable specifications.

Ductile iron pipe shall be furnished with either bell and spigot, mechanical or flanged joints as specified on the plans, in the Special Provisions, or as directed by the Engineer. Restrained joints shall be in accordance with Subsection 510-3.04(F).

Blind flanges shall be manufactured of cast iron or ductile iron. Steel flanges shall not be permitted.

Cutting of ductile iron pipe shall conform to the requirements of AWWA C 600.

The requirements of ANSI/AWWA C105/A 21.5 for materials and installation procedures for polyethylene encasement of underground installations of ductile iron pipe shall be met. The polyethylene wrap shall be marked in accordance with the requirements of ANSI/AWWA C105/A 21.5.

Polyethylene wrap in tube or sheet form for piping encasement shall be manufactured from virgin polyethylene material conforming to the requirements of ANSI/ASTM Standard Specification D 4976. The specified minimum thickness is 0.008 inches (*8 mils*).

(2) Concrete Cylinder Pipe (CCP). Concrete cylinder pipe (CCP) shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

Prior to the start of manufacture of CCP, the contractor shall submit to the Engineer detailed shop drawings of the pipe, joints, fittings, flanges, gasket size reinforcement cage assemblies, steel cylinder thickness, pipe specials, and the pipe-laying diagrams. The laying diagram shall show the location, length, design designation, number designation of each pipe section, cathodic protection coating, bonding clips, thrust restraint, pressure class and maximum depth of cover.

The contractor shall verify the accuracy and completeness of all shop drawings. If errors or discrepancies in the shop drawings are discovered, work shall be stopped until corrected. All submittals shall be furnished to the Agency by the contractor within fourteen working days after Notice to Proceed. The Agency will review the submittals for general conformance with the plans and specifications. Agency approval of the submittals shall in no way relieve the contractor of the responsibility for completeness and accuracy of the submittals.

All pipe shall be manufactured, handled, loaded, and shipped in such a manner that it will be delivered to the job site undamaged in sound condition and conforming in all respects to these Specifications.

Concrete cylinder pipe and appurtenances shall be delivered to the site, stored and handled in accordance with the manufacturer's instructions except as modified by the plans, Special Provisions or as directed by the Engineer.

The interior surface of each length of concrete cylinder pipe shall be legibly marked by the manufacturer with the design pressure, maximum depth of cover and the date of application of the cement mortar coating. The marking shall also indicate the piece number installation or proposed location for each length. No markings or multiple markings will be cause for rejection.

Lengths of beveled pipe shall be marked on the beveled end with the degree of bevel, the point of maximum pipe length at the spigot end, and the field top.

All markings shall be made with a non-toxic waterproof marking material.

The manufacturer shall repair any damage to the cathodic protection coating prior to installation of the pipe. All repairs shall be approved by the Engineer.

Concrete cylinder pipe shall be furnished with a self-centering steel bell and spigot joint sealed with a confined rubber gasket. Blind flanges shall be steel.

Installation of concrete cylinder pipe shall conform with the applicable requirements of AWWA Manual M9, Concrete Pressure Pipe and these specifications.

Cutting of concrete cylinder pipe shall only be with the approval, in writing, of the Engineer.

The contractor shall provide thrust restraint in accordance with the provisions of Subsection 510-3.04(F). Welded joint restraint shall be in accordance with the manufacturer's recommendations. The welded length of pipeline and the size and type of weld shall comply with the requirements of the manufacturer's shop drawings.

The pipe joints shall be bonded with bonding cables or bonding clips which are welded to the joint rings on the exterior pipe in accordance with the manufacturer's recommendations. Joints that have been welded to counteract thrust forces will not require bonding cables or bonding clips. Joints that are specified on the plans to have flange insulation kits or other electrical isolation methods shall not be bonded. After installation of the bonding cables or bonding clips, the recess provided to accommodate this installation shall be filled with a cement-mortar grout which is confined by a polyethylene foam lined grout band.

Joint bonding and corrosion monitoring shall be in accordance with Standard Details W-700 through W-707. The contractor shall provide bonding cable or bonding clip calculations for approval by the Agency prior to beginning construction.

(3) High Density Polyethylene (HDPE) Pipe. High density polyethylene (HDPE) pipe shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

HDPE pipe and fitting assemblies shall be manufactured from the product of one approved manufacturer. The use of pipe and fittings from more than one manufacturer shall be prohibited. Bonds, tees, and associated fittings may be mechanical joint ductile iron or cast iron with restraint features as noted in the Special Provisions.

HDPE pipe joints and fittings shall be heat fused by a qualified technician trained by an approved manufacture's representative, in accordance with the manufacturer's recommended fusion procedures. Training shall have occurred in the previous 12 months or submittals verifying field installation experience within the previous 12 months for all technicians performing heat fusion on polyethylene pipe and fittings shall be submitted prior to the start of installation.

All necessary precautions shall be taken to prevent damage or contamination to pipe and other incidental materials during shipment and delivery. All materials shall be securely fastened to truck or rail car to prevent movement or damage during shipment. The contractor shall examine all materials before unloading.

All pipe materials shall be handled so as to prevent damage. HDPE pipe shall not be dropped, rolled or pushed off from any height on delivery storage or installation.

All pipe materials shall be stored off the ground in a dry location. Pipe shall be stored to prevent sagging or bending. Stored pipe shall be protected from exposure to ultraviolet light.

The design pressure rating of the pipe shall be defined in accordance with ASTM D 3035 and F 714. The HDPE pipe shall have a controlled outside diameter and have been manufactured to the SDR/DR rating specified by the plans or Special Provisions.

Fittings shall be manufactured using the same pressure rating as the designed piping system. The fitting shall have a controlled outside diameter and the SDR/DR rating for the pressure specified by the plans or Special Provisions. Fittings shall be specifically manufactured to standardized dimensions noted on the plans.

Butt fusion fittings shall be manufactured from the same material as the extruded pipe, shall be rated for a pressure service at least equal to that of the system pipe, and shall have outlets manufactured to the same DR as the system pipe. Molded fittings shall be manufactured in accordance with ASTM D 3261 and socket fittings shall comply with ASTM D 2683.

Cutting of HDPE pipe shall be performed in a neat and workmanlike manner without damage to the pipe. Pipe ends shall be cut square and deburred in accordance with the manufacturer's recommendations.

All piping shall be inspected to assure that it is free form defects in material and workmanship. The compatibility of all pipe and fittings shall be verified.

Pipe, fittings and accessories that are cracked, damaged, not identified or in poor condition shall be rejected. Any pipe section or fitting containing significant scratches, dents or marks shall be deemed unusable and rejected. Any substantial scratch may be cause for rejection at the sole discretion of the Engineer.

The Engineer shall have free access to all joints, including test joints for determining the suitability of the joining procedure. Where construction restrictions limit inspection of joints the Engineer may direct the individual joining the pipe and/or fittings to perform a test joint in a manner that it can be clearly and easily observed. The Engineer shall select the method of testing from either visual examination, bent strap testing or ultra-sonic testing. Ultra-sonic testing shall conform to the requirement of the U S Department of Transportation as found in the Code of Federal Regulations 49, Part 192.285 (b) (ii) or (b) (iii).

HDPE pipe and fittings shall be heat fused together creating a homogeneous joint. Joining shall be in accordance with the manufacturer's heat fusion recommendations. Joints shall not be of the solvent weld type.

Personnel responsible for heat fusing the joints shall demonstrate proficiency by fusing trial joints and testing the trial fusion by bent strap testing or ultra-sonic testing. Trial joints shall be allowed to cool completely before testing and shall not fail at the joint. During construction, the first fusion of the day shall be a trial fusion which shall be allowed to cool, and destructively bent strap tested or ultrasonically tested. If the trial fusion fails, additional trial fusion's shall be made and tested until successful fusion's are completed. The procedure used to join the trial fusion shall be used for the balance of the day's work, provided the procedure is in compliance with that recommended by the manufacturer. The Engineer shall provide written notice to the contractor of the unacceptability of any installer whose work is deemed deficient in satisfactorily completing the heat fusion of polyethylene pipe. Any individual deemed unacceptable by the Engineer shall not be utilized by the contractor unless the individual undergoes additional training and meets the requirements specified herein.

All HDPE pipe shall be installed so as to minimize shear or tensile stresses. Pipe shall be installed in a trench as specified by the plans or Special Provisions. The minimum burial depth shall also be as specified in the plans or Special Provisions.

(4) Polyvinyl Chloride (PVC) Pipe. Polyvinyl chloride (PVC) pipe shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

PVC pipe shall be stored in a manner such that it is protected from exposure to sunlight and/or extreme heat.

PVC pipe shall be furnished with bell and spigot joints. Elastomeric gaskets shall be furnished for all joints.

PVC pipe shall be cut in accordance with the manufacturer's recommendations. Cuts shall be neat, square, deburred, and beveled without causing damage to the pipe.

Tapping PVC pipe shall be in accordance with Subsection 510-3.04(H). Size on size tapping for 4 inch (100 millimeter) PVC pipe shall not be allowed.

(5) Galvanized Steel Pipe. Galvanized steel pipe shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

Galvanized steel pipe and fittings shall be delivered to the site, stored and handled in accordance with the manufacturer's instructions except as modified by the plans, Special Provisions or as directed by the Engineer. Threaded ends shall be protected during shipment and handling.

Galvanized steel pipe shall be free of kinks, bends, cracks, laminations, rust, or other production deficiencies.

(6) Copper Service Pipe. Copper service pipe shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

(E) Valves. The contractor shall furnish all labor, equipment, materials, and tools for the installation of all valves in the system as specified in the project plans.

(1) General. Valves shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions except as modified by the plans, Special Provisions, or as directed by the Engineer.

Valves shall be installed in accordance with the valve manufacturer's recommendations.

All valves and metallic fittings, flexible couplings, and repair clamps shall be encased with a 10 mil (*250 micrometer*) polyethylene in accordance with AWWA C 105 Method C.

Just prior to installation in the trench, valves 16 inches (*400 millimeters*) or larger shall be fully opened and closed to check the operation to ensure that the valve fully seats. A record shall be made of the number of turns required to fully open or close the valve. The contractor shall record this information on the record plan set and shall provide a copy to the water utility's inspector. The inside of the valve shall be thoroughly cleaned prior to valve installation.

(2) Tapping Sleeve and Valve. Tapping sleeves and valves shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

(3) Resilient-Seated Gate Valve. Resilient-seated gate valves shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

(4) Butterfly Valve. Butterfly valves shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

Butterfly valves covered by this specification are sized 16 inches (*400 millimeters*) and larger in diameter. Butterfly valves from 4 inches (*100 millimeters*) to 12 inches (*300 millimeters*) are for above ground applications only. Component parts of the butterfly valves shall be in accordance with AWWA C 504. All butterfly valve components shall be tested and certified by an approved testing laboratory located in the United States. All parts shall be readily available.

Valves shall be furnished with flanged ends when specified on the plans, Special Provisions, or as directed by the Engineer. Prior to ordering butterfly valves, the contractor shall verify the clearances of the valve disc and all connecting pipe.

Butterfly valves shall be installed in accordance with AWWA C 600 except as modified herein. All valves and metallic fittings, flexible couplings, and repair clamps shall be encased with a 10 mil (*250 micrometer*) polyethylene in accordance with AWWA C 105 Method C.

Valves designed for underground service shall be installed with the valve shaft in a horizontal position and the operating shaft vertical, unless otherwise noted. Operating nut shall be installed either south or west of the pipeline.

(5) Air Release Valve. Any reference made herein to air release valves shall be synonymous with air release, air/vacuum, and combination air valves unless otherwise specifically stated.

Air release valves shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

Air release valves shall be installed in accordance with this section and Standard Detail W-330 and W-331. The air release line requires a tracer wire in accordance with Standard Detail W-310.

Valves shall not be installed until after the pipeline has been tested or ball valves closed to isolate the air release valves during the test.

After the air release valve assembly has been installed, the contractor shall apply an Outside Paint System (OPS) No. 2 to the entire assembly in accordance with AWWA D 102. The coating shall be holiday free and have a minimum total dry film thickness of 6 mils (*150 micrometers*).

(6) Pressure Regulating Valve. Pressure regulating valves shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

Pressure regulating valves shall be installed in a horizontal position as indicated on the plans or as specified in the Special Provisions.

Pressure regulating valves shall be installed above grade and enclosed by a masonry wall constructed to the dimensions noted on the project plans.

Pressure regulating valve installations shall include 2 pressure gauges.

(F) Joint Restraint. Shop drawings and manufacturer's literature shall be submitted to the Engineer for all joint restraint components. The lengths of restrained pipe, on either side of the joint being restrained, shall be in accordance with Standard Detail W-600 unless otherwise noted on the project plans.

All submittals shall reference the project number.

Joint restraint devices shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions.

(1) Ductile Iron Pipe (DIP). When mechanically restrained joints are required, they shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

Mechanically restrained joints shall be manufactured integrally with the pipe or provided as accessory mechanisms conforming to the requirements of this subsection.

Field welding of ductile iron pipe for joint restraint shall not be permitted. Cadwelds for corrosion protection are acceptable.

Mechanical joint retainer gland restraints for ductile iron pipe shall be designed to fit standard mechanical joint bells with standard "tee" head bolts conforming to ANSI/AWWA C 111/A21.11 and ANSI/AWWA C 153/A21.53. Glands shall be manufactured of ductile iron conforming to ASTM A36 Grade 60-42-10. Set screws shall not be permitted. Mechanical joint restraint devices shall have a working pressure of at least 250 psi (*1.7 megapascals*) with a minimum safety factor of 2:1.

Glands shall be provided with a restraining mechanism consisting of a sufficient number of individually set gripping surfaces which impart a wedging action against the pipe, increasing in resistance with increasing pressure. The gripping surfaces shall incorporate twist-off nuts to insure proper setting. Restraint mechanisms shall be installed in accordance with the manufacturer's recommendations.

(2) Concrete Cylinder Pipe (CCP). Concrete cylinder pipe shall be restrained by welding the joints. All joints which are proximate to in-line valves, bends, tees, outlets larger than 12 inches (*300 millimeters*), bevels and dead ends, and are within the limits noted on the plans or shop drawings, shall be welded evenly around the entire external circumference (360°) of the pipe cylinder (bell and spigot rings) in accordance with the pipe manufacturer's recommendations.

Welded joint restraint for concrete cylinder pipe (CCP) shall be in accordance with the pipe manufacturer's recommendations. The length, size, and type of weld shall comply with the requirements of the approved plans and shop drawings.

Field welding shall be in accordance with the American Welding Society and AWWA C 206. Welding shall be performed by certified welders.

The following maximum allowable stress shall be used to determine the steel cylinder thickness required to account for longitudinal thrust within the welded length:

Axial stress in steel
Cylinder (fs)
= 15,000 psi (*103.4 megapascals*) at test pressure
= 12,560 psi (*86.6 megapascals*) at design pressure

Field welds on CCP shall be placed in passes not more than 1/8 inch (*3 millimeters*) thick unless otherwise approved by the Engineer. Size and type of electrodes, current, and voltages shall be in accordance with the manufacturer's requirements and subject to the approval of the Engineer. Particular attention shall be given to the alignment of edges to be joined in order that complete fusion and penetration will be effected throughout the root of the weld. Welds shall contain no valley or undercuts in the center or edges of the weld. Each pass shall be thoroughly cleaned of dirt, slag, or flux before the succeeding welding pass is applied.

All completed field welds of CCP joints shall be visually inspected. Non-destructive testing of field welds may be specified in the Special Provisions for critical locations or be required by the Engineer to supplement visual inspections. When non-destructive testing is required, the initial test shall be paid for by the Agency. In the event of rejected welds, all retests shall be at no additional cost to the Agency. Porosity, cracks, trapped welding flux, or other

defects in welds discovered during field inspection shall be completely ground out in a manner that will permit proper and complete repair by welding. Under no circumstances will caulking of defective welds be permitted.

Welding of joints shall be by the electric arc process in accordance with the applicable requirements of AWWA C 206. Field welding shall commence as soon as practicable after the laying operation. Field welds shall be completed before lining or coating of joints. All required field welds shall be specified in the shop drawings and pipe design calculations.

The use of Portland cement concrete thrust blocks is not permissible except as shown on the plans or with the approval of the Engineer.

Portland cement concrete thrust blocks shall be placed against undisturbed earth. Where it is not practicable to place the concrete thrust block against undisturbed earth, the fill material placed between the pipe's bearing surface and the undisturbed soil shall be compacted to a minimum of 95% of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, or as directed and approved by the Engineer.

Joint restraint devices of dissimilar material shall be protected against corrosion in accordance with Standard Detail W-700 through W-707.

(3) Polyvinyl Chloride Pipe (PVC). Polyvinyl chloride pipe joints shall be secured by means of a mechanical restraint device conforming to the water utility's approved materials list or to the requirements of the Special Provisions.

Restraint harnesses shall consist of: a split ring that fits behind the bell; either a split or full restraint ring that installs on the spigot end; and tie bars or tee bolts which connect the two rings. The harness restraint may be split to enable installation after the pipe spigot has been installed into the bell. All components which comprise the restraint harness shall be manufactured of ductile iron conforming to the requirements of ASTM A536. Each ring shall have serrations on its full inside diameter (360°) or a sufficient number of individually adjusted gripping surfaces.

The mechanical device shall provide restraint against thrust loads. Typically, external joint restraints employ individual external clamps that fit behind the bell and around the pipe, and tie rods between the clamps.

Thrust restraint utilizing Portland cement concrete thrust blocking shall be only for modifications to existing pipe lines or as may be approved by the Engineer. Portland cement concrete thrust blocks shall comply with the requirements of Standard Detail W-610.

(4) High Density Polyethylene Pipe (HDPE). HDPE mechanical joints shall be designed to mechanically compress the outside diameter of the pipe against a rigid tube or stiffener in the pipe bore.

Insert fittings shall be pushed into the mating pipe bores, and use individual compression sleeves on the outside diameter of the pipe. Compression couplings shall fit over the pipe ends, and use individual insert stiffeners in the pipe bores.

When joining plain end pipe to bell-and- spigot or mechanical-joint type fittings or pipe, an external joint restraint must be used to provide restraint against thrust loads. Typically, external joint restraints employ individual external clamps that fit behind the bell and around the pipe, and tie rods between the clamps.

The contractor shall provide and install joint restraints at all points of directional change (i.e., fittings, valves, bends, tees, and plugs). All thrust restraint methods shall be installed prior to pressure testing. Wooden blocks, wedges, or other non-permanent techniques shall not be permitted.

The length of pipe to be restrained shall be as indicated on the plans, shop drawings, and as called for by the manufacturer's requirements.

All personnel of the contractor shall be skilled and knowledgeable with regard to the installation procedures for the thrust restraint being installed.

(G) Casing Pipe. Casing pipe for water systems shall be Schedule 40, standard wall, smooth steel pipe unless otherwise noted on the project plans or Special Provisions.

Casing installations for water pipe greater than 36 inches (*915 millimeters*) in diameter shall be as noted on the project plans and Special Provisions.

Casing pipe shall be installed at the locations noted on the plans or as directed by the Engineer. Installation of casing pipe shall comply with Standard Detail W-800, Subsection 929-3, the project plans and/or the Special Provisions. Installation shall include all material, labor, equipment, and appurtenances.

All materials shall conform to the Standard Detail W-800.

The carrier pipe shall be ductile iron pipe. The class of pipe shall be as noted in Standard Detail W-800 or as called for on the project plans.

All carrier pipe joints within the steel casing shall be restrained either by an approved integral joint restraint system or a mechanical joint restraint mechanism.

The annular space between the steel casing and the carrier pipe shall NOT be filled with sand.

Ductile iron pipe enclosed within the steel casing does not require polyethylene encasement as specified in Subsection 510-3.04(D). The polyethylene casing shall extend inside the rubber casing end seal a minimum of 2 feet (*600 millimeters*).

(H) Taps and Service Connections. All materials, equipment, tools, and labor required to make a service connection or tie-in shall be on the site prior to commencement of this work. When required, equipment will include a pump with hoses.

Materials shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

The contractor shall thoroughly flush existing dead-end mains prior to making the tie-in.

Unless otherwise approved, in writing by the Engineer, taps and service connections shall be made prior to hydrostatic testing.

The contractor shall furnish all labor, tools, and equipment and performing all operations necessary for drilling and tapping of any water pipe, new or existing, in accordance with the details shown on the plans and the requirements of this subsection.

Taps into concrete cylinder pipe shall be in accordance with the manufacturer's recommendation and must be approved by the Engineer.

Shop drawings, details and calculations shall be submitted for all taps into concrete cylinder pipe and prestressed concrete cylinder pipe.

All submittals shall reference the project plan number.

Tapping sleeves, valves, high density polyethylene and copper service materials and tapping equipment used in the tapping operation shall be delivered to the site and stored in a manner such that it is protected from damage.

Direct tapping is not allowed. Dry tapping of new water pipes shall only be permitted when approved in writing by the Engineer. Requests to dry tap shall include the proposed methods of flushing to ensure removal of all debris from the line.

Prior to any drilling or tapping, the main shall be purged of all entrapped air and the main shall be pressurized to a minimum of 40 psi or the normal system operating pressure, whichever is the higher.

Drilling or tapping of any water pipe shall be undertaken only with equipment having active purging means or shall be modified in accordance with Standard Detail W-317 to continually flush away pipe shavings.

Taps into PVC pipe shall be made with a shell type cutting tool only.

Ductile iron, steel, or cement asbestos pipe may be drilled for taps 2 inches (*50 millimeters*) and less in diameter. Taps of 4 inches (*100 millimeters*) diameter and larger shall be made with a shell cutter.

Taps into HDPE shall be in accordance with the manufacturer's recommendation.

The cutting tool shall be a shell type cutter which will retain the coupon (cookie) and shall be designed to accommodate the wall thickness of the pipe being cut.

Shell cutters and pilot bits shall be maintained sharp and of proper dimension to minimize damage to the pipe and to preserve the integrity of the remainder of the pipe wall. Shell cutters shall produce clean and even entry cuts under normal drilling machine stresses or they shall be replaced.

Tapping sleeves and tapping equipment shall be supported independently from the pipe during tapping operations.

Placement of the tapping machine of the pipe shall be in accordance with the recommendations of the manufacturer of the tapping machine.

Tapping sleeves and valves shall be used when a service connection or lateral larger than 2 inches (*50 millimeters*) in diameter must be installed in a waterpipe.

Service connection taps shall be in accordance with Standard Detail W-309, W-310, W-311, and W-312.

(I)Meter Installation and Service Line Renewal, Adjustment, Tie-Over, Stub and Abandonment. All materials, equipment, tools and labor required to install or relocate water meters and provide service line renewals, adjustments, tie-overs, stubs or abandonments shall comply with the products and materials included in the water utility's approved materials list or the requirements of the Special Provisions and shall be on site prior to commencing work.

The location of water meter installations or relocations as well as service line renewals, adjustments, tie-overs, stubs or abandonments shall be as shown on the project plans or as directed by the Engineer.

Work shall comply with the requirements of Standard Detail W-310, W-311, W-312, and W-318 and the project plans.

All new service lines shall be copper. High density polyethylene (HDPE) pipe is not acceptable unless noted on the project plans or Special Provisions.

If service line renewals are off an existing main, the existing service line piping shall be removed and a threaded cap or plug installed on the threaded end of the existing corporation valve. If the corporation valve is leaking, the corporation and saddle are to be removed and a repair clamp, appropriate for the existing main size and material, shall be installed.

Service taps of new water mains or new taps of existing water mains shall include installation of service clamps, corporation stops, copper pipe, pipe fittings, angle meter stop and ball valve as noted in Standard Detail W-309, W-310, W-311, and W-312.

Meter relocations shall include all required fittings, angle meter stop, ball valve and new service pipe.

The contractor shall replace the service line to within 1 foot (*300 millimeters*) of the property line with new copper pipe and connect to the existing service piping.

After installation of the service line but prior to installation of the water meter, the contractor shall flush the line to remove all debris.

Tracer wire and pipe marking and detecting tape shall conform to the requirements of Subsection 510-3.05 and shall be installed in accordance with the requirements of Standard Detail W-309, W-310, W-311, or W-312.

510-3.05 Pipe Marking Tape, Detecting Tape and Tracer Wire. Pipe marking tape and pipe detection tape shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions except as may be modified by the plans, Special Provisions, or as directed by the Engineer.

Pipe marking tape, detecting tape and tracer wire shall be found on the water utility's list of approved materials or shall be as specified by the Special Provisions.

Pipe marking tape and pipe detection tape shall be stored in a manner such that it is protected from prolonged exposure to sunlight and/or extreme heat.

Detectable pipe locating tape shall be placed 24 inches (*610 millimeters*) above potable water pipes and 6 inches (*150 millimeters*) above potable service lines. The contractor shall place the backfill sufficiently level in order that the tape will be installed on a flat surface. The tape shall be centered in the trench and laid flat with printed side up. Caution shall be exercised to avoid displacement of tape and to ensure its

integrity. Service laterals will require detectable tape and tracer wire as noted in Standard Detail W-309, W-310, W-311, and W-312.

The remainder of the trench is then backfilled in accordance with the applicable requirements.

The tape shall consist of a minimum 4.0 mil (*100 micrometer*) thickness, inert polyethylene plastic which is impervious to all known alkalis, acids, chemical reagents and solvents likely to be encountered in the soil, with a minimum 1/3-mil (*8 micrometer*) metallic foil. The tape shall be at least 6 inches (*150 millimeters*) in width and shall be solid blue with identifying print in black letters. The tape shall have printed thereon the following:

"CAUTION – BURIED WATERLINE BELOW"

The identifying lettering shall be minimum 1 inch (*25 millimeters*) high and repeated continuously the full length of the tape. In no instance shall the spacing of the individual segment of the identifying message be greater than 8 inches (*200 millimeters*).

510-3.06 Fire Hydrants. The manufacturer's make and model of fire hydrant shall appear on the water utility's list of approved products unless otherwise specified in the Special Provisions.

Fire hydrants shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions.

The fire hydrant shall be installed such that when the fire hydrant barrel is broken through any cause, including vehicular damage, it shall be able to be replaced without having to disturb or replace the portion of the hydrant below the ground line. All parts shall be removable from ground level without excavation of the fire hydrant.

Fire hydrants shall open to the left (counter clockwise). The word "OPEN" and a directional arrow shall be cast in the top of the fire hydrant.

Fire hydrants shall be installed in accordance with this section and Standard Detail W-500.

The minimum distance from the centerline of the lowest nozzle and finished grade shall be in accordance with Standard Detail W-500.

After installation, the contractor shall paint the hydrant with one coat of industrial enamel, aluminum/silver color matching the existing hydrant color.

Thrust restraint will be in accordance with Section 510-3.04(F).

Concrete thrust blocking, if required, shall be similar to the thrust blocking required for 6 inch (*150 millimeter*), 90° bends called for in Standard Detail W-610. Concrete thrust blocking

shall only be used for extending existing pipe, which is not mechanically restrained, between the shoe and the main tee. The minimum soil bearing area shall be 7.5 square feet (*0.7 square meters*). The contractor shall insure that the weep hole in the shoe of the fire hydrant is not obstructed by the concrete thrust blocking. Any concrete thrust blocking shall be placed after the fire hydrant is set in place and connected to the main line.

510-3.07 Appurtenances.

(A) Valve Nut Extension. Unless otherwise specified in the Special Provisions, valve nut extensions shall be provided by the Agency. The contractor shall provide transportation from the Agency storage yard to the worksite. Valve nut extensions shall be delivered to the site, stored, and handled so as to avoid damage or deformation.

Shop drawings are not required. Valve nut extensions shall be manufactured in accordance with Standard Detail W-305.

Valve nut extensions shall be provided where the depth to the top of the valve operating nut exceeds 5 feet (*1.5 meters*). The extension stem shall be a continuous length of solid hot rolled roundstock 1-1/4 inch (*32 millimeter*) diameter round bar fitted with a 2 inch (*50 millimeter*) square operating nut on the top and a moveable self centering device. The top of the extension stem operating nut shall be punch marked with a 1-1/2 inch (*40 millimeter*) high letter "E".

The extension stem will have a square socket welded to the bottom. The socket is to be fabricated so as to fit on a standard 2 inch (*50 millimeter*) square valve operating nut. Fabrication of the valve extension stem shall be of A15 steel conforming to Standard Detail W-305.

All surfaces are to receive one shop coat of primer and one finish coat of heavy duty white synthetic gloss enamel paint.

Valve extension stems shall be installed in accordance with Standard Detail W-305.

(B) Valve Box and Cover. Valve boxes and covers shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions except as modified by the plans, Special Provisions, or as directed by the Engineer.

Valve boxes and covers shall be provided from those manufacturers whose products and materials are included in the water utility's approved materials list or shall conform to the requirements of the Special Provisions.

Valve boxes shall be one piece with inside fitting cover. Valve boxes shall be equipped with lugs or lips for setting in concrete. Valve boxes and covers shall conform to the requirements of Standard Detail W-300.

Valve boxes and covers shall be installed in accordance with Standard Detail W-300.

(C) Fittings, Flexible Couplings and Repair Clamps. In order to be accepted for incorporation into the work, the manufacturer's make and model of fittings, flexible couplings, and repair clamps shall conform to the requirements of the water utility's approved materials or the requirements specified in the Special Provisions.

Fittings, flexible couplings, and repair clamps shall be delivered to the site, stored and handled in accordance with the manufacturer's instructions except as may be modified by the plans, Special Provisions, or as directed by the Engineer.

Working pressure for fittings 24 inches (*600 millimeters*) in diameter and larger shall be as indicated on the plans or in the Special Provisions.

All plugs and caps used for stubouts shall be tapped for a 2 inch (*50 millimeter*) national pipe thread.

Restraining methods for fittings shall be in accordance with Subsection 510-3.04(F).

Restraining methods for PVC and HDPE fittings shall be in accordance with Subsection 510-3.04(F).

Field welding of ductile iron fittings shall not be allowed.

Center sleeves may be manufactured from carbon steel, stainless steel, or ductile iron unless otherwise specified on the plans, Special Provisions, or as directed by the Engineer.

Nuts and bolts for couplings 2 inches (*50 millimeters*) in diameter and smaller shall be stainless steel or cadmium plated. Nuts and bolts for couplings larger than 2 inches (*50 millimeters*) in diameter shall be stainless steel 18-8 Type 303.

The minimum working pressure of the coupling shall be the same as the working pressure of the pipeline to which the coupling is to be installed.

Repair clamps shall only be utilized after obtaining written approval from the Engineer. When approved, repair clamps shall meet the following minimum specifications:

Repair clamps 2 inches (*50 millimeters*) and larger shall be of the full circle type.

All repair clamp components shall be constructed of ASTM Type 304 stainless steel. The gasket shall consist of gridded rubber material having tapered ends suitable for the liquid in the pipeline.

Repair clamps smaller than 2 inches (*50 millimeters*) in diameter may have ductile iron or malleable iron lugs which shall be epoxy coated in accordance with AWWA C 550.

Fittings, flexible couplings, and repair clamps shall be installed in accordance with the manufacturer's recommendations and AWWA C 600, except as modified herein.

The contractor shall provide personnel skilled and knowledgeable with regard to the installation procedures for the fittings, flexible couplings, and repair clamps as well as all incidental appurtenances being installed.

(D) Water Meters. Water meters shall be stored and handled in accordance with the manufacturer's instructions except as may be modified by the plans, Special Provisions, or as directed by the Engineer. The contractor shall deliver all water meters to the appropriate utility, notifying the utility 24 hours prior to delivering the water meters.

Water meters and the materials used in their manufacture shall comply with Tucson Water Standards or the requirements specified in the Special Provisions.

(E) Corrosion Test Station. Corrosion test station installations, testing and test reports shall be in accordance with the requirements of Standard Detail W-700, through W-710, as applicable.

All materials shall comply with those of the manufacturers whose products and materials are included in the water utility's list of approved materials or to the requirements of the Special Provisions.

510-3.08 Backfilling and Compacting.

(A) Backfill. Potable water pipe backfill shall consist of trench backfill material. Trench backfill shall be placed from 1 foot (*0.3 meters*) above the top of pipe to the subgrade elevation of the roadway or to existing ground when the installation is outside the roadway prism. Bedding material shall conform to the requirements specified in Subsection 510-2.04. Trench backfill shall conform to the requirements of Subsection 510-2.05 with the exception that, within the roadway prism, trench backfill material shall conform to the requirements of shading material as specified in Subsection 501-2.05. At the contractor's option, trench backfill material may be used in place of backfill material in areas outside the roadway prism.

(B) Placement of Backfill. All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the areas to be backfilled before backfill material is placed.

Trench backfill, compacted by pneumatic or mechanical tamping devices, shall be placed in layers not more than 8 inches (*200 millimeters*) in depth before compaction.

Bedding material shall be placed in accordance with the provisions of Subsection 510-3.03.

(C) Compaction of Backfill. Trench backfill material shall be compacted to at least 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manuel, as directed and approved by the Engineer.

Jetting shall not be used to compact trench backfill.

510-3.09 Encasement of Pipe. When shown on the project plans, or specified in the Special Provisions, pipe shall be encased in Class B concrete conforming to the requirements of Subsection 501-2.02 or controlled low strength material (CLSM) conforming to the requirements of Subsection 501-2.02. CLSM may also be used in lieu of trench backfill material if approved by the Engineer.

510-3.10 Preliminary Flushing. Mains, hydrants and appurtenances shall be flushed at a mean main velocity of at least 2.5 feet per second (*0.75 meters per second*) for a period of 60 seconds per 100 foot (*30 meters*) length of the section of the work being flushed. In areas where the existing system will not produce the required mean velocity, the maximum mean velocity shall be achieved for a commensurately longer duration as directed by the Engineer. All flushing water, both preliminary and final, shall be disposed of by directing into adjacent trench backfill, recovered for compactive or dust palliative purposes, or directed to adequate surface drainage courses. In no instances shall flushing waters be allowed to pond or pool so as to cause hazards or nuisances to adjacent properties or the to the public.

Mains 16 inches (*400 millimeters*) in diameter and larger will not require preliminary flushing. The contractor shall keep all mains of this diameter and larger free of dirt, mud, debris and any deleterious material prior to disinfections.

510-3.11 Hydrostatic Pressure Testing. Potable pipelines shall be tested for leakage following the installation of all thrust restraint devices, placement of the trench backfill material, and final compaction.

The contractor shall furnish all labor, materials, and equipment required to hydrostatically test water facilities. The contractor shall provide a calibrated pump suction tank for the test pressure pump. The pressure gauge shall be provided by the Engineer. The water line to be tested shall pass a pretest conducted by the contractor before the official test is scheduled.

In the event that the new water line requires connection to an existing line for the purpose of filling the new line with water, the connection between the existing and new line shall be broken and the new line plugged prior to commencing the test, unless prior approval is received from the Engineer.

Hydrostatic pressure testing of all potable waterlines shall be conducted with potable water only, air testing is not allowable.

Hydrostatic testing may be conducted against existing valves upon written acceptance of the Engineer. However, it is understood by the contractor that such acceptance shall in no way relieve the contractor of responsibility for damage to lines, valves, or appurtenances caused by the test. Further, the Agency assumes no risk, liability, or obligation of any kind regarding the condition of existing facilities nor any connection the contractor may make to said facilities. Any damage to new or existing water facilities resulting from the hydrostatic testing shall be repaired at no additional cost to the Agency.

Valves shall undergo hydrostatic and leak testing in accordance with the provisions of AWWA C 504.

All sections of newly installed waterline shall be inspected to ensure that all entrapped air has been completely expelled from the pipe, valves, and hydrants. If permanent air release outlets are not located at all high points, the contractor shall install additional air release ports as may be necessary or as directed by the Engineer. These components shall be considered incidental to the construction and testing of the waterline.

For concrete cylinder pipe, the contractor shall specify and require the pipe supplier to include an appropriate number of outlets for the removal of trapped air. The location of the outlets shall be shown on the shop drawings. The cost of these outlets shall be considered incidental to the cost of the pipe and testing.

The test pump may be either hand or motor driven. The test pump shall be connected to the waterline under test only through a tap into the main.

Hydrostatic testing shall be conducted only after all new work has been installed. Hydrostatic testing shall be conducted only in the presence of the Engineer. The hydrostatic test pressures specified herein shall be maintained for a period of two hours.

Unless otherwise noted in the Special Provisions, on the plans or as directed by the Engineer, test pressures shall be in accordance with Table 510-1.

SECTION 510

TABLE 510-1

MINIMUM HYDROSTATIC TEST PRESSURE REQUIREMENTS

Class of Pipe	Lowest Elevation Minimum Test Pressure	Highest Elevation Minimum Test Pressure
Class 150	200 p.s.i. (*1380 kilopascals*)	175 p.s.i. (*1205 kilopascals*)
Class 200	200 p.s.i. (*1380 kilopascals*)	175 p.s.i. (*1205 kilopascals*)

The test pressure shall not vary by more than ± 5 psi (*35 ± kilopascals*) during the duration of the test.

Leakage shall be defined as the quantity of water that must be supplied into the newly installed waterline, or any valved section thereof, to maintain pressure within ± 5 psi (*35 ± kilopascals*) of the specified test pressure after the pipe has been filled with water and all air expelled. Leakage shall not be measured by a drop in pressure in a test section over a period of time.

No pipe installation shall be accepted if the leakage exceeds that determined by either of the following formulas:

$$L = \frac{SD\sqrt{P}}{133{,}200}$$

Where:
- L = Maximum allowable leakage, in gallons per hour (*liters per hour*)
- S = Total length of pipe tested, in feet (*meters*)
- D = Nominal diameter of pipe, in inches (*millimeters*)
- P = Average test pressure during the leakage test, in pounds per square inch (*kilopascals*) (gauge)

Or:

$$L = \frac{ND\sqrt{P}}{7400}$$

Where:
- L = The allowable leakage, gallons per hour (gph) (*liters per hour*)
- N = The number of joints in the length of pipeline tested
- D = Nominal diameter of pipe
- P = The average test pressure during the leakage test, in pounds per square inch (*kilopascals*) (gauge)

Allowable leakage for ductile iron pipe and polyvinyl chloride pipe at various test pressures is provided in Table 510-2 and 510-3 respectively.

TABLE 510-2
DUCTILE IRON PIPE
Allowable Leakage per 1000 ft of Pipeline*--gallons per hour (gph)

Avg. Test Pressure		Nominal Pipe Diameter - in. (mm)															
		3	4	6	8	10	12	14	16	18	20	24	30	36	42	48	54
psi	(kPa)	(75)	(100)	(150)	(200)	(250)	(300)	(350)	(400)	(450)	(500)	(600)	(760)	(910)	(1060)	(1220)	(1370)
450	(3100)	0.48	0.64	0.95	1.27	1.59	1.91	2.23	2.55	2.87	3.18	3.82	4.78	5.73	6.69	7.64	8.60
400	(2760)	0.45	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.60	4.50	5.41	6.31	7.21	8.11
350	(2410)	0.42	0.56	0.84	1.12	1.40	1.69	1.97	2.25	2.53	2.81	3.37	4.21	5.06	5.90	6.74	7.58
300	(2070)	0.39	0.52	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12	3.90	4.68	5.46	6.24	7.02
275	(1900)	0.37	0.50	0.75	1.00	1.24	1.49	1.74	1.99	2.24	2.49	2.99	3.73	4.48	5.23	5.98	6.72
250	(1720)	0.36	0.47	0.71	0.95	1.19	1.42	1.66	1.90	2.14	2.37	2.85	3.56	4.27	4.99	5.70	6.41
225	(1550)	0.34	0.45	0.68	0.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70	3.38	4.05	4.73	5.41	6.03
200	(1880)	0.32	0.43	0.64	0.85	1.06	1.28	1.48	1.70	1.91	2.12	2.55	3.19	3.82	4.46	5.09	5.73
175	(1210)	0.30	0.40	0.59	0.80	0.99	1.19	1.39	1.59	1.79	1.98	2.38	2.98	3.58	4.17	4.77	5.36
150	(1030)	0.28	0.37	0.55	0.74	0.92	1.10	1.29	1.47	1.66	1.84	2.21	2.76	3.31	3.86	4.41	4.97
125	(860)	0.25	0.34	0.50	0.67	0.84	1.01	1.18	1.34	1.51	1.68	2.01	2.52	3.02	3.53	4.03	4.53
100	(690)	0.23	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.80	2.25	2.70	3.15	3.60	4.05

* If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.
To obtain leakage in liters per hour, multiply the values in the Table by 3.78.

TABLE 510-3
POLYVINYL CHLORIDE PIPE
Allowable Leakage per 1000 ft of Pipeline*--gallons per hour (gph)

Avg. Test Pressure		Nominal Pipe Diameter - in. (mm)											
		4	6	8	10	12	14	16	18	20	24	30	36
Psi	(kPa)	(100)	(150)	(200)	(250)	(300)	(350)	(400)	(450)	(500)	(600)	(760)	(910)
300	(2070)	0.47	0.70	0.94	1.17	1.40	1.64	1.87	2.11	2.34	2.81	3.51	4.21
275	(1900)	0.45	0.67	0.90	1.12	1.34	1.57	1.79	2.02	2.24	2.69	3.36	4.03
250	(1720)	0.43	0.64	0.85	1.07	1.28	1.50	1.71	1.92	2.14	2.56	3.21	3.85
225	(1550)	0.41	0.61	0.81	1.01	1.22	1.42	1.62	1.82	2.03	2.49	3.04	3.65
200	(1880)	0.38	0.57	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.29	2.87	3.44
175	(1210)	0.36	0.54	0.72	0.89	1.07	1.25	1.43	1.61	1.79	2.15	2.68	3.22
150	(1030)	0.33	0.50	0.66	0.83	0.99	1.16	1.32	1.49	1.66	1.99	2.48	2.98
125	(860)	0.30	0.45	0.60	0.76	0.91	1.06	1.21	1.36	1.51	1.81	2.27	2.72
100	(690)	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	1.35	1.62	2.03	2.43
75	(520)	0.23	0.35	0.47	0.59	0.70	0.82	0.94	1.05	1.17	1.40	1.76	2.11
50	(340)	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.96	1.15	1.43	1.72

* If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.
To obtain leakage in liters per hour, multiply the values in the Table by 3.78.

Acceptance shall be determined on the basis of allowable leakage. Should any test of installed pipe disclose leakage of a greater quantity than that specified in this subsection, the contractor shall, at no additional cost to the Agency, locate and make repairs approved and inspected by the Engineer, until the leakage falls below the maximum allowable.

Retesting of segments shall be with the identical test parameters used for the initial test.

All visible leaks shall be repaired by the contractor regardless of the amount of leakage.

The contractor shall perform hydrostatic leakage tests on all HDPE pipe in accordance with the monitored make-up water test.

510-3.12 Monitored Make-Up Water Test (HDPE Pipe). This test procedure consists of initial expansion and test phases. During the initial expansion phase, the test section is pressurized to the test pressure, and enough make-up liquid is added each hour for three (3) hours to return to test pressure.

The test phase follows immediately, and may be one, two, or three hours in duration. At the end of the test period, the test section is returned to test pressure by adding a measured amount of liquid. If the amount of make-up liquid added does not exceed the values provided in Table 510-4, the pipe segment is acceptable.

For any test pressure from 1 to 1-1/2 times the system operating design pressure, the total test time including initial pressurization, initial expansion, and time at test pressure, shall not exceed eight hours. If the test is not completed due to leakage, equipment failure, etc., the test section shall be depressurized and allowed to "relax" for at least eight hours prior to bringing the test section up to test pressure again.

TABLE 510-4
TEST PHASE MAKE-UP QUANTITY

Nominal Pipe Size (in.) Inch	(mm)	Gallons / 100 ft. of Pipe * 1 Hour Test	2 Hour Test	3 Hour Test
3	75	0.10	0.15	0.25
4	100	0.13	0.25	0.40
6	150	0.30	0.60	0.90
8	200	0.50	1.0	1.5
10	250	0.75	1.3	2.1
12	300	1.1	2.3	3.4
14	350	1.4	2.8	4.2
16	400	1.7	3.3	5.0
18	450	2.2	4.3	6.5
20	500	2.8	5.5	8.0
22	550	3.5	7.0	10.5
24	600	4.5	8.9	13.5
26	660	5.0	10.0	15.0
28	710	5.5	11.1	16.8
30	760	6.3	12.7	19.2
32	810	7.0	14.3	21.5
34	860	7.0	16.2	24.3
36	910	9.0	18.0	27.0

* To obtain make-up quantity in liters per 30 meters multiply the values in the Table by 3.78

510-3.13 Disinfection. Disinfection shall be performed in accordance with the provisions of the latest revisions of the Arizona Department of Health Services Engineering Bulletin No. 8, except as modified as follows:

- Concentrated chlorine solution shall not enter any part of the existing system. All new work, including mains, hydrants and appurtenances shall be disinfected.

- The method of chlorination shall be the general continuous feed method. The tablet method of chlorination shall not be accepted. The chlorine concentration shall be maintained at a minimum of 50 ppm (*50 mg/1*) of available chlorine in all portions of the new work being disinfected during the application period.

- The retention period shall be 24 hours. At the end of this 24 hour period, the disinfection solution shall contain not less than 10 ppm (*10 mg/1*) of available chlorine in all portions of the new work being disinfected.

510-3.14 Final Flushing and Microbiological Testing. At the end of the disinfection retention period, as approved by the Engineer, the heavily chlorinated disinfection solution shall be flushed from all parts of the new work.

Final flushing shall be performed in accordance with the procedures of Subsection 510-3.06, Preliminary Flushing and except that all main line valves shall be operated throughout their range and be shown to be tight closing during the final flushing.

Final flushing shall continue until the chlorine concentration of the flushing water being discharged from all points in the new work is equivalent to the chlorine level of the flushing water supply or is less than 1 ppm (*1 mg/1*).

Service lines shall be thoroughly flushed prior to meter installation.

After completion of the final flushing and before the new work is accepted, microbiological tests shall be performed and shall show the absence of coliform organisms (no coliform organisms shall be detected in any samples).

Initial failure will require rechlorination and reflushing by the contractor at no additional cost the Agency.

510-4 METHOD OF MEASUREMENT

Ductile iron, concrete cylinder, polyvinyl chloride and high density polyethylene potable water pipe will be measured by the linear foot (*meter*) parallel to the central axis of the pipeline, and shall include the length through the centerline of all valves, fittings and connections, with the exception that fire hydrant runs shall be measured form the centerline of the main valve to the centerline of the hydrant.

Tees, bends and other branches will be measured as pipe along the central axis of the pipes to the point of intersection of said central axis. Pipe reducers will be measured as pipe of the larger diameter along the central axis.

The end of pipe in closed structures will be considered to be at the intersection of the central axis and the inside face of the wall.

Steel casing pipe shall be measured in accordance with the provisions of Subsection 929-4.

Corrosion test stations (CTS) will be measured as a unit for each type of CTS installed.

Copper pipe shall be measured from the center of the corporation stop to the center of the curb stop, or, in the case of a split service, to the center of the yoke.

Potable water system appurtenances not addressed herein shall be measured only if included in the bidding schedule. The applicable unit of measurement for system appurtenances shall be as designated in the bidding schedule.

Unless otherwise provided in the Special Provisions, no measurement shall be made for the following items of work. The cost of these items shall be included in the unit price for potable water pipe.

- All testing, except those tests specifically noted as being paid for by the Agency.
- Shoring and sheetpiling, except that sheetpiling, directed by the Engineer to be cut off and left in place.
- Dewatering.

510-5 ASIS OF PAYMENT

Except as hereinafter specified, no separate measurement or payment will be made for excavating trenches, dewatering compacting subgrade and for furnishing, placing and compacting bedding and backfill material as described and specified herein and on the project plans, the cost thereof being considered as included in the contract unit price per foot (*meter*) of potable water pipe.

Payment for the removal of rock, hard pan, other unyielding material, or soft, spongy or other unstable soil below the vertical limits as shown on the plans, and the backfilling and compaction of these overexcavated areas, as specified herein and as directed by the Engineer, will be paid for in accordance with the requirements of Subsection 104-2.

The accepted quantity of potable water pipe, measured as provided above, will be paid for at the contract unit price complete-in-place for all pipe diameters specified.

The respective unit prices specified to be paid per linear foot (*meter*) of pipe shall be compensation in full for furnishing all pipe, fittings and other materials required for building pipelines, for excavating and for laying, setting, providing and installing polyethylene wrap, and jointing of all pipes and fittings, carrier pipe supports, couplings, rubber casing seal, steel bands, preliminary flushing, all testing, including leakage tests, disinfections, final flushing, microbiological testing, all shoring, sheeting and bracing, de-watering by any and all methods, all backfill, excavation and recompaction of existing sub-grade, all bedding, all clean up, all labor, tools and construction equipment, and for all other work and incidental expenses. Payment includes all costs for maintaining the operation of the existing potable water system during construction and for removing or abandoning existing water systems.

The accepted quantity of steel casing pipe, measured as provided above, will be paid for in accordance with the provisions of Subsection 929-5.

The accepted quantity of corrosion test station, measured as provided above, will be paid for at the contract unit price each.

Minor items or appurtenances necessary to provide a complete and functioning potable water system shall be considered incidental to and included in the payment for those system items designated in the bidding schedule unless the minor item or appurtenance is itself included in the bidding schedule, in which case it will be paid for at the contract unit price for the pay unit designated in the bidding schedule, which price shall be full compensation for the minor item or appurtenance, complete in place.

SECTION 511

RECLAIMED WATER SYSTEMS

511-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, equipment, tools, and labor necessary to install a complete and functioning or reclaimed water distribution system, inclusive of all service connections and appurtenances and installing the pipe including excavation and furnishing, placing and compacting backfill material, in accordance with the details shown on the project plans and the requirements of these specifications.

At each location where a pipe is to be installed, the project plans will specify the size and approximate length along with the requirements for each approved option at that location, such as wall thickness, coatings, class and strength.

The contractor shall furnish and install the pipe specified at each such location. Special sections, fittings, elbows, branch connections, tapered inlets, connectors, coupling, and other such items shall be of the same material and coating as the pipe to which they are attached.

The contractor shall furnish and install such system and service appurtenances and materials specified on the project plans at each location noted.

Bedding material and trench backfill material shall conform to the requirements of these specifications. Placement and compaction requirements for bedding material and trench backfill material shall conform to the requirements of this Section unless otherwise noted on the plans or in the Special Provisions.

511-2 MATERIALS

511-2.01 General. All materials incorporated into the reclaimed water system shall comply with the provisions of this specification and shall be provided from manufacturer's whose products and materials are included in the water utility's approved materials list or shall conform to the requirements specified in the Special Provisions.

511-2.02 Reclaimed Water Pipe. Reclaimed water pipe materials shall conform to the requirements as specified herein.

511-2.03 Concrete for Pipe Encasement. Portland cement concrete for pipe encasement shall conform to the requirements found in Section 1006 for Class B concrete.

511-2.04 Controlled Low Strength Material (CLSM). Materials comprising the controlled low strength material shall conform to the requirements of Section 1006. CLSM mix designs shall be in accordance with the provisions of Subsection 501-2.03, Table 501-1

for reclaimed water system installations within the roadway prism. CLSM mix designs for all other areas shall be as designated on the plans, in the Special Provisions or directed by the Engineer.

511-2.05 Bedding Material. Aggregate for bedding material shall be in accordance with the provisions of Subsection 510-2.04.

Bedding material shall be approved by the Engineer prior to start of construction and must remain consistent throughout the project.

All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the area into which bedding material is to be placed.

511-2.06 Trench Backfill Material. Trench backfill material for reclaimed water pipe shall be in accordance with the provisions of Subsection 510-2.05.

511-3 CONSTRUCTION DETAILS

511-3.01 Abandonment or Removal of Existing Reclaimed Water Pipe and Appurtenances. The contractor shall remove, wholly or in part, and satisfactorily dispose of or salvage, all reclaimed waterpipe and appurtenances, as noted on the plans. The contractor shall dispose of all structures and obstructions, within rights-of-way or easements, as necessary in order to complete the work as noted on the plans.

Reclaimed water pipe shall be abandoned in accordance with the requirements of Standard Detail W-350 or as directed by the Engineer.

Non-hazardous materials removed and designated not to be salvaged or incorporated into the work shall become the property of the contractor, removed from the project, and properly disposed of.

All valves, valve boxes, and fittings removed by the contractor from the abandoned reclaimed water system shall be delivered to the water utility in accordance with the provisions of Standard Detail W-105 and as directed by the Engineer.

Holes, cavities, trenches and depressions within the construction area resulting from the removal of reclaimed waterpipes or obstructions, except in areas to be excavated, shall be backfilled with suitable material and compacted to a density of not less than 95 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

All removed reclaimed waterpipes to be salvaged shall be cleaned of all earth and other deleterious material from both inside and outside prior delivery. Pipe to be salvaged shall be stored, when necessary, so as to avoid damage or loss before delivery.

When necessary, waterpipes shall be cut with straight and smooth edges on a plane perpendicular to the centerline of the pipe.

511-3.02 Preparation of Trenches. Trenches for reclaimed water pipe installations shall be in conformance with the Standard Details, unless otherwise noted on the plans or in the Special Provisions, and shall be in accordance with the provisions of Subsection 510-3.02.

511-3.03 Bedding.

(A) Placement of Bedding Material. Placement of bedding material shall be in accordance with the provisions of Subsection 510-3.03(A).

(B) Compaction of Bedding Material. Bedding material shall be compacted in accordance with the provisions of Subsection 510-3.03(B).

511-3.04 Installation of Reclaimed Water Pipe.

(A) General. Only those materials specified shall be utilized to construct public reclaimed water system facilities. Other materials shall be utilized only upon approval by the Engineer.

Reclaimed water systems shall use purple pipe and purple marking and detecting tape to identify all subsurface piping and fixtures.

All above-ground appurtenances of the reclaimed water system, including valves, valve boxes and covers, controllers, piping, and hose bibs or other outlets, shall be identified using purple paint as specified by the Standard Details or plans, or as directed by the Engineer.

Reclaimed water system valve boxes shall comply with the requirements of Standard Detail W-300.

Pipe ends shall be covered during transportation to prevent exhaust fumes from entering the pipe. Materials delivered to the site of the work in advance of their use shall be stored in a manner which minimizes inconvenience to the public. Materials shall be sorted and stored neatly and shall insure ease of accessibility. Materials shall be protected from the elements in accordance with the recommendations of the manufacturer. Materials which, in the judgment of the Engineer, have been improperly stored or shipped shall not be eligible for the partial payment or installation.

For pipe 24 inch (*600 millimeter*) diameter or larger, the sequence of installation shall be submitted by the contractor prior to the start of work. The sequence shall conform to the contract time and comply with all required phasing noted on the project plans. The sequence shall also minimize inconvenience to the traveling public.

Two working days prior to commencement of excavation, the contractor shall contact Blue Stake to verify the location of all existing utilities in the vicinity of the work.

All personnel of the contractor or their subcontractors shall be skilled and knowledgeable with regard to the installation procedures for the specific pipe, fittings and appurtenances being installed.

Reclaimed water pipe and appurtenances shall be handled in such a manner as to ensure delivery to the trench in sound and undamaged condition. Pipe shall be unloaded opposite or near the location at which it will be installed. Pipe shall not be stored along a residential street for more than ten days or along a business street for more than three days. The interior of the pipe shall be thoroughly cleaned of foreign material before being lowered into the trench.

Repairs shall be allowed only when approved by the Engineer. Repairs shall be made in conformance with the requirements specific to the pipe material as herein noted.

Pipe and pipe appurtenances shall be carefully lowered into the trench by means of slings, pipe tongs or other acceptable means. Waterline materials shall not be dropped or dumped into the trench. Care shall be taken to avoid abrasion of the pipe coating or lining.

Laying of reclaimed water pipe shall be in finished trenches free from water and debris. Each pipe shall be laid true to line and grade, with uniform support under the full length of the pipe barrel.

Upon installation, the meeting surfaces shall be wiped clean of dirt and foreign matter, then an approved lubricant shall be applied at the joint surfaces. The spigot shall be positioned inside the socket and the installation completed.

Any adjustment of line and grade shall be made by excavating or filling under the pipe. Wedging or blocking under the pipe ends is prohibited.

Fittings shall correspond in all respects with the requirements specified for pipe of the corresponding size.

Fittings shall be made to accommodate the joining system provided.

Pipe marking and detecting tape and its installation shall comply with the requirements of Subsection 511-3.05.

The ends of all pipe shall be plugged at the end of each work day, or when work is not in progress, to prevent contamination.

The method of plugging the ends of pipe shall be approved by the Engineer.

If, prior to testing, any debris is found in the pipe, the pipe shall be cleaned by propelling with water a snug-fitting inflated ball through the pipe or by using other adequate methods.

(B) Reclaimed Water Shutoffs. Should construction require shutoff of the reclaimed water system, the contractor shall notify the Engineer a minimum of 48 hours prior to the planned system shutoff. The contractor may be required to operate the necessary valves under the direction of the representative from the water utility. When operating valves under the direction of the water utility's representative, the contractor assumes no liability for normal operation.

The contractor shall be responsible for assisting the water utility in notifying all affected reclaimed water customers of the time and duration of the system shutoff in accordance with the requirements of Standard Detail W-110. Work may be required at night or on weekends. The Engineer, upon request, will provide valve and service maps of the existing water system to the contractor.

(C) Utility Separation. Reclaimed water pipe construction shall conform to the following separation requirements with regard to other existing utility lines:

(1) Electric. Reclaimed water pipes shall not be installed within a 5 foot (*1.5 meter*) horizontal distance to parallel electric duct or conduits. The minimum vertical separation between electric duct or conduits and the water pipe, at any location, shall be 12 inches (*300 millimeters*). Water services shall not be installed at the same property corners as electrical pedestals or transformers and shall be separated by a minimum horizontal distance of 10 feet (*3 meters*).

When electric, telephone, cable, fiber optic, or gas facilities parallel reclaimed water facilities, they shall not be installed with less than 5 feet (*1.5 meter*) horizontal clearance from the reclaimed water pipe unless the system has been approved by the Engineer.

(2) Storm Drain Culvert. The minimum vertical separation between the reclaimed water pipe and storm drain culvert shall be 12 inches (*300 millimeters*) minimum either over or under the culvert.

The separation shall be measured from the outside of the wall of the reclaimed water pipe to the outside wall of the storm drain pipe or culvert. In all cases however, the minimum cover of the water pipe shall be 44 inches (*1.1 meters*) from finish road grade as well as providing for a minimum 36 inches (*910 millimeters*) of cover to the bottom of any excavation.

(3) Sanitary Sewer. Reclaimed water pipes installed in the vicinity of sanitary sewer lines shall be considered potable with respect to clearances and installed in the vicinity of sanitary sewer mains shall comply with Standard Detail WWM-108.

(4) Potable Water. Reclaimed water pipes located adjacent to potable water pipes shall comply with the separation criteria established for pressure sanitary sewer lines.

(D) Pipe Installation and Materials. Pipe installation and materials shall be in accordance with Subsection 510-3.04(D).

(1) Ductile Iron Pipe (DIP). Ductile iron pipe shall conform to the requirements of Subsection 510-3.04(D)(1).

Ductile iron pipe used for reclaimed water lines shall have a double thickness cement mortar interior lining.

Cutting of ductile iron pipe shall conform to the requirements of AWWA C 600.

(2) Concrete Cylinder Pipe (CCP). Concrete cylinder pipe (CCP) shall conform to the requirements of Subsection 510-3.04(D)(2).

(3) High Density Polyethylene (HDPE) Pipe. High density polyethylene (HDPE) pipe shall conform to the requirements of Subsection 510-3.04(D)(3).

HDPE pipe used for reclaimed water systems shall have a purple, embossed, or integral stripe along the entire length of each pipe section.

(4) Polyvinyl Chloride (PVC) Pipe. Polyvinyl chloride (PVC) pipe shall conform to the requirements of Subsection 510-3.04(D)(4).

PVC pipe used in reclaimed water systems shall be colored purple (Panatone 522C) and embossed or integrally stamped/marked: CAUTION – RECLAIMED WATER – DO NOT DRINK. When approved by the Engineer, PVC pipe used for reclaimed water systems may be identified with purple marking tape or a purple polyethylene (Panatone 522C or Seymour Safety Purple) vinyl wrap.

(5) Galvanized Steel Pipe. Galvanized steel pipe shall conform to the requirements of Subsection 510-3.04(D)(5).

(E) Valves. Reclaimed water system valves shall be in accordance with the provisions of Subsection 510-3.04(E).

(F) Joint Restraint. Joint restraint for reclaimed water systems shall be in accordance with the provisions of Subsection 510-3.04(F).

Joint restraint devices of dissimilar material shall be protected against corrosion in accordance with Standard Detail W-700 through W-710.

(G) Casing Pipe. Casing pipe materials and installations shall be in accordance with the provisions of Subsection 510-3.04(G).

(H) Connections and Taps. Reclaimed water system connections and taps shall be in accordance with the provisions of Subsection 510-3.04(H).

511-3.05 Pipe Marking and Detecting Tape. Pipe marking tape and pipe detection tape shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions except as may be modified by the plans, Special Provisions, or as directed by the Engineer.

Pipe marking tape and pipe detection tape shall be stored in a manner such that it is protected from prolonged exposure to sunlight and/or extreme heat.

Detectable pipe locating tape shall be placed 24 inches (*610 millimeters*) above reclaimed water ~~pipe~~s and 6 inches (*150 millimeters*) above reclaimed service lines. Service laterals shall require a tracer wire. The backfill shall be sufficiently level in order that the tape will be installed on a flat surface. The tape shall be centered in the trench and laid flat with printed side up. Caution shall be exercised to avoid displacement of tape and to ensure its integrity. The tape shall consist of a minimum 4.0 mil (*100 micrometer*) thickness, inert polyethylene plastic which is impervious to all known alkalis, acids, chemical reagents and solvents likely to be encountered in the soil, with a minimum 1/3-mil (*8 micrometer*) metallic foil. The tape shall be at least 6 inches (*150 millimeters*) in width and shall be Seymore Safety purple in color with identifying print in black letters. The tape shall have printed thereon the following:

"CAUTION NON-POTABLE WATERLINE: CONTACT (name of water utility)
(insert water utility name)"

The identifying lettering shall be 1 inch (*25 millimeters*) high and repeated continuously the full length of the tape. In no instance shall the spacing of the individual segment of the identifying message be greater than 8 inches (*200 millimeters*). The remainder of the trench shall then be backfilled and compacted in accordance with the applicable requirements.

Pipe marking tape for reclaimed pipe shall consist of a minimum 4.0 mil (*100 micrometer*) thickness, inert polyethylene plastic which is impervious to all known alkalis, acids, chemical reagents and solvents likely to be encountered in the soil. The tape width shall be equal to the diameter of the pipe for mainlines and 3 inches (*75 millimeters*) for service lines. All locating and marking tape shall be Seymore Safety purple in color. The tape shall have printed thereon the following:

"CAUTION NON-POTABLE WATERLINE: CONTACT (name of water utility)
(Insert water utility name)"

Tape shall be imprinted continuously over the entire length in permanent black lettering. The lettering shall be a minimum 1 inch (*25 millimeters*) high. In no instance shall the spacing of the individual segment of the identifying message be greater than 8 inches (*200 millimeters*). The marking tape shall be installed on all reclaimed pipelines and service lines. It shall be laid directly on top of the pipe along the pipe centerline and shall be permanently affixed by wrapping the pipe circumference with 10 mil (*250 micrometer*) PVC pipe tape at no greater than 4 foot (*1.2 meter*) intervals along the pipeline.

511-3.06 Backfilling and Compacting. Backfill and compaction for reclaimed water installations shall be in accordance with the provisions of Subsection 510-3.08.

511-3.07 Encasement of Pipe. Reclaimed water pipe encasement shall be in accordance with the provisions of Subsection 510-3.09.

511-3.08 Appurtenances.

(A) Valve Nut Extension. Unless otherwise specified in the Special Provisions, valve nut extensions shall be in accordance with the provisions of Subsection 510-3.07(A).

Valve extension stems shall be installed in accordance with Standard Detail W-305.

(B) Valve Box and Cover. Valve boxes and covers for reclaimed water systems shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions except as modified by the plans, Special Provisions, or as directed by the Engineer.

All submittals shall refer to the applicable plan number and shall be approved by the Engineer.

Valve boxes shall be one piece with inside fitting cover. Valve boxes and covers shall be heavy cast iron in conformance with ASTM A 48, Class 30B. Covers shall be marked "Reclaimed Water Valve" and the valve box and cover shall be painted purple. Valve boxes shall be equipped with lugs or lips for setting in concrete. Valve boxes and covers shall conform to the requirements of Standard Detail W-300.

Valve boxes and covers shall be installed in accordance with Standard Detail W-300.

(C) Fittings, Flexible Couplings and Repair Clamps. Fittings, flexible couplings, and repair clamps for reclaimed water systems shall be in accordance with the provisions of Subsection 510-3.09(C).

(D) Pressure Gauges. Pressure gauges shall be in accordance with the provisions of Subsection 510-3.07(C).

(E) Corrosion Test Station. Installation of corrosion test stations shall be as noted on the project plans as in accordance with the provisions of Subsection 510-3.07(E).

511-3.09 Preliminary Flushing. Preliminary flushing shall be in accordance with the provisions of Subsection 510-3.10.

511-3.10 Hydrostatic Pressure Testing. Hydrostatic pressure testing of reclaimed water pipelines shall be in accordance with the provisions of Subsection 510-3.11.

Hydrostatic pressure testing of all reclaimed water lines~~,~~ shall be conducted with potable water only, air testing is not allowable.

Discharge of reclaimed water shall require the contractor to obtain the applicable permit from the Arizona Department of Environmental Quality (ADEQ). The discharge of reclaimed water shall be scheduled and closely coordinated with the water utility's representative.

Chlorination of reclaimed waterlines is not required.

Acceptance shall be determined on the basis of allowable leakage. Should any test of installed pipe disclose leakage of a greater quantity than that specified in this subsection, the contractor shall, at no additional cost to the Agency, locate and make repairs approved and inspected by the Engineer, until the leakage falls below the maximum allowable.

Retesting of segments shall be with the identical test parameters used for the initial test.

All visible leaks shall be repaired by the contractor regardless of the amount of leakage.

The contractor shall perform hydrostatic leakage tests on all HDPE pipe in accordance with the monitored make-up water test.

511-3.11 Monitored Make-Up Water Test (HDPE Pipe). This test procedure shall be conducted in accordance with the provisions of Subsection 510-3.12.

511-3.12 Disinfection. Reclaimed waterlines do not require disinfection.

511-4 METHOD OF MEASUREMENT

Ductile iron, concrete cylinder, polyvinyl chloride and high density polyethylene reclaimed water pipe will be measured by the linear foot (*meter*) parallel to the central axis of the pipeline, and shall include the length through the centerline of all valves, fittings and connections, with the exception that fire hydrant runs shall be measured form the centerline of the main valve to the centerline of the hydrant.

Steel casing pipe shall be measured in accordance with the provisions of Subsection 929-4.

Tees, bends and other branches will be measured as pipe along the central axis of the pipes to the point of intersection of said central axis. Pipe reducers will be measured as pipe of the larger diameter along the central axis.

Corrosion test stations (CTS) will be measured as a unit for each type of CTS installed.

The end of pipe in closed structures will be considered to be at the intersection of the central axis and the inside face of the wall.

Reclaimed water system appurtenances not addressed herein shall be measured only if included in the bidding schedule. The applicable unit of measurement for system appurtenances shall be as designated in the bidding schedule.

Unless otherwise provided in the Special Provisions, no measurement shall be made for the following items of work. The cost of these items shall be included in the unit price for reclaimed water pipe.

- All testing, except those tests specifically noted as being paid for by the Agency.
- Shoring and sheetpiling, except that sheetpiling, directed by the Engineer to be cut off and left in place.
- Dewatering.

511-5 BASIS OF PAYMENT

Except as hereinafter specified, no separate measurement or payment will be made for excavating trenches, dewatering compacting subgrade and for furnishing, placing and compacting bedding and backfill material as described and specified herein and on the project plans, the cost thereof being considered as included in the contract unit price per foot (*meter*) of reclaimed water pipe.

Payment for the removal of rock, hard pan, other unyielding material, or soft, spongy or other unstable soil below the vertical limits as shown on the plans, and the backfilling and compaction of these overexcavated areas, as specified herein and as directed by the Engineer, will be paid for in accordance with the requirements of Subsection 104-2.

The accepted quantity of reclaimed water pipe, measured as provided above, shall be paid for at the contract unit price complete-in-place for all pipe diameters specified.

The respective unit prices specified to be paid per linear foot (*meter*) of pipe shall be compensation in full for furnishing all pipe, fittings and other materials required for building pipelines, for excavating and for laying, setting, providing and installing polyethylene wrap, and jointing of all pipes and fittings, carrier pipe supports, couplings, rubber casing seals, steel bands, flushing, all testing, including leakage tests, all shoring, sheeting and bracing, de-watering by any and all methods, all backfill, excavation and recompaction of existing sub-grade, all bedding, all clean up, all labor, tools and construction equipment, and for all other work and incidental expenses. Payment includes all costs for maintaining the operation of the existing reclaimed water system during construction and for removing or abandoning existing water systems.

The accepted quantity of steel casing pipe, measured as provided herein, shall be paid for in accordance with the provisions of Subsection 929-5.

The accepted quantity of corrosion test station, measured as provided above, will be paid for at the contract unit price each.

Minor items or appurtenances necessary to provide a complete and functioning reclaimed water system shall be considered incidental to and included in the payment for those system items designated in the bidding schedule unless the minor item or appurtenance is itself included in the bidding schedule, in which case it will be paid for at the contract unit price for the pay unit designated in the bidding schedule, which price shall be full compensation for the minor item or appurtenance, complete in place.

SECTION 601

CONCRETE STRUCTURES

601-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing structures or parts of structures to the forms, shapes and dimensions shown on the project plans and to the lines and grades established by the Engineer and in accordance with the requirements of these specifications. When the structures or parts of structures are precast, the work shall also include transporting and erecting the units.

Concrete structures such as cattle guards, catch basins, median barriers, headwalls, and other small miscellaneous structures of sizes which can readily be precast as units and furnished and installed in-place are hereby defined as minor structures. Minor structures, at the option of the contractor, may be either constructed of cast-in-place concrete or furnished and installed as precast units providing they are fabricated in accordance with drawings submitted and approved in accordance with requirements which may be found in the special provisions.

601-2 MATERIALS

601-2.01 Portland Cement Concrete. Portland cement concrete shall conform to the requirements of Section 1006 for Class S or Class B as shown on the project plans.

Where a compressive strength is shown on the project plans, but a class of concrete is not indicated, it shall be intended to mean Class S concrete having the minimum 28-day compressive strength shown.

601-2.02 Concrete Curing Compound. Curing compound shall be a liquid membrane-forming compound conforming to the requirements found in Section 1006.

601-2.03 Expansion Joint Filler. Materials furnished for expansion joint filler and joint seal shall conform to the requirements of Section 1011.

601-2.04 Water Stops. Materials furnished for water stops shall conform to the requirements of Section 1011.

601-2.05 Bearing Pads. Preformed bearing pads and elastomeric bearing pads shall conform to the requirements of Section 1013.

601-2.06 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 1003.

601-3 CONSTRUCTION DETAILS

601-3.01 Foundations. Foundations for structures shall be placed on suitable earth or rock bearing, on a concrete foundation seal, or on piling, as shown on the project plans. Excavation and backfill shall be in accordance with the requirements of

Subsection 203-5. No concrete shall be placed under water or against water-bearing strata except where tremie concrete placement procedures are approved by the Engineer.

601-3.02 Falsework and Forms.

(A) Design and Drawings. The contractor shall be responsible for designing and constructing safe and adequate falsework and forms which provide the necessary rigidity, support the loads imposed, and produce in the finished structure the lines, grades, and dimensions shown on the project plans and established by the Engineer.

Forms shall be any system of structural elements which provide horizontal support or restraint to the lateral pressure of concrete.

Falsework shall be any system of structural elements that provide temporary support for loads from plastic concrete, forms, reinforcing steel, structural steel, loads from placement operations, finishing equipment or other related loads, and continues to provide support until the concrete has attained adequate strength and the structure is capable of self-support.

The design load for falsework shall consist of the sum of dead and live vertical loads, and an assumed horizontal load. The minimum total design load for any falsework shall be not less than 100 pounds per square foot (*4,790 Pascals*) for the combined live and dead load regardless of slab thickness.

Dead loads shall include the weight of concrete, reinforcing steel, forms and falsework. The weight of concrete, reinforcing steel and forms shall be assumed to be not less than 160 pounds per cubic foot (*2570 kilograms per cubic meter*) for normal concrete and not less than 130 pounds per cubic foot (*2085 kilograms per cubic meter*) for lightweight concrete.

Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of not less than 50 pounds per square foot (*2,395 Pascals*) applied over the area supported.

The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind, but in no case shall the assumed horizontal load to be resisted in any direction be less than 2 percent of the total dead load. The falsework shall be designed so that it will have sufficient rigidity to resist the assumed horizontal load without considering the weight of the concrete.

If the concrete is to be prestressed, the falsework shall be designed to support any increased or readjusted loads caused by prestressing forces.

Falsework shall be designed by the working stress design method and stresses under all loads shall not exceed the maximum allowable stresses provided for in the current edition of AASHTO Standard Specifications for Highway Bridges. The maximum allowable stresses provided for in the National Design Specification for wood construction (NDS) may be used as an alternate to the AASHTO Specifications for timber design. The maximum allowable horizontal shear stress in timber shall not exceed 125 pounds per square inch (*860 kilopascals*) after all applicable modification factors have been applied. No increase in allowable stresses for repetitive member uses will be allowed.

Unless otherwise specified on the plans, deflection of the falsework span due to the weight of concrete only shall not exceed 1/240 of the falsework beam span irrespective of the fact that the deflection may be compensated for by camber strips.

Drawings shall be prepared in accordance with the requirements of Subsection 105-2.

The drawings shall be complete and fully detailed working drawings showing the dimensions and material for all parts, arrangement, spacing, and connections, and all provisions for adjustment and for measuring displacement. The falsework foundations, any connections or contacts with previously built structures or other works, and the means of protecting such other works from damage shall be detailed. The above data may be presented, as convenient, either on the drawings or in the design summary, which shall also describe the assumptions and types of calculations used in the design and the stresses and deflections found for critical points. For any embankments used, the equivalent of the above drawings and data shall be submitted, and in addition the source, classification, and compaction requirements for the material and the results of any tests performed on the material.

Falsework design will require written approval by the Engineer prior to commencing work.

Except as provided for on the project plans, supports for deck falsework and forming shall not be welded to steel girders, shear connectors, slab ties or girder stirrups.

(B) Falsework Construction. The falsework shall be constructed to conform to the falsework drawings. The materials used in the falsework construction shall be of the quality necessary to sustain the stresses required by the falsework design. The workmanship used in falsework construction shall be of such quality that the falsework will support the loads imposed on the falsework.

Falsework shall be founded on a solid footing safe against undermining and capable of supporting the loads imposed. Falsework which cannot be founded upon a solid footing shall be supported by piling.

Wedges, screws or jacks shall be used in connection with falsework to set the forms to required grade and uniform bearing prior to placing concrete.

All wedges shall be in pairs to insure uniform bearing. Laminated sections will not be permitted. If additional material is required under wedges, either single blocks or thicker wedges will be required. A sufficient number of wedges shall be used to cover the entire bearing area.

The contractor shall provide tell-tales, attached to the soffit forms and readable from the ground, in enough systematically placed locations to determine the total settlement of the entire portion of the structure where concrete is being placed.

If any weakness develops during the placing of the concrete or the falsework shows any undue settlement or distortion, the work shall be stopped and the falsework corrected and strengthened.

(C) Forms Construction.

(1) General Requirements. Forms shall be of wood, metal or other suitable material conforming to the requirements specified herein.

The forms shall be mortar tight and shall be designed, constructed, braced and maintained so that the finished concrete will be true to line and elevation and will conform to the required dimensions and contours. They shall be designed to withstand the pressure of concrete, with consideration given to the rate of concrete placement, temperature of the concrete, use of set-retarding admixtures or pozzolanic materials in the concrete, the effects of vibration as the concrete is being placed and all loads incidental to the construction operations, without distortion or displacement. Forms shall be maintained to eliminate the formation of joints due to shrinkage of the lumber.

Formwork plans shall be submitted by the contractor and reviewed by the Engineer before formwork is constructed, unless otherwise waived by the Engineer.

Stay-in-place forming shall not be used unless specified on the plans or approved by the Engineer. Expanded metal meshes may be used to form construction joints provided: (1) a 3 inch (75 *millimeter*) cover is maintained and; (2) use in bridge decks is prohibited.

Forms shall be maintained at all times in good condition as to accuracy of shape, strength, rigidity, watertightness and smoothness of surface. Forms or form lumber unsatisfactory in any respect shall not be used.

Forms shall be constructed so that portions may be removed without disturbing forms that are to remain. Forms to be used when a Class II finish or ornamental work is required shall be

constructed of metal, fiberglass coated panels, or plywood. All form joints shall be taped or caulked in an acceptable manner. Forms for this work shall be equivalent to first class pattern work.

Forms shall be filleted 3/4 inch (*19 millimeters*) at all exposed, sharp corners of the concrete.

All forms shall be treated with an approved form release agent before concrete is placed. Any material which will adhere to or discolor the concrete shall not be used.

Forms shall be cleaned of all dirt, sawdust, water and other foreign material prior to placing concrete in the forms.

For narrow walls and columns where the bottom of the form is inaccessible, provisions shall be made for cleaning out extraneous material immediately before placing the concrete. The cells of box girders shall be cleared of all loose materials prior to the completion of deck forming when such forming is to remain in-place. When the deck forming is to be removed, the cells of the box girders shall be cleared of all loose materials after removal of the forms.

(2) Wood Forms. All lumber used for forms shall be free from defects affecting the accuracy of shape, strength, rigidity, watertightness and smoothness of the surface. All lumber for forms above stream bed shall be plywood. All form lumber shall be securely fastened to the studding so that cupping cannot occur. Chamfer strips shall be of selected material dressed to true line and uniform dimensions. The interior surfaces of all forms in contact with concrete surfaces which will be exposed in the finished work shall be smooth and even. No uneven or offset joints or single boards projecting so that their impressions are left in the concrete will be allowed. Forms, as far as practicable, shall be so constructed that the form marks will conform to the general lines of the structure. In general, grain of the lumber and direction of side joints shall be horizontal on wide faces and walls and vertical on narrow faces. If varying widths of panels are used, the wider panels shall be placed on the bottom and the narrower ones near the top. Panel and joints shall be staggered not less than 3 feet (*910 millimeters*). Spreaders made of wood shall not be left in the concrete.

(3) Metal and Fiberglass Forms. The same provisions as specified under wood forms shall apply to metal and fiberglass forms and in addition thereto, the following shall apply:

All bolts and rivet heads shall be countersunk. Clamps, rods, pins or other connecting devices shall be designed to hold the forms rigidly together and allow removal without injury to the concrete. Forms which do not present a smooth surface or are not properly aligned shall not be used.

Care shall be exercised to keep the forms free of rust, grease or other foreign matter which will tend to discolor the concrete.

Metal forms shall be used for the casting of precast I-beams, box beams, and voided or flat slabs where the contract number of units combined dictates production runs equal to or longer than the precasting bed length. A limited number of units, having a total combined length at least one unit length less than bed length, may be cast with alternate forms, as approved by the Engineer. Dimensional tolerance using alternate forms shall conform with 601-4.02(B).

Waste slabs used as a part of the forms shall be finished to the appropriate grade including any camber. The finished slab shall not vary more than 1/4 inch (*6 millimeters*) from the theoretical grade nor more than 1/4 inch (*6 millimeters*) from a 10 foot (*3 meter*) straight edge in any direction.

(D) Removal of Falsework and Forms. No falsework or forms shall be relieved of load and no forms shall be removed without approval of the Engineer.

In the determination of the time for removal of falsework and forms, consideration shall be given to the location and character of the structure, the weather, and other conditions influencing the setting of the concrete and the materials used in the concrete.

The following time periods after placement of concrete, together with the specified percentage of the required 28-day compressive strength (f'_c) shall be used by the Engineer as a guide in allowing the removal of falsework and forms:

Structural Component	Period	Percentage of Required 28-Day Compressive Strength
Centering under beams	14 days and	70%
Deck Slabs	5 days and	100%
	or 10 days and	70%
Walls	1 - 7 days	---
Columns	1 - 7 days	---
Sides of beams and all other parts	6 - 24 hours	---

Falsework, excluding bridge deck cantilevered overhangs for cast-in-place prestressed structures, shall not be removed until after the prestressing steel has been tensioned and a minimum of 72 hours after the prestressing steel has been grouted. Falsework for the cantilevered bridge deck overhang shall be removed prior to prestressing but shall not be removed within seven days of concrete placement unless the concrete has attained a minimum

compressive strength of 3,000 pounds per square inch (*20 megapascals*). In no case shall falsework be removed within five days of concrete placement. On bridges with both transverse and longitudinal stressing, the deck or overhang falsework shall not be removed until after the transverse prestressing has been completed unless shown otherwise on the plans. The deck overhang falsework shall then be removed prior to performing the longitudinal prestressing.

The Engineer may reduce these periods if high-early strength concrete is used or if the compressive strength of cylinders, cured under conditions similar to those in the field, indicate that the anticipated 28-day compressive strength has been achieved. The Engineer may extend the above periods for reasons of cold weather or other conditions which may retard the setting of the concrete.

Side forms for footings, beams, girders, box culverts, columns, railings, curbs, or other members where the forms do not resist dead load bending may be removed after the concrete has set and the contractor shall cure and protect the concrete thus exposed in accordance with the requirements of Section 1006. The contractor shall assume all risks and responsibility resulting from such removals.

Placement of backfill material shall be in accordance with Subsection 203-5.03. Where backfill is to be placed against both sides of a structural element, the backfill elevations on one side of the element shall not exceed the backfill elevations on the opposite side of the element by more than 5 feet (*1.5 meters*).

The period of time between the placement of concrete in the top slab of a standard concrete box culvert (12 foot (*3.7 meter*) span or less) and the removal of the slab support forms may be reduced to 48 hours if the top slab remains supported along the center line of the culvert span by a continuous beam and line of posts erected as a part of the original slab form, and which will remain in-place, undisturbed, a minimum of seven days.

If the Engineer allows the removal of forms before the specified curing period has elapsed, the contractor shall cure the concrete for the remaining required curing time by one of the methods specified in Section 1006.

Forms for cast-in-place concrete above the bridge deck, that require a Class II finish may be removed after the concrete has set, providing the required surface finishing of the concrete is completed within four days. If finishing cannot be completed within four days, the forms shall remain in place for seven days.

Forms used to support the deck of box girders when no permanent access to the cells is available shall be left in place.

Care shall be taken in removing falsework and forms so as not to deface or injure the structure. Methods of removal likely to damage or cause over-stressing of the concrete shall not be used.

Unless noted on the approved falsework drawings or approved by the Engineer, all falsework shall be removed from under bridge superstructures prior to opening the structure to traffic. Falsework shall be removed in such a manner that excessive stresses are not induced into the structure. Holes or blockouts shall not be drilled or cast into the structure to facilitate removal of the falsework without the approval, in writing, of the Engineer. Round blockouts may be used for such purposes providing the Contractor can submit evidence that the blockouts are not detrimental to the structure and the Engineer approves their use. The maximum blockout diameter shall not exceed 6 inches (*150 millimeters*).

601-3.03 Placing Concrete.

(A) General Requirements. No concrete shall be placed in a foundation until the extent of the excavation and the character of the bearing material have been approved and no concrete shall be placed in any structure until the placement of reinforcing steel and the adequacy of the forms and falsework have been approved by the Engineer.

Adequate time shall be given to the Engineer to check all form dimensions, embedded items, and placement of reinforcing steel. Concrete shall not be placed until all necessary corrections have been made by the contractor and all work required for the proposed pour has been completed.

Reinforcing steel shall be handled and placed in accordance with the requirements of Section 605.

When concrete is placed on or against soil, the soil shall have been compacted, at its optimum moisture content, to a minimum of 95 percent of its maximum density. Prior to placement of concrete the soil shall be mist sprayed with water so as to moisten all dry, absorbent surfaces with which the concrete will be in contact. Care shall be taken to avoid ponding water within the area of concrete placement.

The sequence of concrete placement shall be as shown on the project plans or as approved by the Engineer when not shown on the project plans.

Concrete shall be placed and consolidated by methods that will not cause harmful segregation, or displacement of reinforcement and will result in dense, homogeneous concrete free of honeycomb or voids.

Concrete shall be placed in horizontal layers not over 18-inches (*450 millimeters*) in depth unless otherwise approved by the Engineer. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and consolidated before the preceding layer has taken its initial set to prevent damage to the green concrete and avoid cold joints.

Concrete shall be placed as nearly as possible in its final position and the use of vibrators for shifting the mass of fresh concrete will not be permitted. Dropping the concrete more than 5 feet (*1.5 meters*) without the use of approved pipes or tubes will not be allowed.

Care shall be taken to fill all areas within the forms, to work the coarser aggregates back from the face of the concrete, and to force the concrete under and around the reinforcement without displacing the reinforcement or other embedded items.

Conveying equipment shall be capable of providing a supply of concrete to the point of placement without segregation of ingredients or interruptions sufficient to permit loss of plasticity between placement of successive layers.

Concrete placed in slabs and floors other than bridge decks shall be struck off by means of a screed. The screed may be self-propelled screed equipment or by manual methods.

When manual methods are permitted, concrete shall be deposited, spread and struck off to such an elevation that, when properly consolidated, the surface will conform to the required lines and grades. The strike board shall be moved forward with a combined longitudinal and transverse motions so that neither end is raised from the side forms. While striking off, a slight excess of concrete shall be kept in front of the cutting edge at all times.

No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the structure.

The rate of concrete placement and consolidation shall be such that the formation of cold joints within monolithic sections of any structure will not occur. Any portion of any structure displaying apparent cold joints will be rejected, unless the contractor, at his expense, can submit evidence that will indicate that either a cold joint does not exist or that a cold joint is not detrimental to the structure. The Engineer shall be the sole judge in determining the existence of a cold joint and whether its existence is detrimental to the structure. The rate of concrete placement for major structures shall not be less than 35 cubic yards per hour (*27 cubic meters per hour*) unless otherwise approved in writing by the Engineer. This rate shall not apply to precast concrete members.

After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.

(B)Bridge Deck. The placing of concrete will not be permitted until the Engineer is satisfied that the rate of producing and placing concrete shall be sufficient to complete the proposed pour and finishing operations within the scheduled time, that experienced concrete finishers are available to finish the deck and that all necessary finishing tools and equipment are on hand

at the site of the work and are in satisfactory condition for use. To this end, the contractor, at least ten days prior to the intended first deck pour, shall provide the following information to the Engineer for approval:

(1) Type and make of concrete screeding machine.

(2) Girder lines over which the support rails will be set.

(3) The height of the top of rails above the proposed finish grade in inches.

(4) The uniform incremental spacing between rail support chairs using one of the following options:

(a) Uniform spacing beginning at the low station centerline of the girder bearing point of each girder with one non-uniform space allowed at the high-station end of each girder.

(b) Uniform spacing beginning at a non-uniform distance from the low-station center line of the girder bearing point of each girder with a non-uniform space at the high-station end of each girder.

(c) Uniform spacing over the length of the girder beginning and ending on the center lines of bearing for each girder.

(5) The location of falsework support points.

Concrete shall be placed for the full width of the panel to be poured. After the concrete has been placed it shall be consolidated and then struck off by means of self-propelled screed equipment.

All one-operation screed machines shall be equipped with a power driven, strike-off auger and a float. Backing up of finishing machines will not be permitted. If the finishing machine is not performing properly the operation shall be suspended and concrete removed to the limits and extent required by the Engineer.

Screed equipment shall be designed to operate as close as practicable to bridge curbs or other obstructions.

Screed equipment shall travel on steel rails. Rails shall be substantially supported by adjustable steel supports of adequate size securely fastened in place and spaced at sufficiently close intervals to prevent any appreciable deflection in the rails. Steel supports shall be of such types and installed in such manner that when the rail and adjustable support have been removed, there will be no void in the concrete.

The steel rails for placing and finishing equipment shall be set to the correct elevation shown on the project plans or as established by the Engineer. The rails shall extend beyond both ends of the scheduled length for placement, a sufficient distance so as to permit the screed and finishing equipment to reach all areas of the concrete placed and allow all screed and finishing equipment as well as work bridges to clear all portions of the area poured.

Placement of the deck concrete shall be in accordance with the placing sequence shown on the project plans. The contractor shall submit a drawing showing the placement sequence, construction joint locations, directions of the concrete placement and any other pertinent data to the Engineer for his review. The drawing shall be submitted at least four weeks prior to the date of deck placement.

Screed beams or rollers shall be made of metal, or the bottom of the beam shall be metal clad. Roller screeds shall be so constructed and of such length that there will be no sag or deflection in the screeds.

Screed assemblies shall be equipped with vibrators. The screed assemblies shall be so designed that the vibrating units do not contact any reinforcing steel. Vibration shall be transmitted to the concrete in such a manner that when the motion of the machine is stopped, all vibration will cease.

A slight excess of concrete shall be maintained in front of the screed at all times during the screeding operation. The screed shall make as many passes over the slab as may be necessary to obtain a uniform surface. A minimum of 15 feet (*4.5 meters*) of placed, struck and consolidated concrete shall be allowed ahead of screed equipment.

The contractor shall furnish a minimum of two transverse work bridges from which floating, straightedging, and curing operations may be accomplished. The work bridges shall be reasonably rigid and free of excessive deflections. The self-propelled mechanical bridge used for texturing the bridge deck may be substituted for one of the required work bridges.

The floating operation shall follow the screeding if required. The float shall have a minimum diameter of 3 inches (*75 millimeters*) and have a minimum length of 12 feet (*3.6 meters*). The float shall be constructed so that the surface will be maintained true at all times.

Prior to placing concrete, the screed shall be traversed the length of the proposed pour and the clearance from the screed to the reinforcing steel as well as the deck thickness shall be checked. The method of determining the clearance shall be approved by the Engineer prior to making such checks. The clearance shall be as indicated on the project plans with a permissible variation of plus or minus 1/4-inch (*6 millimeters*). Deflection of the screed rails as a result of the weight of the

screed equipment will not be permitted. All corrections necessary as a result of this operation shall be performed prior to beginning the pour.

(C) Pumping Concrete. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be of suitable type and shall have adequate capacity for the work. The concrete shall not flow either over or through any piping, fittings or equipment which is fabricated of aluminum or aluminum alloys. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. Excessive segregation due to high velocity discharge of the concrete will not be permitted. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or segregation of the ingredients. Standby equipment shall be readily available to replace initial pumping equipment should breakdown occur.

(D) Vibrating Concrete. All concrete in structures shall be consolidated by means of approved vibrators together with any other equipment necessary to perform the work as specified herein. The minimum frequency of the internal vibrators shall be as specified in Table 601-1 and produce a vibration of sufficient intensity to consolidate the concrete into place without separation of the ingredients.

TABLE 601-1

VIBRATOR ELEMENT FREQUENCIES

	Frequency, Minimum Cycles/Minute
Surface, Pan or Screed	3500
Immersion Tube, Paving Machine Attachment	5000
Immersion Spud, Hand Operated	8000
Immersion Spud, Gang Mounted	8000

Vibration shall be applied in the area of the freshly deposited concrete. Vibrators shall penetrate to the bottom of the concrete layer and at least 6 inches (*150 millimeters*) into the preceding layer. The vibration shall be of sufficient duration and intensity to consolidate the concrete thoroughly within 15 minutes after it has been deposited in the forms. The vibrating element shall be inserted in the concrete mass in as nearly a vertical position as practicable. It shall be withdrawn completely from the concrete before being advanced to the next point of application. Internal vibrators shall not be applied directly to the forms or to the reinforcing steel.

Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

The vibrator shall not be used to push or distribute the concrete laterally.

To secure even and dense surfaces, free from aggregate pockets or honeycomb vibration shall be supplemented by working or spading by hand in the corners and angles of forms and along form surfaces while the concrete is plastic.

Revibration of concrete may be required at any time as directed by the Engineer.

The contractor shall provide sufficient equipment to insure uninterrupted and continuous vibration of the concrete.

(E) Placing Concrete in Water (Tremie Concrete). Tremie concrete shall be deposited in water only if either specified on the project plans or when directed and then only under the Engineer's supervision. When depositing in water is allowed, the concrete shall be carefully placed in a compact mass in the space in which it is to remain by means of a tremie, bottom dump bucket or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. No concrete shall be placed in running water and forms which are not reasonably watertight shall not be used for holding concrete deposited under water.

A head of concrete shall remain above the discharge end of the tremie tube at all times.

(F) Bridge Deck Widening. Where the roadway portion of a bridge deck widening section is more than 12 feet (*3.7 meters*) in width, concrete shall be placed in the roadway portion in accordance with the requirements of Subsection 601-3.03 (B).

Where the roadway portion of a bridge deck widening section is 12 feet (*3.7 meters*) or less in width, the spreading and floating of concrete in the roadway portion shall conform to the requirements of Subsection 601-3.03(A).

601-3.04 Joints in Major Structures.

(A) Construction Joints. Construction joints shall be placed at the locations shown on the project plans or as approved by the Engineer. Except under emergency conditions, construction joints shall be planned and located in advance of placing concrete. All construction joints shall be perpendicular to the principal lines of stress and in general located at points of minimum shear and moment.

Construction joints shall be constructed in accordance with the details shown on the project plans or as directed by the Engineer. Before new concrete is placed against concrete which has hardened, forms shall be drawn tight against the face of the concrete, wood keys shall be removed and the exposed steel or dowels and the entire surface of the construction joint shall be thoroughly cleaned. Immediately ahead of placing fresh concrete on the construction joint, the old concrete shall be thoroughly saturated with water.

After placing of concrete has been completed to the construction joint and before placing fresh concrete, the exposed reinforcing steel and the entire surface of the construction joints shall be thoroughly cleaned of surface laitance, curing compound and other materials foreign to the concrete and clean, coarse aggregate exposed. Surfaces of concrete shall be cleaned of all surface laitance and curing compound.

After the concrete surfaces have been treated as specified, they shall be cleaned of all dust and abrasive material.

(B) Expansion Joints.

(1) Description: This work shall consist of furnishing and installing expansion devices including the seals, anchorage system and hardware in conformity with the project plans and the requirements of these specifications.

(2) Materials: Elastomer seals shall be of the Compression Seal or Strip Seal type and shall conform to the requirements of Section 1011-5.

Steel shapes and plates shall conform to the requirements of ASTM A-36.

(3) Construction Requirements:

(a) General: Expansion joints shall consist of elastomer and metal assemblies which are anchored to the concrete at the joint. The seal armor shall be cast in the concrete. The completed joint shall be in planned position, shall satisfactorily resist the intrusion of foreign material and water and shall provide bump free passage of traffic.

For each size of seal on a project, a Certificate of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

(b) Shop Drawings: Prior to fabrication, the contractor shall submit six sets of shop drawings to the Engineer for his approval in accordance with the requirements of Subsection 105-2. The shop drawings shall show complete details of the method of installation to be followed, including a temperature correction chart for adjusting the

dimensions of the joint according to the ambient temperature and any additions or rearrangements of the reinforcing steel from that shown on the project plans.

Expansion joints for prestressed concrete structures shall be installed at the narrowest joint opening possible to allow for long term creep.

(c) Welding: All welding shall be in accordance with the requirements of Subsection 604-3.06.

(d) Galvanizing: All metal parts of strip seal assemblies shall be galvanized after fabrication in accordance with the requirements of ASTM A123 and ASTM A153. Bolts shall be high strength, conforming to the requirements of ASTM A325, with a protective coating of cadmium or zinc followed by a chromate and baked organic coating according to ASTM F1135, Grade 3, 5, 6, 7, or 8 and Color Code A.

Metal parts of compression seal assemblies do not require galvanizing, plating, or painting.

(e) Joint Preparation and Installation: The contractor shall form the joint with a secondary concrete pour to the concrete being placed with an approved adhesive specifically formulated for bonding new concrete to old concrete.

Joints to be sealed shall be covered or otherwise protected at all times prior to installing the elastomer portion of the assembly. The elastomer shall be installed at such time and in such manner that it will not be damaged by construction operations.

The seal element shall be installed subject to these specifications and the approval of the Engineer. Immediately prior to the installation of the seal element, the metal contact surfaces of the joint armor shall be clean, dry, and free of oil, rust, paint, or foreign material. Any perforation or tearing of the seal element due to installation procedures or construction activities will be caused for rejection of the installed seal element.

(C) Water Stops. Water stops of rubber or plastic shall be placed in accordance with the details shown on the project plans. Where movement at a joint is provided for, the water stops shall be of a type permitting such movement without detrimental effects. Water stops shall be spliced, welded or soldered to form a continuous watertight seal.

601-3.05 Finishing Concrete.

(A) General Requirements. The appropriate finish, as specified herein, shall be applied to each surface of all concrete structures.

All formed surfaces will require a Class I Finish. Formed surfaces shall be finished immediately after the removal of forms in accordance with the requirements specified herein. If rock pockets or honeycomb are of such an extent and character as to affect the strength of the structure and to endanger the steel reinforcement, the Engineer may declare the concrete defective and require the removal and replacement of that portion of the structure affected at the expense of the contractor.

Formed surfaces normally in view of vehicular or pedestrian traffic, or not covered by fill material shall present a pleasing appearance of uniform color and texture commonly achieved by the use of clean, smooth plywood forms joined tightly or taped at the joints, preformed metal forms, paper tubing forms, or specially coated forms. If a pleasing appearance has not been achieved, either in the formed surface or at the joints, the Engineer will order that the surface be finished in accordance with the requirements for a Class II Finish.

Approach slabs shall have a surface finish consistent with that of the bridge deck.

(B) Class I Finish. All bolts, wires, snap-ties, and rods shall be clipped and recessed 1 inch (*25 millimeters*) below the surface of the concrete. All holes, honeycomb, rock pockets and other surface imperfections shall be cleaned to sound concrete, thoroughly moistened and carefully patched with mortar.

Mortar shall be composed of one part cement, two parts of fine sand, water and an adhesive of a type approved by the Engineer. A portion of the required cement shall be white as required to match the color of the surrounding concrete. Small voids due to entrapped air and water in precast members need not be patched.

(C) Class II Finish. The surface shall be patched and pointed as specified herein for Class I finish. When the mortar used in patching and pointing has set sufficiently, the surface shall be rubbed with cork, wood, or rubber floats, polystyrene, or a mechanical carborundum stone. During the rubbing process a thin mortar, matching the color of surrounding concrete, may be used to facilitate producing a satisfactory lather. The mortar used to produce a lather shall not be used in quantities sufficient to cause a plaster coating to be left on the finished surface. Rubbing shall continue until irregularities are removed and there is no excess material. At the time a light dust appears, the surface shall be brushed or sacked. Brushing or sacking shall be carried in one direction so as to produce a uniform texture and color.

(D) Finishing Bridge Deck. Bridge sidewalks shall be finished to a light broomed texture.

When specified on the project plans, bridge decks that will be exposed directly to traffic, covered with a special riding surface, or covered with a waterproofing membrane, shall not be

broom textured and shall be finished to a smooth floated surface free of mortar ridges, hollows, and any other projections prior to curing.

Where the surface will be exposed directly to traffic it shall be textured transversely after the completion of the curing period by concrete sawcutting to produce a uniformly grooved surface in accordance with the requirements of Subsection 601-4.01 Surface Texture.

The textured grooves shall extend transversely across the entire deck surface to within six inches of the edge of bridge barrier wall or curb.

The entire length of the bridge deck shall be textured transversely and shall also include the approach slabs.

The finishing operation shall be completed before the water sheen disappears. Water shall not be applied to the deck surface at any time during floating or finishing except that a fog spray may be applied.

Fogging equipment shall be capable of applying water to the concrete in the form of a fine fog mist of sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck resulting from wind, high temperature, or low humidity, or a combination of these factors.

The finished surface of the concrete shall be tested by means of a 10 foot (*3 meter*) straightedge placed on the deck surface. The surface plane shall not vary by more than 1/8-inch (*3 millimeters*), as measured from the bottom of the straightedge, on deck surfaces exposed directly to traffic. Deck surfaces to be covered with a special riding surface or waterproofing membrane shall not vary by more than 1/4-inch (*6 millimeters*) as measured from the bottom of the straightedge.

Areas showing deviations greater than those specified shall be corrected in a manner approved by the Engineer. All corrected areas shall be textured to match the finish of the surrounding deck surface.

All areas corrected shall not show deviations in excess of that specified when tested with a 10 foot (*3 meter*) straightedge.

For bridge decks in excess of 300 feet (*90 meters*), exclusive of approach slabs, the concrete surface profile shall be tested in accordance with the requirements of Arizona Test Method 801.

Profilograph readings will be taken 3 feet (*910 millimeters*) from each edge of each traffic lane and the Profile Index will be computed for each of these profiles.

Grinding of pavement which has a Profile Index of 14.0 inches or less per mile (*350 millimeters* or less per *kilometer*)in any 0.1 mile (*0.16 kilometer*) section, shall only be permitted to correct deviations in excess of 0.3 inches (*7.6 millimeters*) in 25 feet (*7.6 meters*) unless otherwise directed by the Engineer.

Regardless of whether grinding has been necessary to reduce all individual deviations in excess of 0.3-inch (*7.6 millimeters*) as provided above, grinding shall be performed if necessary to reduce the overall Profile Index to 15 inches per mile (*380 millimeters* per *kilometer) or* less in any 0.1 of a mile (*0.16 kilometer*) section, or remaining portion thereof, along any line parallel to the edge of the pavement.

The machine used for grinding shall be a rotary type equipped with abrasive grinding wheels, shall be adjustable for height, and shall have a wheel base of not less than 10 feet (*3 meters*).

Grinding shall be limited to a maximum of 1 inch (*25 millimeters*) of surface removal unless otherwise approved, in writing, by the Engineer.

The contractor shall clean the pavement by brooming or by any other method acceptable to the Engineer so accurate readings can be obtained by the profilograph. The pavement shall be cleaned as many times as necessary for initial readings and for all subsequent readings.

Areas which have been ground will have to be re-grooved at the Engineer's request.

601-3.06 Curing Concrete. The contractor shall be solely responsible for insuring quality concrete operations at all times in order to prevent the formation of cracks. The appearance of cracks, other than normal, infrequent, sporadic, hairline, dry-shrinkage cracks will be cause for rejection of the concrete.

Curing cast-in-place and curing precast concrete members shall be in accordance with the requirements of Subsection 1006-6.

601-3.07 Supporting, Handling, and Transporting Precast Concrete Items. The manufacturer shall produce and deliver all precast concrete structures as shown on the plans and in accordance with the provisions noted herein. The manufacturer of prestressed units shall be certified by the Prestressed Concrete Institute.

After prestressing, precast members for major structures shall be handled or supported at or near the final bearing points for storage.

Precast items shall be supported during transporting in a manner that will allow reasonable conformity to the proper bearing points with consideration for the limitations of adequate hauling equipment. At all times the items shall be handled or supported securely in an upright position.

Items that have been damaged in shipment will be rejected.

Lifting devices shall not project above the surface of the item after placement unless they will be embedded in a subsequent concrete pour, will have a minimum concrete cover of 2 inches (50 millimeters) and will not interfere with the placement of reinforcing steel or concrete.

601-3.08 Backfilling. Structure backfill shall be placed in accordance with the requirements of Subsection 203-5.03 (B).

601-4 TESTS ON FINISHED STRUCTURES

601-4.01 Surface Texture. The grooves for decks exposed directly to traffic shall be 1/16 to 1/8 inch (2 to 3 millimeters) in width and 5/32 to 7/32 inch (4 *to 5 millimeters*) in depth. The textured groove depth will be measured in accordance with the requirements of Arizona Test Method 310. The center spacing of the grooves shall be 5/8 inch to 3/4 inch (*16 to 19 millimeters*).

601-4.02 Dimensional Tolerances.

(A) Cast-In-Place Concrete. The maximum allowable tolerances or deviations from dimensions shown on the project plans or the approved shop drawings shall be as follows:

(1) Variation from plumb in the lines and surfaces of columns, piers, abutment and girder walls:

In any 10 foot (*3 meter*) or less length: 3/8 inch (*10 millimeters*)
Maximum for the entire length: 1 inch (*25 millimeters*)

(2) Variation in cross-sectional dimensions of columns, piers, girders, and in the thickness of slabs and walls:

+ 1/4 inch (*+6 millimeters*)
- 1/8 inch (*-3 millimeters*)

(3) Girders alignment (deviation from straight line parallel to center line of girder measured between diaphragms):

1/8 inch (*3 millimeters*) per every 10 feet (*3 meters*) of length

(4) Variation in footing cross sectional dimensions as shown in project plans:

+ 2 inch (*+50 millimeters*)
- 1/2 inch (*-13 millimeters*)

(5) Variation in footing thickness:

* Greater than specified - No Limit.
  Less than specified - 5 percent of specified thickness up to a maximum of 1 inch (*25 millimeters*).
* Does not apply to reinforcing steel placement.

(6) Subgrade Tolerances:

Slab poured on subgrade excepting footing thickness:

+ 1/4 inch (*+6 millimeters*)
- 3/4 inch (*-19 millimeters*)

(7) Girder Bearing Seats:

Deviation from level: ± 1/8 inch (*± 3 millimeters) in* 10 feet (*3 meters*).

Deviation from required elevation:

+1/4 inch (*+6 millimeters*)
-1/8 inch (*-3 millimeters*)

(8) Cast-in-Place concrete box girder superstructures:

Deviation in overall depth:

+1/4 inch (*+6 millimeters*)
-1/8 inch (*-3 millimeters*)

Deviation in slab and wall thickness:

+1/4 inch (*+6 millimeters*)
-1/8 inch (*-3 millimeters*)

Deviation of post-tensioning ducts:

±1/4 inch (*±6 millimeters*)

(B) Precast Concrete Structures:

(1) General.

Precast units that do not comply with the dimensional tolerances specified herein will be rejected. Precast units that show evidence of cracks, pop outs, voids or other evidence of structural inadequacy or imperfections that will reduce the aesthetics of the unit after final placement will be rejected.

(2) Precast Concrete I-Beams.

The maximum allowable tolerances for deviations from dimensions and details shown on the project plans or the approved shop drawings shall be as follows:

(a) Length: ± 3/4 inch (*±19 millimeters*)

(b) Width (flanges and fillets): +3/8 inch (*+10 millimeters*), - 1/4 inch (*-6 millimeters*)

(c) *Depth* (over-all): + 1/2 inch (*+13 millimeters*), - 1/4 inch (*-6 millimeters*)

(d) *Width* (web): + 3/8 inch (*+10 millimeters*), - 1/4 inch (*-6 millimeters*)

(e) Depth (flanges and fillets): ± 1/4 inch (*±6 millimeters*)

(f) Bearing plates (center to center): ± 1/8 inch (*±3 millimeters*) per 10 feet (*3 meters*) but not greater than ± 3/4 inch (*±19 millimeters*)

(g) *Horizontal* alignment (deviation from straight line) parallel to center line of member):

1/8 inch (*3 millimeters*) per every 10 feet (*3 meters*) in length

(h) *Camber* deviation from design camber: ± 1/8 inch (*±3 millimeters*) per 10 feet (*3 meters*) but not greater than ± 1/2 inch (*±13 millimeters*)

(i) *Stirrup* bars (deviation from top of beam):

+1/4 *inch* (*+6 millimeters*),
- 3/4 inch (*-19 millimeters*)

(j) Tendon *position*: ± 1/4 inch (*±6 millimeters) c*.g. of strand group and individual strands

(k) Horizontal position of deflection points for deflected strands: ± 6 inches (*±150 millimeters*). Hold downs shall be symmetrical about centerline of girder span.

(l) *Position* of handling devices: ± 6 inches (*±150 millimeters*)

(m) *Bearing* plates (center to end of beam): ± 1/4 inch (*±6 millimeters)*

(n) Side *inserts* (center to center and center to end):

± 1/2 inch (*±13 millimeters)*

(o) *Exposed* beam ends (deviation from square or designated skew):

Horizontal: ± 1/4 inch (*±6 millimeters*)
Vertical: ± 1/8 inch per foot (*±3 millimeters per 300 millimeters*) of beam depth

(p) *Bearing* area deviation from plane: ± 1/8 inch (*±3 millimeters*)

(q) *Stirrup* bars (longitudinal spacing): ± 1 inch (*±25 millimeters*)

(r) Position of post-tensioning duct: ± 1/4 inch (*±6 millimeters*)

(s) Position of weld plates: ± 1 inch (*±25 millimeters*)

(3) Precast *Concrete* Box Beams and Flat Slabs.

The maximum *allowable* tolerances or deviations from dimensions and details shown on the project plans or the approved shop drawings shall be as follows:

(a) Length: ± 3/4 inch (*±19 millimeters*)

(b) Width (over-all): ± 1/4 inch (*±6 millimeters*)

(c) Depth (over-all): ± 1/4 inch (*±6 millimeters*)

(d) Width (web): ± 3/8 inch (*±10 millimeters*)

(e) Depth (top slab): ± 1/4 inch (*±6 millimeters*)

(f) Depth (bottom slab): + 1/4 inch (*±6 millimeters*), - 1/8 inch (*-3 millimeters*)

(g) Horizontal alignment (deviation from straight line parallel to center line of member):

1/8 inch (*3 millimeters*)per every 10 feet (*3 meters*) in length

(h) Camber deviation from design camber: ± 1/8 inch (*±3 millimeters*) per 10 feet (*3 meters*) but not greater than ± 1/2 inch (*±13 millimeters*)

(i) Camber differential between adjacent units: 1/4 inch (*6 millimeters*) per 10 feet (*3 meters*) but not greater than 3/4 inch (*19 millimeters*)

(j) Position of tendons: ± 1/4 inch (*±6 millimeters*) c.g. of strand group

(k) Longitudinal spacing of stirrup bars: ± 1 inch (*±25 millimeters*)

(l) Position of handling devices: ± 6 inches (*±150 millimeters*)

(m) Slab Void Position:

± 1/2 inch (*±13 millimeters*) from end of void to center tie hole
± 1 inch (*±25 millimeters*) adjacent to end block

(n) Square ends (deviation from square): ± 1/2 inch (*±13 millimeters*)

(o) Skew ends (deviation from designated skew): ± 1/2 inch (*±13 millimeters*)

(p) Beam seat bearing area (variation from plane surface when tested with a straightedge through middle half of member): ± 1/8 inch (*±3 millimeters*)

(q) Dowel tubes (spacing between the centers of tubes and from the centers of tubes to the ends and sides of members): ± 1/2 inch (*±13 millimeters*)

(r) Tie rod tubes (spacing between the center of tubes and from the centers of tubes to the end of the member):± 1/2 inch (*±13 millimeters*)

(s) Tie rod tubes (spacing from centers of tubes to the bottom of the beams): ± 3/8 inch (*±10 millimeters*)

(t) Total width of deck: theoretical width ± 1/2 inch (*±13 millimeters*) per joint

(u) Position of side inserts: ± 1/2 inch (*±13 millimeters*)

(v) Position of weld plates: + 1 inch (±25 millimeters)

(4) Precast Minor Structures.

The maximum allowable tolerances or deviations from the dimensions shown on the drawings shall be as follows:

(a) Over-all dimensions of member: ± 1/4 inch (*±6 millimeters*) per 10 feet (*3 meters*), maximum of ± 3/4 inch (*±19 millimeters*)

(b) Cross-sectional dimensions:

Sections 6 inches (*150 millimeters*) or less = ± 1/8 inch (*±3 millimeters*)
Sections over 6 inches (*150 millimeters*)
and less than 18 inches (*450 millimeters*) = ± 3/16 inch (*±5 millimeters*)

Sections over 18 inches (*450 millimeters*) and less than 36 inches (*900 millimeters*) = ± 1/4 inch (*±6 millimeters*)
Sections over 36 inches (*900 millimeters*) = ± 3/8 inch (*±10 millimeters*)

(c) Deviations from straight line: Not more than 1/4 inch (*6 millimeters*) per 10 feet (*3 meters*)

All exposed, sharp corners of the concrete shall be filleted 3/4 inch (*19 millimeters*) with a maximum allowable deviation of ± 1/8 inch (*±3 millimeters*).

601-4.03 Compressive Strength and Acceptance. Sampling and testing for compressive strength and acceptance for compressive strength will be in accordance with the requirements found in Subsection 1006-7.

601-4.04 Opening to Traffic. No vehicular traffic will be allowed on the structure until after the structure has been prestressed, tendons grouted, and all falsework removed from under the superstructure, for cast-in-place prestressed structures.

No vehicular traffic will be allowed until at least ten days after the last concrete has been placed in each continuous portion of a structure and until the compressive strength of all placed concrete, as determined by test cylinders, has reached the required 28-day compressive strength on structures in which cast-in-place concrete has been used.

601-5 METHOD OF MEASUREMENT.

When concrete is to be paid for by the cubic yard (*cubic meter*), measurement will be made in accordance with the dimensions shown on the plans or as revised by authority of the Engineer. In computing the volume of concrete for payment, no deductions shall be made for the volume of joint material, embedded metal reinforcement, structural shapes, chamfers, tops of piles, or pipe with an end area of less than one square foot (*0.1 square meter*).

The quantity of precast, prestressed structural members to be measured for payment will be the actual number of members, except piling, of the various types and sizes, installed in place, complete and accepted. Each member shall include the concrete, steel reinforcement and prestressing steel, enclosures for prestressing steel, anchorages, plates, nuts, elastomeric bearing pads, and such other materials contained within or attached to the unit.

Measurement for sawcutting bridge deck to provide a grooved surface will be made to the nearest square yard (*square meter*) of bridge deck area grooved.

No direct measurement will be made for expansion joints unless otherwise provided for in the special provisions and included in the bidding schedule.

601-6 BASIS OF PAYMENT

Structural concrete in concrete structures, measured as provided above, will be paid for at the contract unit price, complete-in-place, except that an adjustment, to the nearest cent, in the contract unit price will be made for the quantity of concrete represented by the results of a cylinder strength test that is less than the specified 28-day compressive strength, in accordance with Table 110-9.

Sawcutting of bridge deck to provide a grooved surface, measured as provided above, will be paid for by the square yard (*square meter*) of bridge deck area grooved, which price shall be full compensation for the work, complete in place, including geometric layout, sawcutting, and final cleanup of the bridge deck surface.

The contract price paid for structural concrete shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in furnishing, placing, and curing concrete and transporting and erecting falsework, falsework piling, forms, precast concrete items, water stops, roadway drains, scuppers, metal hinges and expansion joints, and bearing pads to provide a concrete structure complete in place as shown on the project plans, as specified herein, and as directed by the Engineer.

All replacements or corrections to concrete surfaces mis-shapen by bulges or deformations shall be made at no additional cost to the Agency.

Payment for minor structures will be made under the various sections of the specifications covering that particular minor structure.

All additional concrete that may be ordered by the Engineer for concrete footings that are below or beyond the lines shown on the plans will be paid for at the unit price bid in the contract.

SECTION 602

PRESTRESSING CONCRETE

602-1 DESCRIPTION

The work under this section shall consist of prestressing precast and cast-in-place concrete by furnishing, placing and tensioning of prestressing steel in accordance with the details shown on the project plans, and the requirements of these specifications.

The work under this section shall also include the furnishing and installation of any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts for post-tensioning systems and strand deflection devices, such as hold-downs.

Prestressing for precast concrete members shall be performed by the pretensioning method. Prestressing for cast-in-place concrete structures shall be performed by the post-tensioning method.

602-2 MATERIALS

602-2.01 Reinforcing Steel and Prestressing Steel. Materials furnished for reinforcing steel shall conform to the requirements of Section 1003.

Prestressing steel shall be high-tensile steel wire, high-tensile seven-wire strand or high-tensile alloy bars, as shown on the project plans.

High-tensile steel wire shall conform to the requirements of AASHTO M 204.

High-tensile seven-wire strand shall conform to the requirements of AASHTO M 203 for Grade 270. In addition to the 0.5 inch (*12.70 millimeter*) diameter prestressing steel shown on the project plans, 0.6 inch (*15.2 millimeter*) diameter seven-wire strand may be used for cast-in-place prestressed structures.

High-tensile alloy bars shall conform to the requirements of AASHTO M 275.

All prestressing steel shall be satisfactorily protected prior to use from damage by abrasion, moisture, rust, or corrosion and shall be free of dirt, rust, oil, grease, or other deleterious substances when installed and when tensioned.

602-2.02 Ducts. Duct enclosures for prestressing steel shall be rigid galvanized ferrous metal.

602-2.03 Grout. Cement grout for bonding prestressing tendons shall consist of not more than five gallons (*19 liters*) of water to one bag (94 pounds (*42.64 Kg*)) of portland cement and may contain an admixture if approved by the Engineer. No admixtures containing chlorides or nitrates shall be used.

Portland cement shall be Type II conforming to the requirements of Subsection 1006-2.01.

Water shall conform to the requirements found in Subsection 1006-2.02.

602-2.04 Structural Steel. Material furnished for structural steel shall conform to the requirements of Section 1004.

602-2.05 Portland Cement Concrete. Portland cement concrete shall conform to the requirements of Section 1006 for the class and strength of concrete shown on the project plans.

602-3 CONSTRUCTION DETAILS

602-3.01 Shop Drawings. Shop drawings of the proposed prestressing system shall be submitted in accordance with the requirements of Subsection 105.2.

(A) General. The drawings shall show the method and procedure of jacking and the type, size, and properties of the strands and number of strands per tendon and of the anchorage assembly. The stresses in the anchorages and distribution plates shall be calculated. The sizes, shapes, dimensions, and concrete cover shall be shown for the ducts and reinforcing steel, including any reinforcing steel to be relocated and any other embedded items.

Calculations shall be submitted showing the elongation of the strands at the time of jacking, the initial forces in the strands, and the final working forces. These calculations may be submitted separately from the drawings, and should also include the latest calibration certifications for the jacking system. In addition, a graph shall be prepared showing the gauge pressure in pounds per square inch (*megapascals*) and force in kips (*kilonewtons*) plotted through the whole range of the tensioning calibration. Not more than two years shall have elapsed between any jack calibration.

In addition to all required working drawings, the contractor shall prepare composite drawings in plan, elevation and section which show to scale the relative positions of all items that are to be embedded in the concrete and their embedment depth for the portions of the structure that are to be prestressed. Such embedded items include the prestressing ducts, vents, anchorage reinforcement and hardware, reinforcing steel, anchor bolts, earthquake restrainers, deck joint assemblies, drainage systems, utility conduits and other such items. Such drawings shall be adequate to ensure that there will be no conflict between the planned positions of any embedded items, and that concrete cover will be adequate. If during the preparation of such drawings conflicts are discovered, the contractor shall revise its working drawing for one or more of the embedded items, or propose changes in the dimensions of the work as necessary to eliminate the conflicts or provide proper cover. Any such revisions shall be approved by the Engineer before work on an effected item is started.

(B) Pretensioning Method. The shop drawings shall show the strand locations and harping points of the strands.

The drawings shall identify the type of finish or surface condition on the top of the precast member.

(C) Post-Tensioning Method. The drawings shall show the type, size, and properties of the strands or bars and the anchorage assemblies. The number of strands per tendon shall be shown. Details in addition to those shown on the contract plans shall be included for any additional reinforcing steel required to resist the concrete bursting stresses in the vicinity of the anchorage assemblies. The force or stress diagram shall be shown on the drawings. The sizes, shapes, dimensions, and concrete cover shall be shown for the ducts. Lay-out dimensions for locating the ducts along the tendon path shall not exceed 15 foot (*4.5 meter*) intervals. Vent locations and details of the vents shall also be included on the drawings.

Calculations shall be submitted showing the stresses in the anchorages and distribution plates.

The drawings shall include complete details of the method, materials, and equipment proposed for use in the prestressing operations. Such details shall outline the method and sequence of jacking, complete details of the prestressing steel, anchoring devices, type of enclosures, blockouts, and all other data pertaining to the post-tensioning system or operations.

602-3.02 Approval of Prestressing Systems. The contractor is responsible for furnishing either basic or special anchorage devices which satisfy the anchor efficiency requirements of AASHTO Division II, Article 10.3.2. The anchor efficiency test shall be conducted by an independent testing agency acceptable to the Engineer.

A basic anchorage device is an anchorage device meeting the restricted bearing compressive strength limits and the minimum plate stiffness requirements as specified in AASHTO Article 9.7.2 Division I – Design. If basic anchorage devices are used, the contractor is responsible for the design of the anchorage device and for determining the required concrete strength.

A special anchorage device is an anchorage device whose adequacy must be proven experimentally in the standardized acceptance test and met the acceptance criteria specified in AASHTO Article 10.3.3 Division II – Construction. If special anchorage devices are used, the contractor is responsible for furnishing anchorage devices that satisfy the acceptance test requirements of Division I, Article 9.21.7.3 and of Division II, Article 10.3.2.3. This acceptance test shall be conducted by an independent testing agency acceptable to the Engineer. The contractor shall provide records of the acceptance test in conformance with Division II, Article 10.3.2.3.12 to the Engineer and shall specify auxiliary

and confining reinforcement, minimum edge distance, minimum anchor spacing, and minimum concrete strength at time of stressing required for proper performance of the local zone.

Post-tensioning systems which have been tested and approved by the California Department of Transportation (Caltrans) will be considered an acceptable alternate to the AASHTO testing criteria. A copy of the approval letter from the Caltrans "Division of New Technology and Research," including any details associated with the approval, shall be submitted with the shop drawings by the post-tensioning company.

The contractor shall provide a calibration of the post- tensioning jacking system and shall provide the appropriate control settings for the transducer, electro-hydraulic load cell system by testing the jacking system in a manner that has been pre-approved by the Engineer.

Any deviation from the approved materials and details will not be permitted unless new details are submitted by the contractor and approved in advance of use.

The approval of any proposed method, material or equipment shall not operate to relieve the contractor in any respect of full responsibility for successfully completing the prestressing in accordance with details shown on the project plans and the requirements of these specifications.

602-3.03 Sampling and Testing. Sampling and testing shall conform to the requirements of AASHTO M 203, AASHTO M 204 and as specified herein.

Samples from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coils of prestressing wire and from each lot of anchorage assemblies and bar couplers to be used shall be furnished for testing. With each sample of prestressing steel wires, bars or strands furnished for testing, there shall be submitted a Certificate of Analysis, conforming to the requirements of Section 106, stating the manufacturer's minimum guaranteed ultimate tensile strength for the sample furnished.

All materials for testing shall be furnished by the contractor at no additional cost to the Agency. The contractor shall have no claim for additional compensation in the event his work is delayed awaiting approval of the materials furnished for testing.

All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies or bar couplers recovered at the site will be rejected.

602-3.04 Anchorage and Distribution. All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

All anchorage devices for post-tensioning shall hold the prestressing steel at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. The load distribution devices shall conform to the following minimum requirements:

The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch (*20.7 megapascals*).

Bending stresses in the plates or assemblies induced by the jacking of the prestressing steel shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 100 percent of the ultimate force is applied as determined by the Engineer.

602-3.05 Duct Installation. Duct enclosures for prestressing steel shall be mortar-tight and accurately placed at the locations shown on the project plans or approved by the Engineer.

Ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at all connections. Transition couplings connecting ducts to anchoring devices need not be galvanized.

All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing.

Ducts for prestressing steel shall be securely fastened in place to prevent movement and displacement during concreting. Ducts shall be placed within ±1/4 inch (*±6 millimeters*) of the dimensions shown on the approved shop drawings.

After installation in the forms, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris. If prestressing steel is to be installed after the concrete has been placed, the contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel.

Prior to placing forms for closing slabs of box girder cells, the contractor shall demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and if the prestressing reinforcement has been placed, that the steel is free and unbonded in the duct.

Prior to placing the forms for closing slabs of box girder cells, the contractor shall demonstrate to the Engineer, by aerostatic or hydrostatic tests, that the duct system, except those ducts not completely encased by concrete, will not permit leakage of grout into the box girder cells. For ducts completely encased in concrete, such tests shall be performed with a charging pressure of 40 pounds per square inch (*275 kilopascals*). Once the charging pressure is attained, the mechanical shutoff valve shall be closed for a period not less than five minutes. A retained pressure of 20 pounds per square inch (*135 kilopascals*), or greater, after five minutes, will be considered an indication of acceptable performance.

Ducts not completely encased by concrete shall have the exposed areas sealed with an epoxy compound and then pressure tested to 20 pounds per square inch (*135 kilopascals*) for five minutes. A retained pressure of 10 pounds per square inch (*70 kilopascals*), or greater, after five minutes, will be considered an indication of acceptable performance.

All leaks shall be repaired and the ducts retested prior to placing the forms. If, after two attempts to repair leaks, the ducts still do not comply with the above performance requirements, the Engineer may, at his discretion, accept the ducting if he is satisfied that no significant leakage of grout will occur. After completing each aerostatic or hydrostatic test, the ducts shall be blown dry with oil free compressed air.

602-3.06 Prestressing.

(A) General. Unless otherwise shown on the project plans, the stresses in the prestressing steel shall not exceed those specified in the current edition of the AASHTO Standard Specifications for Highway Bridges. However, when low relaxation stands are used in post-tensioning cast-in-place concrete, the jacking force shall not exceed 78 percent of the minimum ultimate tensile strength of the prestressing steel.

Working force will be considered as the force remaining in the prestressing steel after all losses, including creep and shrinkage of concrete elastic compression of concrete, losses in prestressing steel due to sequence of stressing, friction, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

All prestressing steel shall be tensioned with hydraulic jacks so that the force in the prestressing steel shall not be less than the value shown on the project plans. Each jack used shall be

equipped with either a pressure gauge or a load cell to determine the jacking force. All jacks and gauges shall be calibrated as a unit and shall be accompanied by a certified calibration chart.

All gauges shall be at least 6 inches (*150 millimeters*) in diameter. The gauges shall show accurate readings of load increments of one percent of the total capacity of the gauge. The increments shall not exceed 2 percent of the jacking force used.

The certified calibration charts for the hydraulic jacks and pressure gauges may be checked before and during jacking operations with Agency furnished load cells. If the certified calibration is found to be in error, the operation shall be immediately discontinued until a new certified calibration is performed by the contractor.

Welding or a welding ground shall not be done near prestressing steel and ducts. Welding near prestressed work shall be done only if specified on the project plans or directed by the Engineer.

(B) Pretensioning Precast Concrete. The tensioning force in pretensioned strands shall not be transferred to the member until tests on cylinders, cured under the same conditions as the member, indicates the required compressive strength has been attained.

Detensioning shall be performed immediately following the curing period if the concrete has been heat-cured. The release of the strands shall be from one or both ends of the casting bed depending upon which method will produce the least movement of members in the casting bed and the least horizontal eccentricity of the initial prestressing force in the member.

All pretensioned members shall be tensioned either by single strand or multiple strand jacks.

Jacking the prestressing steel shall be performed in two increments. An initial tension shall be applied to the strands to straighten them, to eliminate slack and provide a starting or reference point for measuring elongation. The final tension shall then be applied and elongation of strands measured.

Anchoring devices shall be capable of holding strands with a minimum of differential slippage. Stringing of following lengths of strand incorporating points previously gripped within lengths to be stressed will not be permitted. Any rotation of the strand shall be limited to not more than one revolution per 100 feet (*30 meters*) of exposed strand.

Splicing of strands will be permitted but only one splice per strand will be allowed. Strands to be spliced shall have the same lay or direction of twist. Splicing will not be permitted within the member.

When ordered by the Engineer, prestressing strands in precast members, if tensioned individually, shall be checked by the contractor for loss of force not more than three hours prior to

placing concrete for the members. The method and equipment for checking the loss of force shall be subject to approval by the Engineer. All strands which show a loss of prestress in excess of three percent shall be retensioned to the original jacking force.

When concrete has not been placed within 72 hours of the tensioning of the prestressing strands, retensioning of all strands will be required prior to placing of the concrete.

(C) Post-Tensioning Cast-In-Place Concrete. Prestressing steel for post-tensioning, which is installed in structures prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion until grouted by means of an approved corrosion inhibitor placed in the ducts or applied to the steel in the duct. If the strands are in the duct at the time concrete is placed, no tensioning will be allowed until it is demonstrated to the satisfaction of the Engineer that the prestressing strands are free and unbonded in the duct.

When prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within ten calendar days after the installation of the prestressing steel, rust which may form during the ten days will be not cause for rejection of the steel.

Except as herein provided, cast-in-place concrete shall not be prestressed until at least seven days after the last concrete has been placed in the structure to be prestressed and until the compressive strength of all placed concrete, as determined by test cylinders, has reached the required strength for jacking.

The tensioning process shall be so conducted that the force being applied and the elongation of the prestressing steel may be measured at all times. The actual elongation obtained from the calibrated force value shall be compared with the theoretical calculated elongation. A record of the prestressing force and elongations shall be kept at all times and submitted to the Engineer for approval.

Prestressing steel shall be tensioned by jacking from each end of the tendon for continuous structures unless otherwise noted on the project plans. Such jacking of both ends need not be done simultaneously, unless specifically indicated on the plans or in the special provisions.

Prestressing steel may be tensioned by jacking from one end only for simple span structures.

Should the contractor elect to furnish an anchoring device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 2 inches (*50 millimeters*) inside of the end surface of the members, unless a greater embedment is shown on the project plans. Following post-tensioning, the recesses shall be filled with concrete for the structure and finished flush.

At no time will a cutting torch be allowed for cutting prestressing steel for cast-in-place prestressed structures.

602-3.07 Grouting of Post-Tensioned Members. Post-tensioned prestressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout.

All of the tendons in a cast-in-place concrete structure shall have been fully tensioned and anchored prior to any grouting operation.

The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. Water shall be first added to the mixer followed by cement. Retempering of grout will not be permitted. All grout shall pass through a screen with 1/8 inch (*3 millimeters*) maximum clear openings prior to being placed in the grouting equipment and shall be continuously agitated until it is pumped.

The quality of the grout shall be determined by the Engineer in accordance with the requirements of Arizona Test Method 311. The efflux time of a grout sample immediately after mixing shall be not less than 11 seconds.

The maximum temperature of the grout shall be 90 °F (*32 °C*) and the minimum 50 °F (*10 °C*).

Grouting equipment shall be capable of grouting at a pressure of at least 150 pounds per square inch (*1035 kilopascals*) and shall be furnished with a pressure gauge having a full scale reading of not more than 300 pounds per square inch (*2070 kilopascals*). Maximum grouting pressure shall not exceed 250 pounds per square inch (*1725 kilopascals*).

Standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch (*1725 kilopascals*) and of sufficient capacity to flush out any partially grouted ducts shall be provided and available at the job site.

All ducts shall be clean and free of deleterious materials that would impair bonding of the grout or interfere with grouting procedures. Compressed air used to blow out the ducts shall be oil free.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Ejection pipes shall be fitted with valves capable of withstanding the pumping pressures. Valves shall not be removed or opened until the day following the grouting operation, unless otherwise approved by the Engineer.

Grout shall be pumped through the duct and continuously wasted at the outlet until no visible slugs of water or air are ejected. The outlet pipe shall then be closed and the duct shall then be pressurized. The pressurized duct shall maintain a minimum pressure of 75 pounds per square inch (*520 kilopascals*) for a minimum time of one minute. The valve at the inlet shall then be closed while maintaining this minimum pressure.

When hot weather conditions would contribute to quick stiffening of the grout, the grout shall be cooled by approved methods as necessary to prevent blockages during pumping operations.

When freezing weather conditions will prevail during and following the placement of grout, the contractor shall provide adequate means to protect the grout in the ducts from damage by freezing or other causes.

The surfaces of concrete against which concrete encasement of the anchorage assemblies is to be placed shall be abrasive blast cleaned to expose aggregate in the concrete after grouting of the ducts has been completed.

602-4 METHOD OF MEASUREMENT

No measurement or direct payment will be made for prestressing precast concrete, the cost being considered as included in the cost of the precast concrete item.

Prestressing concrete in cast-in-place structures will be measured by the approximate station for which a lump sum item is listed in the bidding schedule for such work.

602-5 BASIS OF PAYMENT

Prestressing cast-in-place concrete will be paid at the contract lump sum price, complete-in-place.

Furnishing and placing reinforcement not shown on the project plans and required only for anchorage zone recesses, blocks, duct ties and grillage assemblies, as recommended by the post-tensioning system used, shall be considered as included in the lump sum price paid for prestressing cast-in-place concrete.

Furnishing and placing concrete used in girder web flares and for concrete used in external anchorage blocks, including cover of distribution plates, shall be considered as included in the contract lump sum price paid for prestressing cast-in-place concrete.

Partial payments may be made in accordance with the provisions of Subsection 109-7.

Payments will be made on the basis of the following:

Installation of Ducts ..... 25 percent of contract lump sum.

Installation of Tendons .... 50 percent of contract lump sum.

Completion of Tensioning ... 15 percent of contract lump sum.

Completion of Grouting ..... 10 percent of contract lump sum.

SECTION 603

PILING

603-1 DESCRIPTION

The work under this section shall consist of the furnishing and driving piles at the locations and in accordance with the details shown on the plans and in accordance with the requirements of these specifications.

Piling shall consist of steel plates, cast-in-place concrete piles, precast concrete piles and timber piles and shall be of the kinds, sizes and lengths shown on the project plans.

When load test piles are shown on the project plans, pile loading tests shall be performed on said test piles in accordance with the requirements of the Special Provisions and as directed by the Engineer.

603-2 MATERIALS

603-2.01 Steel Piles. Steel piles shall be of the section shown on the project plans and shall be structural steel conforming to the requirements of AASHTO M 183.

Pile points, when specified on the project plans or ordered by the Engineer, shall be cast steel and be specially manufactured for hard pile driving.

603-2.02 Cast-In-Place Concrete Piles. Cast-in-place concrete piles shall consist of steel shells driven permanently to the required bearing value and penetration and filled with concrete.

Concrete for filling cast-in-place concrete piles shall be Class S portland cement concrete of the compressive strength shown on the plans and shall conform to the requirements of Section 1006.

Steel shells shall be of the diameter, thickness, length and design shown on the project plans. The shells shall be of sufficient strength and rigidity to permit driving and to prevent distortion caused by soil pressures or the driving of adjacent piles, until filled with concrete. The shells shall also be sufficiently watertight to exclude water during the placing of the concrete.

Unless otherwise shown on the plans or ordered by the Engineer, steel shells shall be equipped with closed driving tips. Driving tips shall be not more than 1/2 inch (*13 millimeters*) greater in diameter than the diameter of the shell at the tip. Closed driving tips may consist of flat steel plates of sufficient strength to suit pile driving conditions or may be cast steel points suitable for driving conditions. The use of wedge tips constructed of flat steel plates will not be permitted.

Reinforcing steel shall be as shown on the project plans and shall conform to the provisions of Section 1003.

603-2.03 Precast Concrete Piles. Precast concrete piles shall be either conventionally reinforced concrete piles or precast prestressed piles with prestressed steel strands.

Concrete shall be Class S concrete of the compressive strength shown on the plans and shall conform to the requirements of Section 1006.

Precast concrete piles shall be constructed in accordance with the details shown on the plans and in accordance with the requirements of Section 601. Prestressing shall be in accordance with the requirements of Section 602 using the pretensioning method.

Steel reinforcement shall conform to the requirements of Section 1003.

Precast concrete piles shall be fabricated on casting beds founded on permanent concrete foundations using steel forms, unless otherwise approved by the Engineer. Outer forms shall enclose all except the top horizontal surface of the pile. The side forms may have a maximum draft on each side not exceeding 1/4 inch per foot (*21 millimeters per meter*). All corners shall be chamfered 2 inches (*50 millimeters*) or rounded to a 2 inch (*50 millimeter*) radius. Forms for piles shall be such as to avoid the formation of fins at the intersection of the surfaces. The top of the concrete casting shall be given a uniformly smooth finish to match the finish surface at the formed sides.

Pile ends shall have plane surfaces and be perpendicular to the longitudinal axis of the pile. The maximum sweep (deviation from straightness measured along two perpendicular faces of the pile while not subject to bending forces) shall not exceed 1/8 inch (*3 millimeters*) in any 10 feet (*3 meters*) of its length, 3/8 inch (*10 millimeters*) in any 40 feet (*12.2 meters*) or 3/16 inch (*5 millimeters*) times the total length in feet (*meters*) and divided by 20 feet (*6.1 meters*).

Pick-up points for piles shall be plainly marked on all piles after removal of the forms, unless special lifting devices are attached for pick-up. All lifting shall be done at these points.

The use of special embedded or attached lifting devices, the employment of other pick-up points or any other method of pick-up shall be subject to written approval by the Engineer.

603-2.04 Timber Piles. All timber piles shall conform to the requirements of ASTM D 25. Treated timber piles shall be either Southern yellow pine, Ponderosa pine, Douglas fir or Larch. All piles for permanent structures shall be cleaned.

Timber piles requiring treatment shall be pressure treated in accordance with the requirements of AASHTO M 133.

Treated piles will be inspected for grade and quality before treatment and each piece accepted for treatment will be hammer-marked on the butt end with the registered brand of the inspector.

603-2.05 Paint. Paint for steel piles or metal shells shall be of the type shown on the project plans and shall conform to the requirements of Section 1002.

603-2.06 Certificates. Certificates of Analysis conforming to the requirements found in Section 106-5(B) shall be furnished for all steel piling and steel shells used.

603-3 CONSTRUCTION DETAILS

603-3.01 General. When the project plans or specifications permit the use of more than one type of pile, the same type of pile shall be used for all piles within each individual footing, unless otherwise permitted by the Engineer. The contractor shall be responsible for furnishing piling of sufficient length to obtain the penetration and bearing value required.

603-3.02 Predrilled Holes. Piles to be driven through embankment constructed by the contractor shall be driven in holes drilled or spudded through the embankment when shown on the project plans or ordered by the Engineer. The hole shall have a diameter of not less than the greatest dimension of the pile cross section plus 6 inches (*150 millimeters*). After driving the pile the space around the pile shall be filled to ground surface with dry sand or pea gravel, or as specified on the plans.

603-3.03 Equipment.

(A) General. Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturer of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of steam, air, or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained. Inefficient steam, air, or diesel hammers shall not be used.

(B) Hammers for Steel Piles. Steel piles shall be driven with a steam or air or diesel hammer which shall develop an energy per blow of not less than 15,000 foot-pounds (*20.3 kilojoules*) unless otherwise specified on the project plans.

(C) Hammers for Metal Shells. Metal shells for cast-in-place concrete piles shall be driven with a steam or air or diesel hammer. For shells driven with the aid of a mandrel, the combined weight of the shell and the mandrel shall be considered as the weight of the pile. The hammer shall develop an energy per blow of not less than 1 foot-pound (1.*3 joules*) for each pound (*kilogram*) of weight driven. In no case shall the total energy

developed by the hammer be less than 10,000 foot-pounds (*13.6 kilojoules*) per blow for driving shells with a mandrel. Hammers used to drive metal shells without a mandrel shall develop an energy per blow of not less than 15,000 foot-pounds (*20.3 kilojoules*).

(D) Hammers for Timber Piles. Drop hammers may be used for timber piles and shall weigh not less than 3,000 pounds (*1360 kilograms*) and shall be equipped with efficient leads and hoisting equipment. The fall of the hammer shall not exceed 12 feet (*3.7 meters*).

(E) Leads. Pile driver leads shall be constructed in such a manner as to afford freedom of movement to the hammer and they shall be blocked or braced so that the initial driving of the pile can be done without rotation or shifting of the pile to assure concentric hits on the piles.

(F) Followers. Driving of piles with followers will not be permitted.

603-3.04 Driving Piles.

(A) General. All piles shall be driven to a minimum bearing value or to a required tip elevation or a combination of both, as follows:

Where a minimum bearing is specified, all piles shall be driven to a bearing value not less than that specified, regardless of tip elevation. Where a required tip elevation is specified and no bearing value is specified, all piles shall be driven to at least the required tip elevation using a hammer that is capable of overcoming the soil resistance shown on the plans to reach that elevation without causing damage to the pile. Where a minimum bearing value and a required tip elevation are both specified, the piles shall be driven to a bearing value not less than that specified and, in addition, if the required tip elevation has not been attained, shall be driven further to the required tip elevation. The required tip elevation shall be the estimated tip elevation shown on the project plans or the adjusted elevation when allowed by the project plans for increased bearing value.

Piles shall not be driven until after the excavation or embankment in the area of the piling is complete. Any material forced up between the piles shall be removed to correct elevation without cost to the Agency before concrete for the foundation is placed.

Piles shall be accurately spaced and shall be driven either vertically or to the batter shown on the project plans. For trestle work and for piles which extend above ground in the completed structure, care shall be exercised to obtain proper alignment. Piles materially out of line shall be pulled and redriven or additional piles shall be driven as directed. Piles

which are to be capped shall be accurately cut off so that true bearing is obtained on all piles without the use of shims. Piles cut off otherwise shall be replaced.

Insofar as practicable, the driving of individual piles shall be a continuous operation.

(B) Driving Steel Piles. The heads of steel piles shall be cut squarely and a cast or structural steel driving head or cap shall be used to hold the axis of the pile in line with the axis of the hammer and to prevent excessive upsetting of the pile head under extremely hard driving conditions.

(C) Driving Metal Shells. An approved driving head, as furnished by the manufacturer or equal, which shall be of proper size and design for the particular size and type of hammer to be used, shall be provided to distribute properly the hammer blows and to prevent damage to the shell while driving.

The contractor shall have available at all times a suitable light, of an approved type, for thoroughly illuminating the interior of the pile shells for their entire length after being driven. Any shell that shows bends, kinks or other deformations incurred during the process of driving that would impair the strength or efficiency of the completed pile shall be replaced as directed by the Engineer and at no additional cost to the Agency. After all the shells have been driven to proper alignment, spacing and elevation and cut off at the required elevation, they shall be given a final inspection before they are filled with concrete. Any water or other foreign substance found in them shall be removed. Any required reinforcing steel shall be placed into the shell and supported and blocked to hold it in position during the concreting operation.

Upon approval, the shells shall be filled with concrete in the presence of the Engineer. The concrete shall be placed in layers and vibrated in accordance with the requirements of Subsection 601-3.03.

(D) Driving Timber Piles. Long piles shall be adequately supported against lateral buckling during the driving process.

All timber piles shall have square recut heads and tips and when necessary, the heads shall be accurately shaped or chamfered to take rings or head blocks. Collars, bands or other devices shall be provided where necessary to prevent splitting or brooming of the timber piles. Tips shall be properly formed to take shoes if, in the judgement of the Engineer, shoes are found necessary. They shall be furnished and attached to the piles by the contractor as directed. The contractor shall do all work necessary or incidental to the furnishing and proper fitting and fastening of said shoes to the piles and any other work necessary in driving the piles.

Treated timber piles shall be carefully handled so that the outer fibers are not broken or unduly injured. Treated piles which have been roughly handled in shipment or driving will be rejected. All treated piles shall be handled by fiber rope slings or other means which will not break the outer fibers. The use of peavies, cant hooks or sharp tools will not be allowed.

The heads or butts of all treated timber piles, except those to be encased in concrete, shall be treated. After the piles have been driven and cut off to the proper elevation for the cross cap, the sawed surface shall be either covered with three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or the surface shall be thoroughly brush coated with three applications of hot creosote oil and covered with hot roofing pitch. A covering of No. 24 gauge (*0.7 millimeter*) galvanized steel 6 inches (*150 millimeters*) in diameter larger than the diameter of the pile shall then be placed on the pile head and bent down over the sides of the pile to shed water.

(E)Driving Precast Concrete Piles. The heads of concrete piles shall be protected from direct impact of the hammer by a cushion driving block. The cushion shall be maintained in good condition during the entire driving operation.

(F)Defective Piles. The methods used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of concrete, injurious splitting, splintering and brooming of the wood, or deformation of the steel. Manipulation of piles to force them into proper position, if considered by the Engineer to be excessive, will not be permitted.

A concrete pile will be considered defective if it has a visible crack, or cracks, extending around the entire periphery of the pile, or any defect which, as determined by the Engineer, affects the strength or life of the pile.

Defective or damaged piles, piles which are driven materially out of position, or timber piles which have been cut too short will be rejected. Rejected piles and any falsework piles shall be removed or cut at least 2 feet (*610 millimeters*) below the final ground surface, except that rejected piles which will interfere with the work shall be removed. Rejected shell piles which are left in place shall be filled, at the contractor's expense, with utility concrete conforming to the requirements of Section 922.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

603-3.05 Pile Splices. Timber piles shall not be spliced, except upon written permission of the Engineer, in which case the method of splicing shall be in accordance with a working drawing submitted by the contractor to the Engineer for approval.

Metal shells and steel piles shall be spliced in accordance with the details shown on the plans. The indiscriminate splicing of steel piles will not be allowed.

Splicing of metal shells and steel piles shall be accomplished only by welders who have been prequalified and certified by the Agency.

Precast concrete piles shall not be spliced but instead shall be extended by casting a further length on top of the pile in accordance with the details shown on the project plans. Precast piles shall not be extended unless specified on the project plans or authorized in writing by the Engineer. If further driving is required, it shall not be done until the concrete has reached its 28-day strength.

In any case where the project plans do not show details of a splicing method, splices shall not be made until the Engineer has approved the method proposed by the contractor.

603-3.06 Pile Cutoffs. After driving has been completed, all piles shall be cut at the elevation determined by the Engineer. Cut-off material shall be removed from the site and disposed of by the contractor.

Each pile shall be cut on a plane normal to its axis. Embedment and anchorage into concrete caps for footings shall be provided as shown on the project plans.

Unless otherwise shown on the project plans, precast concrete piles shall be trimmed off to 3 inches (*75 millimeters*) above the bottom of the cap or footing and the edges beveled. Vertical reinforcement shall be cut off to provide 1'-6" (*450 millimeters*) of embedment, and prestressing strands shall be cut off to provide 2'-0" (*610 millimeters*) of embedment into the cap or footing. Any concrete damaged below cut-off elevation in the driving or cutting shall be removed to solid material and the pile built back up to elevation as specified under Subsection 603-3.04.

603-3.07 Painting Metal Piles. When steel piles or metal shells for cast-in-place concrete piles are driven and portions of these piles either extend above the ground or above the water surface, all surface area thereof, that will be exposed in the completed work, shall be protected by three coats of paint. The protection shall extend from an elevation 2 feet (*610 millimeters*) below the ground surface or 2 feet (*610 millimeters*) below low water level when the piles are in water, to the top of the exposed portion of the pile.

Painting piles shall be in accordance with the requirements of Section 610.

603-3.08 Determination of Bearing Values. The bearing value of each pile that is driven by a hammer shall be measured by the driving formula as specified in Table 603-1 herein. The contractor shall provide facilities and cooperation to the Engineer as needed to obtain the data required for this purpose.

The formulas in Table 603-1 are applicable only when:

The hammer has a free fall, except for double-acting hammers.
The head of the pile is not broomed or crushed.
The penetration is reasonably uniform.
There is no appreciable bounce after the blow. If there is an observable bounce, the value of H shall be reduced by twice the bounce height.

TABLE 603-1

TYPE OF PILE	TYPE OF HAMMER	FORMULA	(*METRIC*)
Timber and Steel	Drop	$P = \frac{2WH}{S+1.0}$	$P = \frac{167FH}{S+2.54}$
Timber, Steel and Metal Shells For Cast-In-Place Concrete	Single-Acting Power	$P = \frac{2WH}{S+0.1}$	$P = \frac{167FH}{S+2.54}$
		$P=\frac{2H(W+Ap)}{S+0.1}$	$P=\frac{16711(Ft0.001\ Ap)}{S+2.54}$
	Double-Acting Power	$P = \frac{2E}{S+0.1}$	$P = \frac{167E}{S+2.54}$

In Table 603-1:

P = safe allowable bearing value of piles, in pounds (*kilonewtons*).
W,(F)= weight of striking parts of the hammer, in pounds (kilonewtons).
H = fall of hammer, in feet (*meters*).
S = average penetration, in inches (*millimeters*) per blow, for the last 5 to 10 blows for drop hammers, and the last 10 to 20 blows for steam or air and diesel hammers.
A = effective area of piston, in square inches (*square* millimeters).
p = mean effective steam or air pressure, in pounds per square inch (megapascals).
E = manufacturer's rating of energy developed by the hammer, in foot-pounds (*Kilojoules*) per blow. The energy rating shall be approved by the Engineer.

603-4 METHOD OF MEASUREMENT

603-4.01 Furnishing Piles. Furnishing piles will be measured by the linear foot (*nearest tenth of a linear meter*) of piles furnished in accordance with the lengths specified on the project plans or ordered by the Engineer, except that no measurement for payment will be made for furnishing piles which are subsequently damaged in handling or driving to the extent that they are unusable.

603-4.02 Driving Piles. Driving piles will be measured by the linear foot (*nearest tenth of a linear meter*) from the tip to the required cut-off point of all piles satisfactorily driven.

603-4.03 Splicing Piles. Splicing piles will be measured as a unit for each splice made, when splicing is required because of pile lengths driven in excess of those specified on the project plans or ordered by the Engineer.

No measurement for payment will be made of splices made to obtain pile lengths in accordance with the details shown on the project plans or ordered by the Engineer.

603-5 BASIS OF PAYMENT

603-5.01 General. The accepted quantities of each of the items of work listed on the bidding schedule, measured as provided above, will be paid for at the contract unit price, as follows: When more than one type of piling is shown, each type will be listed on the bidding schedule and paid for separately.

603-5.02 Furnishing Piles. The contract price for furnishing piles shall include full compensation for furnishing precast concrete piles, steel piles, pile points or shoes, metal shells or pipe casings (for cast-in-place concrete piles) or timber piles delivered to the site of the work, in the quantities, types and size specified and lengths specified or ordered, in a condition ready to be driven.

Furnishing, fitting and fastening metal shoes for timber piles will be paid for in accordance with the requirements of Subsection 104-2.

603-5.03 Driving Piles. The contract price for driving piles shall include full compensation for placing piles and metal shells or pipe casings and driving them at the locations specified and to the required bearing value and tip elevation; furnishing and placing portland cement concrete and reinforcing steel in metal shells for cast-in-place concrete piles; for cutting piles off and furnishing and installing anchoring devices; and for painting piling as required.

The contract price for driving piles shall also include full compensation for jetting, drilling, blasting or other similar work as necessary to obtain the required tip elevation and

furnishing and attaching brackets, lugs, core stoppers or other similar devices to increase the bearing value of the piles, when such work or materials is specified on the project plans or in the special provisions.

When the work and materials described in the preceding paragraph are not specified on the project plans, but the Engineer determines, or it has been demonstrated to his satisfaction, that the required tip elevation cannot be reached without jetting, drilling, blasting or other similar work, or that the required bearing value cannot be obtained without the use of brackets, lugs, core stoppers or other similar devices, the Engineer will order such work to be performed and such materials to be furnished as he considers necessary under the conditions encountered in order that the required tip elevation or bearing value may be obtained. Materials and labor necessary to accomplish the requirements will be paid for in accordance with the provisions of Subsection 104-2.

603-5.04 Splicing Piles. The contract price for splicing piles shall include full compensation for furnishing all materials and labor and splicing piles in accordance with the specifications and the details shown on the project plans.

Payment for splicing piles will be made at the contract unit price per splice determined by multiplying the contract unit price per linear foot (*meter*) for furnishing the pile by the factor 5.

The total quantity of splicing piles necessary to complete the work may vary considerably from the quantity shown in the bidding schedule; however, no adjustment in the contract unit price due to an increase or decrease in quantity, as provided for in Subsection 104-2, will be made for this item.

SECTION 604

STEEL STRUCTURES

604-1 DESCRIPTION

The work under this section shall consist of constructing steel structures in accordance with the details shown on the plans and the requirements of these specifications. The work shall include furnishing, fabricating, erecting and painting the structural steel and other metals and performing all work required to complete the bridge structures and other structures.

604-2 MATERIALS

604-2.01 Structural Steel. Structural steel shall conform to the requirements of ASTM A 36, unless otherwise specified or shown on the plans.

All rolled section girders or structural steel plate used for the fabrication of tension flanges, web plates, eyebars and hanger plates and for splice plates of tension flanges and eyebars shall meet the longitudinal Charpy V-notch impact value requirements specified herein. Sampling procedures shall conform to the provisions in ASTM A 673. The H (Heat) frequency of testing shall be used for structural steels conforming to ASTM A 36, A 441, A 572 and A 588. The P (Piece) frequency of testing shall be used for structural steel conforming to ASTM designation A 514. Charpy V-notch impact values shall be determined in accordance with ASTM E 23.

Charpy V-notch (CVN) impact shall conform to the following minimum values:

Material	Impact Value (Ft. Lbs. at Temp.)
A 36 (*A 36 M*)	15 at 40° F (*20 at 4 °C*)
A 572 (*A* 572 *M*)	15 at 40° F (*20 at 4 °C*)
A 588 (*A* 588 *M*)* (2 inches (*50 mm*) and under in thickness)	15 at 40° F (*20 at 4 °C*)
A 588 (*A 588 M*)* (Over 2 inches (*50 mm*) to 4 inches (100 *mm*) in thickness)	20 at 40° F (*27 at 4 °C*)
A 514 (*A 514 M*) (2 1/2 inches (*63 mm*) and under in thickness)	25 at 0° F (*34 at -18 °C*)
A 614 (Over 2 1/2 inches (*63 mm*) to 4 inches (*100 mm*) in thickness)	35 at 0° F (*47 at -18 °C*)

* If the yield point of the material exceeds 65,000 psi (*450 megapascals*), the temperature for the CVN impact value for acceptability shall be reduced 15° F (*9 °C*) for each increment of 10,000 psi (*70 megapascals*) above 65,000 psi (*450 megapascals*).

604-2.02 Steel Structural Rivets. Steel structural rivets shall conform to the requirements of ASTM A 502.

604-2.03 High-Strength Bolts, Nuts and Washers. High-strength bolts shall conform to the requirements of ASTM A 325 (*A 325 M*) except as may be modified herein.

Nuts and washers, appropriate to the type of high strength bolt to be used, shall conform to ASTM Standards A 563 (*A 563 M*) or A 194 (*A 194 M*), for nuts, and F 436 (*F 436 M*), for washers, respectively.

The maximum hardness of ASTM A 325 (*A 325 M*) bolts shall be 34R_C.

Nuts and washers, appropriate to the type of high strength bolt to be used shall conform to ASTM Standards A 563 (*A 563 M*) or A 194 (*A 194 M*), for nuts, and F 436 (*F 436 M*), for washers, respectively.

Nuts shall be Grade 2H or DH for black or galvanized bolts. For galvanized bolts the nuts shall be overtapped to the minimum amount required for the bolt assembly.

All nuts, bolts and washers shall have the manufacturer's markings on them.

(A)Certificate Of Analysis. Each lot of bolts, nuts or washers shall be accompanied by a Certificate Of Analysis.

The Certificate of Analysis shall provide a lot number corresponding to that appearing on the shipping package. The certification shall note when and where all testing was done, including rotational capacity tests indicated herein, and shall include zinc thickness when galvanized bolts and nuts are used.

Testing to be included in the Certificate Of Analysis shall be done according to the "shipping lot" method. The minimum testing required is as follows:

(1) Rotational-Capacity Test. High strength bolts, both black and galvanized, shall be subjected to a rotational-capacity test, ASTM A 325, (*ASTM A 325 M*) and shall meet the following requirements when tested by the manufacturer:

(a) The tested bolts shall go through two times the required number of turns (from snug tight conditions) indicated in the AASHTO Bridge Specifications, Table 11.5B, in a Skidmore-Wilhelm Calibrator, or equivalent tension measuring device, without stripping or failure.

(b) During this test, the maximum recorded tension shall be equal to or greater than 1.15 times the Required Fastener Tension, as specified in AASHTO Table 11.5A.

(c) The measured torque to produce the Required Fastener Tension shall not exceed the value obtained by the following equation:

Torque = 0.25 PD
Where Torque = Measured Torque (Foot-Pounds) (*newton meters*)
P = Measured Bolt Tension (Pounds) (*newtons*)
D = Nominal Diameter (Feet) (*meters*)

(2) Proof Load And Wedge Tests. Proof load tests, performed by the manufacturer, are required for the bolts ASTM A 325 (*ASTM A 325 M*), and for the nuts ASTM A 563 (*ASTM A 563 M*) or ASTM A 194 (*ASTM A 194 M*)). The proof load tests for nuts to be used with galvanized bolts shall be performed after galvanizing, overtapping and lubricating.

(B) Acceptance Testing. High-strength bolts, nuts and washers will be field sampled at random by the Engineer, according to the "shipping lot" method, upon receipt of the bolt shipment by the contractor. A minimum of 3 bolts, with corresponding nuts and washers, or 0.1% of the lot, for lots in excess of 3,000, will be sampled for acceptance testing, for each bolt diameter. Samples will be submitted to the Agency for the following tests:

(1) Wedge Test. Bolts shall be tested in accordance with ASTM Test Method F 606M-WEDGE TEST METHOD as described in Section 3.5 of that standard. Fracture shall be in the body or threads of the bolt without any fracture at the junction of the head and body.

(2) Rockwell Hardness. Rockwell hardness shall be determined in accordance with ASTM Test Method E 18 within the specified maximum shown above for bolts. Nuts and washers will only be tested for Rockwell hardness, in accordance with ASTM Test Method E 18, to confirm compliance with ASTM Standards A 563 M or A 194 M for nuts and F 436 M for washers.

If any of the test bolts fail either of the above acceptance tests, the entire lot which it represents will be rejected. Similarly, if any of the nuts or washers fail the Rockwell Hardness Test, the entire lot of nuts or washers will be rejected.

(C) Installation. All galvanized nuts shall be lubricated with a lubricant containing a visible dye so that a visual check can be made for the lubricant at the time of field installation. Black bolts must be "oily" to the touch when installed. Weathered or rusted bolts shall be cleaned and re-lubricated prior to installation.

Installation of all high strength bolts shall be in accordance with "Installation", of the AASHTO Bridge Specifications. Of particular importance is obtaining the "Snug tight" condition as defined in the aforementioned specifications for any method of final tightening.

A Skidmore-Wilhelm Calibrator or other acceptable bolt tension indicating device will be provided by the Agency at each job site for use during bolt installation. Periodic tests (daily when calibrated wrench tightening is used) will be performed by the Agency to ensure the as-installed bolt/nut/washer assembly meets the above requirements. [For short grip bolts, direct tension indicators (DTI) with solid plates may be used to perform this test. The DTI shall be checked with a longer grip bolt in the Skidmore-Wilhelm Calibrator first].

The cost of furnishing test bolts, nuts and washers will not be directly reimbursed, but will be considered incidental to the cost of related contract items.

Suitable nuts shall conform to the requirements of ASTM A 563 and suitable hardened washers shall conform to the requirements of ASTM F 436.

604-2.04 Bolts and Nuts. Bolts and nuts shall conform to the requirements of ASTM A 307.

604-2.05 Steel Forgings. Steel forgings shall conform to the requirements of Subsection 1004-5.

604-2.06 Castings. Carbon steel castings, gray iron castings and malleable iron castings shall conform to the requirements of Subsection 1004-6.

604-2.07 Bronze Castings and Copper-Alloy Plates. Bronze castings and copper-alloy bearings and expansion plates shall conform to the requirements of Subsection 1004-7.

604-2.08 Welded Stud Shear Connectors. Shear connector studs shall conform to the requirements of ASTM A 108, Grades 1015, 1018 or 1020 and to the requirements of Section 10 - Steel Structures of the AASHTO Standard Specifications for Highway Bridges.

604-2.09 Bearing Pads.

(A) Preformed Fabric Pads. Preformed fabric pads shall conform to the requirements of Section 1013.

(B) Elastomeric Bearing Pads. Elastomeric bearing pads shall conform to the requirements of Section 1013.

604-2.10 Certification of Structural Steel. Certificates of Analysis conforming to the requirements found in of Subsection 106-5(C) shall be submitted. The certificates shall include three certified copies of mill heat test reports showing the properties of each heat number. Mill test reports for structural steel used for girder flange and web plates as specified in Subsection 604-2.01 shall also include the results of the Charpy V-notch impact test values.

604-3 CONSTRUCTION DETAILS

604-3.01 Shop and Working Drawings. Prior to fabrication, the contractor shall prepare shop and working drawings in accordance with the requirements found in of Subsection 105-2.

Working drawings for steel structures shall show complete fabrication and erection details including fully detailed dimensions and sizes of component parts of the structure and details of miscellaneous parts such as pins, nuts, bolts and rivets.

604-3.02 Fabrication. Fabrication of all metal for steel structures shall be in accordance with the approved shop drawings and shall conform to the requirements of Division II, Construction, Section 11 - Steel Structures of AASHTO Standard Specifications of Highway Bridges, except as specified herein.

The structural steel fabricating plant shall be certified under AISC Quality Certification program as follows:

Category I: Fabrication of simple or continuous rolled beam bridges.
Category III: Fabrication of all bridge structures other than simple or continuous rolled beam bridges.

Fabrication of steel components shall not begin until arrangements have been made for shop inspection.

In planing the surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

604-3.03 Substitutions. Substitutions of structural steel sections having different dimensions or properties of equal or greater value than those shown on the project plans may be made only when approved in writing by the Engineer.

604-3.04 Shop Inspection. Unless otherwise specified in the special provisions, the contractor shall be responsible for the coordination and cost of all shop inspections required during the fabrication of structural steel members. Inspections shall be performed by an approved laboratory and certified reports of the results of the testing shall be submitted to the Engineer for approval.

The contractor shall furnish all facilities for the inspection of material and workmanship in the shop in accordance with the requirements found in Subsection 106-6.

Inspection at the shop is intended as a means of facilitating the work and avoiding errors and it is expressly understood that it will not relieve the contractor from any responsibility in regard to defective material or workmanship and the necessity of replacing defective material or doing the work again. Reinspection costs, due to contractor errors, shall be at the contractor's expense.

604-3.05 Galvanizing.

(A) Structural Steel for Bridges. Structural steel for bridges shall only be galvanized when specified on the project plans. When galvanizing is so specified, the members shall be galvanized in accordance with the requirements of ASTM A 123. The weight of the coating (total for both sides) shall be the weight specified.

(B) Structural Steel for Minor Structures. Structural steel for minor structures and miscellaneous work shall be galvanized when specified on the project plans. When galvanizing is so specified, the members shall be galvanized in accordance with the requirements of ASTM A 123. The weight of the coating (total for both sides) shall be the weight specified.

Steel posts shall be galvanized in accordance with the requirements of AASHTO M 111 or ASTM A 123.

Steel fittings, hardware, etc., shall be galvanized, when specified, in accordance with the requirements of ASTM A 153. The weight of the coating shall be as specified in ASTM A 153.

604-3.06 Welding. All welding and inspection of welding for structural steel except for tubular structures, shall be performed in accordance with the requirements of the American Welding Society, (AWS) Structural Welding Code AWS D1.5-88, and of the AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges. Welders shall be certified.

The use of electro-slag welding process on structural steel will not be permitted.

604-3.07 Painting. All steel and iron surfaces shall be cleaned and painted in accordance with the requirements of Section 610.

604-3.08 Erection. Erection of steel structures shall be in accordance with the requirements of Division II, Construction, Section 11 - Steel Structures of AASHTO Standard Specifications for Highway Bridges.

Straightening of bent metal members will not be permitted unless approved by the Engineer in writing.

604-4 METHOD OF MEASUREMENT

Structural steel for steel structures will be measured by the pound (*kilogram*) or will not be measured but will be paid for on a lump sum basis in accordance with the following:

(A) Weight Basis. Unless otherwise specified, this method of measurement shall conform to the requirements of Division II, Construction, Section 11 - Steel Structures of AASHTO Standard Specifications for Highway Bridges and the pay quantities of structural steel will be determined on the basis of computed net weights.

The weights of plates 36 inches (*900 mm*) or less in width will be computed on the basis of the nominal weight for their width and thickness as shown on the project plans.

All metal parts for steel structures such as plates, shapes, anchor bolts, nuts and washers, rockers, rollers, bearing plates, pins and nuts, expansion dams, roadway drains, weld metal, bolts embedded in concrete, shear connectors, cradles and brackets, plates and shapes for pier protection, and similar metal items will be measured for payment as structural steel.

(B) Lump Sum Basis. The project plans will show an estimated net weight of structural steel required for the structure work. This quantity shall be considered as approximate only. It shall be the responsibility of the bidder to determine the exact quantities of structural steel from computations based upon the details and notes shown on the project plans. No measurement of the quantities of structural steel determined by the contractor will be made, unless an alteration in the work is ordered. When an alteration in the work is ordered, which increases or decreases the quantity of structural steel required, the amount of the increase or decrease will be measured by the pound (*kilogram*).

604-5 BASIS OF PAYMENT

Structural steel for use in steel structures will be paid at the contract unit price per pound (*kilogram*) or at the contract lump sum price, complete in place.

When the lump sum basis of payment is specified and an alteration in the work is ordered; which increases or decreases the quantity of structural steel required, a theoretical unit price, determined by dividing the lump sum bid price by the total estimated quantity of structural steel shown on the project plans, will be the basis for payment for the increase or decrease in quantity. The theoretical unit price will be the subject to adjustment, all in accordance with the provisions of Subsection 104-2.

No measurement or direct payment will be made for any additional weight resulting from substitution of structural steel sections as specified in Subsection 604-3.03.

Partial payment may be made in accordance with the provisions found in Subsection 109-7.

SECTION 605

STEEL REINFORCEMENT

605-1 DESCRIPTION

The work under this section shall consist of fabricating, furnishing, and placing steel reinforcement of the quality, coating, type, size, shape and quantity designated, all in accordance with the details shown on the project plans and the requirements of these specifications.

605-2 MATERIALS

Steel reinforcing bars, wire, and welded wire fabric shall conform to the requirements of Section 1003.

605-3 CONSTRUCTION DETAILS

605-3.01 General. When the project plans show a bar list and bending diagram, the contractor shall carefully check the schedule against the details on the plans in advance of ordering materials.

When bar bending diagrams are not shown on the project plans, shop drawings and lists showing the bending of reinforcement bars shall be submitted by the contractor to the Engineer for approval, but such approval shall not relieve the contractor of responsibility for the correctness of such drawings and lists.

Any discrepancy or error found by the contractor in checking a bar list or bending diagram shown on the project plans or in preparing shop drawings or lists shall be reported immediately to the Engineer, and the discrepancy or error shall be corrected in advance of fabrication and delivery of materials.

Steel reinforcement shall be protected at all times from damage. When placed in the work, all reinforcement shall be free of dirt, oil, paint and grease. Rust, surface irregularities or mill scale shall not be cause for rejection, provided the weight, dimensions, cross-sectional area and tensile properties of a manually wire brushed test specimen are not less than the requirements of these specifications.

When bending is required, it shall be done without the use of heat, and bars having cracks or splits at the bends will be rejected. Grade 40 (*Grade 300*) bars which are No. 8 (*No. 25 M*) and larger and all sizes of Grade 60 (*Grade 400*) bars shall not be rebent at the same location. Grade 40 (*Grade 300*) bars which are size No. 7 (*No. 22 M*) and smaller may be rebent once at the same location.

Reinforcement shall be accurately fabricated and placed as shown on the plans and shall be firmly held in place with 16 gauge (*1.6 millimeters*) or heavier tie wires and with precast mortar blocks or ferrous metal chairs, spacers, hangers, supporting wires or other approved supports at the spacing necessary to maintain the

specified clearance of the reinforcing steel. The use of pebbles, broken stone, concrete masonry blocks, brick, metal pipe, or wood blocks will not be permitted for the purpose of spacing or support. Steel chairs or other metal devices shall be equipped with snug-fitting, high density, polyethylene tips which provide 1/4 inch (*6 millimeter*) minimum coverage of the metal which will rest against an exposed concrete surface. Stainless steel chairs meeting the requirements of ASTM A 493 or AISI Type 430 may be used in lieu of the polyethylene tips. Tack welding of reinforcement will not be permitted unless approved in writing by the Engineer. If tack welding of reinforcement is approved, the reinforcement shall be deformed and shall conform to the requirements of ASTM A 706. (*ASTM A 706 M*)

The following tolerances will be allowed when placing, tying, and supporting reinforcing steel:

In slabs and beams, horizontal bars shall be within 1/4 inch (*6 millimeters*), measured vertically, of the position indicated on the plans.

In vertical walls, columns, wings, and similar members, clearance from the forms shall be within 1/4 inch (*6 millimeters*) of the clearance shown on the plans.

In slabs or walls, long runs or bars may vary up to two inches in spacing; however, the specified number of bars shall be placed.

No concrete shall be placed until reinforcement in the member has been inspected and approved by the Engineer. Reinforcement which does not conform to the above tolerances shall be adjusted or repaired prior to concrete placement.

605-3.02 Splicing and Lapping. All reinforcement shall be furnished in the full lengths indicated on the project plans. Splicing of bars, except as shown on the plans, will not be permitted without the Engineer's approval. Splices shall be staggered as far from each other as possible. The type and method of splices or connections shall be approved by the Engineer.

The contractor may use either lap splices, full welded splices or mechanical connections for reinforcement bars up to and including bar size No. 11 (*No. 36 M*). Where the bar size exceeds No. 11 (*No. 36 M*), full welded splices or mechanical connections shall be used. Welded splices shall not be used on epoxy-coated bars, and no welding shall be performed close enough to epoxy-coated bars to cause any heating of the coating. All exterior surfaces of positive connectors for epoxy-coated bars shall have the same coating as the bar.

In lapped splices, the bars shall be placed in contact with one another and wired together in such a manner as to maintain a clearance of not less than the minimum clear distance to other

bars and the minimum distance to the surface of the concrete, as specified in the AASHTO Standard Specifications for Highway Bridges. Lap lengths shall be as shown on the plans.

A full welded splice is one in which the bars are butted and welded to develop, in tension, at least 125 percent of the specified yield strength of the bar. Test requirements shall be as specified in AWS D 1.4.

Welding shall be performed in accordance with the requirements of Subsection 604-3.06.

A mechanical connection is one in which the bars are connected to develop an ultimate strength, in tension or compression, as required, of at least 125 percent of the specified yield strength of the bar.

Except as otherwise specified, mechanical splices shall be made in accordance with the manufacturer's recommendations as approved by the Engineer. As a condition of approval, the contractor shall make three test splices in the presence of the Engineer of each size he intends to splice. Two of the test splices shall be tension tested to 125 percent of the specified yield strength of the bar and one splice shall be tested to destruction by an approved laboratory and certified reports of the tests shall be submitted to the Engineer for approval. Field splices shall be subject to visual inspection and physical testing. A minimum of two percent of the field splices, chosen at random by the Engineer, shall be removed and tested to 125 percent of specified yield strength by the Engineer. Samples shall be at least 42 inches (*1.1 meters*) long with the splice at mid length. All testing shall be at the contractor's expense. Samples of field splices shall not be required in cases where two percent of the field splices provides less than 3 samples.

Sheets of welded wire fabric or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh width.

605-3.03 Epoxy-Coated Reinforcement.

(A)General. When required by the project plans, all reinforcement and all other steel elements to be encased in the concrete of a bridge deck or bridge barriers shall be epoxy coated. Reinforcement that is to be partially within portions of a bridge deck or bridge barrier, but extend into other structural elements, will not require coating on that part which is to be outside the bridge deck or bridge barrier concrete. The requirements of this subsection for epoxy-coated reinforcement are in addition to the previous requirements which apply to uncoated reinforcement. Epoxy-coated reinforcement shall be in accordance with the provisions of Subsection 1003-5.

(B)Field Operations - Epoxy-Coated Bar Reinforcement. All handling systems for coated bars shall have padded contact areas for the bars wherever possible. All bundling bands shall be padded and all bundles shall be lifted with a strong back, multiple supports or a platform bridge so as to prevent bar to bar abrasion from sags in the bar bundle. The bars or bundles shall not be dropped or dragged.

All hardware that will remain permanently in concrete using epoxy coated reinforcement shall be made of or coated with a dielectric material. Such hardware includes reinforcement chairs, tie wires, screed rail supports, or any other item that would be a potential source of corrosion. The specific hardware that the contractor proposes to use shall be approved by the Engineer.

The contractor shall be required to field repair damaged areas of the coating, and to replace items exhibiting severely damaged coatings. The material used for field repair shall be that supplied by the coating applicator.

Field repair shall be required wherever the area of coating damage exceeds two percent of the surface area of the bar in a one foot length and the damaged spot is larger than 1/4 inch by 1/4 inch (*6 millimeters by 6 millimeters*).

Field repair will not be allowed on bars which have severely damaged coatings. A severely damaged coating is defined as a coating which has a total damaged area greater than five percent of the surface area of the reinforcing bar. The Engineer shall be the sole determiner of the severity of damaged area for purposes of repair or replacement. A reinforcing bar having a coating determined by the Engineer to be severely damaged shall not be incorporated in the work and it shall be removed from the work site. All such bars shall be replaced in kind by the contractor at no additional cost to the Agency.

605-3.04 Dowel Placement. Dowel placement shall consist of drilling or coring dowel holes, furnishing and placing setting materials and placing metal dowels in accordance with the details shown on the plans and the requirements of the specifications.

The diameter of dowel holes shall be 1/4 inch (*6 millimeters*) larger than the diameter of the dowels to be placed and the depth of the holes shall be as shown on the plans.

Setting materials shall be an approved epoxy adhesive unless otherwise specified on the plans.

The minimum tensile pull out strength of the dowel anchorage shall be as specified on the plans.

If required by the Engineer, the contractor shall submit details of the anchorage system to the Engineer prior to dowel placement.

605-4 METHOD OF MEASUREMENT

No measurement for payment will be made for steel reinforcement, whether coated or uncoated as required, which is included in a precast concrete item which is listed in the bidding schedule as a unit to be paid for at a lump sum price.

No measurement for payment will be made for welded wire fabric unless specifically stated in the special provisions or included in the bidding schedule.

Steel reinforcement that is required on the plans to be epoxy-coated for use in bridge concrete and that is partially within the deck yet projects into other structural elements shall be included in the measurement and payment for Reinforcing Steel (Epoxy Coated). The contractor is required to coat only that part of the reinforcement that is contained in the deck.

Reinforcing steel will be measured in pounds (*kilograms*) based on the total computed weight for the size and lengths of bars as shown on the plans or authorized.

Epoxy-coated reinforcement will be measured separate from uncoated reinforcement.

Dowel placement will be measured by the pound (*Kilogram*).

The weight of bars will be calculated from weights shown in Table 605-1 of this Subsection.

When included as a payment item in the bidding schedule, the weight of welded wire fabric will be computed from the theoretical weight of plain wire of the corresponding gauge. If the weight per square foot (*square meter*) is shown on the plans, that weight will be used.

In measuring the weight of epoxy-coated steel reinforcement, no addition to or deduction from the theoretical weight per foot of the uncoated item will be made because of additional requirements for blast cleaning and epoxy coating.

When laps are made for splices other than those shown on the plans for the convenience of the contractor, the extra steel will not be included in the measurement for payment.

TABLE 605-1

Bar Designation Number		Weight		Nominal Diameter	
Inch-Pound	Metric	Pounds per Linear Foot	kg/m	Inches	mm
3	*10*	0.376	*0.560*	0.375	*9.5*
4	*13*	0.668	*1.000*	0.500	*12.7*
5	*16*	1.043	*1.552*	0.625	*15.9*
6	*19*	1.502	*2.235*	0.750	*19.1*
7	*22*	2.044	*3.041*	0.875	*22.2*
8	*25*	2.670	*3.973*	1.000	*25.4*
9	*29*	3.400	*5.060*	1.128	*28.7*
10	*32*	4.303	*6.403*	1.270	*32.3*
11	*36*	5.313	*7.907*	1.410	*35.8*
14	*43*	7.650	*11.384*	1.693	*43.0*
18	*57*	13.600	*20.239*	2.257	*57.3*

Note: The nominal diameter of a deformed bar is equivalent to the diameter of a plain round bar having the same weight per foot as the deformed bar.

The measurement of samples for testing will be the weight in pounds (*Kilograms*) of the samples selected by the Engineer or the weight in pounds (*Kilograms*) of the full length of reinforcing steel bars supplied for sampling purposes when sampling is done at the construction site.

605-5 BASIS OF PAYMENT

The accepted quantities of Reinforcing Steel, of the type shown in the bidding schedule, measured as provided above, will be paid for at the contract unit price per pound (*kilogram*), complete-in-place.

The unit price per pound (*kilogram*) shall also include the cost of chairs, supports, fasteners, connections, and any splices not specifically shown on the plans. If the Engineer permits the substitution of larger bars than those specified or splices not shown on the plans payment will be made only for the amount of steel which would have been required if the specified size and length had been used.

The accepted quantity of smooth dowels placed, measured as provided in Subsection 605-4.01, will be paid for at the contract unit price per pound (*kilogram*), which price shall be full compensation for the work complete-in-place. Steel reinforcement furnished for dowels will be measured and paid for under the Reinforcing Steel item.

No measurement or direct payment will be made for furnishing and placing any dowels which are required to replace existing reinforcing steel that is damaged as a result of the contractor's operations.

SECTION 609

DRILLED CAISSONS

609-1 DESCRIPTION

The work under this section shall include furnishing all materials and constructing cast-in-place reinforced concrete caissons formed within a drilled excavation. Caissons shall be constructed in reasonably close conformity with the details and dimensions shown on the project plans and the requirements of these specifications as may be modified by the Special Provisions.

609-2 MATERIALS

609-2.01 Concrete. Concrete shall conform to the requirements of Section 1006 for the class and strength of portland cement concrete shown on the project plans. The concrete mix shall be designed for maximum workability and minimum segregation such that vibration or rodding of the mix during placement will not be required. The approved mix design shall be based on a 7 inch (*175 millimeter*) slump and a maximum aggregate size of 1 inch (*25 millimeters*). The permissible variation in slump shall be in accordance with the requirements specified in Subsection 1006-4.04.

The mix design data submitted to the Engineer for approval shall include information on set time and slump loss rate. Set time testing shall be conducted in accordance with ASTM C 403. Testing shall be from a minimum batch size of 4 cubic yards (*3 cubic meters*) and shall simulate the mix temperature and environmental conditions which are anticipated during the course of the work.

Slump loss rate shall be measured from slump tests, conducted in accordance with ASTM C 143, taken immediately after completion of mixing and incrementally thereafter until a slump reading cannot be measured. Increments shall be hourly from the completion of mixing until the time at which a slump measurement is equal to or less than one-half the value of the previous test. Thereafter, increments shall be every thirty minutes. The sample batch, after mixing, shall be discharged into a moisture proof container having a minimum volume of 4 cubic yards (*3 cubic meters*). The top of the container shall be covered with plastic sheets to minimize moisture loss. Prior to conducting each slump test, the concrete shall be thoroughly remixed using a shovel, scoop or other device.

The results of the set time and slump loss testing shall be plotted on a single graph. The graph shall indicate penetration resistance, ambient air temperature, concrete temperature and slump on the ordinate scale and time after completion of mixing on the abscissa scale. To render adequate caisson work time where the casing to be used is to be extracted, the slump loss characteristic of the mix should be such that a minimum 2-1/2 inch (*65 millimeter*) slump occurs at four hours after completion of mixing.

609-2.02 Admixtures. Admixtures may be incorporated into the concrete mixture to maintain the specified slump range and facilitate casing extraction. Admixtures shall be tested and certified in the design mix submitted by the contractor and approved by the Engineer prior to their use.

609-2.03 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 1003.

609-2.04 Metal Casing. Casing shall be smooth, true and straight and of unit or sectional construction. Casing shall be of ample strength to withstand handling stresses, the pressure of the concrete and surrounding earth or backfill materials, and shall be watertight. The outside diameter of the metal casing shall not be less than the specified size of the caisson.

609-3 CONSTRUCTION DETAILS

609-3.01 General. Borings and subsurface data included on the plans are for general information only and shall not be relied upon as being the uniform in place conditions throughout the site. All test hole data provided, including soil observations, water table elevations and soil analysis, apply only at the location and to the depths indicated and, in the case of water table elevations, the date on which the testing was conducted. It is not warranted that the soil descriptions or conditions are representative of the subsurface conditions which may be encountered by the contractor during construction and no responsibility shall be assumed by the Agency for conditions encountered which vary from the data provided. The contractor shall assure himself/herself of the conditions existing at the site by making such additional subsurface inspections or explorations as he/she deems necessary.

It is the contractor's responsibility to allow for any ground or surface water at the time of project construction. No direct payment will be made for dewatering ground water or channelizing surface water. The contractor shall submit to the Engineer, for his approval, the plan for handling water during construction.

The contractor shall be responsible for monitoring, controlling, and limiting all vibrations in order to protect all utilities, structures, and other facilities in the vicinity of the caisson construction. Damage to existing utilities or other structures shall be repaired at the sole expense of the contractor.

609-3.02 Construction Procedures. The contractor shall submit his proposed construction procedure for review and approval by the Engineer. The procedure shall indicate, in detail, the techniques proposed for drilling, reinforcing steel placement and concrete placement. Such review and approval shall not relieve the contractor of the responsibility of achieving the desired result of constructing sound caissons, free from defects.

609-3.03 Demonstration Caisson. After approval of the contractor's construction procedures but prior to drilling of production caissons, the contractor must demonstrate that his proposed techniques, equipment and personnel can satisfy the project requirements. Said requirements include, but are not limited to stable shaft excavation, shaft and casing location, alignment, plumbness, etc. The demonstration shall consist of constructing one successful full-scale caisson for each proposed technique. When the plans or special provisions do not require casing, the caisson shaft must be kept open for a minimum period of 4 hours without any caving, sloughing, bottom heave, or ground water seepage. If water seeps into an unlined caisson shaft, full depth casing may be required, or, at the contractor's option and with the approval of the Engineer, slurry can be used.

No concrete or steel will be required for the demonstration shaft.

The demonstration caisson shall be drilled to the design tip elevation of the deepest caisson. Should the demonstration caisson be judged by the Engineer to be unacceptable due to drilling deficiencies or inadequate techniques, an additional full-depth demonstration caisson shall be constructed. Additional demonstration caissons, conforming to the above requirements, shall be constructed at the contractor's expense until a caisson, acceptable to the Engineer, is constructed.

Should the Engineer request an additional demonstration caisson due to factors unrelated to the techniques and methods employed by the contractor, such demonstration caisson(s) shall be paid for in accordance with Subsection 109-5.

Demonstration caisson sites shall not be at production caisson locations, but rather be located within the channel a minimum of 100 feet (*30 meters*) from an adjacent production caisson or as otherwise approved by the Engineer.

609-3.04 Production Caisson. The first production caisson shall be at an abutment location to provide an opportunity for the contractor to demonstrate the applicability of his proposed steel placement and concrete placement procedures.

Both the demonstration caisson and initial production caisson must be successfully completed by the contractor. Upon successful completion of these caissons, the contractor shall develop a caisson drilling sequence plan and submit the same for review by the Engineer prior to the construction of the remaining production caissons. The drilling sequence plan should address operational restrictions and provide a schedule for survey layout.

609-3.05 Procedure Changes. After approval of the demonstration caisson and initial production caisson and during the construction of the remaining production caissons, the contractor may elect to make minor modifications to his procedures for

constructing the caissons. Such a change will be considered by the Engineer when submitted, in writing, by the contractor. The contractor shall address the nature and reason for the change in the request. All procedural changes shall be approved by the Engineer prior to implementation. The contractor may be required to construct an additional demonstration caisson using his modified method to illustrate its acceptability. Should a demonstration caisson be required, it shall be constructed at the contractor's expense.

609-3.06 Excavation. The contractor shall perform all excavation required for the caissons, through whatever strata encountered, to the dimensions and elevations shown on the project plans or required by the site conditions and within the tolerances specified herein. Should the tolerances be exceeded, the contractor shall provide additional construction to bring caissons within the tolerances specified. The drilled caisson shall be constructed such that the axis of the caisson when measured from the bottom of the pier cap or abutment cap is no more than 2 inches (*50 millimeters*) from its plan location. Drilled caissons shall be within one percent (1%) of plumb for the total length of the caisson. The plumbness of the drilled shaft shall be measured by an accurate procedure, approved by the Engineer.

The finished diameter of the caisson within thirty feet (*9 meters*) of the finished channel elevation shall not be more than 1 inch (*25 millimeters*) less, nor 3 inches (*75 millimeters*) greater than the plan dimensions.

In addition to the requirements of the caisson location, alignment and dimensional tolerances, no offsets will be allowed in the caisson, nor along the entire column from the tip elevation of the caisson to the bottom of the abutment or pier cap. No bulges will be allowed in the pier caissons at the caisson/column construction joint.

When the project plans indicate that the drilled shafts are to be constructed within embankment areas, the embankments shall be constructed prior to drilling, except as may otherwise be approved by the Engineer.

Drilled caissons shall be advanced with flight, bucket and coring augers capable of drilling soil, cobbles, boulders, and rock, or other approved drilling tools, through whatever materials encountered, to the dimensions and elevation shown on the plans. The plans indicate the expected depths and elevation where satisfactory bearing material will be encountered. This information will be used as the basis for the Contract. If satisfactory material is not encountered at plan elevation, the bottom of the caisson may be lowered at the direction of the Engineer to satisfactorily comply with the design requirements.

Where casing is not required, caving of the drilled holes shall be prevented at all times during caisson construction by methods acceptable to the Engineer.

When casing is required, the vibratory hammer used for casing installation shall be of sufficient capacity to construct the caissons in a satisfactory manner such that the caisson integrity meets that as set forth in the plans and these Specifications. If bottom stabilization is needed, the contractor shall provide suitable construction that has no detrimental effects on the caisson design or function. The stabilization construction method must be approved by the Engineer prior to its implementation.

The Engineer may allow minor predrilling, to a depth approved, to facilitate casing installation based on the following criteria: predrilling shall be conducted to a diameter smaller than the design caisson diameter; not reduce the in place horizontal and/or vertical soil stresses; not affect the integrity of the caisson design, bearing capacity, skin friction, or construction quality; and be approved, in advance, by the Engineer.

For temporary casing installations, casing removal shall not occur until all free water, soil, debris, and contaminated concrete are removed from the casing to the satisfaction of the Engineer. Casing removal shall not be started until the level of concrete within the casing is a minimum of 3 feet (*900 millimeters*) above the elevation of the construction joint at the caisson/column or caisson/abutment cap. The minimum 3 foot (*900 millimeter*) differential between the level of the concrete and the ground around the casing must be maintained or increased throughout the complete casing extraction operation.

To facilitate casing extraction, movement of the casing for short pulls of less than 4 inches (*100 millimeters*) only, as well as exertion of downward pressure, hammering, and vibrating of the casing will be permitted. Casing extraction shall be done such that the concrete cast against the surrounding soil will develop the designed skin friction.

Casing extraction shall not be allowed unless the concrete within the casing is plastic, workable, and has at least a measurable slump greater than 1 inch (*25 millimeters*). To achieve this, very cool concrete components, and/or retarders or water reducers may be used in the concrete if such were approved in the mix design submitted to the Agency for review. Casing not extracted within the above mentioned plastic state, shall remain in the excavation.

The Engineer will evaluate the effect of leaving the casing in the excavation and determine the appropriate corrective action if necessary. Any corrective action shall be at the sole expense of the contractor.

A partially excavated shaft may be left open overnight prior to the completion of drilling, provided that: the excavation is no deeper than two-thirds the embedment depth; is stabilized at the bottom, sides and surface to prevent soil swelling and reduction of soil strength parameters; the surface is covered to protect the public; and the area around the caisson excavation is adequately fenced.

Should caving occur during any caisson procedure, the excavation shall be immediately halted and corrected.

Regardless of construction methods used, the bottom of the excavation shall be cleaned of loose material using a bucket auger or any other technique approved by the Engineer. After cleaning, a suitable weighted steel probe shall be lowered to the base of the drilled caisson to insure that cleaning has been satisfactorily completed.

Material excavated from the caissons may be used as backfill if it meets the specifications for a given application. Any excess material shall be disposed of by the contractor.

After completion of caisson excavation and prior to placement of reinforcing steel and concrete, the proper condition of the excavated shaft will be demonstrated by the contractor and verified by the Engineer. The contractor shall measure the caisson dimensions, determine the deviation from plumb of the caisson, and produce such information for the Caisson Inspection Report. Any sloughage or other loose material shall be machine cleaned from the shaft prior to placing reinforcing steel and concrete. An accumulation of loose soils at the bottom of the excavation shall not be allowed.

609-3.07 Slurry. When slurry is used in maintaining an uncased excavation, the contractor shall provide for a specialist, experienced in slurry drilling, to design and monitor the slurry. The slurry shall consist of a stable suspension of commercial bentonite in water. The contractor's specialist shall submit slurry design criteria, including density, viscosity, shear strength, pH, and suspended sand content, for drilling and concrete placement operations to the Engineer for review prior to commencement of any slurry drilling. During the drilling operations, the contractor shall monitor the properties of the slurry for conformance to the submitted design criteria. The density of the slurry shall be the minimum required to maintain the excavation. The properties of the slurry may be altered to suit construction conditions by the addition of an admixture, as recommended by the contractor's specialist.

Water for mixing slurry shall be potable and of a chemical composition which will not cause flocculation or other detrimental effects.

Slurry equipment shall be constructed and operated so that free passage of the slurry is provided around the drilling head during its insertion and removal from the hole to the extent that scouring or caving will not occur.

The slurry shall be mixed in an approved mixer specifically designed for the purpose of, and of sufficient size to, mix an appropriate quantity of dry bentonite and water. Facilities to monitor the volume of slurry in the mixer and the quantity of slurry pumped into the excavation shall be provided. No dry material will be allowed to be placed in the excavation and mixed with water by the drilling auger.

Slurry shall continuously be fed into the excavation as drilling progresses, keeping the hole filled to the top of the excavation or at a level within the casing which is 5 feet (*1.5 meters*) above the ground-water level outside of the casing in the adjacent ground.

Just prior to placement of the reinforcing steel, the contractor shall conduct tests on the slurry, including samples obtained from the bottom of the excavation, to establish conformance to the submitted criteria. The consistency of the slurry shall be adjusted, as required, to maintain the excavation and to provide a suitable environment for the concreting operation. Unless otherwise specified on the project plans, at the time of concrete placement the density of the slurry shall not exceed 75 pounds per cubic foot (*1200 kilograms per cubic meter*) and the viscosity of the slurry shall not exceed 90 seconds per quart (*95 seconds per liter*) as measured by the Marsh Funnel Method.

While concrete placement is taking place, the ejected slurry may be reused provided that it is pumped back into a storage tank or reservoir of known volume and passes through a desander to remove gravel chips or other granular materials. The pump used to reclaim the slurry shall be of the self-priming type. A standby pump shall be available during the reclaiming operation.

Slurry disposal methods shall be approved by the Engineer prior to the start of construction.

609-3.08 Inspection. Drilled shaft excavations will be inspected by the Engineer. The contractor shall provide suitable equipment, facilities and personnel so that the Engineer may inspect completed excavations and check the shafts for alignment and dimensions.

Reinforcing steel and concrete shall not be placed in the drilled shaft excavation until the Engineer has made his inspection and given his approval.

609-3.09 Reinforcing Steel. Reinforcing steel shall be handled and placed in accordance with the requirements of Section 605. The reinforcing steel cage for the drilled shaft, consisting of longitudinal bars and spiral hooping or lateral ties shall be

completely assembled and placed into the shaft as a unit. The reinforcing steel unit shall not be placed until immediately before concreting operations are to be started and shall be placed in accordance with the details shown on the project plans.

Cage pickup shall be conducted in a manner such that racking and cage distortion will not occur.

The reinforcing cage shall be adequately supported and anchored to prevent movement from the required location during concrete placement and until such time as the concrete has achieved its initial set or 4 hours, whichever is the greater period. Spacers shall be at sufficient intervals along the shaft to insure concentric spacing and a minimum concrete cover of no more than 1 inch (*25 millimeters*) less than the cover indicated on the plans. The type of spacer used shall be approved by the Engineer.

If the shaft is lengthened and the project plans indicate full depth reinforcement, the bars in the lower portion of the shaft shall be extended accordingly, as directed by the Engineer, to the bottom of the hole. These bars may be lap spliced or spliced by butt welding or other connecting procedures approved by the Engineer to the proper length in accordance with the requirements of Section 605. The spiral reinforcement, if shown full depth on the project plans, shall be required full depth on the extensions.

The rebar cage shall be suspended off the bottom approximately 6 inches (*150 millimeters*) and shall be supported at the top by a ground surface frame, crane, or other positive means during the hereinbefore specified period in order to insure cage plumbness and to minimize downward slumping. The support system shall be concentric with the cage to prevent racking and distortion of the steel. The practice of setting the cage on the bottom of the drilled shaft shall not be allowed. Concrete blocks or cylinders, a minimum of 6 inches (*150 millimeters*) in height, shall be attached to the bottom of the cage to limit the extent of any potential settlement.

609-3.10 Concrete.

(A) General. Concrete shall be placed as soon as possible after the completion of the drilled shaft excavation and placement of the reinforcing steel cage. Concrete shall be placed in accordance with the requirements of Section 601 and as specified herein.

The temperature of the concrete immediately prior to placement shall be at least 50°F (*10°C*) but shall not exceed 86°F (*30°C*).

Prior to concrete placement, the contractor shall make all necessary arrangements to assure the uninterrupted delivery of concrete so that all drilled shaft foundations will be constructed without the formation of cold joints.

Concrete shall be placed by pumping through a suitable tube or direct discharge through a tremie so as to prevent segregation of materials. Free fall placement of concrete shall not be allowed. The tremie conduit shall be rigid and water-tight and shall extend to the full length of the caisson. The tremie conduit shall have a minimum inside diameter of 5 inches (*125 millimeters*). Unless otherwise specified in the Special Provisions, the tube shall be equipped with a bottom valve or other approved device which will prevent the mixing of the concrete with water, slurry or other objectionable material(s). In lieu of the bottom valve, a watertight plug may be inserted into the tube ahead of the plastic concrete.

Concrete placement shall be such as to flow laterally around the reinforcing steel. Vibration shall be required for all concrete which is not pumped.

After the reinforcing steel is put in place, the tremie pipe shall be inserted within 1 foot (*300 millimeters*) of the bottom of the drilled shaft before concrete placement is started. The pump shall be properly primed and the concrete shall be placed in a continuous operation in such a manner that concrete always flows upward within the hole. The delivery pipe shall be slowly withdrawn as the elevation of the concrete in the hole rises, but the discharge end of the pipe shall at all times, be maintained at least 10 feet (*3 meters*) below the surface of the concrete. During concrete placement the contractor shall provide and maintain markings on the tremie pipe, a sounding device, or other adequate methods in which to determine the relative elevation of the concrete surface and the end of the tremie pipe. Raising of the tremie pipe shall be done only when the pipe contains a sufficient head of concrete to prevent the formation of voids at the tip. A predetermined plan shall be formulated between the contractor's job foreman and the pump operator concerning how and when an order will be given to lift the tremie pipe.

Concrete delivery into the caisson shall be within the time frames specified in these Specifications. In no case will the delivery be so fast as to trap air, slurry, water, fluids, soil or any other deleterious materials in the vicinity of the reinforcing steel and the annular zone between the rebar cage and the excavation walls.

Concrete delivery shall continue until the discharge at the top of the caisson is free of water, soil, and debris, and uncontaminated concrete extends to the cutoff elevation. In any case, a minimum of 1 cubic yard (*0.76 cubic meter*) of concrete shall be expelled.

The contractor shall clean any contaminated concrete from the top of the shaft. Such wasted or contaminated concrete shall be removed from the area of the footing. Should a delay occur because of concrete delivery or other factors, the rate of placement for concrete shall be reduced so as to maintain some movement of the concrete. An absolute maximum of 45 minutes

shall be allowed between placements and then only as approved by the Engineer. No concrete older than 90 minutes from batch time will be allowed for placement. In addition to the above, the procedure employed shall be such that the concrete within the caisson consists of a monolithic homogeneous structure. Vibration shall only be employed, if needed, in the upper 10 feet (*3 meters*) of the shaft or to a depth equal to, but not to exceed the length of permanent casing and/or form liners where used.

The elevation of the top of the steel cage and the surface of the concrete shall be carefully checked before and after casing extraction.

If caving or sloughing is experienced, no compensation will be provided to the contractor for additional concrete required to fill the voids.

(B) Placement Under Slurry or Water. Care shall be taken to ensure that all fluid and suspended solids are expelled from the hole during concrete placement. The discharge end of the pump pipe shall always remain a minimum of 10 feet (*3 meters*) below the surface of fluid concrete. Concrete delivery shall continue until the discharge at the top of the excavation or casing is free of water, soil, debris or other deleterious material and uncontaminated concrete is expelled.

609-3.11 Casing Removal. After removal of the casing, any downward movement of the reinforcing steel exceeding 2 inches (*50 millimeters*), or any large mass downward movement of the concrete may be cause for corrective action as determined by the Engineer. Any corrective action required shall be at the sole expense of the contractor.

609-3.12 Curing. The exposed horizontal surface of the caisson, created by the construction joint between the caisson and the pier column or the caisson and the abutment cap, shall be cured a minimum of 7 days by placing wet burlap, overlain by plastic sheets, and 6 inches (*150 millimeters*) of moist soil. The burlap shall be maintained wet at the concrete interface.

609-3.13 Scheduling and Restrictions. Prior to the elapse of at least 16 hours after a caisson has achieved its initial concrete set, as determined by ASTM C 403, no adjacent caissons shall be drilled, no equipment wheel loads, and no excessive vibrations shall be allowed to occur at any point within a 15 foot (*4.5 meter*) radius of the caisson. Excessive vibration is defined as that which will produce a vibration velocity greater than 0.24 inches per second (*6 millimeters per second*). Vibration will be allowed to occur at points within a 15 foot (*4.5 meter*) radius of a newly poured caisson, provided that its concrete is plastic (slump greater than 1 inch (*25 millimeters*)), and the construction is not adversely affected.

The contractor will be required to provide vibratory testing to determine the effects and extent of the vibrations caused by the construction.

609-4 METHOD OF MEASUREMENT

Production caissons will be measured by the lineal foot (*meter*) of embedment from the completed bottom of the shaft, as indicated on the plans or as directed or established by the Engineer, to the elevation of the top of the shaft as indicated on the project plans.

The demonstration caisson(s), as accepted by the Engineer, will be measured by the lineal foot (*meter*) of embedment from the completed bottom of the shaft as established by the Engineer to the top of the shaft as completed.

609-5 BASIS OF PAYMENT

The accepted quantities of demonstration and/or production drilled cast-in-place reinforced concrete caissons, measured as provided above, will be paid for at the Contract unit price per lineal foot (*meter*) for the diameter and designation indicated in the bidding schedule, complete-in-place, including excavation, pre-drilling, casing (when specified in the Special Provisions), bottom stabilization, portland cement concrete, and any needed forming, curing and finishing and all other incidentals to complete this work.

All reinforcing steel will be paid by the pound (*kilogram*) in accordance with Subsection 605-5.

Shaft stabilization, using slurry or temporary casing, which has not been specified in the special provisions but directed by the Engineer, shall be paid for in accordance with the provisions of Subsection 109-5.

No additional payment will be made for temporary casing which remains in place, bracing, concrete overages, dewatering of ground water or surface water, channelizing surface water, or any other item required to produce the designed caisson.

When load tests are required by the Engineer to determine the adequacy and acceptability of drilled caissons, payment for load tests for caissons determined to be adequate and acceptable will be made in accordance with the provisions of Subsection 109-5.

Load tests for drilled caissons determined to be unacceptable will be at no additional cost to the Agency.

SECTION 610

PAINTING

610-1 DESCRIPTION

The work under this section shall consist of furnishing paint and other materials and painting metal structures or other surfaces where shown on the plans in accordance with the requirements of these specifications. The work shall include preparation of the surfaces to be painted, the protection and drying of the paint coatings and the protection of pedestrian, vehicular or other traffic near or under the work from paint spatter and disfigurement.

610-2 MATERIALS

The various types of paints to be applied shall conform to the requirements of Section 1002, unless otherwise specified in the Special Provisions.

610-3 CONSTRUCTION DETAILS

610-3.01 Weather Conditions. Paint shall be applied only on thoroughly dry surfaces and only when the atmospheric temperature is in the range from 50° F to 100° F, inclusive, and when the relative humidity is at or below 75 percent. Paint shall only be applied to a surface which is at least 5° F above the dew point. The surface temperature should remain above the minimum temperature specified above until the paint is thoroughly dry. Paint shall not be applied when the air is misty or when weather conditions exist which might damage the work. If fresh paint is damaged by the elements, it shall be replaced or repaired by the contractor at no additional cost to the Agency.

The contractor may provide suitable enclosures to permit painting during inclement weather. Provisions shall be made by the contractor to artificially control, within limits suitable for painting, the atmospheric conditions inside the enclosures.

610-3.02 Cleaning of Surfaces.

(A) General. All surfaces of structural steel or other metals, except galvanized surfaces, shall be cleaned and painted.

All surfaces of new structural steel or other metals which are to be painted shall be blast cleaned to a near-white finish in accordance with the Steel Structures Painting Council (SSPC) standard SP10, unless otherwise specified or approved in writing by the Engineer.

When repainting existing steel structures, the method of cleaning will be specified in the Special Provisions. Areas not designated for repainting which are damaged as a result of the contractor's operations shall be repaired by the contractor, at no additional cost to the Agency, and as approved by the Engineer.

(B) Blast Cleaning. Abrasives used for blast cleaning shall be clean dry sand, mineral grit, steel shot, or steel grit, at the option of the contractor, and shall be of a grading suitable to produce satisfactory results. The use of other abrasives will not be permitted unless approved in writing by the Engineer.

All dirt, rust, old paint, mill scale and other foreign material shall be removed from steel or other metal surfaces with an approved blast cleaning apparatus. Blast cleaning shall be sufficient to give the surface the appearance of unpolished sandcast aluminum and shall leave all surfaces with a dense and uniform anchor pattern or profile of 1.0 mils to 4.0 mills (*25 to 100 micrometers*) as measured with an approved surface profile comparator.

When blast cleaning is being performed near machinery, all journals, bearings, motors and moving parts shall be sealed against entry of abrasive dust.

Blast cleaned surfaces shall be primed or treated the same day blast cleaning is done, unless otherwise authorized by the Engineer. If cleaned surfaces rust or are contaminated with foreign materials before painting is accomplished, they shall be recleaned by the contractor at no additional cost to the Agency.

(C) Steam Cleaning. All dirt, grease, loose chalky paint or other foreign material which has accumulated on the previously painted or galvanized surfaces shall be removed with a steam cleaning apparatus which shall precede all other phases of cleaning. It is not intended that sound paint be removed by this process. Any paint which becomes loose, curled, lifted or loses its bond with the preceding coat or coats after steam cleaning, shall be removed to sound paint or metal surface by the contractor at no additional cost to the Agency.

A detergent shall be either added to the feed water of the steam generator or applied to the surface to be cleaned. The detergent shall be of such composition and shall be added in such quantity that the cleaning as specified above is accomplished.

Any residue, detergent or other foreign material which may accumulate on cleaned surfaces shall be removed by flushing with fresh water.

Steam cleaning shall not be performed more than two weeks prior to starting painting operations or other phases of cleaning.

Subsequent painting shall not be performed until the cleaned surfaces are thoroughly dry and in no case in less than 24 hours after cleaning.

(D)Hand Cleaning. Wire brushes, either hand or powered, hand scraping tools, power grinders or sandpaper shall be used to remove all dirt, loose rust and millscale, or paint which is not firmly bonded to the surfaces.

(E)Water Blast Cleaning. Water blast cleaning shall be done in accordance with NACE Standard RP-01-72 with normal water, no additives to the water will be allowed. All areas of oil and grease on surfaces to be coated shall be hand cleaned with clean petroleum solvents. The solution of solvent and contaminates shall be wiped clean and the surfaces allowed to air dry prior to the water blast cleaning. The contractor shall not use power spray equipment or similar methods to apply the solvent. All the surfaces to be coated shall be power washed with a water pressure of not less than 2000 psi (*14 megapascals*) and not greater than 5000 psi (*34 megapascals*). The water blasting equipment shall have a minimum water usage of 5 gallons/minute (*20 liters/minute*).

Water blast cleaning shall be performed no more than two weeks prior to the start of painting operations or other phases of cleaning.

Subsequent painting shall not be performed until the cleaned surfaces are thoroughly dry and in no case less than 24 hours after cleaning.

610-3.03 Application. The contractor shall notify the Engineer, in writing, at least one week in advance of the date cleaning and painting operations are to begin.

Painting shall be accomplished in a neat and workmanlike manner. Paint shall be applied by hand brushes, by spray, or roller or by combination thereof except that Paint No. 3, Aluminum, shall be applied by spraying.

Each application of paint shall be smoothly and uniformly spread so that no excess paint will collect at any point. Any skips, holidays, thin areas or other deficiencies shall be corrected before the succeeding paint application. The surface of the paint being covered shall be free from moisture, dust, grease or any other deleterious materials which would prevent the bond of the succeeding applications.

When paint brushes are used, they shall have sufficient body and length or bristle to spread the paint in a uniform film.

Surfaces which are inaccessible shall be painted with daubers or by other means approved by the Engineer.

When rollers are used they shall be of a type which will not leave a stippled texture in the paint film.

When sprayers are used, a water trap, approved by the Engineer shall be furnished and installed at each spray pot.

Prior to application, the paint shall be mixed by mechanical mixers a sufficient length of time to thoroughly mix the pigment and the vehicle together and shall be kept thoroughly agitated during its application.

The handling and the application of paints shall be in accordance with all applicable occupational, safety and health standards, rules and regulations.

610-3.04 Protection Against Damage. The contractor shall provide protective devices as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations.

Paint or paint stains which result in an unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at no additional cost to the Agency, and as approved by the Engineer.

All painted surfaces that are marred or damaged as a result of operations of the contractor shall be repaired by the contractor, at no additional cost to the Agency, and as approved by the Engineer, with materials and to a condition equal to that of the paint coating specified herein.

Upon completion of all painting operations as well as any other work, the painted surfaces shall be thoroughly cleaned.

610-3.05 Painting Structural Steel.

(A) Paint Coats.

(1) General. All surfaces of new structural steel and other metals shall be painted with one shop coat (prime coat) and two field coats (first field coat and the finish coat), unless otherwise specified.

The dry film thickness of the paint will be measured in place with a calibrated magnetic film thickness gauge in accordance with SSPC-PA2.

If the minimum dry film thickness is exceeded, it shall be limited to that which will result in uniform drying throughout the paint film.

(2) Pre-Treatment. When specified in the special provisions, a wash primer, conforming to the requirements of Subsection 1002-3.05 shall be applied to freshly blast cleaned steel surfaces prior to the application of the first undercoat of paint. All blast cleaned surfaces shall be coated with pre-treatment wash within 4 hours of cleaning. Treatment shall be applied sooner, if in the opinion of the Engineer, atmospheric conditions are such that corrosive products will form on freshly blast cleaned surfaces in less than 4 hours.

Pre-treatment washes shall be applied by spraying to produce a uniform wet film on the surface.

During the application of the pre-treatment wash no blast cleaning will be permitted adjacent to the areas being treated.

No paint shall be applied until after the treated surfaces have thoroughly dried.

The first undercoat of paint shall be applied to the treated surfaces the same day as cleaning and pre-treatment.

(3) Prime Coat. The prime coat shall conform to the requirements of Subsection 1002-3 and when applied the dry film thickness of the paint shall be not less than 2 mils (*50 micrometers*), and sufficient to adequately cover the blast profile pattern. A deep profile pattern from steel shot blasting may require two applications of prime coat to obtain sufficient coating of the steel surface.

(4) First Field Coat. The first field coat shall be appropriately tinted to contrast with the prime coat and shall conform to the requirements of Section 1002. When applied, the dry film thickness shall be not less than 1.5 mils (*38 micrometers*).

(5) Finish Coat. The finish coat shall be an aluminum pigmented paint unless specified otherwise on the plans or in the special provisions. This paint shall conform to the requirements of Subsection 1002-3.03. When applied, the dry film thickness shall be not less than 1.0 mil (*25 micrometers*).

(B) Shop Painting. After the structural steel has been fabricated, blast cleaned and certified for acceptance by an approved laboratory, all surfaces, except metal surfaces which are to be embedded in concrete, shall be given the prime coat.

Structural steel which is to be welded shall not be painted before welding is complete. If it is to be welded only in the fabricating shop and subsequently erected by bolting, it shall receive one prime coat after the shop welding is finished. Areas of structural steel to be field welded shall be masked and the remainder of the steel shall be given one prime coat.

As soon as practicable after being accepted by the Engineer and prior to removal from the shop, machine-finished surfaces shall be prime coated, with a rust inhibitor, which can be easily removed.

Erection marks for field identification of steel members and weight marks shall be painted upon surface areas previously painted with the shop coat.

Surfaces of iron and steel castings, either milled or finished, shall be given one shop coat of paint.

(C) Field Painting. After erection of steel structures has been completed, including all riveting, welding, bolting and any straightening of bent metal, all adhering rust, scale, dirt, grease or other foreign material shall be removed as specified under Subsection 610-3.02. All areas where the prime coat has been damaged or has deteriorated shall be thoroughly cleaned and spot painted with the same type of paint used for the shop coat to the specified dry film thickness.

When the spot painting coat is thoroughly dry, the first field coat and the finish coat shall be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film.

All small cracks and cavities which have not become sealed in a watertight manner by the first field coat shall be filled before the finish coat is applied.

At the option of the contractor, the two field coats may be applied in the shop. When finished coats are applied in the shop, the contractor shall repaint all damaged or deteriorated areas in the field as directed by the Engineer.

610-3.06 Painting Damaged Galvanized Coating. Areas of galvanized coating damaged due to welding after fabrication or due to handling, shall be roughened by sanding or acid. The roughened areas shall be painted with at least one full coat of Paint Number 4 - Zinc, conforming to the requirements of Subsection 1002-3.

610-3.07 Painting of Miscellaneous Steel Items. All miscellaneous steel items that are not elements of bridges, cantilever sign supports, or bridge truss sign structures, may be hand cleaned and have the required field paint coats applied in the shop.

610-4 (NONE SPECIFIED)

610-5 BASIS OF PAYMENT

No measurement or direct payment will be made for painting as described and specified herein and on the plans, the cost being considered as included in the prices paid for the various contract items of work involving painting.

SECTION 701

MAINTENANCE AND PROTECTION OF TRAFFIC

701-1 DESCRIPTION

The work under this section shall consist of providing flagging services and furnishing, installing, maintaining, moving, and removing barriers, barricades, warning signs, delineators, lights, signals, cones, pavement markings, impact attenuation devices, and other traffic control devices in order to provide safe and efficient passage through and/or around the work and protecting the public and workers from damage to person and property within the limits and for the duration of the project.

All work shall conform to the requirements of the current edition of the Work Zone Standards and Guidelines published by the U.S. Department of Transportation, Federal Highway Administration as amended by the appropriate jurisdiction and, hereinafter, referred to as the traffic control standards. The requirements of the traffic control standards shall be considered the minimum standards for the protection of workers and the public.

When a traffic control plan is included in the project plans, said plan shall govern unless an alternate plan, acceptable to the Engineer is submitted by the contractor. If no traffic control plan is provided, or, if the contractor desires to deviate from the provision for maintaining traffic as described in this Section, the contractor shall submit to the Engineer, for approval, a proposed sequence of operations and a compatible method for maintaining traffic. The traffic control plan shall address the contractor's proposed scheduling of the work, including, phasing, detours, signing, removal and application of pavement markings, flagging procedures, methods of delineation and channelization, periodic surveillance for required maintenance and inspection of traffic control devices.

The contractor shall submit the traffic control plan not less than five working days prior to commencement of any work on any site included in the project. The traffic control plans shall be on paper reproducible on a copier or blueprint machine (maximum paper size for copier prints is 8-1/2 inches X 14 inches). The plans shall be submitted to the Engineer.

The traffic control plan of the contractor, along with the contractor’s work schedule and actual operations, shall be such that no condition that is considered to be unsafe, in the opinion of the Engineer, shall exist. The traffic control plan shall assure that miscellaneous operations occurring throughout the work, as well as during the final stages, are adequately protected. As a result of effective planning and efficient scheduling of the type and quantity of work, the duration, degree, length, amount, size, etc., of any traffic restriction or lane closures shall be limited to that absolutely necessary to provide a safe condition for both traffic and construction personnel.

No separate payment shall be made for the preparation of traffic control plans. The cost shall be included in the overall cost of the project.

All detours, partial closing, or other traffic alterations shall be approved by the Engineer. The traffic control plan shall also be submitted to the agencies having police and fire responsibility within the project site.

Traffic control/lane closures shall be in accordance with all applicable codes and ordinances. Unless otherwise noted in the Special Provisions or modified by the approved traffic control plan, the following shall apply:

Arterial or collector street lane reductions shall not exist between 7-9 AM and 4-6 PM, Monday-Friday.

The contractor shall provide a uniformed off-duty police officer to direct traffic as required.

The contractor is responsible for the proper installation and inspection of all traffic control devices within the limits of the project.

The contractor shall ensure that existing traffic signs and signals are properly maintained, operated, removed, stored or installed.

The contractor shall obtain permission from the Engineer, a minimum of two days in advance, except in an emergency, before closing or restricting any street or public right-of-way.

Street closures or restrictions shall conform with the approved traffic control plan.

Traffic shall be maintained over a reasonably smooth and safe traveled way which shall be so marked by signs, delineators, guiding devices, and other methods that a person who has no knowledge of conditions may safely and with a minimum of discomfort and inconvenience ride, drive or walk, day or night, over all or any portion of the highway and/or structure under construction where traffic is to be maintained. If shown on the plans or otherwise noted in the specifications the traveled way shall be paved.

The contractor shall at all times conduct operations in a manner to insure the convenience of all travelers and the abutting property owners and their safety as well as the safety of all construction personnel.

Such conduct shall include, but not be limited to, insuring: that all construction materials and equipment are removed from the work site during non-working hours, or are protected in such manner that they shall not constitute a traffic hazard; that shoulder construction and paving operations shall be conducted in such a manner as to minimize the period of time the traveling public is

exposed to sharp dropoffs; and that workers shall not park personal vehicles in areas that hinder the movement of traffic or pedestrians or obstruct sight distance.

The work under this Section shall consist of four principal components as follows:

Basic Maintenance and Protection of Traffic

Construction Traffic Control Area Elements

Flagging Services

Provide Detour

701-2 MATERIALS

All materials used shall comply with the requirements of the appropriate sections and subsections of Division 1000 - Materials, or as established by this section, the traffic control standards, the applicable Standard Details or the project plans.

701-2.01 Existing Pavement Repair. Existing pavements shall be kept in good repair using materials compatible with the pavement. In general, plant-mixed asphaltic concrete is suitable for all pavement surfaces. Material other than plant-mixed asphaltic concrete may be used if approved by the Engineer.

701-2.02 Flashing Arrow Panels. Flashing arrow panels shall conform to the requirements of Section 4.17 of the Traffic Control Manual with the following additions:

Each arrow panel shall have its own independent power source. The power source shall be capable of supplying adequate continuous power for the sign operation over extended periods of time. Fuel capacity shall be such as to provide for at least 12 hours of continuous operation without refueling. Panels may be solar powered with an adequate energy source to provide for a minimum of 12 hours of continuous operation without recharging or refueling.

701-2.03 Temporary Concrete Barrier. Temporary concrete barrier shall conform to the requirements of Subsections 910-2 and 910-3 of these specifications for precast sections.

701-2.04 Temporary Pavement Markings

(A) Raised Pavement Markers. Raised pavement markers may be Temporary Reflective Markers, Permanent Reflective Markers (Used As Temporary) or Non-reflective Markers, as indicated on the project plans or as approved by the Engineer.

Raised pavement markers shall be in conformance with ADOT Standard Drawing 4-M-2.02 and Subsection 706-2 and 706-3 of the specifications.

(B) Pavement Marking Paint. Paint for temporary striping, arrows, symbols and legends shall be white or yellow and shall conform to the requirements specified in the Special Provisions. Paint shall be a minimum of 15 mil (0.4 millimeter) in thickness (wet measured).

Glass beads for use with pavement marking paint shall conform to the requirements specified in Subsection 704-2.04 of these specifications.

(C) Preformed Pavement Markings. Preformed pavement markings shall be either Type II (Temporary-Removable) or Type III (Temporary-Nonremovable), as indicated on the plans or as directed by the Engineer. Preformed pavement markings shall be in conformance with the requirements of Section 705 of these specifications.

701-2.05 Sign Posts. Sign posts may be wood, steel or aluminum, at the option of the contractor and shall be approved by the Engineer prior to installation. Wood posts shall be Southern pine, Douglas fir or other soft wood. Wood posts need not be treated.

Embedded posts shall meet the criteria established under NCHRP Report 350 for breakaway sign supports.

Angle braces and guy wires will not be allowed.

701-2.06 Delineators. Delineators shall be in conformance with ADOT Standard Drawing 4-M-4.01.

701-2.07 Chip Seal Pavement Marker. Chip seal pavement markers shall conform to ADOT Standard Drawing 4-M-2.05.

The chipseal pavement marker body and cover shall be manufactured from a polyurethane material conforming to the following requirements:

Material Property	ASTM Test Requirement	Method
Specific Gravity (Min.)	1.19	D792
Hardness (Min.)	80A	D2240
Tensile Strength (Min. PSI)	4600 (32 MPa)	D412
Ultimate Elongation (Min. %)	330	D412
Modulus @ 300% PSI	1000 (6.9 MPa)	D412
Stiffness @		
-20 deg. F (Min. PSI) [-29 °C (Min. MPa)]	17000 (120 MPa)	D1053
70 deg. F (Min. PSI) [21 °C (Min. MPa)]	900 (6.2 Mpa)	D1053
Compression Set		
22 hrs. @ 70 °C	65	D395
Taber Abrasion		
CS17 wheel		
Wt. Loss mg/1000 cycles	3	-----

Reflective tape shall be metalized polycarbonate microprism retroreflective material with acrylic backing or equal. The tape shall have a minimum reflectance equal to or greater than 1800 candle power per foot-candle per square foot (1800 candelas per lux per square meter) at 1/10 degree observation and 0 degree entrance angles.

701-3 CONSTRUCTION DETAILS

701-3.01 General.

Traffic control is defined as the use of devices and services (flagpersons and uniformed officers) when authorized to safely and efficiently move vehicular and pedestrian traffic through the construction zone and to protect workers from damage to person and property resulting from traffic movement through the construction zone.

Traffic control includes but is not necessarily limited to channelization of traffic approaching the construction zone; the installation, use, and maintenance of detours; the definition and illumination of vehicular and pedestrian ways; transitions beyond the construction zone; and the protection of workers from damage to their person and property, resulting from traffic movement through the construction zone.

Traffic control includes the protection of excavations during the period of actual work in the excavation and for a reasonable time (usually one work day) after the completion of the work for the purpose of backfilling the excavation.

The contractor shall provide for the adequate protection of all vehicular and pedestrian traffic and workers, through any portion of the work where construction operations interfere with, obstruct, or create a hazard to the normal movement of traffic.

At the time of the pre-construction conference, the contractor shall designate an employee who is well qualified and experienced in construction traffic control and safety to be responsible for the implementing, monitoring, and altering, as necessary, of the plan. At this same time, the Engineer will designate an Agency employee as the Agency's representative who will be responsible to see that the plan and any alteration thereto, is implemented and monitored to the end that traffic is carried through the work in an effective manner and that the motorists, pedestrians and workmen are protected from hazards and accidents.

The name of the contractor's employee who is responsible for the implementation, monitoring, and alteration, as necessary, of the traffic control plan shall be made known to the local law enforcement agency of jurisdiction along with the name of the Agency employee who will be responsible to see that the traffic control plan, and any alteration thereto, is implemented and monitored to the end that the traffic is carried through the work in an effective manner and that the motorists, pedestrians, and workers are protected from potential hazards and accidents. The

contractor's designee shall also be available at anytime to respond to calls involving damage to barricades, lights, signs, and other devices through vandalism, traffic accident, or other causes.

In the course of construction it may be found that it is necessary to alter the plan. Such alteration shall be in accordance with the criteria set forth in the herein before referenced traffic control standards.

All contractor personnel, equipment, machinery, tools and supplies shall be kept clear of active traffic lanes, except as necessary for the prosecution of the work. Materials, vehicles and parked equipment shall be kept as far from the traveled way as practical. The contractor shall not park vehicles or equipment, or store materials within 30 feet (*9 meters*) of the edge of a traveled way. Vehicles and equipment may be parked and materials may be stored in the right-of-way only at locations approved by the Engineer.

Any devices provided under this section which are lost, stolen, destroyed or deemed unacceptable by the Engineer while their use is required on the project shall be replaced by the contractor at no additional cost to the Agency.

Traffic control signs and delineators not permanently installed shall be weighted down. Furnishing and replacement of lost or damaged sand bags or flags shall be the responsibility of the contractor.

The Engineer shall determine which signs may require portable stands or embedded posts.

All traffic control devices necessary for the first stage of construction shall be properly placed and in operation before any construction is allowed to start. When work of a progressive nature is involved, such as resurfacing a road under traffic, the necessary devices shall be moved concurrently with the advancing operation.

If shown on the plans or required in the proposal, the contractor shall provide a paved traveled way suitable for two lanes or more of moving traffic. The traveled way shall be kept reasonably smooth and hard at all times, and shall be well drained and free of potholes, bumps, irregularities, and depressions that hold or retain water. Construction operations shall be conducted to insure a minimum of delay to traffic. Stopping traffic for more than five minutes shall not be permitted unless specifically authorized by the Engineer. The necessary equipment and personnel to attain and maintain a satisfactory riding surface shall be available and used as needed at all times when work is under way and when work is temporarily suspended for any period of time. Special attention to maintenance of a satisfactory traveled way shall be given during nights, weekends, and holidays.

701-3.02 Basic Maintenance and Protection of Traffic.

(A) Cleaning of Roadways and Sidewalks. The contractor shall keep the sidewalk and traveled way free of foreign objects such as spilled earth, rock, timber, and other items that may fall from transporting vehicles. Material spilled by or dropped from the undercarriage of any carrying vehicle used in the contractor's hauling operations along or across any public sidewalk or traveled way both within and outside the contract limits shall be removed immediately.

(B) Dust Control. Dusty conditions resulting from either the contractor's operations or vehicular traffic using the roadway shall be corrected. Water used as a dust palliative, shall be distributed uniformly by the use of suitable spray heads or spray bar.

(C) Drainage. The contractor shall devote particular attention to all drainage facilities, keeping them fully operative at all times. Ditches shall be provided at all times, even during grading operations, to adequately drain the traveled way including detours and the remainder of the right-of-way areas.

(D) Ingress and Egress. The contractor shall provide and maintain, at all times, safe and adequate ingress and egress, for both vehicular and pedestrian traffic, to and from intersecting roadways, homes, businesses, commercial establishments and at existing or at new access points, consistent with the work, unless otherwise authorized by the Engineer. On roadways on which bus service is maintained, the contractor shall provide suitable areas or locations for the loading and unloading of passengers. The contractor shall coordinate with utilities to ensure access to their facilities, as required, throughout the construction period. The existing pavement, at improved intersecting streets, shall not be disturbed without prior consent of the Engineer.

Should it become impossible or impractical to maintain access to a business or residence, the contractor shall notify the affected business or property owner a minimum of 24 hours in advance of the disruption of access. Access shall be restored as soon as possible and, in no case shall access be denied for more than eight hours.

(E) Repairs. The contractor shall make the necessary repairs to existing pavement, detours, structure wearing surfaces and other roadway elements as required to provide a reasonably smooth and safe traveled way where vehicle operation or pedestrian traffic is maintained.

(F) Schedule. The contractor shall schedule the work to keep to a minimum, and consistent with the contract documents, the amount of existing pavement and/or facilities that are rendered unusable or obliterated at any one time. Unless otherwise indicated on the project plans or in the contract documents or approved by the Engineer, the length of existing facility rendered unusable or obliterated shall not exceed 1 mile (*1.6 kilometers*).

(G) Responsibility to the Public. The contractor shall protect the public from damage to person and property which may result directly or indirectly from any construction operation. The requirements of Section 107 of these specifications shall apply.

The contractor shall notify all appropriate emergency service providers including police, fire and ambulance departments, of the impending construction two weeks prior to the start of work. This notification shall also be made to the U.S. Postal Service, school district(s) and public transit authorities as well as property owners and businesses adjacent to the project.

Emergency vehicles and school busses will be given priority status in traversing the construction zone. Access to police, fire and ambulance facilities as well as fire hydrants and hospitals shall be maintained at all times.

Auxiliary flashing lights may be required on work vehicles exposed to traffic. Shadow vehicles, equipped with appropriate signs, flags, flashing lights, and/or attenuation devices may be required to protect mobile equipment and moving operations.

(H) Railroad Protection. Where the contract work effects railroad companies, the maintenance and protection of traffic requirements in Subsection 107-9 of these specifications and the Special Provisions shall apply.

(I) Duration of Contract. The duration of the contract, for the purpose of this work, shall be from the date any work is started on the contract, including moving in equipment, signs, offices, shops, and the like, until the date the project is officially accepted.

(J) Existing Signs.

(1) Control and Authority.

All existing roadway signs, markers, delineators and their supports, authorized by the Agency, within the contract limits shall remain under the control and jurisdiction of the Engineer and shall be maintained for the duration of the contract by the contractor as directed by the Engineer. Any signs not authorized by the Agency shall be removed from the right-of-way as ordered by the Engineer.

The contractor shall maintain all existing stop, yield, and street name signs erect, clean, and in full view of the intended traffic at all times. If these signs interfere with construction, the contractor shall temporarily relocate the signs away from construction but still in full view of the intended traffic.

The maintenance needs associated with stop or yield signs shall require the immediate attention and singular priority of the contractor throughout the construction period.

Existing traffic signs other than stop, yield, and street name signs shall be maintained by the contractor until such time as construction renders them obsolete. At that time, the contractor shall remove signs and posts without damage and deliver them as directed by the Engineer.

(2) Storage and Existing Signs, Markers and Delineators.

The contractor, when ordered, shall remove existing signs, markers and delineators and their supports which interfere with construction operations; store, protect, clean, and replace them, as directed, and in a location approved, by the Engineer. Signs, markers, and delineators not to be replaced, shall be cleaned and delivered to the Engineer as directed. Signs, markers and delineators lost or damaged because of negligence on the part of the contractor, shall be replaced at no additional cost to the Agency.

701-3.03 Delineation and Guiding Devices for Construction. The contractor shall furnish, erect, move, and remove delineation and guiding devices as required and directed by the Engineer. In areas where grading is being done, a safe and reasonable roadway shall be properly delineated at all times, either by the use of guiding devices or flaggers. The contractor shall delineate areas where there is a drop-off near the edge of the traveled way and areas on which it is unsafe to travel.

The contractor shall furnish, install, move, and remove orange safety fence anytime that pedestrian traffic is adjacent to an open excavation or as otherwise directed by the Engineer.

Where a drop-off constitutes a hazard or where soft or unsafe areas occur adjacent to the traveled way, an approved barrier shall be placed along the edge of the traveled way.

Signs, delineators and guiding devices shall be kept clean at all times.

701-3.04 Construction Signs. The contractor shall furnish and erect, move, and remove, as required and directed by the Engineer, signs to adequately and safely inform and direct the motorist and to satisfy legal requirements.

All signs shall be kept clean, mounted at the required height on adequate supports, and placed in proper position and alignment so as to give maximum visibility both night and day. All wood supports and backs of plywood sign panels shall be painted with two coats of white paint. All signs and markers shall indicate actual existing conditions and shall be moved, removed, relocated or changed immediately as directed by the Engineer. Sign sizes and details shall conform to the traffic control standards or to details shown in the project plans. The number of signs indicated in the traffic control plans or project plans are a minimum and the contractor shall have an adequate quantity of each of these signs immediately available for use as required. The Engineer may

require additional signs. In that event, they shall be consistent with the arrangement, material and details of those shown in the traffic control standards and the plans.

Specialty signs are signs which are unique to a project. Specialty signs shall be furnished as directed by the Engineer. Specialty signs shall typically be mounted on posts set in the ground unless otherwise directed by the Engineer.

All signs shall be maintained in good condition for the duration of the project and removed from the work site when the project is accepted. Scratches, rips, and tears in reflective sheeting shall be promptly corrected by the contractor, to the Engineer's satisfaction.

Signs mounted on posts set in the ground shall be removed at the completion of the project, the post holes filled and compacted, and the immediate area restored to match the surrounding area.

701-3.05 Exposed Guard Rail Ends or Bridge Railing Ends. All exposed unattenuated ends of guard rail, median barrier, and bridge railing shall be temporarily terminated with temporary concrete barrier or impact attenuation devices when traffic is adjacent to the guard rail, barriers, or bridge railings.

701-3.06 Temporary Concrete Barriers. Barriers shall be installed in accordance with the details and at the locations shown on the project plans or where directed by the Engineer. The barrier shall meet the quality standards of Subsection 910-3 of these specifications. Sections of temporary barrier shall be fastened together as shown on ADOT Standard Drawing 4-C-2.01 to form a continuous chain. After placement, each unit shall be moved longitudinally to remove slack in the joints between the units. Where shown on the project plans or directed by the Engineer, the ends of the barrier run shall be flared back or fitted with an impact attenuation device. Attenuation devices shall be installed in accordance with the requirements of Subsection 701-3.07.

Barrier markers shall be installed as shown on the project plans, or the ADOT Standard Drawings.

Any barrier unit which has been excessively damaged, as determined by the Engineer, shall not be used. Any unit damaged during or after installation shall be replaced with an undamaged unit, at no additional cost to the Agency.

701-3.07 Temporary Impact Attenuation Devices. Sand Barrel Crash Cushion conforming to the requirements of Section 702 of the ADOT Standard Specifications shall be placed in accordance with the details shown on the project plans, in accordance with the manufacturer's instructions, and as directed by the Engineer.

Sand Barrel Crash Cushions damaged by the traveling public shall be removed and disposed of by the contractor. New devices shall be furnished and installed by the contractor. The contractor shall repair any damaged installations within 36 hours. Sand

barrel crash cushions will remain the property of the contractor upon completion of temporary use unless permanently incorporated into the project.

701-3.08 Temporary Pavement Markings (Application and Removal).

(A) General. Application and removal of temporary pavement markings shall conform to the requirements of the traffic control standards and these specifications as applicable. Placement of new and removal of old markings shall be done immediately when the need for each arises, in conjunction with changes in the traffic pattern.

On overlay projects, pavement marking for temporary striping shall be 4 inch (*100 millimeters*) wide by 4 foot (*1200 millimeters*) long strips of either temporary pavement marking tape or paint placed at 40 foot (*12 meters*) intervals. Temporary marking shall be placed on each subsequent pavement course and shall be placed prior to darkness. In situations where a severe degree of curvature exists, the Engineer may require the length and spacing be adjusted to 2 feet (*600 millimeters*) and 20 feet (*6 meters*), respectively. Temporary pavement markings shall have a reflective surface.

Pavement markings may be required by the Engineer in lieu of barricades for temporary delineation when the duration of use, as indicated by the traffic control plan, may exceed 5 days or when lane widths are less than 12 feet (*3.6 meters*).

Both placement of new and removal of old lines and/or markers shall be done immediately when the need for each arises. The area from which a marking is removed shall be reasonably close to the same color and texture as the adjoining pavement within the limitations of available equipment for this purpose. No scars which may misdirect traffic shall be left in the pavement at any time.

(B) Raised Pavement Markers. Adhesive shall be applied uniformly to the cleaned pavement surface and the pavement marker shall be placed in the correct position on the adhesive area with the application of pressure as specified by the manufacturer.

(C) Preformed Pavement Markings. Preformed pavement markings for temporary applications shall be Type II (Temporary-Removable) and Type III (Temporary-Nonremovable) and shall conform to the requirements of Subsection 705-3 of these specifications.

Type II Preformed Pavement Markings shall be used where removal of markings is required by the traffic control plan or as specified in Subsection 705-3 of these specifications.

Type III Preformed Pavement Markings shall be used where removal of markings is not required due to obliteration, abandonment or overlaying the pavement surface. Temporary pavement marking paint may also be used where removal of markings is not required unless otherwise shown on the project plans or in the special provisions.

701-3.09 Obliteration of Existing Pavement Markings. Pavement marking obliteration shall be accomplished by the contractor as indicated on the plans or as directed by the Engineer.

Pavement markings shall be removed to the fullest extent possible from the pavement by any method that does not materially damage the surface, color or texture of the usable pavement. Abrasive blasting, using air or water, is an acceptable method for removing pavement markings, however, other methods may be approved by the Engineer. Overpainting of markings with paint or asphalt will not be permitted.

Sand or other material deposited on the pavement as a result of removing pavement markings shall be removed as the work progresses. Accumulations of sand or other material, which might interfere with drainage or might constitute adverse safety conditions to traffic, shall be removed by the contractor.

Where blast cleaning is used for the removal of pavement markings or for removal of objectionable material, the residue including dust shall be removed immediately after contact between the sand and the surface being treated. Such removal shall be by a vacuum attachment operating concurrently with the blast cleaning operation, or by other methods approved by the Engineer. Blasting shall not be used within 12 feet (*3.6 meters*) of a lane occupied by public traffic.

Obliteration or removal of raised pavement markers shall include removal of the marker and adhesive pad, or the adhesive pad alone if the marker is missing.

Any damage to the pavement caused by pavement marking removal shall be repaired by methods acceptable to the Engineer. When asphalt slurry is used to repair damage to the pavement caused by pavement marking removal or the obliteration of the marks remaining after the markings have been removed, the asphalt slurry shall be placed parallel to the direction of travel and shall be not less than 2 feet (*600 millimeters*) in width.

If obliteration of lead-based striping is necessary, it shall be accomplished in compliance with OSHA regulations, Interim Final Rule. If lead exposure prevention measures are required, the contractor shall ensure that all contractor personnel, subcontractors, and Agency personnel present on the job site are notified of the activity and advised of precautions necessary to avoid contamination by lead compounds. The contractor shall submit a lead exposure plan to the Engineer for review at least 48 hours prior to the start of any striping obliteration activities. Payment for additional work to remove lead-based striping shall be in accordance with Subsections 104-2 or 109-4.

701-3.10 Chip Seal Pavement Marker. Temporary pavement markers and covers shall be located and placed on the asphaltic concrete prior to any work being started on the chip seal coat, all in a manner as approved by the Engineer.

Immediately after application of the chip seal coat to the roadway pavement, the plastic covers shall be removed, exposing the reflective tape surfaces.

Temporary pavement marking damaged by the contractor shall be replaced by the contractor at no additional cost to the Agency.

701-3.11 Flagging Services. Whenever it becomes necessary to maintain traffic on one lane, the contractor shall provide adequate traffic controls on the section of roadway on which vehicle operation is maintained. The contractor shall employ a sufficient number of competent flaggers to control one lane traffic continuously. In the event the length of the one lane operation is extremely short and conditions are favorable for safe operation, the Engineer may, in writing, authorize the contractor to dispense with flaggers.

The contractor shall also provide a sufficient number of competent flaggers in areas where construction equipment is operating in potential conflict with public traffic, regardless of the volume of traffic or the sight distance. Flaggers, other than a uniformed off-duty law enforcement officer, shall wear orange vests in conformance with the traffic control standards and shall direct traffic in conformance with said standards. Uniformed off-duty law enforcement officers may be required to wear a safety vest, approved by their Department and as directed by the Engineer.

701-3.12 Changeable Message Board. Changeable message boards shall be furnished and maintained by the contractor at the locations shown on the plans and as specified by the Engineer. The operations and message programmed into the board controller shall be as directed by the Engineer. The changeable message board shall be a complete and operational portable unit which shall consist of a wheeled trailer with an adjustable, changeable message board, board message controller and self-contained power supply.

The power supply for the changeable message board shall be a fully independent self-contained trailer-mounted system. The power supply shall be either an internal combustion engine generator or batteries which are recharged from a solar panel mounted above the changeable message board.

The message characters shall be delineated by either electromagnetically actuated reflective dots or optically enhanced light emitting diode pixels (LED) operating under the control of a digital computer.

For changeable message boards using electromagnetically actuated reflective dots or for non-solar-powered LED changeable message boards, the contractor shall submit, at the pre-construction conference, a Certificate of Compliance that the message board to be used on this project shall be as described herein.

For solar-powered LED changeable message boards, the contractor shall submit, at the pre-construction conference, a Certificate of Compliance that the message board to be used shall be as described herein.

The character formation system and components shall conform to the following requirements:

(1) The changeable message board shall have a minimum of three separate lines with eight characters per line.

(2) The changeable message board matrix configuration shall be 35 dots or pixels per character in a five horizontal by seven vertical arrangement of the dots or pixels.

(3) The dot or pixel size shall be a 2.5-inch (*65 millimeters*) high by 1.625-inch (*40 millimeters*) wide rectangle minimum, or equivalent area.

(4) Each character shall be 18 inches (*450 millimeters*) in height and 12 inches (*300 millimeters*) in width (minimum.

(5) The horizontal character separation shall be 3 inches (*75 millimeters*) or more.

(6) Dot color shall be fluorescent yellow upon activation and flat black when not activated. The LED pixels shall emit amber light upon activation and be dark when not activated.

(7) The line separation shall be 5 to 12 inches (*130 to 300 millimeters*).

(8) Changeable message boards shall be protected with a clear lexan-type or equivalent shield that shall not interfere with or diminish the visibility of the sign message.

(9) The changeable message board shall be capable of displaying moving arrow patterns as one of the operator-selected programs.

(10) The changeable message board shall be capable of displaying a minimum of three lines of message copy, with a minimum of eight characters per line, in various alphanumeric combinations.

(11) The changeable message board shall also be capable of displaying a minimum of four messages in sequence, with variable timing in a minimum of quarter-second increments.

(12) The changeable message board shall be clearly visible and legible from a distance of 800 feet (*245 meters*) under both day and night conditions. The dot-matrix board shall have an internal illumination system that shall automatically activate under low light conditions to achieve the visibility requirements. The LED-pixel matrix board shall adjust light output (pulse width modulation) to achieve the visibility requirements.

(13) The power supply achieved from an internal combustion engine generator shall be capable of operating the changeable message board for 72 continuous hours without refueling.

(14) The power supply achieved from the battery and solar panel recharging system shall have sufficient capacity to operate the changeable message board for a minimum of 20 days without direct sunshine. The solar panel array shall be capable of recharging the batteries such that 2.5 to 3.5 hours of direct sunshine shall provide for a minimum of one 24-hour period of usage. Additionally, the battery recharging controller shall have an ambient temperature sensing device which will automatically adjust the voltage supplied from the solar panels to the batteries. The sensing device shall ensure that the batteries are properly charged in hot or cold weather and shall provide the sign with sufficient power to operate the sign as specified.

When in operation, the changeable message board trailer shall be offset a minimum of 8 feet (*2.5 meters*) from the nearest traffic lane. Where possible, a 20 foot (*6 meters*) or more offset shall be used. When positioned on the highway, a minimum of ten 28 inch (*710 millimeters*) reflectorized traffic cones shall be set around the sign unit at a spacing of up to 10 feet (*3 meters*).

When not in operation, the changeable message board shall be turned away from oncoming traffic.

The changeable message board trailer shall be placed on a level surface and be secured as recommended by the manufacturer and as directed by the Engineer. The contractor shall provide any necessary incidental grading and clearing work required to provide a level surface and clear area for the sign.

701-3.13 Provide Detour. When the contract provides for the construction of detours, such detours, including any temporary drainage structures, base and surfacing materials, and accessory features, shall be constructed to the lines and grades established.

When the use of a detour is no longer required, any temporary structures and accessory features shall be removed and disposed of and the detour roadways shall be removed and the ground shall be restored, as nearly as practicable, to the condition existing prior to the construction of the detour.

When specific details are not indicated on the project plans or when a detour is proposed by the contractor, the contractor shall provide all elements of the detour including all warranted safety features. The proposal shall be done in accordance with the following guidelines:

Guidelines regarding horizontal and vertical alignment shall be shown.

The posted speed limit for the detour shall be determined by the Agency Traffic Engineer or the Traffic Engineer's agent.

The detour shall be paved, or stabilized as approved by the Engineer, and shall provide as a minimum two, 10-foot (*3 meters*) lanes, one for each direction of travel.

Signing and striping plans shall conform to the traffic control standards.

Prior to beginning construction of any detour proposed by the contractor, subcontractor, or agent, the contractor shall submit details to the Agency, through the Engineer, for review and approval. Such review, however, shall not relieve the contractor of the responsibility for the adequacy of such detour.

Detours shall be constructed in a manner and sequence such that interference with and inconvenience to the traveling public and abutting property owners is kept to a minimum.

The contractor shall be responsible for the materials, workmanship, maintenance and safety of all detours.

701-4 METHOD OF MEASUREMENT

701-4.01 Basic Maintenance and Protection of Traffic. The elements of work which comprise this subsection are as described in Subsection 701-3.02 (A) through (J), and as follows:

Storm water control.

Storm and emergency response to the project including labor, equipment and material(s).

Relocation services for all traffic control devices including labor, vehicles, equipment and supervision costs for installation, moving, damage repair, relocation and final removal.

Monitoring of the project on nights, weekends and holidays.

Traffic control plan preparation and approval process.

Construction, maintenance, and obliteration of temporary detours utilized for the convenience of the contractor, except as provided for in Subsection 701-3.13.

The work comprising this subsection will be measured as a single, complete, lump sum item.

701-4.02 Construction Area Elements.

(A) Elements of Work (Complete-in-Place). The elements of work listed under this subsection will be measured for payment upon the satisfactory completion of the initial installation or obliteration. Except as hereinafter specified under Basis of Payment, no subsequent measurements will be made.

Element of Work	Unit
Temporary Concrete Barrier (Installation & Removal)	LF (*m*)
Temporary Impact Attenuators(Sand Barrel) (Installation & Removal)	Each
Specialty Sign	Each
Preformed Pavement Marking (Type II)	LF (*m*)
Preformed Pavement Marking (Type III)	LF (*m*)
Temporary Pavement Marking (Painted Line)	LF (*m*)
Obliterate Pavement Marking	LF (*m*)
Obliterate Pavement Legends or Arrows	Each
Delineator (ADOT Std. Dwg. 4-M-4.01) (Temporary)	Each
Reflective Raised Pavement Marker (Temporary)	Each
Reflective Raised Pavement Marker (Permanent) (Used as Temporary)	Each
Non-Reflective Raised Pavement Marker (Temporary)	Each
Remove Raised Pavement Marker	Each
Chip Seal Pavement Marker (Single Capped)	Each
Chip Seal Pavement Marker (Double Capped)	Each
Embedded Sign Post (Initial Installation)	Each

Temporary Concrete Barrier will be measured by the linear foot (linear meter) along the center line of the uppermost surface.

Temporary Impact Attenuators, Sand Barrel Crash Cushion, will be measured by each barrel upon its initial installation (complete-in-place).

Specialty Signs are signs which are required on the project, as determined by the Engineer or shown on project plans, and are not reusable as traffic control signs. Specialty Signs shall contain information which is project and location specific. The sign sheeting shall be Type II; and the size, type and legend of the Specialty Signs will be determined by the Engineer in accordance with Federal Highway Administration (FHWA) guidelines, unless specified on the project plans. Specialty Signs will be measured as a unit for each sign furnished and subsequently utilized on the project.

Preformed Pavement Markings, Type II and Type III, will be measured in accordance with the requirements of Subsection 705-4.

Temporary Pavement Marking, Painted Line, will be measured in accordance with the requirements of the Special Provisions.

Obliterate Raised Pavement Markers will be measured for each unit, with a unit being a marker and adhesive pad or an adhesive pad alone where the marker is missing.

Delineators (ADOT Standard Drawing 4-M-4.01) and pavement markers will be measured as a unit for each delineator and marker furnished, utilized and subsequently removed at the project site. No measurement will be made for delineators and markers that are furnished to replace damaged units as specified under Subsection 701-5.02(A).

(B) Elements of Work (In Use). The elements of work listed under this subsection will be measured for payment from the time at which the element is put into active use on the project and accepted by the Engineer until such time that the Engineer determines that the element is no longer required. The work shall also include all maintenance, cleaning, and repair of all elements.

Element of Work	**Unit**
Temporary Concrete Barrier (In Use)	LF/Day (*m/Day*)
Temporary Impact Attenuators (Sand Barrel)(in Use)	Ea./Day
Flashing Arrow Panel	Ea./Day
Changeable Message Board	Ea./Day
Pilot Truck and Driver	Hour
Vertical Panels	Ea./Day
Barricade (Type II)	Ea./Day
Traffic Cones (28 inch (*710 mm*))	Ea./Day
Barricade (Type II)	Ea./Day
Barricade (Type III)	Ea./Day
Flashing Warning Light (Type A)	Ea./Day
Flashing Warning Light (Type B)	Ea./Day
Steady-Burning Warning Light (Type C)	Ea./Day
Temporary Sign (Small:less than 10 Sq.Ft. (*0.9 m^2*))	Ea./Day
Temporary Sign (Large:more than 10 Sq.Ft. (*0.9 m^2*))	Ea./Day
Embedded Sign Post (In Use)	Ea./Day
Portable Sign Stand (Spring type)	Ea./Day
Portable Sign Stand (10 Sq.Ft. (*0.9 m^2*) or Larger)	Ea./Day
Portable Sign Stand (Less than 10 Sq.Ft. (*0.9 m^2*))	Ea./Day
High Level Flag Tree Sign Stand	Ea./Day
Drum (18 in. X 36 in. (*450 mm x 900 mm*))	Ea./Day
Orange Safety Fence (4 ft. min x 50 ft.) (1.2 m min x 15 m)	Ea./Day

Temporary Concrete Barrier will be measured by the linear foot (*meter*) for each day it is in use upon its initial installation.

Temporary Impact Attenuators, Sand Barrel Crash Cushion, will be measured by each barrel by the day for each day that it is in place and functional for the "In-Use" condition.

Flashing Arrow Panels and Changeable Message Boards will be measured by the day for each day that it is utilized to maintain and control traffic.

Individual flags and sandbags used in conjunction with the above elements of work shall be considered as incidental items. No separate payment shall be made for flags and sandbags. Rather, their cost shall be included in the predetermined reimbursement rate noted in the special provisions.

Vertical panels, barricades, warning lights, signs, sign stands/posts, traffic cones, and flag trees, and drums will be measured as a unit for each device furnished and subsequently utilized at the project site.

Vertical panels, barricades (Types II and III warning lights (Types A, B, and C), Traffic Cones (28 inch), high-level flag trees, drums, embedded sign posts, and portable sign stands (spring-type and rigid), will be measured as a unit for each device furnished and subsequently utilized at the project site for each 24-hour day.

Temporary Signs will be measured as Small (less than 10 square feet (*0.9 square meter*)) with either Type II or Type III/IV sheeting, and Large (10 square feet or more (*0.9 square meter*)) either Type II or Type III/IV sheeting. Temporary Signs will be measured as a unit for each sign furnished and subsequently utilized at the project site for each 24-hour day.

Utilization shall be defined as including those devices ordered to remain on site or covered in accordance with Subsection 701-5 and approved by the Engineer.

(C)Limitation of Measurement. Elements of work listed under Subsection 701-4.02(B) that are measured on a unit day basis will be measured for reimbursement once and only once for each full work day or work shift. Measurement will be based on the maximum number of units of the specific element of work that are in simultaneous use during any given period regardless of the length of time that the elements are in use and regardless of the number of times the elements are relocated.

701-4.03 Provide Detour. Detours indicated on the plans will be measured as specified in the special provisions.

When provided for in the bidding schedule individual items of work such as embankment, grading roadway for pavement, culverts or other items of work comprising the detour will be specified as pertaining to the detour construction and will be measured by the units established in the bidding schedule.

Construction, maintenance, and obliteration of temporary detours utilized for the convenience of the contractor shall be measured as provided in Subsection 701-4.01.

Unless otherwise specified in the special provisions, Agency personnel will provide traffic striping for all detours shown on the plans. Temporary detours constructed and utilized for the contractor's convenience shall be striped by the contractor.

701-5 BASIS OF PAYMENT

The contractor will be compensated for the accepted quantities of Maintenance and Protection of Traffic in accordance with the procedures set forth herein and in Subsection 701-4.

701-5.01 Basic Maintenance and Protection of Traffic. The elements comprising basic maintenance and protection of traffic as specified in Subsection 701-4.01, will be paid for at the contract lump sum price, which price shall be full compensation for the work, complete, as specified herein and as shown on the plans and special provisions.

701-5.02 Construction Area Elements.

(A) General. The Agency will reimburse the contractor for the work of providing, and maintaining, traffic control elements on the basis of bid prices or the predetermined reimbursement rates specified in the special provisions.

No additional reimbursement will be made to the contractor for any elements of work other than those listed in the special provisions unless approved in writing by the Engineer prior to use. The cost for elements of work required for traffic control and not listed in the special provisions or included in Basic Maintenance and Protection of Traffic, will be negotiated with the Engineer prior to approval.

Elements of work specified under this subsection which are lost, stolen, destroyed, or are deemed unacceptable by the Engineer, while in use on a project shall be replaced by the contractor and, except as hereinafter specified for temporary impact attenuation devices, at no additional cost to the Agency.

An item for Construction Area Elements (Predetermined Reimbursement Rates) is included in the Bidding Schedule for the purpose of establishing an account from which the contractor will be reimbursed for the work of maintaining and protecting traffic on the basis of the predetermined reimbursement rates specified in the special provisions under Subsections 701-4.02(A) and 701-4.02(B) for the various elements of work.

(B) Elements of Work (Complete-in-Place).

(1) Temporary Concrete Barrier (Installation and Removal).

Temporary concrete barrier, measured as provided, will be paid for at the contract unit price, which price shall be full compensation for the work, complete, as specified herein and as shown on the plans, including, but not limited to,

furnishing, placing, dismantling, and removal. The price bid shall also include any required connection devices and barrier markers.

Should it be necessary to dismantle, pick up and relocate a portion of the barrier installation a lateral distance of more than 12 feet (3.6 meters) during construction, that portion of the removed and relocated barrier will be considered a new installation and measured for payment at the contract unit price.

For a lateral movement of 12 feet or less, or any vertical movement, the contractor will be paid for 50 percent of the length of the relocated Temporary Concrete Barrier (Installation and Removal), provided the contractor can demonstrate, to the Engineer's satisfaction, that it is not possible to move the barrier without dismantling and lifting. No payment will be made for portions of the barrier which the contractor can relocate without dismantling and lifting.

(2) Temporary Impact Attenuators (Sand Barrel) (Installation and Removal)

Temporary Impact Attenuators, Sand Barrel Crash Cushion, measured as provided above, will be paid for at the contract unit price, which price shall be full compensation for the work complete in place, as specified herein and as shown on the plans, including furnishing, installing, removing and stockpiling the devices.

Should it be necessary to dismantle, pick up and reinstall attenuation devices during construction, for use on the project site, the work of removing and reinstalling the devices will be measured for payment as a new installation.

The Engineer will be the sole judge as to whether devices are to be dismantled, picked up and reinstalled or are to be adjusted or realigned.

Measurement and payment for furnishing materials, equipment and labor and repairing attenuation devices that are damaged by the traveling public will be made in accordance with the requirements of Subsection 109 of these specifications.

No measurement or direct payment will be made for repairing devices damaged by other than the traveling public as determined by the Engineer.

(3) Preformed Pavement Markings.

The accepted quantities of preformed pavement markings, measured as provided, will be paid for at the predetermined reimbursement rate for the type specified, which rate shall be full compensation for the work, complete in place, including necessary pavement cleaning, removal of Type II temporary markings, and maintaining Type II and Type III temporary

markings in construction work zones. Installation for accepted quantities shall be considered satisfactory when the markings are installed within one inch of the true alignment.

When the type of preformed marking is not specified, the contractor shall furnish Type II.

Additional reimbursement will be made for replacement of temporary markings when the contractor is required by the Engineer to install marking materials on distressed pavements or during adverse weather conditions and subsequent failure occurs. Distressed pavement conditions are defined as alligator cracking, bleeding, or spalling of bituminous pavements and spalling of PCC pavements. Adverse weather conditions are defined as any occurrence where application is required at pavement temperatures less than 60 degrees F (15 °C) or when precipitation occurs within 24 hours before or after application. The Agency will pay for the replacement, where failures occur, at the reimbursement rate for the initial occurrence.

In the event a second failure occurs when markings have been reapplied on distressed pavements or under weather conditions described above, the Engineer shall determine if conditions require primer, alternate methods of marking or reapplication of preformed markings. Preformed markings will be paid for at the reimbursement rate. Primers or other methods of markings deemed necessary by the Engineer will be paid for in accordance with the provisions of Subsection 109-5.

(4) Temporary Pavement Marking (Painted Line).

The accepted quantities of Temporary Pavement Marking (Painted Line), measured as provided, will be paid for at the predetermined reimbursement rate per linear foot (linear meter), which rate shall be full compensation for the work, complete in place, as specified herein.

(5) Delineators (ADOT Std. Dwg. 4-M-4.01) and Pavement Markers.

The accepted quantities of delineators, and pavement markers, measured as provided, will be paid for at the predetermined reimbursement rate each, which rate shall be full compensation for the work, complete-in-place, as specified herein and as shown on the plans. If it is necessary to remove and relocate delineators, no direct measurement for reimbursement of the work associated with such relocations will be made, rather, this work shall be considered as incidental to and included in the amount bid for Basic Maintenance and Protection of Traffic.

(6) Raised Pavement Marker and Chip Seal Marker.

The accepted quantities of raised pavement markers and chip seal markers, measured as provided, will be paid for at the predetermined reimbursement rate each, which rate shall be full compensation for the work, complete-in-place, as specified herein and as shown on the plans.

(7) Obliterate Pavement Marking will be measured in accordance with the requirements of Subsection 708-4 of these specifications.

(8) Obliterate Pavement Markers will be measured for each unit, Markers and Adhesive pad, or Adhesive pad alone where Markers are missing.

(9) Specialty signs shall be paid in accordance with Subsection 104-3. The contractor shall provide an invoice from the provider of the specialty sign to determine the cost to make and deliver the specialty sign. The contractor will be allowed a markup of 10% of the invoice amount. Payment for the installation of the sign will be in accordance with Subsection 701-4.02(A), which shall be full compensation for furnishing, delivery to the project site, storage, installation, relocation and removal from the project site as specified herein and as shown on the plans.

(C) Elements of Work (In Use).

(1) Temporary Concrete Barrier (In Use).

The accepted quantities of temporary concrete barrier, measured as previously provided on a daily basis, will be paid for at the predetermined reimbursement rate noted in the special provisions, which rate shall be full compensation for the use of the barrier installation(s) and for furnishing all material, equipment and labor and maintaining, realigning and adjusting the barrier installation(s) as specified herein and as shown on the plans. No payment will be made for barrier not in service, such as, barrier in stockpiled configuration awaiting phase construction change.

There will be no reimbursement for each day that the Engineer determines the barrier traffic reflectors are not in good reflective condition, or for each day that the Engineer determines the barrier is out of alignment.

(2) Temporary Impact Attenuators (Sand Barrel) (In-Use).

The accepted quantities of temporary impact attenuators, Sand Barrel Crash Cushion, measured as provided above, will be paid for at the predetermined reimbursement rate, noted in the Special Provisions, which shall be full compensation for the use of the complete attenuating device and for furnishing all material, equipment and labor for maintaining, realigning and adjusting the attenuator installation, as specified herein and

as shown on the plans. No payment will be made for attenuators not in service, such as attenuators stockpiled awaiting phase construction change.

(3) Flashing Arrow Panels.

The accepted quantity of flashing arrow panels, measured as provided, will be paid for at the predetermined reimbursement rate, noted in the special provisions, which rate shall be full compensation for the work, complete, including, but not limited to, operation, maintenance and movement on the job site.

(4) Pilot Trucks and Driver.

The accepted quantities of pilot trucks and driver, measured as provided, will be paid for at the predetermined hourly reimbursement rate, noted in the special provisions, which rate shall be full compensation for the work, complete, including, but not limited to, furnishing and maintaining the vehicle and driver.

(5) Vertical Panels, Barricades, Warning Lights, Signs, Sign Stands/Posts, Traffic Cones, and Flag Trees.

The accepted unit quantities of vertical panels, barricades, warning lights, signs, sign stands/posts, traffic cones, and flag trees, measured as provided on a daily basis, will be paid for at the predetermined reimbursement rate, noted in the special provisions, which rate shall be full compensation for the use and maintenance of each device (in use).

Payment for relocation of vertical panels, barricades, warning lights, signs, sign stands/posts, traffic cones, flag trees, and work of a progressive nature will be made in accordance with the procedures of Subsection 701-4.01.

The work of removing and reinstalling signs on embedded posts will be considered as incidental to the daily cost of the sign, regardless of the type of work or operation, when directed by the Engineer.

The predetermined reimbursement rate for signs, vertical panels, and flag trees includes the cost of flags and ballasting.

The predetermined reimbursement rate for barricades includes the cost of ballasting.

Payment as provided herein shall be full compensation for furnishing to the jobsite, stockpiling, and installation of flashing arrow panels, vertical panels, barricades, warning lights, signs, sign stands/posts, traffic cones, and flag trees, complete-in-place and also includes the cost of relocation of all necessary traffic control elements or the

moving of elements for the contractor's advancing operation(s) as specified herein and as shown on the plans, except for items specifically directed by the Engineer.

(6) Changeable Message Boards:

The accepted quantities of Changeable Message Boards, measured as provided above, will be paid for at the predetermined reimbursement rate per day, which price shall be full compensation for the work, complete, including incidental grading; and furnishing, operating, maintaining, and relocating the boards on the work site, and providing all necessary labor and equipment. No payment will be made for incidental grading, the cost being considered a part of contract items.

(D) Reimbursement Exceptions.

(1) Deficient Elements of Work.

Any deficiencies in the traffic control plan, devices, equipment, services, or other elements of work listed under Subsection 701-4.01 and 701-4.02, (B) and (C) will be brought to the attention of the contractor by the Engineer and all deficiencies shall be corrected before the close of that work day or work shift.

Reimbursement will not be withheld from the contractor for those elements of work that are restored to full usefulness prior to the close of the work day or work shift in which notice of the defect is given.

No reimbursement will be made to the contractor for those deficient elements of work listed in the special provisions under Subsection 701-4.02 (B) and (C) that are not restored to full usefulness prior to the close of the work day or work shift in which notice of the defect is given. Measurement for reimbursement will not resume until the beginning of the work day or work shift following that work day or work shift in which those elements are restored to usefulness.

(2) Substantial Deficiencies.

The Engineer shall notify the contractor in writing of substantial deficiencies in compliance with the requirements of this Section. Once notification is received, the contractor will be given 24 hours to correct the deficiency unless said deficiency poses peril to the public, in which case its correction will require immediate attention. No payment will be made for Basic Maintenance and Protection of Traffic nor for any element of work listed under Subsection 701-4.02 (B) and (C) for each calendar day, beyond the aforementioned 24 hour period, during which substantial deficiencies exist in the compliance with the specification requirements of any subsection of this section, as determined

by the Engineer, including but not limited to Basic Maintenance and Protection of Traffic and/or any individual item of work as specified in Subsection 701-4 and 701-5.

The amount of such calendar day non-payment will be determined by dividing the lump sum amount bid for Basic Maintenance and Protection of Traffic by the number of calendar days between the date the contractor commences work and the date of completion as designated in the proposal, without regard to any extension time.

If at any time the Engineer determines that proper provisions for safe traffic control are not being provided or maintained, he may order suspension of the work until the proper level of traffic control is achieved. In cases of serious or willful disregard for safety of the public or his employees by the contractor, the Engineer may proceed forthwith to place the traffic control measures in proper condition and deduct the cost thereof from monies due or becoming due the contractor.

Measurement for reimbursement will not resume for any element of work until the beginning of the work day or work shift following that work day or work shift in which all corrective measures have been performed by the contractor and approved by the Engineer.

(3) Non-Diligent Prosecution of Work.

In the event that the Engineer determines that the contractor's construction operations are not resulting in the diligent prosecution of the work under contract, no reimbursement will be made to the contractor for the elements of work listed under Subsection 701-4.02 (B) and (C) until such time as the Engineer determines that the contractor is devoting appropriate efforts toward completion of the work. Payment will be suspended effective with the end of the work day or work shift in which written notice is issued to the contractor by the Engineer notifying the contractor of his failure to prosecute the work. Payment will resume with the beginning of the work day or work shift following that work day or work shift in which the Engineer determines that satisfactory efforts are being made by the contractor toward completion of the work. In any case, the contractor shall continue to be responsible for maintaining all barriers, attenuators, signs, lights and other traffic control devices in proper functioning condition at all times.

(4) Non-Working Periods.

Measurement for reimbursement of the elements of work listed under Subsection 701-4.02 (B) and (C) will begin on the day they are installed in place for traffic control and direction. When the elements are not needed for traffic control, they shall be removed or covered and will not be measured. During non-working periods such as holidays, Sunday, etc. the elements in place and in satisfactory condition will be measured for reimbursement on the day following such downtime. During these

non-working periods the contractor shall conduct a minimum of one check per day to see that the elements are in place and in satisfactory condition.

No reimbursement will be made to the contractor for the elements of work listed under Subsection 701-4.02 (B) and (C) for non-working periods resulting from a suspension of work that, in the opinion of the Engineer, is due to the fault of the contractor. In any case, the contractor shall continue to be responsible for maintaining all barriers, attenuators, signs, lights and other traffic control devices in proper functioning condition at all times.

(5) Limitation of Measurement.

Elements of work listed under 701-4.02 (B) and (C) that are measured on a unit per day basis will be measured for reimbursement once and only once for each full work day or work shift. Measurement will be based on the maximum number of units of the specific element of work that are in simultaneous use during any given period regardless of the length of time that the elements are in use and regardless of the number of times the elements are relocated.

(6) Expiration of Contract Time.

No reimbursement will be made to the contractor for the elements of work listed under Subsection 701-4.02 (B) and (C) when they are required in association with construction work being performed after the expiration of the contract time and all approved extensions.

In any case, the contractor shall continue to be responsible for maintaining all barriers, attenuators, signs, lights and other traffic control devices in proper functioning condition at all times.

701-5.03 Flagging Services. The Engineer must approve the use of flagging services. Flagging services will be paid in accordance with Subsection 109-5, Force Account Work.

Off-duty law enforcement personnel and official police vehicles will be paid for at the law enforcement agency's reimbursement rates, as invoiced to the contractor, including, but not limited to, furnishing and maintaining the vehicle. Payment shall be in accordance with the provisions of Subsection 104-3. The contractor will be allowed a markup of 10% of the invoice amount.

701-5.04 Provide Detour. Payment for detours will be made in accordance with the measurement provisions of Subsection 701-4.04. Payment shall be full compensation for the work of providing a detour complete-in-place, inclusive of maintenance and removal, as indicated on the plans and specified herein.

When specified in the special provisions and the bidding schedule, individual items of work comprising the detour, including embankment, grading roadway for pavement, and culverts, will be paid for at the unit price for these individual items according to the units designated in the bidding schedule.

SECTION 702

ATTENUATION DEVICES

702-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and installing attenuation devices of the types and at the locations and in accordance with the details shown on the project plans and the requirements of these specifications.

702-2 MATERIALS

702-2.01 General. Materials used in the construction of the vehicular impact attenuator system shall all be new except that undamaged attenuation devices used for Maintenance and Protection of Traffic may be used for permanent installation when approved by the Engineer.

Materials used in transitions or connections between impact attenuators and metal-beam guard rail shall conform to the requirements of Section 1012.

Materials used in transitions or connections between impact attenuators and concrete structures or barriers shall conform to the applicable requirements of Subsection 910-2, except anchors and anchor bolts shall conform to the requirements of Subsection 1012-3.

Concrete shall be utility concrete conforming to the requirements of Section 922. Steel reinforcement shall conform to the requirements of Section 1003.

Asphaltic concrete shall conform to the requirements of Section 406.

Attenuation devices shall be approved by the Agency prior to use.

702-2.02 Energy Absorbing Terminal. Energy absorbing terminals shall be multiple bin units of collapsible cartridges positioned between diaphragms that are enclosed by a framework of the beam guardrail fender panels conforming to the details shown on the project plans.

702-2.03 Sand Barrel Crash Cushion. Sand barrel crash cushions shall be frangible, plastic modules formulated or processed to resist deterioration from ambient ultraviolet rays. The color of the outer module or stabilizer and lids shall be the standard gray or yellow color as furnished by the vendor.

The modules shall exhibit good workmanship free from structural flaws and objectionable surface defects. The Engineer may measure the thickness of the inner module and stabilizer walls as shown on the plans by any means he considers appropriate. When filled with the specified weight of sand, the module walls shall not distort, either as an indentation or a protrusion, more than 1/2-inch (*13 millimeter*) from the original module wall configuration.

Modules shall be filled to the designated height with sand (fine aggregate) meeting the requirements of Subsection 1006-2.03(B). The sand, when placed in the module, shall have a dry unit weight of from 90 to 100 pounds per cubic foot (*1440 to 1600 kilograms per cubic meter*) and a moisture content of less than two percent, by weight.

Sand barrel crash cushion installations at elevations above 3,000 feet (*900 meters*) shall have five percent rock salt (by weight) mixed with the sand.

702-3 CONSTRUCTION DETAILS

Attenuation devices shall be placed at the locations shown on the project plans or as directed by the Engineer and shall conform to the details shown on the plans and the requirements of the manufacturer.

Unless otherwise specified on the project plans, when the plans require the attenuation device to be placed on a paved pad the pavement shall be 4 inches (*100 millimeters*) thick and shall be made either of utility concrete or asphaltic concrete, at the option of the contractor. The soil under the pad, or under the impact attenuator when no pad is required, shall be compacted to not less than 95 percent of the maximum density determined in accordance with the applicable test methods of the ADOT Materials Testing Manual. When installation of the attenuation device is complete, all trash shall be removed from its area and the soil surface around it shall be smoothed to the elevation indicated on the project plans.

Any welding required shall be performed in accordance with the requirements of the American Welding Society Structural Welding Code AWS D 1.1-80.

702-4 METHOD OF MEASUREMENT

Attenuation devices will be measured as a unit for each device installed, except that devices which were previously used for maintenance and protection of traffic and are being reused as a permanent installation will not be measured for payment.

702-5 BASIS OF PAYMENT

The accepted quantities of attenuation devices, measured as provided above, will be paid for at the contract unit price for the type designated in the bidding schedule, complete-in-place. No extra measurement or payment will be made for any concrete, reinforcing steel, hardware, fasteners, structural steel, pavement pad materials, any connection or transition section needed to connect the impact attenuator to guard rail or concrete barriers, grading in the area of the impact attenuator and required only to

smooth vehicle approach paths to it, excavation and backfill required immediately adjacent to the barrier, and sand to fill crash cushion modules, as the cost thereof will be considered as included in the contract unit price for the impact attenuator, complete-in-place.

Labor and equipment used to remove and reinstall attenuation devices used for maintenance and protection of traffic and being reused as a permanent installation will be paid for in accordance with the provisions of Subsection 109-4.

SECTION 704

THERMOPLASTIC STRIPES AND MARKINGS

704-1 DESCRIPTION

The work under this section shall consist of cleaning and preparing pavement surfaces and furnishing and applying either white or yellow hot-sprayed thermoplastic reflectorized stripes or pavement markings to the prepared pavement at the locations and in accordance with the details shown on the project plans and the requirements of these specifications.

Screed or extrusion application of thermoplastic may be allowed, if approved by the Engineer, for short application work such as intersections.

704-2 MATERIALS

704-2.01 General Requirements. The thermoplastic reflectorized material shall consist of a mixture of binder, white or yellow pigment, glass spheres, filler, and other materials in granular form specifically compounded for pavement stripes and markings that is applied to the pavement in a molten state. Upon cooling to normal pavement temperature, this material shall produce an adherent reflectorized stripe or marking of specified thickness capable of resisting deformation.

Certificates of Compliance conforming to the requirements found in Subsection 106-5(B) shall be submitted.

704-2.02 Composition. The thermoplastic composition shall conform to the following requirements:

	Percent by Weight	
	White	Yellow
Binder	18-26	18-26
Titanium dioxide	8-15	-----
Basic lead chromate	-----	4-10
Reflective glass spheres	30-40	30-40
Calcium carbonate or equivalent filler	20-40	25-45

The ingredients of the thermoplastic composition shall be thoroughly mixed and in a free flowing granular form. The material shall readily melt into a uniform mixture and be free from all skins, dirt, foreign objects or any other ingredient which would cause bleeding, staining or discoloration when applied to the bituminous and Portland cement concrete pavement.

The thermoplastic shall be one of the following two types of binder composition:

Hydrocarbon, consisting mainly of synthetic petroleum hydrocarbon resins with appropriate fillers and pigments.

Alkyd, consisting mainly of maleic modified glycerol ester of tall oil resin for the binder.

(A) Reflective Glass Beads. In addition to incorporating glass beads in the thermoplastic mix, glass beads shall be applied to the surface of the molten material at a uniform rate of at least 7-1/2 pounds of glass beads per 100 square feet of line (*0.5 kilogram per square meter*) (300 feet (*10 meters*) of 4 inch (*100 millimeter*) stripe).

(B) Filler. The filler shall be a white calcium carbonate or equivalent filler with a compressive strength of at least 5,000 pounds per square inch (*34 megapascals*).

(C) Titanium Dioxides. Titanium dioxide shall conform to the requirements of ASTM D 476 for Type II (92 percent)

(D) Lead Chromate Pigment. The lead chromate pigment shall be silica encapsulated heat resistant lead chromatic pigment.

704-2.03 Physical Characteristics of the Composition.

(A) General Requirements. The thermoplastic material shall not exude fumes which are toxic or injurious when heated to the temperature range specified by the manufacturer for application. The material shall remain stable when held for 4 hours at this temperature, or when subjected to 4 reheatings, not exceeding a total of 4 hours, after cooling to ambient temperature. The temperature viscosity characteristics of the plastic material shall remain constant throughout the reheatings and shall show like characteristics from batch to batch. There shall be no obvious change in color of the thermoplastic material as a result of reheating, and the color of the material shall not vary from batch to batch.

(B) Color. The thermoplastic material, after heating for four hours ± five minutes at 218 ± 2 °C and cooled to 25 ± 2 °C, shall meet the following:

White: Daylight reflectance at 45 degrees – 0 degrees shall be 75 percent minimum.

The color shall match Federal Test Standard Number 595, Color Chip No. 17925.

Yellow: Daylight reflectance at 45 degrees – 0 degrees shall be 45 percent minimum.

The color shall match Federal Test Standard Number 595, Color Chip No. 13538.

(C) Retroreflectance. The white and yellow thermoplastic materials shall have the following minimum retroreflectance values at 86.5 degrees illumination angle and 1.5 degrees observation angle as measured by a Mirolux 212 portable retrorefectometer 30 days after application to the roadway surface:

Product	Retroreflectance (Millicandelas)
White	200
Yellow	150

(D) Water Absorption and Specific Gravity. The thermoplastic material shall not exceed 0.5 percent by weight of retained water when tested in accordance with the requirements of ASTM D 570.

The specific gravity of the material, as determined by Section 11 of AASHTO T 250, shall be between 1.85 and 2.3.

(E) Bond Strength. After heating the thermoplastic material for four hours ± five minutes at 218 ± 2 °C, the bond strength to Portland cement concrete shall be not less than 173 psi (1.2 megapascals). The bond strength shall be determined in accordance with the procedures specified in Section 7 of AASHTO T 250

(F) Cracking Resistance at Low Temperature. After heating the thermoplastic material for four hours ± five minutes at 218 ± 2 °C, applying to concrete blocks, and cooling to -9 ± 2 °C, the material shall show no cracks when observed from a distance exceeding 1 foot (*300 millimeters*). Testing for low temperature crack resistance shall be in accordance with the procedures specified in Section 8 of AASHTO T 250.

(G) Impact Resistance. After heating the thermoplastic material for four hours ± five minutes at 218 ± 2 °C, and forming test specimens, the impact resistance shall be not less than 1.13 joules when tested in accordance with Section 9 of AASHTO T 250

(H) Softening Point. After heating the thermoplastic material for four hours ± five minutes at 218 ± 2 °C and testing in accordance with ASTM D 36, the thermoplastic materials shall have a softening point of 102 ± 8 °C.

(I) Flowability. After heating the thermoplastic material for four hours ± five minutes at 218 ± 2 °C and testing for flowability in accordance with Section 6 of AASHTO T 250, the white thermoplastic shall have a maximum percent residue of 18 and the yellow thermoplastic shall have maximum percent residue of 12.

(J) Yellowness Index. The white thermoplastic material shall not exceed a yellowness index 0.12 when tested in accordance with Section 4 of AASHTO T 250.

(K) Flowability (Extended Heating). After heating the thermoplastic material for eight hours ± 1/2 hours at 218 ± 2 °C, with stirring the last six hours, and testing for flowability in accordance with Section 12 of AASHTO T 250, the thermoplastic shall have a maximum percent residue of 28.

(L) Abrasion Resistance. The abrasion resistance of the thermoplastic material shall be determined by forming a representative lot of the materials at a thickness of 1/8 inch (*3 millimeters*) on a 4 inch by 4 inch (*100 by 100 millimeter*) square

monel panel 0.050 inch ± 0.0001 inch in thickness (*1.27 ± 0.02 millimeters*), on which a suitable primer has been previously applied, and subjecting it to 200 revolutions on a Taber Abraser at 25 °C, using H-22 calibrated wheels weighted to 1/2 pound (*250 grams*). The wearing surface shall be kept wet with distilled water throughout the test.

The maximum loss thermoplastic material shall be 0.5 grams.

(M) Flash Point. The thermoplastic material shall have a flash point not less than 246 °C when tested in accordance with the requirements of ASTM D 92.

(N) Storage Life. The materials shall meet the requirements of this specification for a period of one year from the date of manufacture. The thermoplastic must also melt uniformly with no evidence of skeins or unmelted particles for this one year period. Any material which does not meet the above requirements, or which is no longer within this one year period at the time of application, shall be replaced by the contractor at no additional cost to the Department.

(O) Primer Sealer. Primer Sealers for use on Portland cement concrete or hot mix asphaltic concrete surfaces prior to application of the thermoplastic material shall be either as recommended by the thermoplastic material manufacturer or especially compounded for use with the specified thermoplastic material.

704-2.04 Physical Requirements for Glass Beads.

The term "glass bead" shall be synonymous with the term "glass sphere" as used herein.

Inter-mix and drop on reflective glass beads shall conform to the requirements of Subsection 708-2.02, except as noted herein.

The inter-mix beads shall conform to AASHTO M 247-81 (1986), type 1, and may be coated or uncoated as recommended by the manufacturer. If uncoated beads are used, the thermoplastic formulation shall be configured to minimize settling of the intermix beads when the material is heated and applied.

If recommended by the manufacturer, the drop-on beads shall have an adherence coating.

704-3 CONSTRUCTION REQUIREMENTS

704-3.01 Control of Alignment and Layout. Traffic stripes shall be placed to the line established by the Engineer, which will consist of existing stripes or control points spaced at 200 feet (*60 meters*) on tangents and 50 feet (*15 meters*) on curves.

All additional work necessary to establish satisfactory lines for stripes and all layout work required for pavement markings shall be performed by the contractor at his expense. Lines shall be

established by the application of cat tracks or dribble lines, the use of laser guidance devices, or by a combination of these techniques.

Cat tracking shall consist of stretching a rope on a straight line between control points on tangent alignment and on a true arc through control points on curved alignment and placing spots of paint along the rope. The spots shall be not more than 2 inches (*50 millimeters*) in width and not more than 5 feet (*1.5 meters*) apart on curves nor more than 10 feet (*3 meters*) apart on tangents.

Dribble lines shall consist of marking the pavement with a thin line of paint using a striping machine or other suitable device. Dribble lines shall be on a straight line between control points on tangent alignment and on a true arc through control points on curved alignment.

Paint for cat tracks and dribble lines shall be the same color as the traffic stripe for which they are placed.

Laser guidance equipment shall be capable of maintaining the alignment of traffic stripes with an accuracy equivalent to, or better than, that obtainable through use of cat tracking or dribble lines, as determined by the Engineer.

704-3.02 Equipment. The equipment used to install hot applied thermoplastic material shall be constructed to provide continuous uniform heating to temperatures exceeding 400° F (*204 °C*) while mixing and agitating the material. The conveying portion of the equipment, between the main material reservoir and the line dispensing device, shall be configured to prevent accumulation and clogging. All parts of the equipment which will come in contact with the material shall be constructed for easy accessibility for cleaning and maintenance. The equipment shall operate so that all mixing and conveying parts including the line dispensing device, will maintain the material at the plastic temperature. The use of pans, aprons or similar appliances which the dispenser overruns will not be permitted. The equipment shall provide for varying traffic marking applications widths.

The applicating equipment to be used on roadway installations shall consist of either truck-mounted units, motorized ride-on equipment, or manually pushed equipment, depending on the type of marking required. The truck-mounted or motorized ride-on units for center lines, lane lines, and edge lines shall consist of a mobile self-contained unit carrying its own material capable of operating at a minimum speed of five miles per hour (*8 kilometers per hour*) while applying striping. The hand applicator equipment shall be sufficiently maneuverable to install curved and straight lines, both longitudinally and transversely.

The applicating equipment shall be so constructed as to assure continuous uniformity in the dimensions of the stripe. The applicator shall provide a means for cleanly cutting off square stripe ends and shall provide a method of applying skip lines.

The equipment shall be constructed so as to provide varying widths of traffic markings. The applicating equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment operator shall be located in such a position as to enable full visibility of the striping apparatus.

A glass bead top dressing shall be applied to the completed thermoplastic stripe by an automatic glass bead dispenser attached to the striping machine in such a manner that the beads are applied to the molten thermoplastic material immediately after it has been applied. The bead dispenser shall utilize pressure type spray guns which will embed the beads into the stripe surface to at least 1/2 the bead diameter. The bead dispenser shall be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

A special kettle shall be provided for uniformly melting and heating the thermoplastic material. The kettle must be equipped with an automatic thermostat control device and material thermometer for positive temperature control to prevent overheating or underheating of the material.

The heating kettle and application equipment shall meet the requirements of the National Fire Underwriters and the National Fire Protection Association and the state and local authorities.

If screed or extrusion application or thermoplastic is allowed by the Engineer for short applications, the screed/extrusion application method shall be utilized wherein one side of the shaping die is the pavement and the other three sides are contained by equipment suitable for heating or controlling the flow of material. The equipment utilized shall form an extruded line which shall be uniform in shape having clear and sharp dimensions.

For handliner applications, a gravity bead dispenser may be allowed by the engineer if it properly gauges and dispenses the correct amount of glass spheres.

704-3.03 Application. The contractor shall remove all dirt, dust, grease, oil or other detrimental material from the road surface prior to application of the thermoplastic material. The method of surface cleaning is subject to approval by the Engineer and shall include sweeping, and the use of high-pressured abrasive air spray. The cost for cleaning the surface, including sweeping and high-pressure air spray, shall be considered part of the cost for applying thermoplastic striping and no separate measurement or payment will be made for this work.

When thermoplastic striping, symbols or legends are to be applied to new portland cement concrete pavement, any curing compound present shall be removed by means of a high-pressured water jet or sandblasting, followed up by sweeping and high-pressure air spray. On both old and new portland cement concrete pavement a primer-sealer, as recommended by the thermoplastic manufacturer, shall be

applied prior to placing the thermoplastic material to ensure a satisfactory bond. The primer shall be free of solvent and water prior to the thermoplastic application.

The air and road surface temperature at the time of application shall not be less than 50° F (*10 °C*) and the pavement surface shall be absolutely dry. To insure optimum adhesion, the thermoplastic material shall be installed in a molded state at a temperature range of 400° F to 440° F (*204 °C to 227 °C*).

The thermoplastic striping and markings shall be a minimum of 0.060 inches (*1.5 millimeter*) thick in all applications. Random spot checks of the thermoplastic thickness will be made by the Engineer to ensure conformance with the above criteria. A suggested spot check procedure is to place a small strip of metal with a known thickness immediately ahead of the striping apparatus. After striping, remove the sample and using a suitable measuring device, i.e., micrometer, determine the thickness of the marking.

Longitudinal lines shall be offset at least 1 foot (*300 millimeters*) clear from construction joints unless directed otherwise by the Engineer.

It shall be the responsibility of the contractor to provide for adequate disposal of all empty material containers.

The finished thermoplastic line shall have well-defined edges and be free of waviness. Lateral deviation of the thermoplastic stripe shall not exceed 1 inch (*25 millimeters*) in 100 feet (*30 meter*). The longitudinal deviation of a painted segment and gap shall not vary more than 6 inches (*150 millimeters*) in a 40 foot (*12 meters*) cycle. The actual width of stripe shall be within the limits specified in the following table, according to the width of stripe called for on the plans:

Plan Width	**Actual Width**
4 inches (*100 mm*)	4 to 4 1/2 inches (*100 to 115 mm*)
8 inches (*200 mm*)	8 to 9 inches (*200 to 225 mm*)
Over 8 inches (*200 mm*)	± 1 inch (*± 25 mm*)

After application and sufficient drying time, the thermoplastic marking shall show no appreciable deformation or discoloration under local traffic conditions in an air and/or road temperature ranging from -10 degrees to +180 degrees F (*-23 to +82 °C*). The drying time shall be defined as the minimum elapsed time, after application, when the thermoplastic pavement markings shall have and shall retain the characteristics required herein and after which normal traffic will leave no impression or imprint on the newly applied marking. The thermoplastic material shall set to bear traffic in not more than 2 minutes when the road surface temperature is approximately 50° F (*10 °C*), and not more than 10 minutes at a road temperature of 90° F (*32 °C*).

704-4 METHOD OF MEASUREMENT

Thermoplastic pavement stripes will be measured by the linear foot (*meter*) along the center line of the pavement stripe and will be based on a 4 inch (*100 millimeter*) wide stripe. Measurement for striping with a plan width greater or less than the basic 4 inches (*100 millimeters*) as shown on the plans or directed by the Engineer will be made by the following method:

$$\frac{\text{Plan Width of Striping (Inches) (}\textit{millimeters}\text{) x Linear Feet (}\textit{meters}\text{)}}{\text{4 Inches (}\textit{100 millimeters}\text{)}}$$

No measurement will be made of the number of linear feet (*meters*) of skips in the dashed lines.

Thermoplastic pavement symbols and legends will be measured by each unit applied. Each pavement symbol and each legend, as shown on the plans, will be considered a unit.

No measurement shall be made for removal of curing compound from new portland cement concrete pavement and the application of primer-sealer, which is to be applied to both old and new portland cement concrete pavement, prior to application of thermoplastic striping or marking. This work shall be considered incidental to the application of the thermoplastic stripes and symbols.

704-5 BASIS OF PAYMENT

The accepted quantities of thermoplastic pavement markings of the type specified in the bidding schedule, measured as provided above, will be paid for at the contract unit price, complete in place, including pavement surface preparation and glass beads.

SECTION 705

PREFORMED PLASTIC PAVEMENT MARKING

705-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, preparing the pavement surface and applying preformed reflectorized pavement marking tape, symbols and legends to the pavement in accordance with the details shown on the project plans and the requirements of these specifications.

Preformed pavement marking tape, symbols and legends shall be limited to the following applications unless otherwise specified in the contract documents:

(A) Preformed Pavement Markings - Type I (Permanent). Type I shall be a general purpose high durability retroreflective pliant polymer film for preformed striping and markings to be used for finished permanent markings. Type I shall be capable of performing as specified herein when subjected to high traffic volumes and severe wear conditions such as repeated shear action from crossover or encroachment on edge and channelization lines, starting, stopping, and turning movements.

(B) Preformed Pavement Markings - Type II (Temporary - Removable). Type II shall be a removable preformed retroreflective pavement marking capable of performing for the duration of a normal construction season. It shall be a nonmetallic mixture of high quality material and shall be capable of being removed intact or in large pieces either manually or with a recommended roll up device. Type II shall be used on finished pavement surfaces where traffic control or channelization through the construction zone is temporary requiring removal prior to final pavement markings.

(C) Preformed Pavement Markings - Type III (Temporary - Nonremovable). Type II shall be a nonremovable preformed retroreflective film on a conformable metallic backing capable of performing for the duration of a normal construction season. Type III shall be used in construction zones where removal is unnecessary due to placement of future paving courses or where pavement will be removed, obliterated or abandoned at the completion of the project.

705-2 MATERIALS

705-2.01 Preformed Pavement Markings – Type I (Permanent).

(A) General: Certificates of Compliance conforming to the requirements of subsection 106-5(B) shall be submitted.

Type I preformed plastic pavement marking material shall consist of a homogeneous, extruded, pre-fabricated white or yellow thermoplastic film of specified thickness and width that shall be capable of being affixed to non-bleeding bituminous surfaces or Portland cement concrete. It shall contain reflective glass beads uniformly distributed throughout the entire cross section and bonded to the top surface of the material. The preformed plastic

film shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting, or shrinkage or significant tearing, roll back, or other signs of poor adhesion throughout the useful life of the marking.

When extruded, the plastic film, without adhesive, shall be a minimum of 0.060 inch (*1.5 millimeter*) thick. The plastic film, as supplied, shall be of good appearance, free of cracks and discolorations, and the edges shall be clean-cut and well defined. The plastic film may be supplied complete with a precoated, factory-applied pressure sensitive adhesive backing with a protective release paper, or it may be furnished with separate adhesive as recommended by the manufacturer. Whether the adhesive is precoated or supplied separately, the adhesive shall be such as to allow the plastic film to be repositioned on the pavement surface to which it is applied before permanently fixing it in its final position with a downward pressure.

A list of manufacturers and distributors acceptable to the Agency for Type I (Permanent) preformed pavement marking material are contained in the Approved Products List (APL) compiled by the Arizona Department of Transportation.

(B) Composition Requirements: The preformed plastic pavement marking material shall consist of the following components:

Minimum Percent by Weight	
Resins and Plasticizers	20
Pigments	30
Reflective Glass Beads	20

(C) Physical Requirements:

(1) Color: The pigments shall be selected and blended to provide a white or yellow marking film which conforms to standard highway colors throughout the expected life of the film.

(2) Bend Test: The plastic film shall be sufficiently flexible so that at a temperature of 78° F (*25 °C*) to 82° F (*28 °C*) an unmounted piece of material (without adhesive and paper backing), 3 inches (*75 millimeters*) by 6 inches (*150 millimeters*) in size, may be bent over a 1 inch (*25 millimeters*) mandrel until the end faces are parallel and 1 inch (*25 millimeters*) apart without showing any fracture lines in the uppermost surface.

(3) Tensile Strength: The plastic film (without adhesive or paper backing) shall have a minimum tensile strength of 40 pounds per square inch (*275 kilopascals*) when a specimen 6 inches (*150 millimeters*) long by 1 inch (*25 millimeters*) wide is tested in accordance with the requirements of ASTM D 638. The rate of pull of the test shall be 0.25 of an inch (*6*

millimeters) per minute. The test shall be conducted at a temperature between 70° F (*21 °C*) and 80° F (*27 °C*). The elongation shall be no greater than 75 percent.

(4) Plastic Pull Test: A 6 inch (*150 millimeter*) long by 1 inch (*25 millimeter*) wide section of the plastic film (without adhesive and paper backing) shall support a dead load weight of 4 pounds (*1.8 kilograms*) for not less than five minutes at a temperature between 70° F (*21 °C*) and 80° F (*27 °C*).

(5) Abrasion Resistance: The plastic film shall have a maximum loss in weight of 0.25 grams in 500 revolutions when abraded according to Federal Test Method Standard No. 141, Method 6192, using H-18 calibrase wheels with a 1000-gram load on each wheel.

705-2.02 Preformed Pavement Markings - Type II (Temporary Removable). Certificates of Compliance conforming to the requirements found in Subsection 106-5(B) shall be submitted.

Type II preformed pavement markings shall be a nonmetallic mixture of conformable materials and pigments intended for marking applications where removability is required. The marking material shall be white or yellow retroreflective film conforming to standard highway colors with glass spheres in a reflective layer bonded to the top surface. The glass beads shall meet the durability and reflectance criteria specified in Subsection 705-2.03.

The markings shall be precoated with a pressure sensitive adhesive capable of adhering to roadway surfaces under climatic and traffic conditions normally encountered in the construction work zone when applied in accordance with the manufacturer's instructions and without the use of heat, solvents or other additional adhesives. Newly applied markings shall be capable of being immediately exposed to traffic without pickup or distortion by vehicles. The markings shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting, shrinkage, tearing, roll back, or other signs of poor adhesion throughout the useful life of the marking.

Temporary pavement markings shall be removable from asphalt and concrete pavement intact or in large sections by following the manufacturer's instructions. It shall be removable either manually or with a roll-up device at pavement temperatures above 40° F (*4 °C*) without the use of heat, solvents, grinding, or sand blasting. Visual adhesive residue remaining after removal of temporary pavement markings shall be easily removable without damaging or scarring the pavement surface and without the use of solvents or grinding.

When extruded, pavement marking material without adhesive shall be a minimum of 0.045-inch (*1.1 millimeters*) thick. When supplied, the material shall be of good appearance, free from cracks, and edges, shall be true, straight, and unbroken.

705-2.03 Preformed Pavement Markings - Type III (Temporary-Nonremovable). Certificates of Compliance conforming to the requirements found in Subsection 106-5(B) shall be submitted.

Type III preformed pavement markings shall be a retroreflective film on a conformable metallic backing intended for marking applications where removal is not a requirement. The marking material shall be white or yellow conforming to standard highway colors and shall contain glass beads meeting the durability and reflectance criteria specified in Subsection 705-2.04.

The markings shall be precoated with a pressure sensitive adhesive capable of adhering to roadway surfaces under climatic and traffic conditions normally encountered in the construction work zone when applied in accordance with the manufacturer's instructions and without the use of heat, solvents or other additional adhesives. Newly applied markings shall be capable of being immediately exposed to traffic without pickup or distortion by vehicles. The markings shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting, shrinkage, tearing, roll back, or other signs of poor adhesion throughout the useful life of the marking.

705-2.04 Reflective Glass Beads.

(A) General Requirements. The beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering.

During manufacture of the preformed plastic pavement marking material, reflective glass beads shall be mixed into the material in the amounts indicated previously. A layer of reflective glass beads shall be bonded to the top surface of all types of preformed pavement marking materials.

(B) Physical Requirements.

(1) Roundness. The roundness of the glass beads shall be determined in accordance with the requirements of ASTM D-1155. A minimum of 75 percent of the beads shall be water-white true spheres free from imperfections of all types including air inclusions, film, scratches, clusters, and surface scoring.

(2) Index of Reflection. The glass beads used with the preformed pavement marking material shall have a reflective index of not less than 1.50 when tested by the liquid immersion method at *25 ℃*.

(3) Gradation. The size of the glass beads shall be such that performance requirements for the preformed pavement marking material shall be met.

(4) Chemical Resistance. The glass beads shall withstand immersion in water and acids without undergoing noticeable corrosion or etching and shall not be darkened or otherwise noticeably decomposed by sulfides. The test for chemical

resistance shall consist of placing 3 to 5 gram portions of the sample in each of three pyrex glass beakers or porcelain dishes; one sample shall be covered with distilled water, one with a 3N solution of sulfuric acid and the other with a 50 percent solution of sodium sulfide. After 1 hour of immersion, the glass beads of each sample shall be examined microscopically for evidence of darkening and frosting.

705-3 CONSTRUCTION REQUIREMENTS

The contractor shall install temporary preformed pavement markings at the locations shown on the project plans, as specified in the special provisions, or as directed by the Engineer.

Unless otherwise noted on the project plans or the Special Provisions, Preformed Pavement Markings-Type I (Permanent) shall only be used for symbols and legends and then, only when specifically noted on the bid schedule, the project plans or the Special provisions. Preformed Pavement Markings - Type I (Permanent) shall not be substituted for thermoplastic markings applied by extrusion, ribbon or spray dispensing devices unless approved, in writing, by the Engineer.

Preformed marking tape shall be applied manually or with the tape applicators approved by the tape manufacturer. All markings shall be applied in accordance with the manufacturer's recommendations and as specified herein. Preformed pavement markings shall not be applied over other markings or old paint unless specified in the project plans or directed by the Engineer. The contractor shall remove all old markings and prepare the surface for application in accordance with these specifications and as directed by the Engineer.

Preformed pavement markings shall be applied to surfaces that are free of moisture and thoroughly cleaned of loose, foreign or other material that may adversely affect bonding. The contractor shall remove all dirt, dust, grease, oil or other detrimental material from the road surface. Preformed pavement markings shall be applied immediately after the surface has been prepared or as soon as possible after placement and completion of new pavement. At the time of application, the road surface temperature shall not be less than 60° F (*15 °C*) and the pavement surface shall be absolutely dry. For temporary markings, the weather conditions noted above may be waived at the Engineer's discretion to obtain a traffic stripe prior to allowing traffic to traverse the roadway. Despite the required minimum surface temperature and surface condition, the Engineer, at any time, may require that work cease or that the work day be reduced in the event of weather conditions either existing or expected which would have an adverse effect upon the working conditions.

The contractor shall use butt splices only and shall not overlap the marking material. All markings shall be thoroughly tamped with approved mechanical tampers.

The contractor shall immediately correct all misalignments. The misaligned portions shall be removed and reinstalled in accordance with these specifications. All areas marked with preformed marking tape shall be ready for traffic immediately after application.

Temporary pavement markings shall be maintained and replaced when necessary by the contractor until they are covered with the next overlay course or are removed because they are no longer applicable. The temporary pavement markings shall be removed immediately, when no longer needed for traffic control or when the temporary pavement markings will be in conflict with the succeeding traffic pattern. This removal includes the removal of pronounced markings caused by the adhesive across lanes, transitions or tapers. Removable temporary marking material shall not be burned or ground off. Preformed pavement markings shall be removed by methods recommended by the manufacturer and approved by the Engineer. Residual adhesive, ghosting, shadows, or pavement scarring which might cause confusion during darkness or adverse weather conditions shall be removed or corrected immediately by the contractor when so ordered by the Engineer.

The application of preformed pavement marking shall be in accordance with the recommendations of the manufacturer of the material and these specifications; however, minor changes will be allowed if such are shown to produce an equal or better application and are approved by the Engineer. Failure to satisfactorily adhere to the pavement or to be satisfactorily removable shall be reason for disallowing the use of any particular type of marking material. Approval for use of any type of marking material is subject to satisfactory performance under traffic. Any failure during the time frame the material is scheduled to perform shall be repaired immediately by the contractor. Continued failure of a material to perform shall be cause for disallowing further use of that particular manufacturer's material.

Failure of materials, inadequate marking characteristics or any other confusing or unsafe condition in a construction work zone will not be tolerated. Any condition where the safety of workmen or the travelling public might be endangered shall be remedied immediately by the contractor, if so ordered by the Engineer.

705-4 METHOD OF MEASUREMENT

Measurement of preformed pavement marking symbols and legends will be made for each symbol or legend, as shown on the plans, furnished and applied in accordance with the requirements specified herein and on the plans.

Measurement of preformed pavement marking lines will be made by the linear foot (*meter*) along the center line of the pavement line and will be based on a 4-inch (*100 millimeters*) wide stripe. Measurement for pavement lines with a plan width greater or less than the basic 4-inches (*100 millimeters*) will be made by the following method:

$$\frac{\text{Plan Width of Striping (inches or } \textit{millimeters}\text{) x Linear Feet (}\textit{meters}\text{)}}{\text{4 inches (}\textit{100 millimeters}\text{)}}$$

When Type II or Type III temporary preformed pavement markings are required for maintaining traffic through a construction work zone, but are not listed as pay items in the bidding schedule, they will be considered as included in the lump sum measurement of Maintenance and Protection of Traffic in accordance with Subsection 701-4.

705-5 BASIS OF PAYMENT

The accepted quantities of preformed pavement markings, measured as provided above, will be paid for at the contract unit price for the type specified in the bidding schedule, which price shall be full compensation for the item, complete-in-place, including necessary pavement cleaning, removal of Type II temporary markings, and maintaining Type II and Type III temporary markings in construction work zones.

When Type II or Type III temporary preformed pavement markings are required for maintaining traffic through a construction work zone, but are not listed as pay items in the bidding schedule, they will be considered as included in the lump sum paid for Maintenance and Protection of Traffic in accordance with Subsection 701-5.

Additional payment will be made for replacement of temporary markings when the contractor is required by the Engineer to install marking materials on distressed pavements or during adverse weather conditions and subsequent failure occurs. Distressed pavement conditions are defined as alligator cracking, bleeding, or spalling of bituminous pavements and spalling of PCC pavements. Adverse weather conditions are defined as any occurrence where application is required at pavement temperatures less than 60° F (*15 °C*) or when precipitation occurs within 24 hours before or after application. The Agency will pay for the replacement, when failures occur, at the contract unit price for the initial occurrence.

In the event a second failure occurs when markings have been reapplied on distressed pavements or under weather conditions described above, the Engineer shall determine if conditions require primer, alternate methods of marking or reapplication of preformed markings. Preformed markings will be paid for at the contract unit price. Primers or other methods of markings deemed necessary by the Engineer will be paid for in accordance with the provisions found in Subsection 109-5.

SECTION 706

RAISED PAVEMENT MARKERS

706-1 DESCRIPTION

The work under this section shall consist of cleaning and preparing the pavement surface, furnishing all materials, equipment, tools and labor, and placing raised pavement markers of the type specified at the locations and in accordance with the details shown on the plans and the requirements of these specifications.

706-2 MATERIALS

706-2.01 General. Certificates of Compliance conforming to the requirements found in Subsection 106-5(B) shall be submitted to the Engineer at least ten (10) days prior to installation.

A minimum of one sample per lot per type of marker shall be collected by the Engineer. Pavement marker samples(s) may be tested, at the option of the Agency, to determine conformance with the applicable ADOT Standard Drawings and these specifications.

The base of the pavement markers shall be free from glass glaze or from substances which may reduce its bond to the adhesive. The base shall be flat and it's deviation from a flat surface shall not exceed 0.05-inch (*1.3 millimeters*).

706-2.02 Reflective Pavement Markers. Reflective pavement markers shall be of the following type:

Type C	Clear, red
Type D	Yellow, two-way
Type G	Clear, one-way
Type H	Yellow, one-way
-	Blue, two-way

Reflective pavement markers shall be of the prismatic reflector type consisting of a molded methyl methacrylate or suitably compounded acrylonitrile butadiene styrene (ABS) shell conforming to Federal Specification L-P-380 2, Type I, Class 3, filled with a mixture of an inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and shall contain one or two prismatic reflector faces of the color specified.

When illuminated by an automobile headlight, the color of the reflectors shall be an approved clear, yellow, red, or blue as designated. Reflectors not meeting the required color may be rejected.

Permanent reflective pavement markers will be tested for compressive strength, abrasion resistance, and specific intensity. Permanent reflective pavement markers shall have thin untempered glass or other abrasion resistant material bonded to the prismatic reflector face to provide an extremely hard and durable, abrasive resistant reflector surface.

The glass, or other abrasion resistant surface, is not required on the red faces of two-way (Clear/Red) permanent reflective markers. The area covered by the glass, or other abrasion resistant surface, shall not be less than 1500 square millimeters.

Reflective pavement markers will be tested for compressive strength, specific intensity, and for abrasion resistance.

The strength by compressive loading shall be at least 2,000 pounds (*9.0 kilonewton*).

The original specific intensity of each reflecting surface for both temporary and permanent reflective markers shall not be less than the following:

Reflectance (Degrees Incidence)	Specific Intensity candelas/foot-candle (mcd/lux)			
	Clear	Yellow	Red	Blue
0	3.0 (*280*)	1.8 (*165*)	0.75 (*70*)	*
20	1.2 (*110*)	0.72 (*65*)	0.30 (*30*)	*

* Refer to manufacturer's literature.

Permanent reflective pavement markers shall be subject to an abrasion resistance test as follows:

Steel Wool Abrasion Procedure: Form a 1 inch (*25 millimeter*) diameter flat pad using No. 3 coarse steel wool per Federal Specification FF-W1825. Place the steel wool pad on the reflector lens face. Apply a force of 50 pounds (*222 Newtons*) and rub the entire lens surface 100 times. After the lens surface has been abraded, the specific intensity of each clear and yellow reflective surface shall be not less than that required above for the original specific intensity.

706-2.03 Non-reflective Pavement Markers and Reflectorized Dagmars. Non-reflective pavement markers shall be of the following types:

Type A - White

Type AY - Yellow

Reflectorized Dagmars shall be of the following types:

Type J - White

Type JY - Yellow

Non-reflective pavement markers and reflectorized dagmars shall consist of a heat-fired, vitreous ceramic base and a heat-fired, opaque glazed surface which will produce the required properties. Markers shall be produced from any suitable combination of intimately mixed clays, shales, flints, feldspars, or other

inorganic material which will meet the properties herein required. Markers shall be thoroughly and evenly matured and free from defects which will affect appearance or serviceability.

The top surface of the marker shall be in reasonably close conformity with the configuration shown on the plans. Markers shall be convex and the radius of curvature shall be between 3-1/2 inches (*90 millimeters*) and 6 inches (*150 millimeters*), except that the radius of the 1/2-inch (*13 millimeters*) nearest the edge may be less. All edges shall be rounded and any change in curvature shall be gradual. The top and sides shall be smooth and free of mold marks, pits, indentations, air bubbles, or other objectionable marks or discolorations.

Non-reflective pavement markers and dagmars shall meet the following requirements:

Glaze Thickness, minimum	.005 inch (*0.127 mm*)
Moh Hardness, minimum	6
Directional Reflectance (White Only), minimum	
Glazed Surface	75
Body Marker	70
Yellowness Index (White Only), maximum	
Glazed Surface	0.07
Body of Marker	0.12
Color (Yellow Only)	
Purity, percent, range	75-96
Dominant Wave Length, mu, range	579-585
Total Lummous Reflectance (Y valve), min.	0.41
Compressive Strength, pounds, minimum	1,500 (*6.7 kN*)
Water Absorption, percent, maximum	2.0
Autoclave	Glaze shall not spall, craze or peel

Reflectorized dagmars shall have encapsulated lens reflectors conforming to standard manufacturing practices.

706-2.04 Jiggle Bars.

(A) General. Type K and KY jiggle bars shall be concrete or ceramic, at the option of the contractor, and shall be shaped to conform with the details shown on the plans. The same type of jiggle bar shall be used throughout any one project.

Jiggle bars shall be painted either white or yellow and shall be reflectorized, as shown on the plans. The color shall be uniform.

The bottom surface of the jiggle bars shall be of a roughness comparable to at least that of a fine grade of sandpaper. The bottom surface shall not be grooved such that air will be trapped in the grooves when it is pressed into the epoxy adhesive.

(B) Concrete. Concrete jiggle bars shall be made of Class B concrete conforming to the requirements of Section 1006.

(C)Ceramic. Ceramic jiggle bars shall be made of a heat-fired vitreous base. The glazed surface shall not craze, spall or peel when tested in accordance with the requirements of ASTM C 424 for one cycle at 250 psi (*1.7 megapascals*).

The jiggle bar tiles shall have a compressive strength as follows when tested in accordance with the requirements of ASTM C 773:

Minimum average of five units	6,000 psi (*41 MPa*)
Individual minimum, one unit	5,000 psi (*34 MPa*)

706-2.05 Bituminous Adhesive. A list of approved manufacturers and distributors for bituminous adhesive may be found in the special provisions.

706-3 CONSTRUCTION REQUIREMENTS

The portion of the highway surface to which the marker is to be attached shall be free of dirt, existing painted lines, curing compound, grease, oil, moisture, loose or unsound layers and any other detrimental material which could adversely affect the bond of the adhesive. Newly placed asphaltic concrete pavement need not be sand blasted unless, in the opinion of the Engineer, the surface is contaminated with any material which would adversely affect the bond of the adhesive.

The adhesive shall be placed uniformly on the cleaned pavement surface in an amount sufficient to result in complete coverage of the area of contact of the markers with no voids present and with a slight excess after the marker has been placed. The markers shall be placed in position and pressure applied until firm contact is made with the pavement. The markers shall be protected against impact until the adhesive has set to the degree acceptable to the Engineer.

Excess adhesive on the pavement and on the exposed surfaces of the markers shall be immediately removed. Thinners or solvents which may be detrimental to either the markers or the bond provided by the adhesive shall not be used in removing excess adhesive.

Markers shall not be installed when the temperature of the pavement surface or the atmosphere is less than 40° F (*4 °C*), when the relative humidity is 80 percent or higher, or when the pavement is not surface dry.

All markers shall be installed to the line approved by the Engineer and in such a manner that the reflective face of the marker is perpendicular to a line parallel to the roadway center line. No pavement markers shall be installed over longitudinal or transverse joints of the pavement surface.

706-4 METHOD OF MEASUREMENT

Pavement markers will be measured as a unit for each marker furnished and placed.

706-5 BASIS OF PAYMENT

The accepted quantities of pavement markers, measured as provided above, will be paid for the contract unit price for the type designated in the bidding schedule, complete-in-place, including the adhesive and surface preparation.

SECTION 707

TUBULAR MARKER (FLEXIBLE)

707-1 DESCRIPTION

The work under this Section shall consist of furnishing and installing flexible tubular markers in accordance with the details shown on the project plans and the requirements of these specifications. The work shall also include the removal and salvage of the markers when ordered by the Engineer.

707-2 MATERIALS

The post shall be of a flexible material which is resistant to impact, ultra violet light, ozone, hydrocarbons, and stiffening with age. The base shall prevent post removal by impact or vandals. The post and base shall exhibit good workmanship and shall be free of burns, discoloration, contamination, and other objectionable marks or defects which affect appearance or serviceability.

The post shall be designed to resist overturning, twisting and displacement from wind and impact forces. A 50 mph (*80 kilometer per hour*) wind load shall not deflect the post more than 2 inches (*50 millimeters*) from the at-rest position. Measurement shall be made at the point of maximum deflection and normal to the movement.

The post shall have minimum tensile strength of 1,100 pounds per square inch (*7.6 megapascal*). The tensile stress shall be determined in accordance with the Standard Method of Test for Tensile Properties of Plastic, ASTM Designation D 638 (Test Specimen Type 1). The rate of jaw separation shall be 20 inches per minute (*500 millimeters per minute*).

The post shall be conditioned for a minimum of 2 hours in an oven at 140° F ± 3° F (*60 °C ± 2 °C*). The conditioned post shall be capable of straightening itself within 30 seconds when bent 180 degrees at the midpoint for each of 4 bends. The stress test on each post shall be completed within 2 minutes of removal from oven.

The post shall be sufficiently rigid to resist wilting after conditioning for a minimum of 2 hours at 180° ± 3° F (*82 °C ± 2°C*).

The post shall be conditioned for a minimum of 2 hours at -5° F ± 3° F (*-21 °C ± 2 °C*) in an environmentally controlled test chamber. Testing shall be performed in the environmental chamber. The post shall be sufficiently flexible to permit four 180 degree bends at the midpoint without cracking, each time straightening itself within 60 seconds.

The post shall be manufactured from an impact resistant material so that an installed post is capable of self-erecting and withstanding 10 vehicle impacts at 55 mph (*88 kilometers per hour*) at temperatures of 40° F (*4°C*) or above without breakage or loss

of serviceability. Little or no damage shall be caused to the impacting vehicle. The vehicle shall be a typical sedan with a weight of 4,000 ± 1,000 pounds (*1800 ± 450 kilograms*).

The post shall also be capable of sustaining a wheel hit during testing at 55 mph (*88 kilometers per hour*) without loss of serviceability.

The reflective sheeting shall be a high reflectivity flexible sheeting conforming to the requirements of Section 1007. The sheeting must retain 75 percent of its reflectivity after ten vehicle impacts at 55 mph (*88 kilometers per hour*). Color shall be silver-white, yellow, or green in accordance with the appropriate Federal Highway Administration color tolerance chart.

The base shall prevent post removal by impact or vandals. The base shall not protrude more than 4 inches (*100 millimeters*) above the pavement surface.

707-3 CONSTRUCTION

The base shall be installed with an epoxy adhesive or acceptable alternate, in accordance with the manufacturer's specifications.

When used in a construction work zone, it shall be the contractor's responsibility to keep the tubular markers bright and clean for maximum target value.

When replacement, repair, or resetting of markers is necessary during traffic control in a construction work zone, such work shall be done immediately by the contractor.

707-4 METHOD OF MEASUREMENT

Tubular markers will be measured by the unit for each marker furnished and installed.

707-5 BASIS OF PAYMENT

The accepted quantities of tubular markers, measured as provided above, will be paid for at the contract unit price each, which price shall be full compensation for the work, complete-in-place, as specified herein and as shown on the plans.

It shall be the contractor's responsibility to reset those markers that become detached from the pavement at no additional cost to the Agency.

Where the Engineer determines markers are in need of repair, such repairs shall be made by the contractor and will be paid for in accordance with the provisions of Subsection 109-5.

Where the Engineer determines markers need to be replaced, such replacement shall be made by the contractor and additional payment will be made at the contract unit price.

No measurement or direct payment will be made for removing, hauling and stockpiling salvaged markers, the cost being considered as included in the cost of the contract items.

SECTION 708

PAINTED PAVEMENT MARKINGS

708-1 DESCRIPTION

The work under this section shall consist of cleaning and preparing the pavement surface, furnishing all materials and applying white or yellow, water-borne, lead-free, rapid-dry traffic paint and reflective glass beads at the locations and in accordance with the details shown on the project plans, the Manual on Uniform Traffic Control Devices (MUTCD), the Special Provisions and the requirements of these specifications, or as directed by the Engineer.

708-2 MATERIALS

708-2.01 Pavement Marking Paint.

(A) General. All material used in the formulation of the pavement marking paint shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Engineer.

Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted for each lot or batch of paint prior to its use.

(B) Composition Requirements. The pavement marking paint shall be a ready-mixed, one component, water-borne traffic line paint, of the correct color, to be applied to either asphaltic or portland cement concrete pavement. The composition of the paint shall be determined by the manufacturer. It will be the manufacturer's responsibility to produce a pigmented water-borne paint containing all the necessary co-solvents, dispersant, wetting agents, preservatives and all other additives, so that the paint shall retain its viscosity, stability and all of the properties as specified herein. The manufacturer shall certify that the product does not contain mercury, hexavalent chromium, toluene, chlorinated solvents, hydrolysable chlorine derivatives, ethylene-based glycol ethers and their acetates, nor any carcinogen, as defined in 29 CFR 1910.1200. The certification shall indicate a lead content not exceeding 0.06 percent by weight of the dry film, and the test for chromium content shall be negative.

No glass beads will be allowed in the pavement marking paint. Glass beads will be applied after the paint has been applied.

(C) Manufacturing Formulations. The manufacturer shall formulate the pavement marking paint in a consistent manner and notify the Engineer of any change of formulation. The formulation of the paint shall be determined by the manufacturer. It will be the manufacturer's responsibility to formulate paint which will meet the quantitative and qualitative requirements of this specification. Any change in the formulation of the paint must be approved by the Engineer.

(D) Quantitative Requirements of Mixed Paints:

	White	Yellow
Pigment: Percent by weight, ASTM D 3723, Allowable variation from qualifying sample	± 2.0	± 2.0
Non-Volatile Content: Percent by weight, ASTM D 2369, allowable variation from qualifying sample	± 2.0	± 2.0
Viscosity: Krebs Units at 77 ± 1° F, ASTM D 562	70 – 85	70 – 85
Weight per Gallon: Pounds per gallon 77 ± 1° F, ASTM D 1475P, allowable variation from qualifying sample	± 0.3	± 0.3
Vehicle Composition: Vehicle Infrared Spectra, ASTM D 2621, allowable variation from qualifying sample	None	None
pH: ASTM E 70, Allowable variation from qualifying sample	± 1.0	± 1.0
Fineness of Dispersion: HEGMAN, minimum, ASTM D 1210	3.0	3.0
Volatile Organic Compounds: Pounds per gallon of paint, maximum, ASTM D 3960 according to 7.1.2.	2.1	2.1
Flash Point: Degrees F., minimum, ASTM d 93, Method A	100	100
Dry Time to No Pick Up: With no beads: minutes, maximum, ASTM D 711	10	10
Dry Through Time: Minutes, ASTM D 1640 except no thumb pressure is used when thumb is rotated 90° on paint film	20	20
Flexibility: TT-P-1952D	Pass	Pass

(E) Qualitative Requirements:

(1) Color of Yellow Paint: The color of the yellow paint shall closely match Federal Standard 595b, Color No. 33538. The color shall be checked visually, and will be checked against Tristimulus Values for the color according to Federal Test Method Standard No. 141.

(2) Dry Opacity: Dry opacity for the paint will be determined using a black-white Leneta Chart, Form 2C Opacity and a Photovolt 577 Reflectance Meter or equal. Using a 10-mil gap doctor blade, a film of paint is drawn down, covering both black and white portions of the chart. The film shall be

allowed to dry 24 hours. After calibrating the Reflectance Meter according to the manufacturer's instructions, measure the reflectance over the white and black portions with the green Tristimulus filter. Dry Opacity is calculated as follows:

$$\text{Dry Opacity} = \frac{\text{Reflectance over black}}{\text{Reflectance over white}}$$

Dry Opacity for both white and yellow paint shall be a minimum 0.90.

(3) Yellowness Index: Yellowness Index for white paint will be determined as described for dry opacity, only use a 15-mil gap doctor blade to draw down the paint. After 24 hours for drying, measure the reflectance of the paint film, using the green, blue, and amber Tristimulus filters. Calculate the Yellowness Index as follows:

$$\text{Yellowness Index} = \frac{\text{Amber - Blue}}{\text{Green}} \times 100$$

Yellowness Index for the white paint shall be a maximum of 10.

(4) Reflectance: Reflectance for both white and yellow paint will be determined using the same 15-mil draw-down film as for the Yellowness Index. For white paint, the same sample may be utilized for both the Yellowness Index and Reflectance. Measure the reflectance of the paint film using the green Tristimulus filter. Reflectance for the white paint shall be a minimum of 85. Reflectance for the yellow paint may range from 42 to 59, inclusive.

(5) UV Color Durability: UV Color Durability shall be determined using a QUV Weatherometer, with Ultra Violet Light and Condensate Exposure according to ASTM G 53, for 300 hours total. The repeating cycle shall be four hours UV exposure at 60 °C followed by four hours condensate exposure at 40 °C. After 300 hours of exposure, the Yellowness Index for white paint shall not exceed 12, and yellow paint must still match Federal Standard 595b, Color No. 33538.

(6) Static Heat Stability: To determine static heat stability for the paint, place one pint of paint in a sealed can and heat in an air circulation oven at 120 ± 1° F for a period of one week. Remove the paint from the oven and check the viscosity in Krebs Units at 77 ± 1° F according to ASTM D 562. The viscosity measured must be in the range from 68 to 90, inclusive. Also, check for any signs of instability.

(7) Heat-Shear Stability: To determine heat-shear stability for the paint, one pint of the paint is sheared in a Waring Blender at high speed to 150° F. The blender should have a tight fitting lid taped onto it to minimize volatile loss. When the paint reaches 150° F, stop the blender, immediately pour

the paint into a sample can, and apply a cover to seal the can. Let the paint cool overnight and examine for jelling or other signs of instability. Measure viscosity in Krebs Units at 77 ± 1° F according to ASTM D 562. The viscosity measures must be in the range from 68 to 95 inclusive. If not within the upper limit, run total solids on the sheared paint and adjust solids, if necessary, by adding water to reach the original solids content. If the solids content required adjustment, again check the viscosity of the paint. The viscosity must be in the range from 68 to 95 inclusive.

(8) Scrub Resistance: Scrub Resistance will be determined according to ASTM D 2486. Use an appropriate doctor blade to provide a dry film thickness of three to four mils. Allow the paint to cure for 24 hours. Perform the scrub resistance test at 77 ± 1° F and 50 ± five percent humidity. Record the number of cycles to remove the paint film. The number of cycles recorded must be a minimum of 800.

(9) Spraying Properties: The paint shall be applied at a 15 mils (*375 micrometers*) wet film thickness in the field. The paint shall show the following properties at ambient temperatures of 50° F to 100° F (*10 °C to 38 °C*) with a paint spray temperature of 150° F (*65 °C*), maximum, and 6 to 8 pounds of post-applied glass beads per gallon (*0.7 to 0.9 kilograms per liter*) of paint conforming to Subsection 708-2.02 of these specifications:

(a) Dry to a no-track condition in five minutes or less when the line is crossed over in a passing maneuver with a standard-sized automobile.

(b) Produce a clean-cut, smooth line with no overspray or puddling.

(c) Paint immediately after application shall accept glass beads so that the spheres shall be embedded into the paint film to a depth of 50 percent of their diameter.

(d) Paint when heated to the temperature necessary to obtain the specified dry time, shall show no evidence of instability such as viscosity increase, jelling, or poor spray application.

(10) Freeze-Thaw Properties: The paint viscosity or consistency shall not change significantly when the paint is tested for resistance to five cycles of freeze-thaw according to ASTM D 2243.

(11) Workmanship: Paint shall be free from foreign materials, such as dirt, sand, fibers from bags, or other material capable of clogging screens, valves, pumps, and other equipment used in a paint striping apparatus.

The paint pigment shall be well ground and properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of a paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. If the paint cannot be easily redispersed, due to excessive pigment settlement as described above or due to any other cause, the paint shall be considered unfit for use.

The paint shall retain all specified properties under normal storage conditions for 12 months after acceptance and delivery. The contractor shall be responsible for all costs and transportation charges incurred in replacing paint that is unfit for use. The properties of any replacement paint, as specified herein, shall remain satisfactory for eight months from the date of acceptance and delivery.

(F) Manufacturing Requirements:

(1) Inspection: The manufacturer of the paint shall advise the Engineer when paint is to be manufactured, shall furnish the Engineer free access to all parts of the plant involved in the paint manufacture, and shall furnish every reasonable facility for sampling both the paint and the raw materials during the process of manufacturing.

All materials used in formulation shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Engineer.

All manufactured paint shall be prepared at the factory ready for application.

When paint is shipped to a distributor or paint applicator who will store the paint prior to its use, the distributor or paint applicator shall furnish the Engineer free access to all parts of the facility where paint is stored and shall furnish every reasonable facility for sampling the paint.

Paint shall normally be sampled at the place of storage either at a warehouse or on the site prior to application of the paint. Application of the paint will not be permitted until the paint has been approved by the Engineer. It is the contractor’s responsibility to notify the Engineer a minimum of 14 working days prior to any traffic painting operation and to allow access at that time for paint sampling at the storage location.

A minimum of one paint sample shall be obtained from each lot of paint.

Check-samples of finished paint while being applied will be taken at intervals as determined by the Engineer.

(2) Testing: All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141.

Evidence of adulteration or improper formulation shall be cause for rejection.

(3) Packaging: All shipping containers for paint must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulation Board, Reference 49 CFR. The container and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

Containers shall be colored white, including lids, and containers shall have an identifying band of the appropriate color around and within the top one third of the container.

All containers shall be properly sealed with suitable gaskets, shall show no evidence of leakage, and shall remain in satisfactory condition for a period of 12 months after delivery to a distributor or paint applicator. The contractor shall be responsible for all costs and transportation charges incurred in replacing paint and containers.

(4) Marking: All containers of paint shall be labeled showing the manufacturer's name, date of manufacture, paint color, product code, manufacturer's batch number, and quantity or weight of paint on both the side of the container and also the lid. Containers shall be clearly marked or labeled Rapid or Fast Dry lead-free Water-Borne Traffic Paints.

All containers of paint shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of Arizona, Pima County.

The manufacturer of the paint shall be responsible for proper shipping labels with reference to whether the contents are toxic, corrosive, flammable, etc., as outlined in the U.S. Department of Transportation, Hazardous Materials Regulations, Reference 49 CFR.

(5) Unused Paint: Disposal of unused quantities of traffic paint shall be the responsibility of the contractor and must meet all applicable Federal regulations for waste disposal. Paint which is saved to be used later shall be packaged as specified previously and shipped to a storage location. Unused paint must be identified on the container. Unused paint may be utilized on a future project provided the paint still conforms to all specifications contained herein.

708-2.02 Reflective Glass Beads (Spheres).

(A) General. The term "glass bead" shall be synonymous with the term "glass sphere" as used herein.

The beads shall be manufactured from glass of a composition designated to be highly resistant to traffic wear and to the effects of weathering.

The glass beads shall be moisture-proof; contain less than 0.25 percent moisture by weight; and be free of trash, dirt, or other deleterious materials.

Beads shall be essentially free of sharp angular particles showing milkiness or surface scoring or scratching. Beads shall be water white in color.

(B) Physical Requirements.

(1) Gradation: When tested by the method provided in ASTM D 1214, the grade sizes of the beads shall be as follows:

Size of Sieve	Percent Passing
No. 30 (*600 μm*)	100
No. 50 (*300 μm*)	15 – 35
No. 70 (*212 μm*)	0 – 15
No. 100 (*150 μm*)	0 – 5

(2) Roundness: When tested by the method provided in ASTM D 1155 (Procedure B except Paragraphs (F) and (G) are deleted), beads retained on any screen specified in the gradation requirements shall contain a minimum of 75 percent true spheres.

(3) Index of Refraction: When tested by a liquid immersion method at a temperature of 25 °C, the beads shall have an index of refraction of 1.50 to 1.57.

(4) Specific Gravity: The specific gravity of the beads shall be in the range 2.40-2.60 when tested in accordance with the following procedures:

(a) Place 100 grams in an oven at 110 °C for one hour.

(b) Remove beads and place in a desiccator until the sample is cool.

(c) Remove approximately 60 grams of beads from the desiccator and weigh the sample accurately.

(d) Pour the beads slowly into a clean 100-milliliter graduated cylinder containing 50 milliliters of isopropyl alcohol. Make certain that air is not entrapped among the beads.

(e) The total volume, minus 50, will give the volume of the

beads.

(f) Calculate the specific gravity as follows:

$$\text{Specific Gravity} = \frac{\text{Weight of the sample}}{\text{Volume of the sample}}$$

(5) Chemical Stability: Beads which show any tendency toward decomposition, including surface etching, when exposed to atmospheric conditions, moisture, dilute acids, or alkalis or paint film constituents, may be required to demonstrate satisfactory reflectance behavior, prior to acceptance, under such tests as may be prescribed.

(C)Moisture Proofing. All glass beads shall have a moisture-proof overlay consisting of water repellent material applied during the process of bead manufacture. The beads so treated shall not absorb moisture in storage and shall remain free of clusters and lumps and shall flow freely from dispensing and testing equipment.

The beads shall pass the test for water repellency and free flow using the following equipment:

(1) Test Bag: The bag used is approximately 10-1/2 inches (*265 millimeters*) by 17-1/2 inches (*490 millimeters*) after sewing. The material used in the construction of the bag is unbleached cotton sheeting with a thread count of 48 by 48. The material before sewing is approximately 18 inches (*450 millimeters*) by 22 inches (*550 millimeters*). The cloth is folded in half lengthwise and stitched in the shape of an "L" with the short side left open at the top. The material can be obtained from selected manufacturers of cloth and paper packaging. The finished bag may also be obtained from the manufacturer of the glass beads.

Newly fabricated bags must be thoroughly washed with hot water and detergent and rinsed before use to remove the sizing which may be present in the cloth. Subsequent to the initial washing, the bags need only be rinsed clean of beads from previous tests and dried thoroughly before use.

(2) Funnel: The funnel used is a standard laboratory funnel with a top opening diameter of 125 millimeters and a 150 millimeter stem length. The inside diameter of the stem is between nine and 10 millimeters. This funnel is available from most laboratory glassware supply houses, Corning No. 6100 or equal.

(3) Ring Stand and Clamp.

(4) Balance accurate to 0.1 grams.

(5) Distilled water.

Moisture Testing Procedure:

Glass beads shall be tested for compliance with specification requirements. Testing shall be conducted at standard conditions of temperature (25 ± 1 °C) and humidity (50 ± five percent Relative Humidity) and shall consist of the following procedure or an approved alternate:

(1) Weigh 900.0 grams of glass beads into a clean, dry, flat-bottomed pan.

(2) Dry beads at 150 °C for two hours.

(3) Cool beads to room temperature (25 ± 1 °C) in a desiccator.

(4) Using the clean, pre-washed bag described under apparatus section, turn the bag inside-out so that the sewn seam and seam-allowance are on the outside.

(5) Quantitatively transfer the beads into the inverted cotton bag.

(6) Grasp the gathered top of the bag with one hand and lower the bag into a container of distilled water until the beads are approximately one inch below the water level. The container shall be of such dimensions that the bag does not contact the bottom or sides during immersion. Each bag shall be immersed individually. Do not allow one bag to contact another if multiple tests are run.

(7) Remove the bag after 30 seconds of immersion time.

(8) Cradle the bottom of the bag uniformly in the palm of one hand and twist the top neck of the bag until the twisted bag is compressed firmly against the beads. Twist until excess water no longer drips from the bag.

(9) After the excess water has been squeezed from the bag, allow the bag to unwind.

(10) Gather the top of the bag and clamp. Suspend the bag on a ring stand or other support such that the bottom or sides of bag do not contact the support.

(11) After a standing time of two hours at room temperature (25 ± 1 °C), remove bag from support. Mix sample thoroughly by holding the bottom seam allowance in one hand and gathered neck of the bag in the other, invert bag and shake up and down five times. Transfer the sample into a clean, dry funnel of the type described under apparatus. If consecutive tests are run, be sure the funnel is clean, dry and free of beads from prior tests.

(12) The entire sample shall flow through the funnel without stoppage.

(13) At the start of the test only, it is permissible to

lightly tap the stem of the funnel to initiate flow.

(14) Small quantities of beads which have adhered to the side of the funnel or stem shall not be cause for failure.

708-3 CONSTRUCTION REQUIREMENTS

708-3.01 Equipment. The traffic paint and beads shall be placed on the pavement by a spray-type, self-propelled pavement marking machine except that temporary striping during construction may be placed with other equipment designed for application of paint and beads.

The application equipment to be used on roadway installation shall have, as a minimum, the following characteristic and/or apparatus:

(1) The machine shall be capable of applying clear-cut lines of the width specified on the project plans.

(2) The machines shall be equipped with a mechanical device capable of placing a broken reflectorized line with a 10 foot (*3 meter*) painted segment and a 30 foot (*9 meter*) gap.

(3) The machine shall be equipped with an air-operated glass bead drop-in dispenser controlled by the spray gun mechanism.

A glass bead dispenser, which is capable of placing the glass beads into the paint line as the paint is applied to the pavement, shall be utilized. This dispenser shall provide satisfactory marking and delineation.

708-3.02 Application. Pavement markings shall be applied when the pavement surface is dry and the weather is not foggy, rainy, or otherwise adverse to the application of markings. The surface shall be free from excess asphalt or other deleterious substances before traffic paint, beads or primer are applied. The contractor shall remove dirt, debris, grease, oil, rocks, or chips from the pavement surface before applying markings. The method of cleaning the pavement surface and removal of detrimental material is subject to approval by the Engineer and shall include sweeping and the use of high-pressure air spray. The placing of traffic markings shall be done only by personnel who are experienced in this work.

Painting shall not be performed when the atmospheric temperature is below 50° F (*10 °C*) when using water-borne paint, nor when it can be anticipated that the atmospheric temperature will drop below said 50° F (*10 °C*) temperature during the drying period. Water-borne paints shall not be applied if rain is expected within one hour of its application, unless otherwise approved by the Engineer. Water-borne paint shall not be heated to a temperature greater than 150° F (*65 °C*) to accelerate drying.

The volume of paint in place shall be determined by measuring the paint tank with a calibrated rod. At the option of the Engineer, if the striping machine is equipped with air-atomized spray units (not airless) and paint gauges, the volume of paint may be determined by utilizing said gauges.

The quantity of glass reflectorizing beads in place shall be determined by measuring the glass reflectorizing bead tank with a calibrated rod.

The contractor shall provide the necessary personnel and equipment to divert traffic from the installation area where the work is in progress and during drying time when, in the opinion of the Engineer, such diversion of traffic is necessary.

Tolerances for Placing Paint, Beads, and Primer:

(1) The length of painted segment and gap shall not vary more than 6 inches (*150 millimeters*) in a 40 foot (*12 meter*) cycle.

(2) The finished line shall be smooth, aesthetically acceptable and free from undue waviness.

(3) Painted lines shall be either 4 inches (*100 millimeters*), 8 inches (*200 millimeters*), or 12 inches (*300 millimeters*) wide as shown on the plans with a tolerance of ± 1/8 inch (± *3 millimeters*) and shall be placed at a minimum rate of 16 gallons per mile (*38 liters per kilometer*) for a solid 4 inch (*100 millimeter*) line and 4 gallons per mile (*9.5 liters per kilometer*) for a broken 4 inch (*100 millimeters*) line, based on a 10 foot (*3 meter*) stripe and a 30 foot (*9 meter*) gap (40 foot (*12 meter*) cycle aggregate).

(4) Glass reflectorizing beads shall be applied on the wet paint at a minimum rate of 6 pounds per gallon (*0.7 kilograms per liter*) of paint.

(5) Wet thickness shall not be less than 15 mils (*375 micrometers*).

708-4 METHOD OF MEASUREMENT

Pavement marking paint will be measured by the linear foot (*meter*) along the centerline of the pavement stripe. Skips in dashed lines will not be included in the measurement. Length of pavement markings will be based on 4 inch (*100 millimeter*) wide stripe. Measurement for striping with a plan width greater or less than the basic 4 inches (*100 millimeters*) as shown on the plans or directed by the Engineer will be made by the following method:

$$\frac{\text{Plan width of Striping (inches or } millimeters\text{)} \times \text{Linear Feet (}meters\text{)}}{\text{4 inches (}100\ millimeters\text{)}}$$

Symbols and legends will be measured by each unit applied. Each legend, regardless of the number of letters, will be considered as a single unit.

701-5 BASIS OF PAYMENT

Pavement striping of the type specified, measured as provided above, will be paid for at the contract price per linear foot (*meter*) for the total length of painted line applied to the nearest foot (*meter*) which price shall be full compensation for the work complete, including glass beads, as described and specified herein and on the project plans.

Pavement symbols and legends measured as provided above, will be paid for at the contract price for each painted symbol or legend, which price shall be full compensation for the work complete, including glass beads, as described and specified herein and on the project plans.

SECTION 730

GENERAL REQUIREMENTS FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

730-1 DESCRIPTION

The purpose of this section is to provide general information necessary for completion of the work on traffic signal and street lighting systems in accordance with the Agency's standard drawings or standard details, the details shown on the project plans and requirements of these specifications.

All electrical systems and appurtenances shall be complete, functional and in operating condition at the time of acceptance.

730-2 DEFINITIONS

The words defined in the following subsection shall, for the purpose of these specifications, have the meanings ascribed to them pertaining to signals and lighting.

730-2.01 Actuation. The operation of any type of controller initiated by a detector.

730-2.02 Back Plate. A thin metal strip extending outward parallel to the signal face on all sides of a signal housing to provide suitable background for the signal indications.

730-2.03 Controller. That part of the controller assembly which performs the basic timing and logic functions for the operation of the traffic signal.

730-2.04 Controller Assembly. The complete assembly for controlling the operation of a traffic signal, consisting of a controller unit, all auxiliary and external equipment, and a weatherproof cabinet.

730-2.05 Cycle. A complete sequence of signal indications.

730-2.06 Detector. A device for indicating the passage or presence of vehicles or pedestrians.

(A) Inductive Loop Detector. A detector capable of sensing the passage or presence of a vehicle by a change in the inductance characteristics of the wire loop.

(B) Pedestrian Detector. A detector for pedestrians, usually of the button type.

730-2.07 Flasher. A device used to open and close signal circuits at a repetitive rate.

730-2.08 Flashing Feature. This feature, when operated, discontinues normal signal operation and causes a predetermined combination of flashing signal lights.

730-2.09 Interval. The part or parts of the signal cycle during which signal indications do not change.

730-2.10 Luminaire. The assembly which houses the light source and controls the light emitted from the light source. Luminaires consist of a housing, lamp socket, reflector, ballast, and glass globe or refractor when specified.

730-2.11 Manual Operation. The operation of a signal controller unit by means of a hand-operated switch.

730-2.12 Mounting Assembly. The framework and hardware required to mount the signal face(s) and pedestrian signal(s) to a pole or mast arm, or to a messenger cable.

730-2.13 Pedestrian Signal. A traffic control signal for the exclusive purpose of directing pedestrian traffic at signalized locations.

730-2.14 Red Clearance Interval. A clearance interval which follows the yellow change interval during which both the terminating phase and the next right-of-way phase display red.

730-2.15 Signal Face. An assembly controlling traffic in a single direction and consisting of one or more signal sections. Circular and arrow indications may be included in a signal assembly. The signal face assembly shall include the backplate and visors.

730-2.16 Signal Indication. The illumination of a signal section or other device, or of a combination of sections or other devices, at the same time.

730-2.17 Signal Section. A complete unit for providing a signal indication consisting of a housing, lens, reflector, lamp receptacle and lamp.

730-2.18 Traffic Phase. A part of the time cycle allotted to any traffic movement or combination of movements receiving the right-of-way during one or more intervals.

730-2.19 Traffic-Actuated Controller. A controller for operating traffic signals in accordance with the varying demands of traffic as registered with the controller unit by detectors.

730-2.20 Vehicle. Any bicycle or motor vehicle normally licensed for highway use.

730-2.21 Yellow Change Interval. The first interval following the green right-of-way interval in which the signal indication for the phase is yellow.

730-3 REGULATIONS AND CODES

All electrical equipment shall conform to the standards of National Electrical Manufacturers Association (NEMA), National Electric Safety Code (NESC), Underwriters' Laboratory Inc. (UL), and/or the Electronic Industries Association (EIA), when applicable. All materials and workmanship shall conform to the requirements of the National Electric Code (NEC), Illumination Engineers Society (IES), Standards of the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), Institute of Transportation Engineers (ITE), requirements of the plans, these specifications, and the special provisions, and to any other codes, standards, or ordinances of the applicable city, town or county which apply. Whenever reference is made to any of the standards mentioned, the reference shall be construed to mean the code, ordinance, or standard that is in effect at the time of the bid advertisement.

730-4 EQUIPMENT LIST AND DRAWINGS

The contractor shall note that approval by the Engineer is required before ordering or installing any material that is to be used on the project.

A Certificate of Compliance, conforming to the requirements of Subsection 106-5(B) shall be submitted for all poles, mast arms and bolts, nuts and washers.

The contractor shall submit three copies of a complete project material list for approval at the pre-construction conference which shall conform to these specifications. The project material list shall state all relevant information regarding materials and equipment to allow the Agency to procure exact replacements of any or all items on the project. To be acceptable, the material list shall be complete and contain all items supplied on the project by the contractor. The Agency reserves the right to reject an incomplete or unclear material list submittal.

The materials on the list shall be identified by the contract project number, bid item numbers, catalog part numbers, catalog cuts, shop drawings for signal and lighting equipment, trade names, and schedules for other pertinent information. The materials from any catalog cuts shall be clearly indicated by the contractor. Any material designations used in the contract documents shall be so noted on the materials list. If requested by the Engineer, the contractor shall submit manufacturer shop drawings for review and approval.

There shall be no substitution for any of the materials on the list without prior written approval by the Engineer. Changes to the approved materials list shall be submitted in writing to the Engineer. If requested by the Engineer, the contractor shall

submit samples of the proposed materials for inspections, testing, and approval by the Agency. The Agency will not be liable for any electrical materials procured or any labor performed prior to approval.

When the plans include lighting, the contractor shall submit three copies of photometric data sheets indicating the IES distribution classification for each type of luminaire submitted for approval. In addition, the contractor shall submit data from the manufacturer detailing lamp socket positions in relation to lamps and optical systems furnished for each IES distribution type specified. If required by the special provisions, the contractor shall provide computer printout grids of both luminance and illuminance values for the spacing, height, roadway width, and type of luminaire submitted.

The contractor shall provide complete wiring diagrams for controller assemblies and auxiliary controller cabinets at the time of delivery for testing. A mylar original and four sets of prints shall be provided with each controller assembly. The wiring diagram shall illustrate all circuits and components in detail. All components shall be identified by name or number so as to be clearly noted in the drawings.

730-5 WARRANTIES AND GUARANTIES

Manufacturer's warranties and guaranties, furnished for materials and equipment used in the work, shall be delivered to the Engineer prior to acceptance of the project. Warranties and guaranties shall conform to the requirements of Subsection 106-13.

730-6 LOCATIONS OF UTILITIES

The locations of utilities shown on the project plans are approximate. All involved utilities may not be shown on the plans.

In addition to the requirements of Subsection 107-21, the contractor's attention is directed to the requirements of A.R.S. 40-360.21 through .29 requiring all parties excavating in public streets, alleys or utility easements to first secure the locations of all underground facilities in the vicinity of the excavation.

The contractor shall contact the Blue Stake Center at least two working days prior to commencing excavation, for information relative to the location of buried utilities within the project limits. The contractor shall also be responsible for directly contacting, at least 48 hours prior to commencing excavation operations, all utilities which are not participants in the Blue Stake program.

730-7 ELECTRICAL SERVICE APPLICATION

The Agency shall supply a service address to the contractor and make application for electrical service to the power company.

All electrical service requirements and connections shall be coordinated with the local electric utility. The contractor shall contact the local electric utility and provide four weeks prior notice for new power service for the traffic signal controller and the street lighting system controller.

Any existing traffic signal telephone interconnect shall be maintained during all construction phases.

730-8 PERMITS

The contractor shall be responsible for obtaining all permits required for the work in accordance with Subsection 107-2.

No unprotected excavation shall be left open overnight or during periods from Friday afternoon to Monday morning, or holidays.

SECTION 731

STRUCTURAL SUPPORTS AND FOUNDATIONS FOR TRAFFIC SIGNAL AND STREET LIGHTING SYSTEMS

731-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing new supports and foundations for traffic signal and street lighting systems or modifying poles and mast arms of existing systems at the locations shown on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

Pole foundations shall include all conduit, elbows, anchor bolts, grounding wire and reinforcing steel. Cabinet foundations shall include ground rod(s), conduit, elbows, anchor bolts and service pad.

731-2 MATERIALS

731-2.01 Foundations. Excavation and backfill shall conform to the requirements of Subsection 203-5.03. Concrete shall conform to the requirements of 601 and 1006. Reinforcing steel and wire mesh shall conform to the requirements of 606 and 1003. Grout for use on foundations shall be a non-metallic, non-shrink type and shall be approved by the Engineer.

Concrete for all foundations shall be Class S and shall have a required 28-day compressive strength of 3,000 psi (*20.7 megapascals*).

731-2.02 Standard Steel Poles

(A) General. Standard steel poles for traffic signals and street lighting shall include pole shafts, pole bases, handhole covers, pole top caps, and pole extensions.

Material standards for traffic signal and lighting supports shall be in conformance with the current edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals. All pole supports, except Type K and R, shall be designed to withstand 70 mile per hour (*110 kilometer per hour*) winds. Type K & R poles shall be designed to withstand 80 mile per hour (*130 kilometer per hour*) winds. Metal parts of standard steel poles and hardware shall conform to the details shown on the plans and the following specifications and they shall be fully galvanized in accordance with ASTM A 123, unless otherwise specified. Welding shall conform to the requirements of Subsection 604-3.06.

The manufacturer shall certify the wind speed for which the pole is designed for and indicate the maximum supported weight for equipment, the location of equipment, the wind cross section of equipment and the pole extension length. The manufacturer shall also indicate any precautions regarding drilling of holes in the pole.

(B) Pole Shafts. Tapered pole shafts shall be fabricated from sheet steel of weldable grade which shall meet or exceed the minimum strength requirements of ASTM A 36, for all poles except the Type K and R poles and Type 1 street light poles. The Type K and R poles shall be constructed from sheet steel that has a minimum yield stress, after fabrication, of 48,000 psi (*330 megapascals*). A taper rate of 0.14 inches in diameter per linear foot (*12 millimeters per linear meter*) shall be required unless otherwise specified. Pole shafts shall be galvanized in accordance with the requirements of ASTM A 123. Pole shafts shall be fabricated according to the gauge and strength requirements shown on the plans and/or the Agency's standard drawings or standard details and shall be straight and true.

Pole shafts shall be galvanized in accordance with the requirements of ASTM A 123. The visual appearance of the galvanized finish shall be uniform. Discoloration of the galvanized finish such as dark areas, dark streaks, dark rings or transportation handling marks which are considered excessive by the Engineer shall not be allowed. Pole shafts that have a finish unacceptable to the Engineer shall either be repaired or replaced to the satisfaction of the Engineer at no additional cost to the Agency.

Hand holes in the base of the poles shall conform to the details shown on the Agency's standard drawings or standard details. All welds shall be continuous and any exposed welds, except fillet welds, shall be ground flush with the base metal.

A metal tag shall be permanently attached to the pole and mast arm above the hand hole stating the manufacturer's name, pole type per the Agency's standard drawings or standard details reference number, pole drawing number, shaft length, gauge number, and year.

(C) Steel Pole Extensions and Twin Luminaire Brackets. Pole extensions and twin luminaire brackets shall be fabricated from new pipe conforming to the requirements of ASTM A 53. All welding shall conform to the requirements of Subsection 604-3.06. Pole extensions and twin luminaire brackets shall be fully galvanized in accordance with the requirements of ASTM A 123. Fabrication of the pole extensions and twin luminaire brackets shall be in accordance with the dimensions as specified in the Agency's standard drawings or standard details.

(D) Standard Bases. Poles shall have standard bases unless break-away or slip-away bases are specified. Standard bases shall be fabricated from structural steel plates conforming to the minimum strength requirements of ASTM A 36. Exposed surfaces shall be finished smooth and all exposed edges shall be neatly rounded to a 1/8-inch (*3 millimeter*) radius. Standard bases shall be galvanized with the requirements of ASTM A 123.

(E) Slip-Away Bases. Slip-away bases shall be fabricated from structural steel conforming to the requirements of ASTM A 36. Exposed surfaces shall be finished smooth and all exposed edges shall be neatly rounded to a 1/8-inch (*3 millimeter*) radius. Slip-

away bases shall be galvanized in accordance with the requirements of ASTM A 123 and shall have all the necessary hardware to make a complete and functioning unit. High strength flat washers, bolts and nuts used to connect slip-away base plates shall conform to the requirements of ASTM A 325 and shall be electro galvanized in accordance with the requirements of ASTM B 633. Slip-away bases shall be used on roadway lighting poles where specified on the plans.

(F) Break-Away Bases. Break-away bases shall be fabricated from 365 T4 or SG 70AT6 aluminum alloy. The base shall be heat-treated in accordance with the requirements of ASTM B 108, temper designation T6, before shipment. The break-away base shall have all the necessary hardware to make a complete and functional unit. Bolts, washers and nuts shall meet or exceed ASTM A 36 (A 36M) minimum strength requirements and shall be fully galvanized in accordance with ASTM A 153.

Break-away bases shall be certified by the manufacturer to meet or exceed the change in momentum requirements of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, and to be acceptable for use on Federal Aid projects. The manufacturer shall also certify that the break-away base has been tested and approved by the Federal Highway Administration and that the castings have the same chemistry, mechanical properties, and geometry as the castings used in the tests.

Break-away bases shall be used where specified on the plans.

(G) Anchor Bolts. All anchor bolts shall be threaded at the top and shall conform to the Agency's standard drawings or standard details.

Standard anchor bolts, washers, and nuts shall be fabricated from steel conforming to the strength requirements of ASTM A 36 (A 36M). The anchor bolts, washers, and nuts shall be fully galvanized in accordance with the requirements of ASTM A 153.

High strength anchor bolts, washers and nuts shall be fabricated from steel which meets or exceeds the minimum requirements of ASTM A 325 (A 325M) and shall be electro-galvanized in accordance with the requirements of ASTM B 633. Welding shall not be performed on any portion of the body of these anchor bolts.

Certificates of Analysis conforming to the requirements of Subsection 106-5(C) shall be submitted for high strength anchor bolts, washers, and nuts.

(H) Type 2 Street Lighting Pole. Type 2 street lighting poles shall be single-assembled units consisting of the pole shaft, tapered arm, pipe arm end, base plate and anchor bolts.

The unit components shall be fabricated from sheet steel of weldable grade according to the gauge and strength requirements shown on the plans and/or the standard drawings or Standard Details. All welds shall be continuous, and any exposed welds, except fillet welds, shall be ground flush with the base metal.

Hand holes in the base of the pole shaft shall conform to the details shown on the standard drawings or Standard Details. All welds shall be continuous and any exposed welds, except fillet welds, shall be ground flush with the base metal.

A metal tag shall be permanently attached to the pole shaft above the hand hole stating the manufacturer's name, pole type per the standard drawings or Standard Details reference number, pole drawing number, shaft length, pipe arm length, gauge number and year.

Each pole shall receive a stenciled number at the pole base. These numbers will be shown on the plan sheets, or provided for the contractor during the preconstruction meeting.

731-2.03 Wood Poles.

(A) General. Wood poles shall consist of full length, pressure treated material. Unless specified herein, material, treatment, and preservatives shall be in accordance with the latest revisions of the AWPA Book of Standards.

No deviations from these specifications will be allowed without the written approval of the Engineer.

Wood poles shall be used for service, traffic signal or roadway lighting installations when specified. The lengths of the poles shall be 25 feet (*7.6 meters*) for service poles and 40 feet (*12.2 meters*) for other poles and shall be Class 3, unless otherwise specified.

(B) Definitions.

(1) AWPA: American Wood Preservers Association.

(2) Supplier: The person, partnership, association, or corporation furnishing the material covered by these specifications.

(3) Check: A separation of the wood along the grain, the greater part of which occurs across the annual growth rings. A through check extends from surface to surface of the pole, usually through the pith center.

(4) Compression Wood: Abnormal wood that often forms on the lower side of branches and inclined trunks of coniferous trees. Characteristics include: (a) relatively wide annual ring, usually eccentric; (b) relatively high proportion of summerwood (frequently more than 50 percent of the width of

the annual ring in which it occurs); (c) exhibits very little contrast in color between springwood and summerwood; and (d) shrinks excessively lengthwise as compared with normal wood.

(5) Cross-Break (Crack): A separation of the wood cells across the grain. Such breaks may be due to internal strains resulting from unequal longitudinal shrinkage or to external force.

(6) Dead Knot: A knot left by a branch that dies before the tree is cut. An encased knot is a dead knot in which the growth layers are not intergrown with those of the surrounding wood. Dead knots may contain soft fibers (decay) that usually do not extend deeper than 1 or 2 inches (*25 or 50 millimeters*) from the pole surface. They are distinct from rotten or decayed knots in which the loose or soft fibers (decay) may extend the full length of the knot into the pole, and which are frequently associated with heart rot.

(7) Dead Streak: Any portion of sapwood in which the life processes had ended prior to the cutting of the tree. A dead streak starts from the butt and differs from a wound, such as a catface or scar, where the growth of new wood shows that life processes are still acting to repair the injured part.

(8) Decay: Decay or rot (advanced decay) is the disintegration of wood substance due to the action of wood destroying fungi.

(9) Face of Pole: The concave side, or the side of greatest curvature in poles having reverse or double sweep, between the ground line and top of pole.

(10) Ground Line Section: That portion of a pole between one foot above and two feet below the ground line as defined in the pole dimension tables.

(11) Hollow Heart: A hollow in the heartwood of a living tree caused by insects or fungi.

(12) Hollow Pith Center: A small hole at the pith center of the trunk or of a knot, caused by disintegration of the pith (small soft core occurring in the structural center of a tree or branch.)

(13) Insect Damage: The result of boring in the pole by insects or insect larvae. Scoring or channeling of the pole surface is not classed as insect damage.

(14) Knot Diameter: The diameter of a knot on the surface of the pole measured in a direction at right angles to the lengthwise axis of the pole.

(15) Red Heart: A fungus caused by Fomes Pini, occurring in the living tree, and characterized in the early stages of infection by a reddish or brownish color in the heartwood. This is known as "firm red heart". Later, the wood, in the case of the

living tree, disintegrates (decays) in small, usually distinct, areas that develop into white-line pockets.

(16) Sap Satin: A discoloration of the sapwood caused by the action of certain molds and fungi that is not accompanied by softening or other disintegration of the wood. Refer to Subsection 731-2.03 (D) (2) (a) for blue stain.

(17) Scar (Catface): A depression in the surface of the pole resulting from a wound where healing has not re-established the normal cross section of the pole.

(18) Shake: A separation along the grain, the greater part of which occurs between the rings of annual growth.

(19) Short Crook: Any localized deviation from straightness, in a five-foot section or less, shall be classified as a short crook.

(20) Spiral Grain (Twist Grain): A type of growth in which the fibers take a spiral course around the bole of a tree instead of the normal vertical course. The spiral may extend right-handed or left-handed around the tree trunk. The amount of spiral grain in a pole is measured as the distance in feet (meters), along the axis of the pole, in which one complete twist of the spiral occurs, and is expressed as a ratio; for example, 1 in 30, that is, 1 twist in 30 feet (*1 twist in 10 meters*).

(21) Split: A lengthwise separation of the wood due to the tearing apart of the wood cells, extending from surface to surface of the pole.

(22) Sweep: The deviation of a pole from straightness.

(C) Acceptance/Species.

(1) Douglas Fir (Pseudotsuga menziesii, MIRB. Franco).

(2) Southern Pine.

(3) Western Pine.

(a) Loblolly (Pinus taeda).

(b) Longleaf (Pinus palustris).

(c) Pond (Pinus rigida serotina).

(d) Shortleaf (Pinus echinata).

(e) Slash (Pinus caribaea).

(f) Ponderosa (Pinus ponderosa laws).

(D) Defects.

(1) Prohibited Defects: Pole exhibiting any of the following defects will not be accepted:

Bird holes.
Breaks.
Catface (scars).
Compound through checks.
Decay.
Double sweep (poles having sweep in two places).
Hollow butts or tops.
Improper framing.
Nails or other metal not authorized by the Engineer.
Plugged holes (other than increment borer).
Small butt.
Small top.
Spike knots or any knot with bark inclusion.
Split top.
Worm or insect holes.

(2) Limited Defects: The following defects are acceptable subject to the limitations stated:

(a) Blue Stain. The core used to check penetration of preservative will be checked for blue stain. Any core with 50 percent or more blue stain in the sapwood will be rejected. Additional cores may be taken to determine the extent of the stain.

(b) Check. Any check more than 1/8 inch (*3 millimeters*) wide and extending down from the top of the pole more than 12 inches (*30 millimeters*) and within 30 angular degrees from the axis of the face of pole directly above brand will be unacceptable. Through checks or splits in the butt surface are permitted, provided their height from the butt along the side surface does not exceed 2 feet (*60 millimeters*).

A check is considered to be continuous if it is not separated by at least 1/2 inch (*13 millimeters*) of wood. Check criteria shall be as follows:

Length of Pole	**Maximum Width**	**Maximum Length**
30 feet (*9 meters*) and shorter	1/4 inch (*6 millimeters*)	5 feet (*1.5 meters*)
35 and 40 feet (*10.7 and 12.2 meters*)	5/16 inch (*8 millimeters*)	5 feet (*1.5 meters*)
45 feet (*13.7 meters*) and longer	3/8 inch (*10 millimeters*)	8 feet (*2.4 meters*)

(c) Compression wood. Compression wood in the outer 1-1/2 inch (*38 millimeters*) of pole.

(d) Insect damage. Insect damage consisting of surface scoring or channeling are permitted; all other forms of insect damage are prohibited.

(e) Insufficient Sapwood. Sapwood thickness less than the following:

Douglas Fir:	1 inch (*25 millimeters*)
Pine:	3 inches (*75 millimeters*)

(f) Knot. The following criteria applies:

All knots shall be measured at right angles to lengthwise surface, including the sapwood as well as the heartwood portions. All end grained, completely concentric annual rings surrounding the prominent heartwood portion of the knot shall be included in the measurement.

The diameter of any single knot or the sum of the diameters of all knots in any 1 foot (300 millimeters) section shall not exceed the limits set up in the following table. Knots 1/2 inch (13 millimeters) or less in diameter shall be ignored in applying the limitations for the sum of diameter.

Length/Class of Pole	**Diameter of Any Single Knot**	**Sum of Diameters of Knots in Any 1 Foot Section (*300 millimeter*) Section**
45 feet (*13.7 meters*) and shorter	2.5 inches (*65 millimeters*)	8 inches (*200 millimeters*)
50 feet (15.2 meters) and longer	*3.0 inches (75 millimeters)*	*10 inches (250 millimeters*)

Maximum single knot in any sworl shall be 2 inches (*50 millimeters*) in diameter.

Maximum sum of knots in any sworl shall not exceed 20 percent of the pole circumference at the point of the sworl or more than the amount shown in the preceding table under the column heading "Sum of Diameter of Knots in Any One Foot (*300 millimeter*) Section".

(g) Mechanical Damage. Poles are not acceptable if they have abrasions or damage caused by forklifts, dragging along the ground, indentation of chains, cables, cant hooks, peaveys, pole tongs, or other mechanical damage penetrating the pole more than 3/4 inch (*19 millimeters*).

(h) Pilodyn. The pilodyn can be used to check hardness of poles. The test will normally be taken at the ground line and any measurement 7/8 inch (*22 millimeters*) and over on ponderosa pine will result in that pole being rejected. Additional tests may be taken at any point on the pole to determine extent of softness.

(i) Ring Count. The annual ring count shall be not less than six rings per inch (*25 millimeters*) average, measured in the outer 3 inches (*75 millimeters*) on the butt face.

(j) Sapstain. Stain that is not accompanied by softening or other disintegration (decay) of the wood is permitted.

(k) Shake. Shakes in the butt surface extending through an arc of not more than 90 degrees are permitted, provided they are at least 2 inches (*50 millimeters*) from the outside diameter of butt.

(l) Short Crook. Any localized deviation from straightness in a five foot section or less shall be classified as a short crook, and the deviation from straightness shall not exceed 1-1/2 inches (*38 millimeters*).

(m) Spiral Grain. Spiral grain is permitted provided it does not exceed 1/2-turn in 15 feet (*4.5 meters*) or one complete turn in any 30 feet (*9 meters*) of the pole.

(n) Sweep. Where sweep is in one plane and one direction only, a straight line connecting the surface of the pole at a point located 6 feet (*1.8 meters*) from the butt and the edge of the pole at the top shall not be separated from the surface of the pole at any point by more than 1 inch (*25 millimeters*) for each 10 feet (*3 meters*) of length between these points.

Where sweep is in one plane and two directions (reverse sweep), a straight line connecting the midpoint at a point located 6 feet (*1.8 meters*) from the butt with the midpoint of the top shall not deviate from the center line of the pole more than 1/4 the diameter of the pole at the point of widest deviation.

(E) Dimensions.

(1) Length.

Poles less than 50 feet (*15.2 meters*) in length shall be not more than 3 inches (*75 millimeters*) shorter or 6 inches (*150 millimeters*) longer than nominal length.

Poles 50 feet (*15.2 meters*) or more in length shall be not more than 6 inches (*150 millimeters*) shorter or 12 inches (*300 millimeters*) longer than nominal length.

The minimal lengths for the wood species shown are as follows:

Wood Species	**Minimum Length Of Pole**
Douglas Fir	50 (*15.2 meters*)
Western Pine	45 (*13.7 meters*)
Southern Pine	30 (*9.1 meters*)

(2) Classification: The pole circumference at the top and at a point 6 feet (*1.8 meters*) from the butt shall not be less than the dimensions shown below.

POLE DIMENSIONS, CLASS 3

Minimum Circumference At Top Is 23-Inches				Minimum Circumference At 6 Feet (*1.8 meters*) From Butt			
Length Of Pole		Groundline Distance From Butt		Western Pine		Douglas Fir And Southern Pine (All Types)	
feet	*meters*	feet	*meters*	inches	*millimeters*	inches	*millimeters*
20	*6.1*	4	*1.2*	29.5	*749*	27.0	*686*
25	*7.6*	5	*1.5*	32.5	*825*	29.5	*749*
30	*9.1*	5.5	*1.65*	35.0	*889*	32.0	*813*
35	*10.7*	6	*1.8*	37.5	*952*	34.0	*864*
40	*12.2*	6	*1.8*	39.5	*1003*	36.0	*914*
45	*13.7*	6.5	*1.95*	41.5	*1054*	37.5	*952*
50	*15.2*	7	*2.1*	43.5	*1105*	39.0	*990*
55	16.8	7.5	*2.25*	45.0	*1143*	40.5	*1029*
60	*18.3*	8	*2.4*	46.5	*1151*	42.0	*1067*

(F) Manufacturing Requirements.

(1) Bark Removal: Poles shall be smoothly trimmed by machine and the depth of the cut shall be kept to a minimum consistent with proper removal of the bark. Beveling the top or butt, excessive trimming around knots which results in separation in wood structure (knot pop-up), prominent spiral ridges on pole surfaces, rough or feathery surfaces, exposed heartwood (except at knot areas), patches of inner bark more than 1/2 inch (*13 millimeters*) wide and 6 inches (*150 millimeters*) long, and abrupt changes in contour due to shaving are evidences of improper removal of bark. Individual poles with such defects shall be rejected.

(2) Marking.

The following marks shall be burnbranded legibly on the butt and on the face of the pole per AWPA Standard M6 at a point 12 feet (*3.7 meters*) (plus or minus 2 inches (*50 millimeters*) tolerance):

The supplier's code or trademark.

The plant location and the year of treatment.

Code letters denoting pole species and preservative used.

The circumference class numeral and numerals showing the length of the pole.

(3) Treating Charge Number: Code numerals indicating the treating charge number must be placed on the butt either by stamping or on metal tags.

(G) Preservatives.

(1) Preservative Requirements: The type of preservative to be used shall be Penta-Volatile Petroleum solvent (Cellon or Dow process).

(2) Penta-Volatile Petroleum Solvent: The pentachlorophenol shall conform to AWPA Standard P8. The carriers shall be hydrocarbon solvents Type B or D conforming to AWPA Standard P9.

(H) Treatment.

(1) Poles: Poles shall be treated in accordance to AWPA Standards C1 and C4.

(2) Moisture Content: Prior to treatment, poles shall be sufficiently air-seasoned, boultonized or kiln-dried to minimize checking after treatment and to permit maximum penetration and retention of preservative. Moisture content of the sapwood shall be below 25 percent. The moisture content may be determined by electrical resistance type moisture meters and shall have insulated needles driven 2 inches (*50 millimeters*) in fir or 2-1/2 inches (*64 millimeters*) in pine.

(3) Retention.

Douglas Fir - The treating process must produce not less than 1 inch (*25 millimeters*) penetration at any point on the pole. If the sapwood thickness exceeds 1 inch (*25 millimeters*) between the butt and standard ground line, 85 percent of the sapwood shall be treated. The assay zone shall be 0.25 to 1.0-inch (*6 to 25 millimeters*).

Cellon or Dow Process - Retention shall be not less than 0.90 pounds per cubic foot (*14.4 kilograms per cubic meter*) in the assay zone.

Western and Southern Pines - The treating process must produce complete sapwood penetration. The assay zone shall be 0.5 to 2.0-inches (*13 to 50 millimeters*).

Cellon or Dow Process - Retention shall be not less than 0.60 pounds per cubic foot (*9.6 kilograms per cubic meter*) in assay zone.

(4) Penetration.

Not less than one increment core shall be taken in the ground line area. All increment borer holes shall be plugged with tight fitting cylindrical wood plugs treated with the same preservative used to treat the pole. Penetration shall be determined by the following methods:

Cellon or Dow Process - Penta Check or Wetzel Stain.

(5) Cleanliness - After Treatment: Cellon or Dow Process - Poles shall be washed or brushed so they are clean and free of surface crystals.

(6) Retreatment.

All poles which fail to meet the treating requirements of this specification may be treated one time after initial inspection. Temperature and pressure must conform to AWPA Standard C1 for retreatment.

Stored Poles - All poles showing brands or marks indicating treatment within any calendar year, three years or more previous to the year of shipment, shall be retreated one time in conformance with AWPA Standard C1.

Cut Back Poles - All poles that are shortened or trimmed shall be retreated within 7 days in conformance with AWPA Standard C1.

(I) Inspection. Inspection shall be made upon delivery. The contractor shall provide the necessary assistance and facilities to enable the safe and efficient inspection of the pole(s). A certificate of compliance shall be furnished to the Engineer upon delivery to the job site or other approved locations.

731-2.04 Prestressed Concrete Lighting Poles. Poles to be furnished shall be of the design and dimensions shown in the Agency's standard drawings or standard details.

Aggregate shall meet current requirements of ASTM Designation C 33, except for grading requirements which may be altered to create the desired architectural effect.

The high early strength cement used in the manufacture of these poles shall conform to current ASTM Specification C 150.

The water used in manufacture shall be potable and free from acids, alkalies, oil, or vegetable matter.

Prestressing steel shall be in accordance with ASTM A 416, and shall be prestressed in accordance with the provisions set forth in the current "Recommended Practice for Prestressed Concrete," ACI-ASCE joint report. The design of the primary steel shall provide sufficient steel area to meet load requirements for the particular type of pole specified, considering an end-of-arm load of 50 pounds (*22.7 kilograms*) with a maximum effective projecting area of 1.25 square feet (*0.12 square meters*). The steel shall be maintained in a rigid position to provide a minimum coverage of 5/8 inch (*16 millimeters*) at all times. Where the above minimum coverage cannot be maintained next to the cable entrance, handhole, wire outlet, etc., the prestressing steel shall be protected from corrosion with a moisture-resistant sleeve.

All poles shall be cast in metal molds true to design. Time of

mixing shall insure a proper and adequate mix. Concrete shall be placed in one continuous operation. When filled, the mold shall be rotated at a high speed to insure a dense concrete by centrifugal force, and to produce a cable raceway throughout the length of the pole.

The poles shall have an exposed aggregate surface, which is obtained by using a sandblasting method. The poles shall be light gray in color.

The arms shall consist of standard schedule 40 steel pipe (ASTM A 501) or aluminum pipe (ASTM B 241-6063-TG) welded to fabricated steel clamps or cast aluminum fittings of the design and dimensions shown in the Agency's standard drawings or standard details. After welding, spatter and flux shall be removed and the entire bracket (steel) galvanized in accordance with ASTM A 123-53. All nuts and bolts shall be stainless steel or silicone bronze.

All poles shall be furnished with a removable metal cap which will protect the required open cable raceway at the top from the weather. All poles shall be furnished with inserts for securing accessories such as ornamental pole cap, ballast adapter cap, bracket brace, handhole door, etc. All metal accessories shall be furnished on or with poles and shall be aluminum or galvanized steel per ASTM A 123.

A metal tag shall be permanently attached to the pole above the handhole stating the manufacturer's name, pole type per the Agency's standard drawings or standard details reference number, and year.

731-2.05 Type 2 Street Lighting Poles. The Type 2 street lighting pole shall be a single-assembled unit consisting of the pole shaft, tapered mast arm, pipe arm end, base plate, and anchor bolts. Poles to be furnished shall be of the design and dimensions shown on the Agency's standard drawings or standard details.

The unit components shall be fabricated from sheet steel of a weldable grade according to the gauge and strength requirements shown on the Agency's standard drawings or standard details.

Hand holes in the base of the pole shaft shall conform to the details shown on the Agency's standards drawings or standard details. All welds shall be continuous and any exposed welds, except fillet welds, shall be ground flush with the base metal.

A metal tag shall be permanently attached to the pole shaft above the hand hole stating the manufacturer's name, pole type per the Agency's standard drawings or standard details reference number, pole drawing number, shaft length, tapered arm length, gauge number, and year.

731-2.06 Type 3 and 4 Street Lighting Poles with Special Architectural Coating. The Type 3 and 4 street lighting poles shall include the base plate, hand hole, pipe arm end, and anchor bolts. Poles furnished shall be of the design and dimensions shown on the Agency's standard drawings or standard details.

Type 3 and 4 street lighting poles shall be fabricated from sheet steel of weldable grade according to the gauge and strength requirements shown on the Agency's standard drawings or standard details.

Hand holes in the base of the pole shaft shall conform to the details shown on the Agency's standard drawings or standard details.

All welds shall be continuous and any exposed welds, except fillet welds, shall be ground flush with the base metal.

A metal tag shall be permanently attached to the pole shaft above the hand hole stating the manufacturer's name, pole type per the Agency's standard drawings or standard details reference number, pole drawing number, shaft length, gauge number and year.

The architectural coating for the Type 3 and 4 poles shall conform to the following requirements:

The exterior steel surface is blast cleaned to Steel Structures Painting Council Surface Preparation Specification No. 6 (SSPC-SP6) requirements utilizing cast steel abrasives conforming to the Society of Automotive Engineers (SAE) Recommended Practice J827. The Blast method used is a recirculating, closed cycle centrifugal wheel system with abrasive conforming to SAE Shot Number S280.

All accessible interior surfaces are coated with a lead and chromate free red oxide rust inhibitive alkyd primer to a minimum dry film thickness of 1.0 mils (*25 micrometers*). The coating is cured by heating the steel substrate to a minimum of 350° F (*175 °C*) and a maximum of 400° F. (*205 °C*).

All exterior surfaces are prime coated with a Urethane Polyester Powder to a minimum dry film thickness of 2.0 mils (*50 micrometers*). The coating is electrostatically applied and cured by heating the substrate in a convection oven to a minimum of 350° F (*175 °C*) and maximum of 400° F (*205 °C*).

The powder primed exterior surfaces are coated with multi (4) colored, synthetic resins (terpolymer chemistry process) suspended independently in an aqueous solution. The colors employed in each coating vary in article size and volume to obtain a textured, three dimensional (depth) effect. The substrate must be heated to a minimum of 40° F (*5 °C*) prior to coating application and air temperature maintained above freezing for the coating to cure.

731-2.07 Standard Mast Arms. Mast arms for wood poles and standard steel poles, that are not tapered, shall be fabricated from steel pipe as specified in ASTM A 53, with an outside

diameter of 2-3/8 inches (*60 millimeters*). The mast arms shall conform to the dimensions shown on the Agency's standard drawings or standard details. The pipe shall be one piece and free from burrs.

Mast arms shall be designed to withstand 70 mile per hour (*110 kilometer per hour*) winds.

The manufacturer shall certify the wind speed for which the mast arm is designed for and indicate the maximum supported weight for equipment, the location of equipment, and the permissible wind cross-section of equipment. The manufacturer shall also indicate any precautions regarding the drilling of holes in the mast arms.

Tapered mast arms shall be fabricated from sheet steel conforming to the requirements of ASTM A 36 (A 36M), except for the Type K and R pole mast arms. The mast arms for the Type K and R poles shall be constructed of sheet steel with a minimum yield stress of 48,000 psi (*330 megapascals*) after fabrication. Mast arms shall be fabricated according to the thickness requirements shown on the plans or in the Agency's standard drawings or standard details. A taper rate of 0.14 inches (*11.7 millimeters*) change in diameter per linear foot (*meter*) shall be required unless otherwise specified. All bolts, washers, and nuts for mast arms shall be fabricated from steel conforming to the requirements of ASTM A 325 (A 325M) and shall be electro-galvanized in accordance with the requirements of ASTM B 633.

Mast arms shall be bent to the dimensions and curvature shown on the plans or in the Agency's standard drawings or standard details.

Tie rods shall be fabricated from weldable structural steel pipe and steel rod and shall have no kinks or bends. All dimensions of the tie rods shall be as specified in the plans, except that the mast arms and tie rods for wood pole installations shall conform to the details shown on the project plans.

Mast arms and tie rods shall be galvanized in accordance with the requirements of ASTM A 123. The visual appearance of the galvanized finish shall be uniform. Discoloration of the galvanized finish such as dark areas, dark streaks, dark rings or transportation handling marks which are considered excessive by the Engineer shall not be allowed. Mast arms and tie rods that have a finish unacceptable to the Engineer shall either be repaired or replaced to the satisfaction of the Engineer at no additional cost to the Agency.

A metal tag shall be permanently attached on the side of the mast arm near the base stating the manufacturer's name, pole type as required on the plans or in the Agency's standard drawings or standard details, mast arm or pole drawing number, length, and gauge number (thickness in millimeters).

731-2.08 Type 3 and 4 Street Lighting Pole Mast Arms with Special Architectural Coating. The Type 3 and 4 street lighting pole mast arms shall be fabricated from sheet steel of weldable grade according to the design, dimensions, curvature, gauge and strength requirements shown on the Agency's standard drawings or standard details.

All welds shall be continuous and any exposed welds, except fillet welds, shall be ground flush with the base metal.

A metal tag shall be permanently attached on the side of the mast arm near the base stating the manufacturer's name, pole type as required in the Agency's standard drawings or standard details, mast arm or pole drawing number, length, and gauge number (thickness in millimeters).

The architectural coating for the Type 3 and 4 poles shall conform to the following:

The exterior steel surface is blast cleaned to Steel Structures Painting Council Surface Preparation Specification No. 6 (SSPC-SP6) requirements utilizing cast steel abrasive conforming to the Society of Automotive Engineers (SAE) Recommended Practice J827. The Blast method used is a recirculating, closed cycle centrifugal wheel system with abrasive conforming to SAE Shot Number S280.

All accessible interior surfaces are coated with a lead and chromate free red oxide rust inhibitive alkyd primer to a minimum dry film thickness of 1.0 mils (*25 micrometers*). The coating is cured by heating the steel substrate to a minimum of 350° F (*175 °C*) and a maximum of 400° F (*205 °C*).

All exterior surfaces are prime coated with a Urethane Polyester Powder to a minimum dry film thickness of 2.0 mils (*50 micrometers*). The coating is electrostatically applied and cured by heating the substrate in a convection oven to a minimum of 350° F (*175 °C*) and maximum of 400° F (*205 °C*).

The powder primed exterior surfaces are coated with multi (4) colored, synthetic resins (terpolymer chemistry process) suspended independently in an aqueous solution. The colors employed in each coating vary in article size and volume to obtain a textured, three dimensional (depth) effect. The substrate must be heated to a minimum of 40° F (*5 °C*) prior to coating application and air temperature maintained above freezing for the coating to cure.

731-2.09 Down Guy Assemblies. The down guy assembly shall consist of an anchor cone, an anchor rod, two 3-bolt wire clamps, a utility grade stranded guy wire, a guy wire guard, and an angled thimble eye-bolt with double nuts. Where a sidewalk type down guy assembly is required, a galvanized pipe, a pole plate and a guy wire clamp end fitting shall also be included components in the down guy assembly.

Sizes and dimensions of the down guy assembly components shall be as shown on the plans and/or in the Agency's standard drawings or standard details.

731-3 CONSTRUCTION DETAILS

731-3.01 Foundations. The excavations required for the installation of foundations and other items shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping, and other improvements. The trenches shall not be excavated wider than necessary for the proper construction of the foundations and other equipment. Excavation shall not be performed until immediately before construction of foundations. The material from the excavation shall be placed in a position that will minimize obstructions to traffic and interference with surface drainage.

All surplus excavated material shall be removed and properly disposed of within 48 hours by the contractor, as directed by the Engineer. After each excavation is completed, the contractor shall notify the Engineer for an inspection, and under no circumstances shall any underground materials or equipment be covered with fill without the approval of the Engineer.

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5. At the end of each working period, all unused foundations and excavations shall be barricaded and securely covered and shall be lit to provide safe passage for pedestrian and vehicular traffic.

Excavations in the street or highway shall be performed in such a manner that not more than one traffic lane is restricted at any time, unless otherwise provided in the special provisions.

Sidewalk and pavement excavations shall be kept well covered and protected to provide safe passage for pedestrian and vehicular traffic until permanent repairs are made.

Signal and lighting pole foundations shall be set to the grade of the existing or new curb and sidewalk or to the finished grade where there is no curb or sidewalk, except that in steeply sloped areas they shall be as shown on the project plans. The dimensions and locations of foundations shall be as shown on the project plans; however, the Engineer may direct that changes be made in locations due to obstructions or other existing conditions.

Where obstructions prevent construction of foundations as shown on the plans or in the Agency standard drawing or standard detail, the contractor shall propose an alternate foundation design for the Engineer's approval prior to placing any concrete.

Concrete shall be placed in holes which have been augured against undisturbed earth. If the material in the bottom of the hole is not firm and stable, it shall be compacted or treated as directed by the Engineer. The walls and the bottoms of the holes shall be thoroughly moistened prior to placing the concrete.

If the soil is not stable and a hole cannot be augured, forms shall be used. They shall be of the proper size and dimensions and shall be rigid and securely braced. The forms and the bottoms of the holes shall be thoroughly moistened prior to placing the concrete.

All pole foundations shall be poured to within 3 to 6-inches (*75 to 150 millimeters*) of the final top-of-foundation grade. After the pole has all equipment mounted and has been plumbed to vertical, the top portion shall be filled with non-shrink grout and finished smooth.

Pole or cabinet foundations adjacent to other concrete shall be isolated from the other concrete by use of bituminous expansion joint material.

If the Engineer requires foundations to be larger or deeper than on the plans because of soil conditions, the additional work will be paid for in accordance with the provisions of Subsection 109-4.

Anchor bolts and conduit stubs shall be placed and held in proper alignment, position, and height during the placing and vibrating of concrete. All pole foundations shall set for three days prior to pole installations except for type J, K, Q, R and strain pole foundations which shall set for 7 days.

Conduits terminating at the top of pole and cabinet foundations shall be vertical, shall extend 2 inches (*50 millimeters*) above the final top of foundation grade, and shall be fitted with an end bell fitting.

Cabinet foundations in other than asphalt or concrete areas shall include a concrete service pad, 4 feet (*1.2 meters*) wide by 40-inches (*1.0 meter*) long by 4 inches (*100 millimeters*) deep, finished smooth, and set to grade on the cabinet door side of the foundation.

Before the concrete for cabinet foundations has set, depressions shall be made around the anchor bolts for adjustment of the cabinet leveling nuts.

Concrete for foundations shall be placed monolithically and vibrated to eliminate voids.

The contractor shall notify the Engineer 24 hours prior to any foundation pours. Foundations poured without the Engineer present shall be subject to rejection. Rejected foundations shall be removed and replaced by the Contractor at no additional cost to the Agency.

Should other utilities exist in close proximity to the work, the contractor shall excavate in a manner that will avoid damage to or undermining of the existing utility. Existing conduits which are unavoidable or cannot be rerouted, shall be wrapped with PVC tape

and encased in the new foundation. If existing conduits are damaged by the contractor, they shall be repaired at no additional cost to the Agency.

Abandoned conduits within new foundations shall be cut off and removed so they are not encased in the new foundations.

Foundation excavations shall not be prepared and left open for more than 48 hours before concrete placement.

It is the Contractor's option, after giving notice to the Engineer, to use any one of the following foundations in conjunction with Type 2 poles:

(1) A foundation excavation of 3 feet (*900 millimeters*) in diameter and 5 feet (*1.5 meters*) in depth. Anchor bolts shall be 1-1/4 inch by 44 inch by 4 *inch (30 millimeters by 1.1 meters by 100 millimeters*).

(2) A foundation excavation of 30 inches (*750 millimeters*) in diameter and 6 feet (*1.8 meters*) in depth. The anchor bolts shall be 1 1/4 inch by 66 inches by 4 inches (*30 millimeters by 1.7 meters by 100 millimeters*) or replaced by a steel reinforcing cage 24 inches (*600 millimeters*) in diameter by 66 inches (*1.7 meters*) in depth. When a reinforcing cage is used the anchor bolts shall be the same dimensions as in above.

(3) A foundation excavation of 2 feet (*600 millimeters*) in diameter and 7 feet (*2.1 meters*) in depth. The anchor bolts shall be 1 1/4 inches by 78 inches by 4 inches (*30 millimeters by 2 meters by 100 millimeters*) or replaced by a reinforcing cage 18 inches (*450 millimeters*) in diameter by 78 inches (*2 meters*) in depth. When a reinforcing cage is used the anchor bolts shall be the same dimensions as in 1 above.

The reinforcing cages in (2) and (3) above shall be constructed in manner similar to that shown on Standard Detail T.S. 4-11. Specifically there will be eight No. 7 (No 22) vertical rebars tied to a 3/8 inch (*10 millimeter*) diameter cold drawn spiral cage with a 3 inch (*75 millimeter*) pitch.

Street lighting pole foundations shall be installed where indicated on plans. However, all foundation locations shall be field verified by the contractor with the Engineer prior to excavation. The Engineer may direct changes in pole locations due to field obstructions, utilities, or other existing conditions.

731-3.02 Base Plates and Poles. High strength bolts, nuts, and washers for slip-away bases shall be assembled and torqued as specified by the Agency's standard drawings or standard details. Anchor bolts, washers, and nuts required for relocating existing poles shall be furnished by the contractor.

Poles shall be drilled and tapped for mounting hardware as shown on the Agency's standard drawings or standard details. Use of through bolts will not be permitted. Poles will be rejected if holes are not properly positioned for the required mounts.

All steel poles shall be plumbed to the vertical with all mast arms, signal heads and luminaries installed.

Sidewalks, curbs, gutters, pavement, base material, lawns, plants, and any other improvements removed, broken, or damaged by the contractor's operations shall be replaced or reconstructed with materials in accordance with the standard specifications. The replaced or reconstructed improvements shall be left in a serviceable condition satisfactory to the Engineer, and shall conform to these specifications where applicable.

Where existing pole installations are to be modified, materials and equipment shall be used, salvaged, or disposed of as specified in the special provisions and/or as directed by the Engineer.

Poles to be installed on existing foundation shall be installed such that the base sits firmly on the existing anchor bolts, with the top nut having the anchor bolt completely through the nut's threads. The contractor shall jackhammer down the existing foundation as needed to expose enough of the anchor bolt, and repour the foundation cap after the new pole has been set and plumbed.

Wood poles shall be placed in the ground to the depth specified in the Agency's standard drawings or standard details. After each wood pole is set in the ground, the pole shall be backfilled with selected backfill. Backfill shall be free of large rocks and debris, and placed in layers of no more than 6 inches (*150 millimeters*) before compaction. Each layer shall be moistened and thoroughly compacted as directed by the Engineer.

Where wood pole type span wire installations are specified for traffic signal supports, each wood pole shall be guyed with the number and type of down guy assemblies shown on the plans. Down guy assemblies shall be installed in conformance with the plans and/or the Agency's standard drawings or standard details. When all of the traffic signal mounting assemblies have been affixed to the messenger cables, the guy wire in each down guy assembly shall be adjusted to taut as required by the Engineer.

Existing poles shall be either relocated or used in place as specified in the project plans. The contractor shall inspect the poles and provide the materials and work necessary to recondition the poles so they can be reused. Holes left in the shafts of existing poles, due to removal of items such as signal mounting assemblies, shall be repaired and coated with a zinc galvanized paint.

If any poles are damaged by the contractor's operations, such repairs or replacements required by the Engineer shall be at no additional cost to the Agency. If the Engineer orders additional work to be done following the contractor's inspection of the poles, such work will be paid for as provided in Subsection 109-5.

New poles that are damaged by improper drilling of holes will be rejected.

731-3.03 Removing and Replacing Improvements. Wherever a part of a section or slab of existing concrete or sidewalk or curb is damaged by the contractor, the entire section between tooled and/or expansion joints shall be removed and the concrete reconstructed as directed by the Engineer.

All areas of concrete sidewalks and driveways and all areas of portland cement concrete and asphaltic concrete pavements to be removed shall be outlined and cut to a minimum depth of 1-1/2 inches (*40 millimeters*) with an abrasive type saw prior to removing the material. The cut for the remainder of the required depth may be made by any method satisfactory to the Engineer. Saw cuts shall be neat and true with no shattering or chipping of concrete adjacent to the outside removal area.

Existing foundations, not to be reused in the new traffic signal or street lighting systems, shall be removed to a minimum depth of 60 inches (*1.5 meters*) below finished grade. The removal depression shall be backfilled in kind, or better, to the surrounding materials.

731-4 METHOD OF MEASUREMENT

The structural supports, poles, mast arms, Type 1, 2, 3 and 4 street lighting poles, down guy assemblies, and foundations for traffic signal poles, street lighting poles, controller cabinets and service pedestal cabinets will be measured as a unit for each type of support, pole, mast arm, Type 1, 2, 3 and 4 street lighting pole, down guy assembly, and foundation furnished and installed.

Modification of existing poles and mast arms will be measured as a unit for each pole or mast arm modified.

731-5 BASIS OF PAYMENT

The accepted quantities of supports, poles, mast arms, Type 1, 2, 3 and 4 street lighting poles, down guy assemblies, and foundations for poles and cabinets, measured as provided above, will be paid for at the contract unit price each, for the type of support, pole, mast arm, Type 1, 2, 3 and 4 street lighting poles, down guy assembly, or foundation designated in the bidding schedule, complete in place, which price shall be full compensation for the work described and specified herein and on

the plans, including all conduit, elbows, anchor bolts, down guy cable and anchors, messenger cable anchoring, hardware, wire, excavation, backfill, service pad, and incidentals necessary to complete the work.

The accepted quantities of modified pole and modified mast arm, measured as provided above, will be paid for at the contract unit price each, for the type of pole or mast arm designated in the bidding schedule to be modified, which price shall be full compensation for the work described and specified herein and on the plans, including all parts, hardware and incidentals necessary to complete the work.

No measurement or direct payment will be made for anchor bolts, the cost being considered as included in the unit price paid for foundations.

SECTION 732

ELECTRICAL MATERIAL AND SERVICE

732-1 DESCRIPTION

The work under this section shall consist of furnishing and installing electrical conduit, conductors, pull boxes, and messenger and tether cable for traffic signals, street lighting, and wide area networks (WANs) including securing electrical service, obtaining permits, utility coordination, jacking, boring, excavating, backfilling, compacting, and pavement patching at the locations designated on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

732-2 MATERIALS

732-2.01 Electrical Conductors. Electrical conductors shall be stranded or solid conductor, thermoplastic insulated electrical wire or cable. Conductors shall conform to the specifications of the NEC, UL, and other applicable industry standards.

Wire and cable for traffic signal, street lighting and other electrical systems shall be UL listed and rated for 600-volt operation and shall be types THW or XHHW, except as otherwise specified for certain cables and conductors. The UL label shall be present on each reel, coil or container of wire or cable. When requested, the contractor shall submit to the Engineer the manufacturer's written certification that the product conforms to the requirements of these specifications.

All single conductors, except detector lead-in cables, shall have plain, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type letter designation, conductor size, voltage rating and the number of conductors in the cable.

The wire shall be annealed copper and shall be uncoated unless otherwise specified. The wire shall be solid for number 10 AWG and smaller, conforming to the requirements of ASTM B 3 for annealed bare copper wire. Conductors for sizes number 8 AWG and larger shall be stranded and shall conform to ASTM B 8 for Class B stranding, unless otherwise specified. The conductors shall be insulated as noted on the plans and shall meet the requirements of UL 83. Insulation colors shall be permanent and an integral part of the insulation and shall not be applied as a surface treatment or coating. The insulation thickness shall conform to the requirements of the NEC. Conductor insulation shall be a solid color as shown in the wire insulation color table, unless otherwise specified. The color shall be continuous over the entire length of the conductor.

WIRE INSULATION COLOR TABLE
(Not Applicable to IMSA Cables)

Insulation Color	Circuit
Red	Red Signal DONT WALK (Hand) Photocell Control Red Flasher
Yellow	Yellow Signal Yellow Arrow Yellow Flasher
Green	Green Signal Green Arrow WALK (Man)
White	Common Neutral
Black	Photocell Hot Street Light Hot Power Hot
Orange	Pedestrian Button
Blue	Pre-Empt Beacon Hot

(A) Roadway Loop Detector Wire. Roadway loop detector wire shall be a factory assembled combination of PVC or polyethylene tubing and wire. Loop detector wire shall be stranded number 14 AWG copper, rated at 600 volts with THWN insulation. The wire shall be enclosed in a factory extruded PVC flexible tubing by the wire manufacturer. Tubing shall be orange in color from the factory. Contractor assembly of the wire in the flexible tubing will not be acceptable.

The tubing shall be UL FR-1 rated at 105 °C and have a moisture absorption of less than one percent. The wall thickness shall be 31 ± 3 mils (*775 ± 75 micrometers*) with a nominal inner diameter of 0.186 inches (*5 millimeters*). The tubing shall be highly resistant to chemicals and oils and shall have a dielectric strength of 900 volts/cm.

(B) Cable.

(1) Detector Lead-In Cable.

Detector lead-in cable shall be shielded and twisted pair cable meeting the requirements of IMSA Specification No. 50-2-1984, or as described in Section 732-2.01 (B)(2), in accordance with the plans and/or special provisions. The number of pairs and the wire gauge shall be as shown on the plans.

(2) Telephone Drop, Emergency Pre-Empt, and Interconnect Cable.

Telephone drop, emergency pre-empt, and interconnect cable shall be 4-conductor, cabled, stranded, UL listed and rated for 600 volts. The cable conductors shall be 20 gauge tinned copper. Insulation of the conductors in each cable shall be colored red, black, green and white (or clear). A braided shield shall be provided in the cable with a minimum 87% shielded coverage. The cable jacket shall be PVC, blue in color (for telephone and emergency preempt), red in color (for interconnect), and 0.032 inch (*1 millimeter*) minimum thickness. The nominal diameter of the cable shall be 0.350 inches (*9 millimeters*).

(3) IMSA Cable.

IMSA cable shall be used only when specified on the plans. IMSA signal cables shall be polyethylene insulated copper conductors, polyvinyl chloride jacketed, rated at 600 volts for use in underground conduit or as aerial cable conforming to International Municipal Signal Association Specification No. 19-1.

The IMSA-19 cable shall be provided with the number and size of conductors as specified on the plans. The cable shall use the standard IMSA colors for conductor insulation. The colors and tracers shall be permanent and an integral part of the insulation, and shall not be painted or surface coated.

Unless otherwise shown on the plans or unless a wiring schedule to the contrary is furnished by the Engineer to the contractor, the contractor shall wire IMSA cables in accordance with the following tables. Where a signal cable in excess of 15 conductors is required in the plans, the conductors not shown in the signal cable table shall be used as spares. Where a signal cable with less than 15 conductors is required in the plans, the conductors shall be used as shown, beginning with conductor No. 1, up to the conductor number corresponding to the total number of conductors in the cable.

IMSA SIGNAL CABLE TABLE

Cond. No.	Base Color	Tracer Color	Use
1	Black		Ped. Signal WALK (Man) Green
2	White		Signal Common
3	Red		A Phase Signal Red
4	Green		A Phase Signal Green
5	Orange		Ped. Push Button
6	Blue		A Phase Yellow
7	White	Black	Low Voltage Common
8	Red	Black	A Phase Aux. Signal Red (When Used)
9	Green	Black	A Phase Aux. Signal Green (When Used)
10	Orange	Black	Spare (Ped. Push Button)
11	Blue	Black	A Phase Aux. Signal Yellow (When Used)
12	Black	White	Ped. Signal DONT WALK (Hand) Red
13	Red	White	Spare
14	Green	White	B Phase Left Turn Signal Green
15	Blue	White	B Phase Left Turn Signal Yellow

IMSA PHOTOELECTRIC CELL CABLE TABLE

Cond No.	Base Color	Tracer Color	Use
1	Black		To Photoelectric Cell
2	White		Common
3	Red		From Photoelectric Cell

IMSA UTILITY CABLE TABLE

Cond No.	Base Color	Tracer Color	Use
1	Black		Spare
2	White		Low Voltage Common *
3	Red		Spare
4	Green		Spare
5	Orange		Ped. Push Button
6	Blue		Spare

* Mark with Black Tape.

732-2.02 Electrical Conduit and Warning Tape. All conduit and fittings shall be listed by UL and conform to NEC standards. Unless otherwise specified, all conduit to be installed underground or in concrete structures shall be rigid Polyvinyl Chloride (PVC) non-metallic type conforming to the requirements of UL 651 for Rigid Non-Metallic Conduit. PVC conduit and fittings shall be Schedule 40, heavy wall, manufactured from high impact material and shall be rated for use at 90 °C.

PVC duct designed for direct burial installation shall comply with one of the following standards: conduit marked "EPC-40-PVC," conduit marked "Schedule 40 PVC TC-2," conduit marked "DB-120 S ASTM F-512," or conduit marked "DB-120 TC-8."

All exposed conduit and fittings to be installed above ground shall be the rigid metal type manufactured of galvanized steel conforming to requirements of UL 6 for Rigid Metallic Conduit. Non-threaded couplings shall not be used. Rigid galvanized steel conduit with a 40 mil (*1000 micrometers*) PVC exterior tape or factory applied coating shall be used between service pedestals and service poles unless otherwise specified.

Flexible conduit shall be a liquid-tight flexible metal type and shall be used as specified. The conduit shall be a flexible galvanized steel core over which is extruded an ultra-violet (UV) resistant PVC cover. Approved liquid-tight fittings shall be furnished and installed with the conduit.

Sampling and testing procedures shall conform to UL Standards. Samples for testing, when requested by the Engineer, shall be furnished at the contractor's expense. Samples of conduit shall be tested by UL standards and be approved for use by the Engineer prior to installation on the project.

Conduit warning tape shall be a 4 mil (*100 micrometer*) inert plastic film specially formulated for prolonged use underground. All tape shall be highly resistant to alkalis, acids, and other destructive agents found in the soil.

Tape shall have a continuous printed message warning of the location of underground conduits. The message shall be in permanent ink specifically formulated for prolonged underground use and shall bear the words, "CAUTION--ELECTRIC LINE BURIED BELOW" in black letters on a red background.

732-2.03 Pull Boxes. Precast reinforced concrete pull boxes, covers and extensions shall be installed and located as shown on the project plans and shall be the size specified. Chipped or cracked pull boxes, covers, and extensions will not be accepted.

Portland cement concrete shall conform to the requirements of Section 1006 for Class B concrete. When requested by the Engineer, pull boxes, covers, and extensions shall be furnished for testing at the contractor's expense.

Covers shall be marked as follows:

"TRAFFIC SIGNAL" or "STREET LIGHTING", depending on the use of the pull box.

Pullboxes shall have an etched polyethylene face, anchored in concrete, with an ultraviolet inhibitor.

Unless otherwise specified on the plans or in the Special Provisions pullbox lids shall be of 'fiberlight' materials, polyester pre-mix with Calcium Carbonate, and shall be equipped with boltdowns.

Markings shall be clearly defined and uniform in depth and shall be placed parallel to the long side of the cover. Letters shall be one inch high.

732-2.04 Metal Junction Boxes. Metal junction boxes and covers for installation in concrete structures shall be fabricated from a minimum of 16 gauge type 304 stainless steel. All seams shall be continuously welded and shall conform to the dimensions and details shown on the project plans. A neoprene gasket with a thickness of 1/8 inch (*3 millimeters*) shall fit between the box and the cover to provide a raintight seal. The cover shall be made to fit securely and shall be held in place with a minimum of four stainless steel machine screws. Tabs for ease of installation may be attached to the junction box at the option of the contractor. The size shall be adequate for the use shown on the plans, if the plans show no dimensions.

732-2.05 Messenger and Tether Cables. The messenger cable, used for suspending vehicular traffic signal assemblies and anchoring, in span wire installations shall be 7-strand, utility grade, galvanized steel messenger cable of the diameter required by the plans and/or special provisions. Tie wraps for attaching IMSA cable to the messenger cable shall be of the stainless steel type, standard cross section and shall be installed at 15 inch (*375 millimeters*) maximum spacing. The tie wrap shall be installed snug, without damaging the conductor cable insulation. The cable tie shall be cut off flush. Excessive and unsightly slack in the IMSA cable shall not be permitted.

The tether cable shall be 7-strand, utility grade, galvanized steel cable of the diameter required by the plans and/or special provisions.

732-2.06 Service Pedestal Cabinets. The service pedestal cabinets furnished shall satisfy the plans and special provisions, these specifications, and the standard drawings or standard details of the Agency regarding equipment construction and installation, and any utility company requirements. The service pedestal cabinets provided shall be for metered use, as shown in the plans or specified in the special provisions.

The service pedestal cabinet shall be UL approved and rated for 125 amp, 120/240 VAC, 60 Hz, single phase, 3- or 4-wire service, unless otherwise specified. The cabinet shall be equipped with a 125 amp, double pole main breaker and, in addition, shall provide for at least 12 plug-in breakers of the type manufactured by Bryant, GE, Westinghouse, ITE, or Crouse-Hinds, as specified in the plans or the special provisions. Copper bussed circuit breaker interiors and factory installed copper wiring shall be

used. One or two 120/240 volt, single phase, 3-wire lighting arrester(s) shall be provided as required. Metered service pedestal cabinets shall be equipped with factory installed test blocks for use by the serving utility company.

The cabinet shall have separate sections for the Agency and the utility company. The service pull section shall be 4 1/2 inches (*113 millimeters*) deep and shall be located in the back of the cabinet. An access opening in the cabinet shall be provided at the bottom of the service pull section and shall be capable of being sealed by the utility company.

The cabinet shall be of NEMA 3R, tamperproof construction and shall have the nominal dimensions shown on the referenced standard drawing or standard detail of the Agency. The cabinet construction shall be, at a minimum, 12 gauge steel with 14 gauge steel doors. Stainless steel fasteners shall be used. The doors or covers shall be capable of padlocking. The cabinet shall be treated on the inside and the outside with one coat of zinc chromate primer and painted with two coats of white enamel conforming to the requirements of Section 1002. Each cabinet shall be supplied with a detachable base for attachment to a concrete foundation. The base shall attach to the cabinet with bolts and have anchor bolts or rebars set into the concrete foundation per the standard drawings or standard details.

732-3 CONSTRUCTION DETAILS

732-3.01 Conduit.

(A) Storing and Handling. All PVC conduit shall be stored and handled in an approved manner to minimize ultraviolet deterioration due to exposure to sunlight.

(B) Cleaning. Existing conduit to be incorporated into a new system and conduit embedded in concrete structures shall be blown out with compressed air and a mandrel shall be pulled through the conduit to remove any obstructions.

(C) Size. The minimum inside diameter of each conduit shall be as shown on the plans. The contractor may, at his option and expense, use a larger size conduit than specified provided the larger size is continuous for the entire length of the run from outlet to outlet. Reducing couplings shall not be used. Changes in the location and size shown on the project plans shall be documented by the contractor and submitted to the Engineer.

(D) Cuts and Connections. The PVC conduit shall be cut square and trimmed to remove rough edges.

Conduit connections shall be of the solvent weld type. Where a connection is made to steel conduit, the coupling used shall be a PVC female adapter.

Expansion fittings shall not be installed in PVC conduit runs between two pull boxes unless otherwise specified. Expansion fittings shall be installed in conduit runs where both ends are fixed in place, such as between two foundations. Expansion fittings shall be installed in conduit runs which cross any expansion joint in a concrete structure. Expansion fittings shall allow for a linear thermal expansion of up to 6 inches (*150 millimeters*).

(E) Bends. Except for factory bends, conduit bends shall have a radius of not less than that specified in the NEC or acceptable to the electric utility whichever is the most stringent. Conduit shall be bent without crimping or flattening, using the longest radius practicable. The sum of the deflection angles of all bends in any conduit run shall not exceed 360 degrees between termination and/or junction points.

(F) End Treatments. Conduit ends shall be capped with conduit end cap fittings until wiring is started. When end caps are removed, non-metallic conduit shall be provided with an approved conduit end bell. End bells shall be installed prior to the installation of the conductors. Approved insulated grounding bushings shall be used on ends of steel conduit runs. Conduits with grounding bushings shall be bonded together, bonded to a metal box and grounded.

Ends of conduit runs, designated for future use, shall be capped with conduit end cap fittings.

(G) Placement. Conduit runs shown on the plans shall be changed only to avoid underground obstructions and only as directed by the Engineer.

Conduit installed for street lighting and signal systems shall comply with the following: In protected areas (i.e. behind curbs, in sidewalk areas etc.) not subject to vehicular traffic, the conduit shall be installed a minimum of 30 inches (*750 millimeters*) below finished grade. Conduit installed under roadways, driveways, or any open areas subject to vehicles, or conduits with conductors that have voltages over 250 volts, shall be installed a minimum of 36 inches (*900 millimeters*) below finished grade.

When a conduit run, or any part thereof, cannot be installed at the minimum depth, the run, or part thereof that does not meet the minimum depth requirement, shall be encased in concrete in conformance to the Agency's standard drawings or standard details.

Conduit entering pull boxes shall terminate a minimum of 3 inches (*75 millimeters*) inside the box wall. The conduit shall be between 2 inches (*50 millimeters*) and 4 inches (*100 millimeters*) above the bottom of the pull box and shall be sloped to facilitate pulling of the cable and conductors. Conduit entering through the bottom of a pull box shall be located near the sides and ends of

the pull box in order to leave the major interior portion clear. At all outlets, conduits shall enter from the direction of the run and allow for expansion and contraction.

A 3 inch (*75 millimeters*) "Y" shall be cut into the face of the curb directly over every conduit run placed under a curb.

Conduit for future use shall have a number 8 AWG bare bond wire installed with at least two feet of the wire doubled back into the conduit prior to capping.

(1) Trenching.

Unless otherwise specified, any new conduit run, shown on the plans in any of the following locations, regardless of depth, shall be placed by the trenching method and shall be concrete encased, from end to end, in conformance to the Agency's standard drawings or standard details:

(a) Below any roadway pavement (new or existing).

(b) Below any temporary roadway pavement.

(c) Below a paved shoulder.

(d) Within a median, except for conduit running longitudinally within the median.

Any obstructions to the trenching operation such as existing improvements, utilities, roof drains, irrigation ditches, structures, buildings, foundations, and property markers are to be protected from damage by the contractor during construction and until the work is completed. In the event of damage, the contractor shall be responsible for repair/ replacement at this expense with materials and methods which leave the damaged items in as good or better condition than original.

Where the depth of conduit changes, the trench bottom shall be sloped 3 horizontal to 1 vertical to accommodate the depth change.

If a trench is left open overnight, a minimum of 6 inches (*150 millimeters*) of backfill material shall be used as a protective cover to eliminate contraction of the conduit system. The backfill material shall be removed if final inspection by the Engineer has not been made.

Where concrete encasement of conduit is required, the conduit shall be supported with masonry block or brick on 5 foot (*1.5 meter*) centers so that the conduit will be completely encased.

Where trenching of an existing pavement is required by these specifications or is approved in writing by the Engineer prior to commencing the trenching work, the conduit run

installed in such trench shall be encased in concrete, end to end, and the trench repair shall be in conformance with these specifications and the Agency's standard drawings or standard details.

Backfill material placed within 6 inches (*150 millimeters*) of the conduit shall not contain frozen lumps, stones larger than 3 inches (*75 millimeters*) in diameter, chunks of clay, or other objectionable material. The remaining trench backfill material shall conform to the requirements of Subsection 501-3.05.

Where necessary to prevent damage to the raceway or cable, protection shall be provided in the form of granular or select material, suitable running boards, suitable sleeves, or other approved means.

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5.

The contractor shall place warning tape in all trenches where new conduit is placed. All warning tape shall be buried at a depth of 10 to 14 inches (*350 millimeters*) below the finished grade.

(2) Boring and Jacking.

When indicated on the plans, conduit runs crossing existing pavement shall be placed by jacking and boring methods. The boring or jacking method used shall be approved by the Engineer prior to commencing work. Where field conditions prohibit boring or jacking, trenching methods may be used after written approval has been obtained from the Engineer. Unless otherwise indicated on the plans or in the Special Provisions, payment for patching of conduit runs crossing paved alleyways or drives shall be incidental to the installation of the conduit. Pavement patching shall conform to the Standard Details.

Boring or jacking pits shall be kept 2 feet (*600 millimeters*) clear outside of the pavement edge.

(3) Concrete Structures.

Conduit embedded in concrete structures shall be securely attached to the reinforcing steel at intervals of approximately 12 inches (*300 millimeters*). Expansion fittings shall be installed where the conduit crosses expansion joints in the structure. Where bonding is not continuous, expansion fittings shall be provided with a bonding jumper of number 6 AWG flexible wire. Where it is not possible to use expansion fittings, sleeves of sufficient size shall be installed to provide a minimum 1/2 inch (*13 millimeters*) clearance between the conduit and the inside wall of the sleeves. The sleeve shall be discontinuous at the expansion joints.

(4) Special Requirements.

Conduit to be installed on the utility company's wood service pole shall be placed in the quadrant of the pole specified by the utility's representative.

Installation of conduit for underground primary service shall conform to the utility company requirements, local codes and the special provisions.

Conduit installed in railroad right-of-way shall be to the depth specified by the railroad company.

(H) Conduit Crossing Existing Concrete. Conduit runs shall be placed by boring or jacking methods under existing concrete. The boring or jacking method used shall be approved by the Engineer prior to commencement of work. Where field conditions prohibit boring or jacking, the concrete shall be replaced in accordance with the requirements of Section 908. Removal of concrete shall be in accordance with the requirements of Section 202-3.04. Where removal of concrete at a curb access ramp is required, the entire ramp shall be removed and replaced.

(I) Conduit for Fiber Optic System. Conduit for fiber optic system shall have 30 degree sweeps into pullboxes and cabinets. Conduit bends shall have a minimum radius of 18 inches (*450 millimeters*). Conduit installed as a part of a Fiber Optic System shall not deviate more than thirty degrees both vertically and horizontally from pull box to pull box. Unless otherwise specified on the plans or in the Special Provisions, conduit for fiber optics systems shall be Schedule 40 PVC conduit having a minimum 4 inch (*100 millimeters*) diameter. Conduit shall terminate without bends if possible. Bends shall be rigid steel conduit, having a minimum radius of 10 times the nominal diameter of the conduit. The exterior of steel bends shall be double wrapped with 10-mil PVC tape. Rigid steel conduit shall be measured and paid for at the 4 inch (*100 millimeter*) PVC conduit rate. Conduit shall terminate in #7 pull boxes with extensions. Pull box knockouts shall be centered as practicable. Pull box lids shall be marked "COMMUNICATIONS", and shall be equipped with bolt-down lids. One No. 6 AWG Green, unspliced THW/XHHW wire shall be installed in each conduit. Lubricants used in pulling the tracer wire shall be water soluble. A minimum of 5 feet (*1.5 meters*) of wire shall be coiled, and secured, in the pull box. The ends of all tracer wire within a pull box or vault shall be connected to a common lug to allow for locating multiple segments of conduit run with one setup of the detection equipment. Warning tape, bearing the word "COMMUNICATIONS" in black letters on an orange background, shall be installed. Testing shall be carried out in the presence of the Engineer. The Engineer shall notify appropriate Agency personnel of the construction schedule to facilitate inspection of the conduit(s). An Agency representative shall observe all conduit testing and attend the final inspection of the project.

To ensure that interducts and cabling can be installed at a future date, the installed conduit shall not be deformed. After completion of backfilling and subgrade preparation operations, conduit runs shall be tested with a mandrel. The diameter of the mandrel shall not be less than 1/4 inch (*6 millimeters*) smaller than the inside diameter of the conduit. The mandrel shall be a minimum of 10 inches (*250 millimeters*) long and shall pass freely through the entire conduit run. Should the mandrel not pass through the conduit, the conduit run shall be deemed unacceptable and repaired or replaced at no additional cost to the Agency.

A dry pathway shall be provided for fiber optic cables. No water shall be allowed to remain in the conduit(s). If water enters the conduit during construction, it shall be blown out or removed by other satisfactory means prior to acceptance of the system. The completed system shall be left in a clean, dry condition with all conduit ends plugged.

When specified on the project plans, inner duct shall be installed. Inner duct shall be 3 x 1-1/4 inches (*31 millimeters*) or 4 x 1 inch (*25 millimeters*) as specified or as directed by the Engineer. Three feet (*900 millimeters*) of the inner duct shall extend beyond the end of the conduit, and coiled inside of the pull box.

732-3.02 Pull Boxes and Metal Junction Boxes. Pull boxes shall be installed in accordance with the details shown on the plans and the Agency's standard drawings or standard details. Pull boxes shall be installed flush with the finished grade and, when in concrete, shall have a 1/2 inch (*13 millimeter*) felt expansion joint installed around all sides of the pull box. All pull boxes which are not located in concrete areas shall have collars installed unless noted on the plans or special provisions.

Metal junction boxes placed in concrete structures shall be flush with the finished concrete surface.

732-3.03 Span Wire Installations. Span wire traffic signal installations shall conform to the requirements of the plans and/or the Agency's standard drawings or standard details. Supports for span wire installations shall either be the steel strain pole type or the wood pole type, as required by the plans and/or special provisions.

Messenger cable shall have a maximum sag of 5 percent of the distance between its supports. The clearance above the roadway to the lowest point on any traffic signal, backplate or tether cable shall initially be set at 18 feet (*5.5 meters*) and, at no time prior to acceptance of the work, shall this clearance be permitted by the contractor to become less than 17 feet (*5.2 meters*).

Tie wraps for attaching IMSA cable to the messenger cable shall be of the stainless steel type, standard cross section and shall be installed at 15 inch (*375 millimeter*) maximum spacing. The tie wrap shall be installed snug, without damaging the conductor cable

insulation. The cable tie tail shall be cut off flush with the cable tie lockinghead. Excessive and unsightly slack in the IMSA cable shall not be permitted.

732-3.04 Wiring Procedures.

(A) General. Wiring shall conform to the regulations and codes listed in Subsection 730-3 and the following requirements:

The conductors shall be pulled into runs in a smooth continuous manner, avoiding contact with sharp objects that might damage the insulation. Approved lubricants shall be used for inserting conductors in conduit. Before installation, conductor ends shall be taped for moisture protection until connections are made. Cables travelling up poles shall be supported by cable anchors provided inside the pole. Cable socks shall be used for this purpose.

Each conductor shall have a minimum of 36 inches (*900 millimeters*) of slack from the top of the pull box.

For controller cabinets, the contractor shall allow for 9 feet (*2.75 meters*) of cable or conductors for termination. IMSA cables shall be stripped back and the individual conductors tagged. All other single- and multi- conductor cables shall be tagged or, as required by these specifications, tagged and taped. Tagging and taping shall be completed before Agency personnel begin controller cabinet termination work or testing will be permitted.

All ungrounded ballast primary leads shall be protected with fused in-line connectors. Unfused in-line connectors shall be installed on all ballast secondary leads. In-line connectors shall be fused with fast-acting, high-interrupting capacity fuses with a fault current rating of 100,000 amperes at 600 volts AC. The in-line connectors shall be watertight, non-locking and rated at 600 volts AC.

(B) Splices. In circuits where the voltage does not exceed 240 volts AC, splices shall be made utilizing approved spring-type wire connectors. All neutral and ground wire splices shall be made using split bolt connectors. Soldered connections will not be permitted unless so specified. The insulation for the splice shall consist of two layers of electrical rubber tape, four layers of plastic electrical tape and two layers of friction tape. The tapes shall be securely applied over the bare wire splice area and back onto the original insulation a minimum of 1 inch (*25 millimeters*). A minimum of three coats of approved liquid waterproof splicing compound shall then be applied to the splice. The finished splices shall be such that their electrical and mechanical characteristics and insulation quality are equal to those of the original cable. Street lighting conductors shall be spliced only in pull boxes, terminal compartments, steel pole

handholes, or street light pole transformer bases. Unless otherwise specified, traffic signal conductors shall not be spliced between the traffic signal support pole terminal compartment and the traffic signal controller cabinet.

Splices for circuits in the range greater than 240 volts to and including 600 volts shall be made with the appropriate size and type of split bolt connectors and approved "Scotch Cast Kits" or approved equal splicing kits. Spring type connectors will be acceptable for No. 10 gauge or smaller diameter wire. A limitation of three wires per splice shall not be exceeded. The splices shall consist of epoxy resin mold type splice insulation kits and shall be rated at 600 volts. The finished splice shall make a sealed waterproof connection which shall be equal to the original cable conductors and insulation.

Splices for high-voltage series lighting conductors shall be made from an approved splice kit. The splices shall consist of epoxy resin mold type splice insulating kits and shall be rated at 5 KV. The finished splice shall make a sealed waterproof connection which shall be equal to the original cable conductors and insulation.

Cable used for detector lead-in, pre-empt sensors, and telephone drop circuits shall be run continuous and unspliced to the controller cabinet.

Splices in interconnect runs where the interconnect cable is installed in street lighting conduits shall be more than 2700 feet (*825 meters*) apart.

Spare conductors shall be installed and spliced as necessary from the end-of-arm signal on the mast arm, and pole-top signals on 10 foot poles, to the controller cabinet to provide a usable complete circuit. These "future" conductors shall be coiled and taped in the middle section of the signal heads with adequate length to the terminal strips.

Unless otherwise specified, signal circuit conductors for each mast arm mounted signal shall be continuous without splicing from the terminal compartment to the terminal block in each signal head.

(C) Tagging and Taping. All conductors shall be tagged to identify their circuit number or function with wire marking tags. The tag identification shall correlate with the conductor schedule shown on the project plans. Tags shall be nylon cable ties with integral marking tag. Tags shall be labeled with a permanent ink pen. The tags shall be furnished and installed by the contractor. Each tag shall be wrapped entirely around the conductor. Each signal wire shall be tagged as to phase, color indication, or pedestrian push button (Phase A1 - Red, Yellow, Green, etc.). Each phase group shall also be tied together and tagged. Each lighting circuit wire shall be tagged to identify the circuit number and other types of circuits. Black wires used as spares shall be tagged as "spares".

Additionally, wire marking tags shall be affixed to the loop lead-ins indicating which lane that pair of leads serves. Lane No. 1 shall always be the lane closest to the median island or double yellow center line, with lanes being numbered consecutively, working to the outside curb or roadway edge. Where there is only one loop or one lane, tagging is still required.

In addition to the above tagging requirements, plastic tape wraps shall be affixed to each of the following cables in the controller cabinet and in each pull box through which the cable runs:

(1) Detector Lead-In Cable.

One circumferential wrap shall indicate that the cable serves the "rear" set of loops for the direction of travel. Two wraps shall indicate the "front" set of loops for the direction of travel. Three wraps shall indicate left turn lane loops for the direction of travel. Taping shall be color coded as follows:

Direction of Travel	Color Code
Northbound	Yellow
Southbound	Red
Eastbound	Green
Westbound	Orange

(2) Interconnect Cable.

Each interconnect cable shall be identified with a single wrap of black tape.

(3) Pre-Empt Cable.

Each pre-empt sensor cable shall be identified with two wraps of black tape to indicate the northbound/southbound directions of travel and three wraps of black tape to indicate the eastbound/westbound directions of travel.

Wires shall be tagged in controller cabinets, street lighting cabinets, pull boxes, or wherever splicing occurs, except in terminal compartments. Tagging shall be made in pull boxes wherever an unspliced IMSA, interconnect, telephone drop, or detector lead-in cable runs through.

(D) Testing.

(1) Signal Circuits.

Prior to controller cabinet installation, the contractor shall apply 120 volts to signal circuits and verify that the equipment is operational. The Agency will connect field wiring inside the controller cabinet.

The Agency shall perform both an insulation to ground test and an insulation line to line test on all conductors after splices and/or terminations have been completed. A second test shall be performed prior to final acceptance. Both tests may be carried out simultaneously if requested by the contractor. In no case shall the resistance to ground as measured in the first test be less than 50 megohms when measured with a 1,000 volt DC meggering device.

(2) Street Lighting Circuits.

The contractor shall connect field wiring to the load center terminals. Lighting circuits shall be energized for 100 hours as directed by the Engineer prior to final acceptance. Failures occurring during this test period shall be corrected.

The Agency shall perform an insulation to ground test on all conductors as specified in (1) above.

732-3.05 Bonding and Grounding. All metallic enclosures including, but no limited to, cabinets, pedestals, poles, mast arms on wood poles, span cables, metal conduit and cable sheaths shall be bonded to form a continuous grounded system. Non-metallic portions of the system such as PVC conduit shall have a bare copper bond wire installed with suitable connections to form a continuous grounded system.

All grounding connections shall be exposed in services, pull boxes, and pole bases. An additional ground rod shall be installed in the pull box nearest to the control cabinet and bonded to the cabinet rod with No. 4 bare bond wire. Connections shall be made with split bolt connectors or lugs of appropriate size and type. Spring type connectors will not be acceptable for grounding applications.

At each service disconnect, two approved copper-plated ground rods, separated by at least 6 feet (*1.8 meters*), shall be installed. At each cabinet foundation, or where otherwise specified, an approved copper-plated ground rod shall be installed. Each ground rod shall be a one-piece solid rod of the copper weld type, or approved equal, and shall be a minimum of 3/4 inch (*19 millimeters*) in diameter and 10 feet (*3 meters*) in length. The rod shall be driven vertically into the ground to a minimum of 9 feet (*2.7 meters*) below the surface. The ground rod may be located in a pull box. The service equipment neutral and the system grounding bond shall be connected to the ground rod with a copper-plated bolt or a brass bolt on the ground clamp.

Pole foundations shall have 25 feet (*7.6 meters*) of number 4 AWG bare copper conductor coiled and placed at the bottom of the excavation, with a small amount of dirt cover, before concrete is poured. The conductor shall be connected to the pole grounding screw in the hand hole with an approved lug connector.

A ground resistance test shall be performed for each installed ground rod. Pole foundation coil grounds shall be tested as determined by the Engineer in the field.

The ground resistance shall be measured with a three terminal, fall of potential, direct reading, battery powered earth tester with a 0.50 to 500 ohm scale or digital read-out. The 25 ohm reading shall be approximately at mid scale.

The test shall be performed according to the manufacturer's instructions and OSHA requirements. Two auxiliary copper clad ground rods shall be driven into the ground a minimum of three feet. The lateral spacing for each test rod shall be given in writing on the test report form and the spacing shall be approved by the Engineer.

All tests shall be performed in the presence of the Engineer and test results shall be written down, dated, and given to the Engineer for approval.

Each ground rod or foundation ground shall be isolated with the bond wires disconnected when the test is being performed. The resistance to ground shall be 25 ohms or less. If it is not, additional ground rods shall be installed as required at least 15 feet (*4.6 meters*) from the original ground and shall be bonded to it. The test shall then be repeated for multiple grounds as necessary to achieve proper grounding below 25 ohms. As many additional ground rods shall be installed as is necessary to achieve proper grounding of 25 ohms or less.

The test shall be performed when the soil is dry. The contractor shall not add any chemical, or salt solutions to any portion of the grounding system. All grounding rods and foundation grounds to be tested shall be installed a minimum of ten days prior to testing unless otherwise determined by the Engineer in the field.

732-3.06 Service. Installation of the service pedestal cabinet shall be one of the first items of construction so that coordination may be made with other agencies involved in the electrical hook-up and inspection.

Service system components and their installation shall conform to regulations and codes listed in Subsection 730-3, NEC, UL, local applicable codes, and the requirements of the utility company providing service. The contractor shall secure the necessary utility company permits, pay related fee(s) for said permit, and coordinate the installation of the required power service(s).

Unless otherwise specified on the project plans or in the Special Provisions, the contractor shall supply and install reflective numbers and letters for the service address on the street side of the service pedestal or street lighting station cabinet.

Service risers shall be rigid galvanized steel as specified. Fastening of the service risers and all other conduits on wood poles shall be done through the use of conduit stand off holders

utilizing wood screws of a minimum 1-1/2 inches (*40 millimeters*) in length. Tape, nails, drive hooks or other means of attachment shall not be used.

All safety switch and multi-breaker enclosures shall be provided with a padlock to prevent unauthorized persons from operating equipment or disconnects. Padlocks will be furnished by the Agency.

Meter sockets shall be approved by the serving utility company. They shall be furnished and installed by the contractor. The meter socket shall be located as shown on the project plans. Meter service inspection shall be approved by the Engineer prior to service connection by the utility company.

Service pedestals shall be furnished with a single pole breaker for the traffic signal and a single pole breaker for the street lighting when specified on the project plans.

If work is required on existing high voltage and series lighting circuits, the contractor shall obtain daily safety circuit clearance from the Agency and the serving utility company prior to any work being done.

Signs painted "Danger-High Voltage" shall be installed permanently by the contractor on all Agency electrical service structures. These signs shall be furnished by the contractor.

Fused cutouts on the source side of a series lighting service structure shall be pulled out and safety signs shall be furnished by the contractor and posted on the cutouts before any work is done. The signs shall be painted "Danger-High Voltage" and shall give the name of the company doing the work.

732-4 METHOD OF MEASUREMENT

Conductors (for street lighting systems), will be measured by the linear foot for each gauge size as follows:

(1) From center to center of pull boxes.

(2) From edge of foundation to center of pull box.

(3) From edge to edge of foundation.

(4) From end of conduit to center of pull box.

(5) From end to end of conduit when no pull boxes are used.

(6) From edge of wood pole to edge of foundation or center of pull box.

Conductors (for signals and integral street lighting), will be measured as a complete unit of work.

No measurement or direct payment will be made for conductors in poles, foundations and pull boxes, the cost being considered as included in the contract price for the pole, foundation and pull box items.

Conduit will be measured by the linear foot (*meter*) for each diameter size as follows:

(1) From center to center of pull boxes.

(2) From edge of foundation to center of pull box.

(3) From edge to edge of foundation.

(4) From end of conduit to center of pull box.

(5) From end to end of conduit when no pull boxes are used.

(6) From edge of wood pole to edge of foundation or center of pull box.

Pull boxes and metal junction boxes will be measured as a unit for each pull box or metal junction box.

Messenger and tether cable will be measured by the linear foot (*meter*) for each diameter size from center to center of poles.

Service pedestal cabinets will be measured as a unit for each service pedestal cabinet furnished and installed.

732-5 BASIS OF PAYMENT

732-5.01 Conductors (For Street Lighting Systems). The accepted quantities of conductors (for street lighting systems), measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), which price shall be full compensation for the item, complete in place.

732-5.02 Conductors (For Signals and Integral Street Lighting). Conductors (for signals and integral street lighting), measured as provided above, will be paid for at the contract lump sum price, which price shall be full compensation for the work, complete in place.

732-5.03 Conduit. The accepted quantities of conduit, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), which price shall be full compensation for the work, complete in place, including excavation, concrete encasement, backfill, conduit crossing existing pavement, conduit crossing existing concrete, removal and replacement of existing concrete for placement of conduit and light poles, and any incidentals necessary to complete the work.

732-5.04 Pull Boxes and Metal Junction Boxes. The accepted quantities for pull boxes and metal junction boxes, measured as provided above, will be paid for at the contract unit price each, which price shall be full compensation for the work, complete in place, including any excavating and backfilling necessary to complete the work.

732-5.05 Messenger and Tether Cable. The accepted quantities of messenger and tether cable, measured as provided above, will be paid for at the contract unit price per linear foot (meter), which price shall be full compensation for the work, complete in place, including tie wraps and any incidentals necessary to complete the work.

732-5.06 Service Pedestal Cabinets. The accepted quantities of service pedestal cabinets, measured as provided above, will be paid for at the contract unit price each for the type service pedestal cabinet designated in the bidding schedule, complete-in-place, which price shall be full compensation for the work described and specified herein and on the plans, including service terminal boxes, meter sockets when specified, breaker panels, and all other components necessary to complete the work and delivery of the required materials.

732.5.07 Electrical Service Installations. The accepted quantities of electrical service installations, measured as provided above, will be paid for at the contract lump sum price which price shall be full compensation for the work, complete in place and inclusive of the:

the cost of purchase and installation of related above ground conduit and meter enclosure for each service;

the cost of trenching and backfill for the installation of service provided cable in conduit; and/or

the cost of purchase and installation of related conduit, meter enclosure and pole riser.

SECTION 733

SIGNAL INDICATIONS AND MOUNTING ASSEMBLIES

733-1 DESCRIPTION

The work under this section shall consist of furnishing, installing and/or modifying traffic signal indication assemblies, pedestrian signal indications, flashing beacons, pre-empt sensors and beacons, and mounting assemblies at the locations shown on the project plans and in accordance with the details shown on the plans, the special provisions, and the requirements of these specifications.

733-2 MATERIALS

Unless otherwise specified, all new signals, except the programmed visibility and the pedestrian types, installed at any one intersection shall be of the same manufacturer and of the same material.

Metal parts for signal indications shall be painted a minimum of two coats of either yellow enamel paint or dull black enamel paint, as shown in the following table, which shall conform to the requirements of Section 1002. Polycarbonate molded parts for signal indications shall be colored throughout the material, except that visor interiors shall be painted with enamel in conformance with this subsection and Section 1002. Polycarbonate parts shall either be yellow or dull black in color, as shown in the following table, which shall match the color chips specified in Subsection 1002-4.

COLOR TABLE FOR SIGNAL INDICATION PARTS

PARTS	COLOR
Traffic Signal Indication Housing and Doors	Yellow or Dull Black
Pedestrian Indication Housings	Yellow or Dull Black
Pedestrian Indication Doors	Dull Black
Visor Exteriors	Yellow or Dull Black
Visor Interiors	Dull Black
Louvers	Dull Black
Backplates, Both Sides	Dull Black
Mounting Assemblies	Yellow or Dull Black
Push Button Stations	Yellow or Dull Black

733-2.01 Signal Indications.

(A) Standard Signal Faces. Each vehicle signal face shall be of the adjustable vertical type with the number and type of sections specified on the plans and the Agency's standard drawings or standard details.

Adjustment shall permit rotation of 360 degrees about a vertical axis. Each vehicle signal face shall provide an indication in one direction only.

Unless otherwise shown on the plans, all vehicle signal faces shall contain three sections arranged vertically; red-top, yellow-center, green-bottom.

Signal faces shall be standard 8 inch (*200 millimeter*) or 12 inch (*300 millimeter*) lens size.

(1) Optical Equipment.

Each optical unit shall consist of a lens, reflector or reflector assembly, a lamp holder, and a clear traffic signal lamp of the appropriate size and type as specified herein or in the special provisions. The optical units shall conform to ITE Standards and ANSI Standard D 10.1.

(a) Lenses. Polycarbonate lenses shall be supplied and installed in all circular red, circular yellow, and circular green lenses. Red arrow, yellow arrow, and green arrow lenses shall be made of glass except that polycarbonate lenses may be used for arrow indications when aluminum cutout inserts are installed.

Lenses shall be of the color indicated, circular in shape, with a nominal visible diameter as indicated on the project plans and of such design as to give an outward and downward distribution of light with a minimum above the horizontal. Each lens shall be true to color, manufactured of first quality glass or polycarbonate, free from imperfections and provide high illumination transmission. Lenses shall conform to ITE Standards.

Polycarbonate lenses shall be made of ultraviolet stabilized polycarbonate conforming to the specifications of ASTM D 2473. Polycarbonate lenses shall not distort due to heat from a 150 watt signal lamp.

(b) Reflectors. Each reflector shall be a single piece of silvered glass or specular aluminum with an anodic coating. Reflectors shall conform to ITE Standards. An opening in the back of the reflector for the lamp holder shall be constructed so that there will be no dark spots cast on the lens.

(c) Lamp Holders. The lamp holder shall have a heat-resistant molded phenolic housing and be designed to accommodate up to a 150 watt standard A-21 traffic signal lamp, in the proper focal position.

(d) Lamps. Lamps to be used in vehicular traffic signal faces shall conform to the standards set forth in the ITE publication "Standard for Traffic Signal Lamps" and the following table, unless otherwise specified:

TRAFFIC SIGNAL LAMP TABLE

Nominal Size	Bulb Type	Lens Color	Initial Lumens	Rated User-Hours	Rated Wattage	Center Length
8 Inch (*200 mm*)	AT19	Green Yellow	610	7500-8500	60	2-7/16 inch (*61 mm*)
8 Inch (*200 mm*)	AT19	Red	610	7500-8500	60	2-7/16 inch (*61 mm*)
12 Inch (*300 mm*)	AT21	Green Yellow Red	1750	5500-6500	135	3 inch (*75 mm*)
Pedestrian	AT21	White Orange	1250	5500-8000	~~116~~ 75	2-7/16 inch (*61 mm*)

All lamps shall be rated at 120 volts AC.

Lamps shall be clear and have an aluminum reflector disc. Projection type filaments shall be used, and supported at 7 points. Name of manufacturer, wattage, voltage, and user hours shall be etched on lamps. Amount of krypton gas shall be not less than 80 percent of the total fill gas of the lamp. If requested by the Engineer, the lamp manufacturer shall provide a report by an independent testing laboratory certifying the beam candle power and composition of the fill gas.

(2) Hardware.

Hardware for a standard signal section shall include a one-piece hinged door, a simple locking device, housing for lenses and other optical components, water-tight gaskets, terminal block and wiring. The sections shall be interchangeable and so constructed that sections can be added or removed. All exterior hardware such as hinge pins, bolts, screws, and locking devices shall be of 304 or 305 stainless steel. All interior screws and fittings shall be stainless steel or approved non-ferrous corrosion resistant material.

(a) Housing. Unless otherwise specified, the housing for each signal section shall be one piece, injection molded, virgin polycarbonate resin and shall conform to ITE Standards.

Where aluminum signals are specified, the housing for each signal section shall be one piece, corrosion resistant, die cast or permanent mold cast aluminum conforming to ITE Standards.

The housing of each section shall be designed to permit access to the section for relamping without use of tools. Fittings and locking devices shall conform to the details of the Agency's standard drawings or standard details. The reflector, reflector ring, lamp holder, and spring wire bail shall be designed so they may be removed or replaced without the use of tools.

(b) Door. The door shall be suitably hinged and securely held to the housing by hinge pins and locking devices. Door material and thickness shall be identical to the housing material and thickness.

(c) Gasketing. Lamp holder gaskets shall be of material not affected by heat. All other gaskets, including door, lens and reflector gaskets, shall be of weather-resistant neoprene.

(d) Terminal Blocks and Wiring. The terminal block for a standard three section signal shall be a four position, eight terminal barrier type strip mounted in the back of the middle unit. To the left of each terminal strip shall be attached the white, red, yellow, and green signal section leads and the opposite terminals shall be for field wires. The wires from the terminal block to the lamp socket shall be minimum size number 18 AWG, type TFF, 30 mil (750 micrometers) insulation thickness and rated at 105 °C.

(3) Visors.

Aluminum visors shall be used with aluminum housings and doors, and polycarbonate visors shall be used with polycarbonate housings and doors. Each aluminum signal section shall have an 11 to 12 inch (*280 to 300 millimeters*) long tunnel visor which shall be fabricated from number 3003 H-16 aluminum alloy. Each polycarbonate signal section shall have an 8 to 10 inch (*200 to 250 millimeters*) long tunnel visor which shall be molded of virgin polycarbonate resin. Visors shall conform to ITE Standards and to the Agency's standard drawings or standard details.

(4) Backplates.

Backplates shall be furnished and installed on all vehicular signal sections with 10 x 5/8 inch (*16 millimeter*) hex, HD, SMS, zinc coated screws and a 3/8 inch (*10 millimeter*) flat zinc coated washer. Anodized aluminum sheet, 16 gauge (*1.6 millimeters*), shall be used. Five inch (*130 millimeters*) backplates shall be installed on all signal sections. Louvered backplates shall be provided with a 1/2 inch (*13 millimeter*), 90° reinforcing angle on each side and shall conform to the Agency's standard drawings or standard details.

(5) Directional Louvers.

Where shown on the plans, directional louvers shall be furnished and installed in signal visors. Directional louvers shall be so constructed as to have a snug fit in the signal visors. The cylinder and vanes shall be fabricated from 5052-H32 aluminum alloy. Dimensions of louvers and vane configuration shall be as shown on the plans. The outer cylinder and the vanes shall be 0.032 inch (*0.8 millimeter*) minimum thickness and the vanes shall be 0.016 inch *(0.4 millimeter*) minimum thickness.

(B) Programmed Visibility Signal Faces.

(1) General.

Each programmed visibility signal face shall conform to the provisions in Subsection 733-2.01 (A), except the provisions for optical equipment shall not apply. The programmed visibility signal section shall provide a nominal 12 inch (*300 millimeters*) diameter circular or arrow indication.

Each section shall be provided with a sun visor and an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal axis. The visibility of each programmed visibility signal face shall be adjustable within the signal for the lane(s) in which traffic is to be controlled. When unprogrammed, the indication shall be visible from anywhere within 15 degrees of the optical axis.

(2) Optical Requirements.

The components of the programmed visibility signal face optical assembly shall be a circlet reflector, optical limiter-diffuser and objective lens conforming to ITE Standards. A circlet reflector with a specular inner surface shall join the lamp to the diffusion element.

The optical limiter-diffuser shall provide an image focused for objects at a distance of 900 to 1200 feet (*275 to 365 meters*) limited by a veiling system.

The objective lens shall be a high resolution planar incremental lens, hermetically sealed with a flat laminate of weather resistant acrylic. The lens shall be symmetrical and able to be rotated to any 90 degree orientation about the optical axis.

Each signal section with a yellow indication priority programming shall provide a minimum luminous intensity of 3,000 candela on the optical axis and a maximum intensity of 30 candela at 15 degrees horizontally from the axis. Each

section shall be capable of having visibility programmed for a minimum 3,000 candela at 2 to 15 degrees horizontal from the axis. Under the same conditions, the intensities of the red indication and the green indication shall be at least 19 and 35 percent respectively of the yellow indication.

(3) Lamps and Dimming Devices.

The lamp for each signal section shall be a nominal 150 watt, sealed beam, 120 volt, 6000-hour minimum rated life lamp as specified. During daylight, the signal indications shall be visible only in the lanes designated. For nighttime operation, dimming devices shall be provided to reduce the intensity by 15 percent.

(4) Terminal Blocks.

Terminal blocks shall conform to the provisions in Subsection 733-2.01 (A) (2) (d).

(C) Light Emitting Diode (LED) Signal Faces:

(1) General.

Each light emitting diode (LED) signal face shall conform with the requirements of Subsection 733-2.01(A), except that the requirements for optical equipment shall not apply. The LED signal shall provide a nominal 12 inch (*300 millimeter*) or 8 inch (*200 millimeter*) diameter circular or arrow indication as identified on the plans. Two extra 12 inch (*300 millimeters*) and two 8 inch (*200 millimeters*) signal heads shall be provided to the Agency as spares.

The manufacturer shall provide a statement indicating a minimum of 3 years acceptable experience in the production of LED traffic signal lamps.

(2) Optical Requirements.

Each signal face shall be comprised of a smooth surface ultraviolet (U.V.) stabilized poly carbonate outer shell, multiple LED light sources, a regulated power supply and a poly carbonate back cover assembled in a sealed module. LED's shall be mounted on a poly carbonate positioning plate. Mechanical alignment and assembly mechanism shall ensure that each LED is retained in a predetermined position. The light distribution of each LED shall be maximized by an internal beam controlling the optical faceted lens.

The "legs" of the LED's shall be kept at full length to improve heat dissipation. No cutting or trimming of the original length of any LED shall be allowed.

Replacement of one or more LED's or LED circuits shall be possible without de-soldering or soldering.

(3) Electrical.

Each unit shall incorporate a regulated power supply engineered to electrically protect the LED's.

The power supply shall provide capacitor filtered, regulated direct current to the LED's in accordance with the manufacturer's specifications. The power supply shall conform to the requirements of UL No 1012.

The unit shall operate on a 60 hertz AC line voltage ranging from 89 volts RMS to 135 volts RMS with less than a 10% light intensity variation. Nominal rated voltage for all measurements shall be 117 volts RMS. The circuitry shall prevent flickering over this voltage range. The maximum wattage required for the unit shall not exceed 14 watts for red and green and 25 watts for yellow.

The LED signal module circuitry shall provide an AC electrical power factor of 0.95 or greater. The total harmonic distortion (current and voltage) induced into an AC power line by a signal module shall not exceed 10 percent.

(4) Environmental Requirements.

The module shall be rated for use in ambient operating temperature range of minus 40° F (*minus 40 °C*) to 178° F (*81.1 °C*).

The module shall be dust and moisture resistant in order to protect the internal LED and electrical components.

(5) Testing Requirements.

Each LED traffic signal lamp unit shall be energized for a minimum of 24 hours at operating voltage and at a temperature of 140° F (60 °C). In order to detect any electronic defect, and to ensure electronic component reliability after the burn-in process is completed, each LED traffic signal lamp unit shall be tested by the manufacturer for comparison to the initial intensity at rated operating voltage for measurement.

(6) Documentation and Warranty.

Each unit shall be provided with the following: A complete and accurate installation wiring guide; the contact name, address and telephone number for the representative, manufacture or distributor for warranty repair; a copy of a test report certified by an independent laboratory stating that the supplied unit meets ITE standards and requirements; and a warranty against failure due to workmanship or material defects within the first 60 months of field operation.

Additionally, the contractor shall provide the serial number for each LED together with the location where it was installed.

733-2.02 Pedestrian Signals. Incandescent international man/hand symbol pedestrian signals shall be furnished and installed unless specified otherwise.

Pedestrian signal assemblies shall be complete and operational with the international man/hand symbol indications, and the mounting assemblies shall be furnished and installed by the Contractor as shown on the plans and/or the Agency's standard drawings or standard details.

(A) Incandescent Pedestrian Signal Indications.

(1) General Requirements.

Each incandescent pedestrian signal shall consist of a housing, two color message plate, a reflector assembly, two incandescent lamps and a front screen.

The pedestrian signal shall be furnished complete with incandescent lamps as described herein.

The overall maximum dimensions of each housing, including the front screen, shall be 18-1/2 inches (*463 millimeters*) in width, 18-3/4 inches (*469 millimeters*) in height and 11-1/2 inches (*293 millimeters*) in depth.

(2) Case and Door Frame.

The case shall be one-piece, corrosion-resistant, aluminum alloy die casting, complete with integrally cast top, bottom, sides and back. Four integrally cast hinge lug pairs, two at the top and two at the bottom of each case, shall be provided for operation of a swing-down door.

The case shall be properly matched to other pedestrian signal components to provide a dustproof and weatherproof enclosure and shall provide easy access to replace all components.

The door frame shall be a one-piece, corrosion resistant, aluminum alloy die casting, complete with two hinge lugs cast at the bottom and two latch slots cast at the top of each door. The door shall be attached to the case by means of two type 304 stainless steel spring pins. Two stainless steel hinged bolts with captive stainless steel wing nuts and washers shall be attached to the case with the use of stainless steel spring pins. Latching or unlatching of the door shall not require tools.

(3) Message Lenses.

Each message lens shall be one piece and shall be made of 1/8 inch (*3 millimeters*) minimum thickness, ultraviolet stabilized polycarbonate or 3/16 inch (*5 millimeters*) tempered glass. Either lens shall have a textured outside surface to eliminate

message "hot spots". Message lens shall not degrade due to heat from bulb. The "Hand" symbol shall be Portland orange and the "Man" symbol shall be white.

(4) Reflector.

Each reflector shall be a single piece double parabolic reflector constructed from textured plastic or aluminum. All reflectors shall conform to the requirements of ITE Standards. Plastic reflectors shall consist of vacuum formed polycarbonate with a vacuum deposited aluminum reflector surface and shall not distort when used with a lamp of specified wattage normally used in the signal.

(5) Lamp Holder.

Each lamp holder shall be positioned so as to be centered and pre-focused in its respective position when an A21 bulb with medium base is used. The lamp holder shall be made of molded phenolic and shall have a brass screw shell with lamp grip.

(6) Visor.

Each incandescent pedestrian signal shall be provided with an egg-crate type visor designed to eliminate sun phantoms.

The crate assembly shall consist of 15 vertical members and 26 horizontal members plus two integral locking strips to prevent vandalism. The vertical spacing of the horizontal member shall be 1/2 inch (*13 millimeters*). The completed egg-crate portion shall be 1-1/2 inches (*40 millimeters*) deep.

The material for the crate visor shall be 0.030 inches (*1 millimeter*) thick and shall be 100 percent impregnated black polycarbonate plastic with a flat finish.

(7) Wiring and Terminal Blocks.

Each lamp socket for incandescent pedestrian signals shall be provided with one red lead for "Hand" symbol and one green lead for "Walking Man" and one white lead from the shell. Leads shall be number 18 AWG and shall be wired to respective terminals of a three terminal block. The two white wires shall be connected to a common terminal.

(B) Light Emitting Diode (LED) Pedestrian Signals.

Light Emitting Diode (LED) international "hand/man" pedestrian signal symbol assemblies shall be complete and operational with the international "hand/man" symbol indications and mounting assemblies furnished and installed by the contractor as shown on the project plans.

(1) General Requirements

The LED hand/man pedestrian signal and color shall meet ITE requirements. A separate transformer shall be used for each message.

733-2.03 Flashing Beacons.

(A) Intersection Control Beacons. The intersection control beacon shall consist of one or two signal sections as designated on the project plans, conforming to the provisions in Subsection 733-2.01 (A). A yellow or red lens shall be used as specified on the project plans.

(B) Overhead Flashers. The overhead flashing beacon shall consist of one or two signal sections, as shown on the plans, mounted on a cantilever arm assembly. Each overhead assembly shall incorporate 12 inch (*300 millimeters*) signal sections with yellow lenses unless otherwise specified.

(C) Pole Flashers. Each pole flasher shall consist of two signal sections. Each pole flasher assembly shall contain 8 inch (*200 millimeters*) or 12 inch (*300 millimeters*) signal sections with yellow lenses as specified as in the project plans.

(D) Control Equipment Housing. The control equipment housing shall be as shown on the plans unless otherwise specified.

733-2.04 Pre-Empt Sensors and Beacons.

The pre-empt nylon clip shall be furnished by the Agency.

The pre-empt beacon shall be furnished by the contractor and shall be an industrial type strobe beacon with a 2-1/2 inch (*65 millimeters*) diameter, Fresnel type, clear optic lens and a xenon flash tube lamp having an 80 flash per minute (fpm) flash rate and minimum 15 joules per flash. Power consumption of the pre-empt beacon shall be approximately 0.3 amps. The pre-empt beacon shall be 6 inches (*150 millimeters*) high, exclusive of mount, and 4-3/4 inches (*119 millimeters*) in diameter maximum. Each pre-empt beacon shall be mountable on a standard 1 inch (*25 millimeters*) galvanized pipe.

The beacon mounting pipe shall be fit to a length such that the base of the beacon assembly appears flush with the upper edge of the signal backplate. No portion of the pipe shall be visible.

733-2.05 Mounting Assemblies. Mounting assemblies shall consist of terminal compartments and assemblies of 1-1/2 inch (*38 millimeters*) standard pipe and fittings. All members shall be so fabricated that they shall provide plumb, symmetrically arranged, and securely fabricated assemblies.

Unless otherwise specified, each span wire mounted traffic signal face shall be attached to the messenger and tether cables utilizing the adjustable, rigid mounting assembly shown in the Agency's standard drawings or standard details.

A terminal compartment shall be assembled as shown in the Agency's standard drawings or standard details. The terminal compartment shall be manufactured of bronze or ductile iron.

Each terminal compartment shall be fitted with a 12-position, 24-terminal block. Each type of mounting assembly shall be supplied with wiring from the terminal block through the support arm which holds the signal. This wiring shall be in the form of color-coded wire leads with spade terminals for connecting to the signal head, and soldered ends for connecting to terminal strips in the terminal compartment. The wiring shall be colored-coded as follows:

White - Common to all heads
Red - Red lens head
Yellow - Yellow lens head
Green - Green lens head

The leads shall be minimum number 16 stranded AWG Type THW with 30 mils (*750 micrometers*) thermoplastic insulation. Leads shall be of sufficient length to extend from the center section of the signal head to the top of the terminal compartment.

Terminal compartment wire hookup shall be as follows:

Top terminal - Phase A Red
Next terminal - Phase A Yellow
Next terminal - Phase A Green
Next two terminals - Phase B LT Yellow-Green
Bottom terminal - Common - White

A rainproof cover shall be provided for all terminal compartments which will provide ready access to the internal terminal block wiring.

The types of frameworks used and the methods of mounting them shall be as shown on the plans or specified in the special provisions.

733-3 CONSTRUCTION DETAILS

Construction shall be such that all conductors are concealed within assemblies. Cable guides shall be used to support and protect conductors entering through poles. All threads shall be coated with rust-preventive paint during assembly.

Each vehicle signal face, pedestrian signal, or flasher assembly shall be mounted at the location and in the manner shown on the project plans.

When signal faces are mounted on a mast arm, the mounting assembly shall be placed on the mast arm and a 3/8 inch (*10 millimeters*) by 4 inch (*100 millimeters*) bolt shall be used to fasten both together.

When signal faces are span wire mounted, the mounting assembly shall be installed on the messenger and tether cables in conformance to the Agency's standard drawings or standard details.

Unless an approved elevator plumbizer or framework assembly is used, reinforcing plates shall be installed wherever polycarbonate signal faces are rigidly mounted, e.g. on mast arm and Type III mounts.

Pre-empt sensors and pre-empt beacons shall be installed at the locations shown on the plans. The contractor shall arrange with the Engineer to pick up the pre-empt sensor units if supplied by Agency. All other materials and work required shall be provided by the contractor. Pre-empt sensor units shall be installed beneath the end-of-arm signal head on mast arm installations and above the signal head on pole-top mountings using a vertical riser nipple which shall be installed on the mounting assembly or on the top cap of the signal head. Installation of the sensor shall be such that line-of-sight transmissions from approaching emergency vehicles are not blocked by the backplate. Unless otherwise specified, the pre-empt beacon shall be installed above the end-of-arm signal head on mast arms by use of a 1 inch (*25 millimeters*) standard galvanized pipe, 6 inches (*150 millimeters*) in length, attached to the top cap of the signal head. Leads shall be run through the pipe into the terminal section of the signal head and be connected to the field cable conductors with wire caps.

At locations where a traffic signal does not currently operate, field mounting of vehicular signal heads shall not be made until definite arrangements for power, "flash out", and turn on have been made with the Engineer and, in no case, shall field mounting occur 48 hours prior to the scheduled turn on. Turn on days are restricted to Monday through Thursday. All vehicular and pedestrian signal heads that are not operating shall be covered with burlap. In addition, pedestrian heads shall be turned as directed by the Engineer.

Materials removed and not designated to be salvaged or incorporated into the work shall become the property of the Agency and shall be delivered to the location(s) designated by the Engineer.

733-4 METHOD OF MEASUREMENT

Traffic signal faces, pedestrian signal faces, traffic signal mounting assemblies, flashing beacons, and pre-empt beacons will be measured as a unit for each type of signal face, mounting assembly, flashing beacon, or pre-empt beacon furnished, installed and/or modified. Pre-empt sensors will be measured as a unit for each pre-empt sensor installed and/or modified.

733-5 BASIS OF PAYMENT

The accepted quantities of traffic signal faces, pedestrian signal faces, traffic signal mounting assemblies, flashing beacons, and pre-empt sensors and beacons, measured as provided above, will be paid for at the contract unit price each, for the type signal face, mounting assembly, flashing beacon, or pre-empt sensor or beacon designated in the bidding schedule, complete-in-place, which price shall be full compensation for the work described and specified herein and on the plans, including visors, backplates, lamps and all hardware necessary to provide a complete and functional installation.

No direct payment will be made for assembly of Agency-furnished items, the cost being considered as included in the contract price bid for the item in place.

SECTION 734

TRAFFIC SIGNAL CONTROLLER ASSEMBLY

734-1 DESCRIPTION

The work under this section shall consist of furnishing and/or installing traffic signal controller assemblies, in whole or in part according to the plans and/or special provisions, at the locations shown on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

A traffic signal controller assembly shall consist of a complete assemblage of electrical equipment and components for controlling the operation and timing of traffic control signals.

734-2 MATERIALS

The traffic signal controller assembly shall include the controller unit, all necessary auxiliary equipment, the controller cabinet, concrete foundation, conduit, elbows, anchor bolts and service pad.

The auxiliary equipment shall include all appurtenances such as flasher controls, loop detector amplifiers, power assemblies, signal load switches, malfunction management unit, pre-emptors, coordinators, time switches, external logic, lighting controls, and accessories as indicated on the plans or in the special provisions.

The following auxiliary equipment shall be furnished with all wired traffic controller assemblies when required:

Power Panel
Signal Load Switches
Detectors
Controller Flasher Assembly
Flash Switches
Surge Protector
Radio Interference Suppressor
Cabinet Ventilation Fan
Terminal Tie Points
Field Terminals
Machine Vision Processor
Lightning Suppression
Bus Interface Unit
Malfunction Management Unit
Controller

734-2.01 General Requirements. The traffic signal controller assembly equipment shall conform to the requirements of the current edition of NEMA Publication TS-2 at the date of advertisement of the project.

(A) Documentation. The contractor's material proposal shall include complete technical information, shop drawings, photographs, graphs, circuit diagrams, instruction manuals, and any other necessary documents to fully describe the proposed traffic controller assembly items.

At the time of delivery, the contractor shall furnish three sets of instruction books and an itemized price list for each type of equipment, their sub-assemblies, and their replacement parts.

The instruction books shall include the following information:

Table of Contents
Operating Procedure
Theory of Operation

Step by step maintenance and trouble-shooting information for the entire assembly and for all components capable of being adjusted

Circuit Wiring Diagrams
Pictorial Diagrams of Parts Locations
Parts Numbers

The instruction manuals shall include itemized parts lists. The itemized parts list shall include the manufacturer's name and part number for all components (such as transistors, integrated circuits, diodes, switches, resistors, capacitors, relays, etc.) used in each circuit module. The list shall also include cross-references to parts numbers of other manufacturers who make the same replacement part.

The circuit wiring diagrams shall be provided in hard copy as well as on computer disk.

(B) Warranties. Each controller unit and all of its auxiliary equipment shall be warranted by the supplier against all defects in materials and workmanship in accordance with Subsection 106-13, except that the warranty period shall be one year for cabinet, bus interface units and cabinet power supply and 5 years for the controller and malfunction management unit, with the additional requirements as specified hereinafter.

The warranty for the controller unit and its auxiliary equipment shall provide that in the event of malfunction during the warranty period, a like controller unit, module, or auxiliary equipment shall be furnished, within three working days, for use while the warranted unit is being repaired. The isolation of any malfunction and the repair and/or replacement of any device within the warranty period shall be the responsibility of the supplier.

The video detection system including image sensor, shall be warranted by the supplier for two years. During this warranty period, the supplier shall provide software support including updates of the MVP and supervisor software. Updates shall be provided at no additional cost to the Agency during the warranty.

The supplier shall maintain a program of technical support and software updates following expiration of the warranty period. The support program shall be in the form of a separate agreement with the Agency.

The Agency reserves the right to reject equipment of a specific model type in which the Agency has determined that its past field performance has been unsatisfactory. The Agency's rejection of an item shall be final.

(C) Certificate of Compliance. The contractor or supplier shall submit a Certificate of Compliance for each NEMA specified component stating that all applicable NEMA tests have been performed and results comply with the requirement of NEMA Standards. The Certificate of Compliance shall be in accordance with the provisions found in Subsection 106-5(B).

The Agency reserves the right to perform tests on any equipment supplied by the contractor.

(D) Pre-Approval of Controller Equipment. The Agency will only accept equipment furnished by manufacturers or vendors with proof of liability insurance for controller units, malfunction management unit, load switches, flashers, and flash relays, and which have been preapproved by the Agency.

All traffic signal controller units shall be tested by the Agency's testing procedures and be pre-approved by the Agency. Pre-approved traffic signal controller units will be listed in the special provisions. Any controller unit and specified component not listed in the special provisions will not be accepted.

The Agency reserves the right to re-test any pre-approved equipment supplied by the contractor in testing facilities designated by the Agency.

(E) Testing of Control Equipment. A completely wired traffic signal controller assembly with wiring diagrams and instruction books shall be delivered for inspection and testing unless otherwise specified. The equipment shall be delivered to the location specified in the Special Provisions.

It shall be the responsibility of the contractor to correct or replace any equipment that fails Agency testing. Such corrections or replacements shall be as directed by the Engineer.

(F) Testing Procedures of Bid Items. The traffic signal controller assembly shop test procedure shall be as follows:

(1) The contractor shall deliver the equipment to the location specified in the Special Provisions.

(2) The Agency will take inventory of the delivered equipment.

(3) The Agency will conduct a load test for a minimum of 72 hours under on-line conditions.

(4) Environmental or other tests will be performed by the Agency at the discretion of the Engineer.

(5) After any test failures, the contractor shall have three working days to correct the failure. Procedures 3 and 4 above shall then be repeated until the equipment passes the tests. The Engineer may require the replacement of any component after that component's second failure under test.

(6) After the controller operation tests are approved, the contractor shall pick up the controller cabinet, safely transport it to the job site and install the equipment as specified. After the contractor has mounted the controller cabinet on the cabinet foundation, Agency personnel will connect all the field wiring inside the controller cabinet and test the signal circuits.

734-2.02 Traffic Signal Controllers. A traffic signal controller shall consist of an electronic device dedicated to the selection and timing of traffic movements. Each controller shall provide all the features, functions and phasing operations as indicated on the plans and the Special Provisions.

(A) Controller Unit. Controllers shall be NEMA TS-2 Type 2 controllers. The Controller shall be programmable in any combination of twelve phases, eight concurrent groups and two timing rings. Any input function shall be capable of being remapped to any input pin and any output function shall be capable of being remapped to any output pin. When a component is of such special design (proprietary) that it precludes the purchase of identical components from any parts distributor or component manufacturer, one spare duplicate component shall be furnished with each unit.

The display size shall contain a minimum of 16 x 40 alphanumeric characters. The display shall be LCD with multiple levels of contrast. Display Visibility shall be maintained in bright sunlight.

(1) Operational Display. The controller keyboard shall be capable of placing vehicle, pedestrian, and preemption calls while displaying intersection status information.

(2) Controller Unit Programming. The programming of the controllers selectable functions and phase timing intervals shall be set by front panel keyboard entry. The controller shall also be programmable via a serial port with a laptop computer.

(3) Software. Software shall be provided on disks for programming of controllers via a laptop for uploading and downloading of all controller timings and parameters.

(4) Volatile Memory. Volatile memory shall not be utilized for storage of configuration and timing parameters. All configuration and timing parameters shall be retained in EEPROM memory.

(5) Startup. The controller shall provide the capability to program startup phases, intervals, and interval duration.

(6) Detector Switching. The controller shall be capable of assigning any vehicle detector phase 1 input to any phase or phases or leaving any detector or detectors unassigned (i.e., vehicle detector phase 1 detector input could be assigned to phase 5, vehicle detector phase 2 detector input could be assigned to phases 2 and 6, etc.).

(7) Communication Protocol. The signal controller shall include a standard communications protocol that meets or exceeds the requirements of AB 3418 as specified by the State of California Department of Transportation (Caltrans). This protocol shall be selectable by the user as an alternative to the normal protocol when communications with a master supporting the AB 3418 protocol is desired. The AB 3418 protocol in the controller shall not substitute for or alter the operation of the normal communications protocol without the written approval of the Engineer. The normal communications protocol shall be the default protocol enabled on controller set up. The manufacturer shall certify, in writing, that the controller software complies with AB 3418.

(8) Preemption. The controller unit shall provide a minimum of six (6) railroad/fire-emergency vehicle preemption sequences plus four bus preemption sequences. Preemption capability shall be standard and shall not require additional modules or software. The controller shall provide a minimum of six independent preempt runs with individual inputs. As a minimum, the controller shall provide one standard NEMA output to indicate when the controller is in Preempt.

The controller shall be capable of using the parent phase minimum green, pedestrian clearance, yellow and red times upon entering preempt. If the parent phase times are used for preemption timing, any modifications to the standard controller timing will affect the preempt timing.

When a preempt input is activated the controller as a minimum shall be capable of timing the minimum interval or pedestrian interval along with the yellow and red clearance intervals before reverting the specified preempt. As an example, when the controller is timing phases 2 and 6 and receives a preempt call for phases 1 and 6, the minimum and/or pedestrian clearance intervals shall be timed followed by the yellow and red clearance intervals. Next the controller shall return to phases 1 and 6 until the preempt call is dropped.

During preemption, the controller coded status bits shall operate providing standard codes per NEMA TS2 3.5.

The controller shall recognize a 6.25 hertz pulsed preemption input through the BIU as a Bus input. A steady (constant) input shall be recognized as priority input.

All controller inputs other than detection and external start shall be inhibited during preemption any preemptor shall be capable of having priority over any other preemptor depending on programming.

734-2.03 Controller Cabinets.

(A) General. The controller cabinets covered in this section shall be used to house all traffic actuated traffic signal controller assemblies and auxiliary controller cabinets. The cabinets shall be wired for all additional future phases and all associated equipment for the future phases shall be furnished and installed.

A complete NEMA TS-2 Type 1 eight-phase cabinet shall be supplied and installed. The controller and cabinet assembly shall be provided by the same manufacturer. Cabinets shall meet all applicable sections of the NEMA Standard Publication No. TS2-1992. Where differences occur, this specification shall govern.

(1) The cabinet shall be supplied with a Natural Aluminum finish on the inside of the cabinet.

The following cabinet types shall be supplied when specified on the plans or in the Special Provisions. The cabinets shall be constructed according to the Agency's standard drawings or Standard Details:

Type V Controller Cabinet

The aluminum fabricated cabinet housings shall be constructed with 0.125-inch thick (*3 millimeter*) gauge welded sheet 5052-H32 aluminum.

The controller cabinet housings shall be of a NEMA 3 weather resistant construction. Cabinets shall have continuous welded seams on all outside seams.

The aluminum cabinet housing and accessories to be painted shall first undergo a phosphatizing treatment. Prior to the application of the paint, all parts shall be thoroughly dried. Two coats of white enamel in accordance with Section 1002 shall be applied.

The painted finish shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters, and other defects that would impair serviceability or detract from the general appearance.

The cabinet shall be painted with high gloss white paint on the outside. The white paint must be polyurethane capable of resisting graffiti and withstand repeated cleanings. This paint should be able to protect smooth non-porous surfaces of metal

electrical cabinet. The anti-graffiti coating shall retain the exterior durability, chemical and solvent resistance of its polyurethane base while providing a surface which makes graffiti difficult to adhere to.

Mix Ratios and VOC Content

340 Grams/Liter	VOC	420 Grams/Liter	VOC
6409 G	4 Parts	6409 G	4 Parts
340 HP Catalyst	1 Part	340 HP Catalyst	1 Part
1800 Reducer	None	1600 Reducer	1 Part

Ratios are by volume.
1600 reducers vary by evaporation rate.
1600, fast-02, medium; 1600-03, slow.

Specifications of Separate Components

	% Solids by Volume	Density lbs/gal	VOC grms/l	Content lbs/gal
6409 G	53%	8.5-11.0	395	3.30
340 HP	87.2	9.6	112	0.93

(B) Hardware.

(1) Doors.

The doors shall have a neoprene gasket around the perimeters of each door frame. The door hinge pins shall be stainless steel. The main doors of the controller cabinets shall be secured by a three point locking device with nylon rollers. The door handle shall be cast aluminum.

(2) Locks.

The main doors of controller cabinets shall have a standard traffic signal self-locking tumbler lock. The three point door latch cam shall be steel.

The pedestal base cabinet doors and the police panel doors, when required, shall have a standard police type lock. The police type lock key shaft shall be a minimum of 1-3/4 inches (*45 millimeters*) in length.

A minimum of two keys per lock shall be furnished with each cabinet.

(3) Shelves.

Each controller cabinet shall be furnished with metal shelves capable of supporting all shelf mounted equipment without bending or sagging. Type IV and Type V controller cabinets shall each be provided with two shelves minimum manufactured from 5052-H32 Aluminum. Shelves shall be removable or installable with out hand tools. Shelves shall extend the full length of the cabinet.

The shelves shall not sag or restrict the free flow of air. The cabinets shall contain adjustable support brackets.

The cabinet shall include a pull out shelf installed on the second shelf to support a laptop computer and schematics.

(C) Cabinet Accessories. The following accessories shall be provided with each controller cabinet as specified herein:

(1) Cabinet Light.

Type V controller cabinets shall contain a minimum 18 inch (*450 millimeters*) fluorescent light fixture and lamp. The fixture shall be mounted on the inside top of the cabinet near the front edge of the roof so that the front panels of the control equipment will be illuminated.

A door actuated switch, as specified, shall automatically turn the light fixture on and off when the door is opened and closed.

(2) Switches.

The switches described in this section shall be provided for all solid state digital controller cabinets. Each switch shall be a commercial grade switch properly rated for the circuits they control. Each switch shall be individually labeled to identify its function. The label shall be an engraved laminated plastic legend plate or a permanently printed metallic legend plate.

The following switches shall be mounted on the cabinet switch panel inside the controller cabinet housing. When a police panel is required, the main, auto/flash and photo-off-manual switches shall be mounted in the police panel. Door panel switches shall be hard wired only and printed circuit boards shall not be used for the door panel switches.

(a) Indicator Lamp Control. A door actuated switch that shall operate with any controller unit which activates the controller indicator lamps.

(b) Auto/Flash Switch. A toggle switch to transfer to flashing operation. During the flash operation the AC power shall not be disconnected from the controller. The controller shall not be stop timed when in flash.

(c) Detector Call Test Switches. Push button microswitchs shall be furnished to simulate vehicle and pedestrian actuations. The metering controller shall have test switches for each detector input shown on the plans or described in the special provisions. Each switch shall be labeled to identify its function and phase.

(d) Pre-Emptor Switch. When a traffic control pre-emptor is specified on the plans or described in the special provisions, it shall be controlled by a two-position toggle switch. The "Test" position shall manually turn on the pre-emption operation. The "Auto" position shall be for automatic external control of the pre-emptor.

(e) Stop Time Switch. A three-position toggle switch shall be provided to control the controller stop timing input. The switch positions shall function as follows: Stop Time (up) – activates controller stop timing input, Run (center) – disconnects all stop time inputs, Normal (down) – permits the conflict monitor or other switches to activate stop timing. When applied the controller shall be stop timed in the current interval.

(f) Main Switch. This shall be the main on/off switch to control the AC power to the traffic signal controller assembly. The switch shall be properly sized for the amperage of the equipment. This switch shall control the controller, mmu, and cabinet power supply AC power.

(g) Photo-Off-Manual Switch. Lighting contactors shall be controlled by a three position, double pole, double throw switch. The "Photo" position shall place the contactor under the control of the photoelectric cell unit. The "Off" position shall disconnect the contactor's coil from the photoelectric control. The "Manual" position shall activate the contactor and turn on the intersection lighting.

(h) Convenience Outlet. A 120 volt AC, 15 amp, NEMA 5-15 GFI convenience duplex outlet shall be mounted in each cabinet for energizing test equipment or tools. The outlet shall be fuse protected. The outlet shall be mounted in the lower right corner of the cabinet facing the inside of the cabinet door and within 6 inches (*150 millimeters*) of the front edge of the opening of the door.

(i) Police Panel Switches. The Police Panel shall contain three (3) switches: SIGNALS ON/OFF, AUTO/FLASH and AUTO/MANUAL SWITCH. All police panel switches shall be hard wired.

(j) Signal On/Off Switch. In the OFF position, power shall be removed from the signal heads in the intersection. The controller shall continue to operate. In the OFF position, the MMU shall not conflict or require reset.

(k) Auto/Flash Switch. In the flash position, power shall not be removed from the controller and stop time shall be applied.

(l) Auto/Manual Switch. The cabinet wiring shall include provisions for an AUTO/MANUAL switch and a momentary push-button or hand cord. The AUTO/MANUAL switch and push-button or hand cord shall not be provided unless it is called for in the Special Provisions.

(D) Cabinet Ventilation Equipment/Cabinet Fan and Filters. Controller cabinets containing solid state electronic equipment shall be ventilated by means of two 120 VAC, 60 Hz, tube axial compact type fans. The fan's free delivery air flow shall be not less than 100 cubic feet per *minute (2.83 cubic meters per minute*).

The fan housing shall be approximately 4 inches (*100 millimeters*) square by 1-1/2 inches (*40 millimeters*) deep.

The magnetic field of the fan motor shall not affect the performance of the control equipment.

The fan bearings shall operate freely within the environmental standards specified herein.

The fan unit shall not crack, creep, warp, or have bearing failure within a 5 year rated duty cycle. The maximum noise level shall be 40 decibels. The fan unit shall be corrosion resistant.

The cabinet fan shall be controlled by an adjustable snap action thermostat. The thermostat's turn-on setting shall be adjustable from 80° to 150° F (*26 to 65 °C*). The fan shall run until the cabinet temperature decreases approximately 20° F (*10 °C*) below the turn-on temperature setting. The fan shall be fused.

The cabinet fan assembly shall be mounted inside the controller cabinet.

Cabinets shall have louvered air inlets in the lower portion of the main door. A high capacity pleated air filter shall be mounted behind all the louvered air inlets in the cabinet. Filters shall be one piece, removable, non-corrosive, vermin and insect proof.

The air outlets shall be screened on the exhaust side of the fan unit. The cabinet shall have a dust resistant, air outlet baffle in the top of the cabinet which shall be well secured and removable.

Auxiliary cabinets containing solid state electronic equipment shall use fan units with a free delivery air flow of not less than 100 cubic feet (*2.83 cubic meters*) per minute. The fan unit shall be approximately 3-1/2 inches (*90 millimeters*) square. All other fan characteristics shall be as described above in this section.

(E) Electrical Devices.

(1) Legend Plates. An engraved laminated plastic legend plate or a permanently printed metallic legend plate shall be provided inside the control cabinet for each control device, connector cable, connector, and fuse mounted in the cabinet. Each control device shall be labeled to identify the type of device and its connector number. Each fuse shall be labeled to identify its rating and circuit function.

(2) Power Panel. The power supplied to the controller cabinet shall be 120 VAC, 3 wire, 60 hertz, single-phase service unless otherwise specified.

A 15-amp auxiliary breakers shall supply power to the fan, light and GFI outlet.

The power leg to the controller and the signal load circuits shall be protected by a single pole, 50 amp, 120 VAC, circuit breaker. The breaker shall have a 10,000 amp interruption rating, a trip indicator, and shall be the bolt-on type. The ampere rating shall be properly sized for the traffic signal intersection's load.

Panel shall include a normally open, 60-amp, mercury contactor Durakool model BBC-7032 or approved equal.

The neutral service leg shall be connected to the AC neutral bus.

Install line protector type HS-P-SP-120A-60A-RJ and shall be shielded to prevent hazardous contact with live voltages.

The 120 VAC intersection lighting control circuit and the convenience outlet shall not be connected to the same service leg to which the controller's power supply is connected.

Highway Lighting Control. A lighting contactor shall be required in all cabinets. The contactor shall be a two pole design used for highway lighting requirements. The lighting contactor and its associated equipment shall be shielded to prevent hazardous contact with live voltages.

The cabinet power supply shall comply with NEMA TS2, Section 5.3.5 requirements. All power supplies shall also provide a separate front panel indicator LED for each of the four outputs. Front panel banana jack test points for 24VDC and logic ground shall also be provided.

The lighting load shall be 120 VAC unless otherwise specified.

(3) Radio Interference Suppressor. Each control cabinet shall be equipped with a single radio interference suppressor (RIS) of sufficient ampere rating to handle the load requirements. The RIS shall be installed at the input power point. It shall minimize interference in both the broadcast and the aircraft

frequencies, and shall provide a minimum attenuation of 50 decibels over a frequency range of from 200 kilohertz to 75 megahertz, when used in connection with normal installations.

The RIS shall be hermetically sealed in a substantial metal case which shall be filled with a suitable insulating compound. The terminals shall be nickel-plated 10/24 brass studs of sufficient external length to provide space to connect No. 8 AWG wires and shall be so mounted that they cannot be turned in the case. Ungrounded terminals shall be properly insulated from each other, and shall maintain a surface leakage distance of not less than 1/4 inch (*6 millimeters*) between any exposed current conductor and any other metallic parts. The terminals shall have an insulation factor of 100-200 megohms dependent upon external circuit conditions. The RIS shall not be rated less than 50 amperes.

The RIS shall be designed for operation on 125 VAC ± 10 percent, 60 Hz, single phase circuits, and shall meet the standards of UL and the Radio Manufacturers Association.

(4) Surge Protector. Each controller cabinet shall be provided with a 350 volt surge protector at the input power point. The surge protector shall reduce the effects of power line voltage transients and shall have ratings as follows:

Impulse Breakdown - less than 1,000 volts in less than 0.1 microseconds at 10 kilovolts per microsecond.

Standby Current - less than 1.0 milliampere.

Striking Voltage - 350 volts D.C.

The surge protector shall be capable of withstanding 15 pulses of peak current each of which will rise in 8.0 microseconds to one half the peak voltage at 3 minute intervals. The peak current rating shall be 20,000 amperes.

(5) Inductive Suppressors. Each 120 VAC circuit that serves an inductive device, such as a fan motor, cabinet light, or a mechanical relay, shall have a suppressor to protect the controller's solid state devices from excessive voltage surges. Such suppressors shall be in addition to the surge protector at the main input power point.

(6) Lighting Suppression. The cabinet shall be equipped with an EDCO model SHP-300-10 or approved equivalent surge arrestor.

(F) Cables and Wiring.

(1) All controller and Malfunction Management Unit cables shall be of sufficient length to access any shelf position. All cables shall be encased in a protective sleeve along their entire free length.

(2) Color Coding. All cabinet wiring shall be color coded as follows:

Purple	=	MMU Wiring
Orange	=	Flash color programming
Brown	=	Green Signal Wiring
Yellow	=	Yellow signal wiring
Red	=	Red signal wiring
Blue	=	Controller wiring
Gray	=	DC ground
AC+	=	Black
AC-	=	White
Chassis Ground	=	Green

(3) Main Panel And Wire Terminations. All wires terminated behind the main panel and other panels shall be soldered. No pressure or solderless connectors shall be used. Printed circuit boards shall not be used on main panels, with the only exception being on the Bus Interface Units.

(4) Flashing Operation. All cabinets shall be wired to flash red for all phases and programmable to flash yellow and red when needed. Flashing display shall alternate between phases 1, 2, 5, 6 and phases 3, 4, 7, 8.

(G) Detector Amplifiers.

(1) General.

The correct type and quantity of detector amplifiers shall be furnished as specified herein and as required on the plans or in the special provisions. Type 1 detector amplifiers shall be rack mounted. Type 2 detector amplifiers shall be encased and shelf mounted.

Each detector amplifier assembly or case shall include one power supply card per each set of four loop detector modules. Unless otherwise specified, the required quantity of cards and modules, including those required for future phases, shall be furnished with each controller cabinet and the cabinet rack or shelf positions shall be labeled.

Cards and modules shall be the edge connected type. Where Type 1 detector amplifiers are required to be provided with the controller cabinets, one spare edge connector shall be furnished and installed. The edge connector shall be a 44 pin, double read out contact. The edge connector shall have 0.128 inch diameter mounting holes on each end, be of MIL-M-14 insulation material, and have MIL-C-21097 contacts.

Unless otherwise specified, the controller cabinet shall be wired from the mounting position of the edge connector terminals to the tie points and field terminals. All detector channel inputs and outputs, including those channels specified for future use, shall be wired.

Loop detector module rack positions shall be mechanically and electrically interchangeable such that loop detector modules of different manufacturers can be connected into any loop detector module position. The rack spacing shall be for NEMA, 2.31 inch (*58 millimeters*) wide, front panels on all card rack units. Unless otherwise specified the rack will have 6 slots to accommodate 2.25 inch (*55 millimeters*) modules. Each rack will be furnished with 5 modules: 1- power supply, 2- LCR-2T and 2- LCR-4. The slots will be arranged as follows:

SLOT	FUNCTION	PHASE ASSIGNMENT
1	Power supply	
2	Spare slot	
3	LCR-2T	5,7
4	LCR-2T	1,3
5	LCR-4	2,4,6,8
6	LCR-4	2,4,6,8

The call outputs from slot 6 shall have a diode or other DC circuitry that will permit a call to be placed only when the assigned phase is red and will not call during a green or yellow interval.

The detector amplifier shall detect bicycles and all licensed motor vehicles when using the loop configuration shown on the plans. The detector amplifier shall be operational when using up to 1,000 feet (*305 meters*) of lead-in cable for a 6 foot by 6 foot (*1.8 meter by 1.8 meter*), 3 turn loop. Each detector amplifier shall detect vehicles at speeds of 0 to 80 miles per hour (*0 to 128 kilometers per hour*) using loop configurations ranging from 6 foot by 6 foot (*1.8 meters by 1.8 meters*) with 2 turns, 6 foot by 50 foot (*1.8 meters by 15 meters*) with 1 turn, and 6 foot by 70 foot (*1.8 meters by 21 meters*) with 1 turn to 6 foot by 100 foot (*1.8 meters by 30 meters*) with 1 turn. The 6 foot by 6 foot (*1.8 meters by 1.8 meters*) loop shall be capable of being connected to the detector amplifier either in series or in parallel.

The detector amplifier shall operate in compliance with all the requirements herein specified when connected to a loop, including lead-in, having an inductance of 20 to 2500 microhenries with a loop Q parameter as low as 5.0 at the amplifier's operating frequency.

The operation of the detector amplifier shall not be affected by environmental temperature changes at the rate of 1.5° *F (0.8 °C*) per three minutes.

Each detector amplifier shall have lightning protection as an integral part of its own circuitry. The protection shall enable the detector to withstand the discharge of a 10 microfarad capacitor, charged to 1,000 volts. The discharge shall be applied directly across the detector loop input pins with no loop load present.

The lightning protection shall enable the detector amplifier to withstand the discharge of 10 microfarad capacitor, charged to 2,000 volts. The discharge shall be applied directly across either the detector loop input pins or across either side of the loop input pins to earth ground. For this test, the detector amplifier chassis shall be grounded and the detector loop input pins shall have a 5.0 ohm dummy resistive load connected across them.

(2) Power Supply. Each detector amplifier shall have a 24 volt DC power supply. The power supply shall have four power outputs, each fused and rated at 300 milliamps and 24 volts DC and a maximum ripple voltage of 2.2 volts peak to peak. All 120 volt AC circuits shall have fused inputs.

The power supply pin numbers and functions shall be as designated in the following table:

Standard Input and Output Functions for Detector Amplifiers
Power Supply

Pin No.	Function	Pin No.	Function
A	Output Logic Ground	1	(Redundant Side)
B	Output 1 (+24 VDC)	2	
C	Output 2 (+24 VDC)	3	
D		4	
E		5	
F		6	
H		7	
J		8	
K		9	
L	Chassis Ground	10	
M	115 VAC (-)	11	
N	115 VAC (+)	12	
P		13	
R		14	
S		15	
T		16	
U	Output 3 (+24 VDC)	17	
V	Output 4 (+24 VDC)	18	
W		19	
X		20	
Y		21	
Z		22	

(3) Loop Detector Modules.

(a) General Requirements.

There shall be one detector amplifier channel per loop detector, unless otherwise specified.

The loop detector module shall contain two to four channels.

The following types of loop detector modules shall be used to identify the number of detector channels and timing functions for each card:

LCR-2 - Loop detector module with 2 channels.

LCR-2T - Loop detector module with 2 channels having timing functions.

LCR-4 - Loop detector module with 4 channels.

LCR-4T - Loop detector module with 4 channels having timing functions.

Pin numbers and functions, for loop detector modules and loop detector modules with timing functions, shall be as designated in the following tables:

Standard Input and Output Functions for Detector Amplifiers

Loop Detector Module			2 or 4 Channel
Pin No.	**Function**	**Pin No.**	**Function**
A	Logic Ground	1	No Connection
B	+24 VDC IN	2	No Connection
C		3	No Connection
D	Loop 1 Twisted	4	
E	Loop 1 Pair	5	
F	Output 1 (+)	6	
H	Output 1 (-)	7	
J	Loop 2 Twisted	8	
K	Loop 2 Pair	9	
L	Chassis	10	No Connection
M		11	
N		12	
P	Loop 3 Twisted	13	
R	Loop 3 Pair	14	
S	Output 3 (+)	15	
T	Output 3 (-)	16	
U	Loop 4 Twisted	17	
V	Loop 4 Pair	18	
W	Output 2 (+)	19	
X	Output 2 (-)	20	
Y	Output 4 (+)	21	
Z	Output 4 (-)	22	

Polarization keys shall be located at two positions:

1. Between B/2 and C/3
2. Between M/11 and N/12

Standard Input and Output Functions for Detector Amplifiers

Loop Detector Module With Timing Functions

Pin No.	Function	Pin No.	4 Channel Function
A	Logic Ground	1	Channel 1 Green
B	+24 VDC In	2	Channel 2 Green
C		3	Channel 3 Green
D	Loop 1 Twisted	4	
E	Loop 1 Pair	5	
F	Output 1 (+)	6	
H	Output 1 (-)	7	
J	Loop 2 Twisted	8	
K	Loop 2 Pair	9	
L	Chassis Ground	10	Channel 4 Green
M		11	
N		12	
P	Loop 3 Twisted	13	
R	Loop 3 Pair	14	
S	Output 3 (+)	15	
T	Output 3 (-)	16	
U	Loop 4 Twisted	17	
V	Loop 4 Pair	18	
W	Output 2 (+)	19	
X	Output 2 (-)	20	
Y	Output 4 (+)	21	
Z	Output 4 (-)	22	

Polarization keys shall be located at two positions:

1. Between B/2 and C/3
2. Between M/11 and N/12

The loop detector module shall utilize digital solid state circuitry. The detection, frequency counting, and inductance measuring circuitry shall utilize crystal controlled MOS-LSI microelectronic circuits. Each channel's call output shall be an optically isolated, solid state type.

(b) Detector Amplifier Channels. Each detector amplifier channel shall meet the following requirements:

1) Channel Indicators. Each channel shall have a front panel mounted indicator to provide a visual indication of each vehicle detection. The indicator shall be visible in bright sunlight from 3 feet (*900 millimeters*) directly in front of the detector amplifier.

2) Tuning. Each channel shall be self-tuning and shall be fully operational within three minutes after power up. After a power interruption, the channel shall automatically return to normal operation.

3) Tracking. Each channel's circuits shall be designed so that changes due to environmental drift and applied power fluctuations shall not cause an actuation. The self-tracking function shall be capable of compensating for environmental changes of up to 0.001 percent per second. The requirement must be met within two hours after initial power up. The channel shall be capable of normal operation as the input inductance is changed ± 5.0 percent from the quiescent tuning point regardless of initial circuit drift.

4) Detection Modes. Each channel shall have a mode selection switch on the front panel which shall permit the selection of either the presence mode or the pulse mode of operation. In the pulse mode, the pulse width shall be 100 milliseconds unless otherwise specified. Each loop detector module shall have an off switch position for disabling unused channels.

(c) Special Timing Functions.

The following special timing functions shall be furnished only when specified on the plans or in the special provisions.

1) Delay Timing Function. This timing function shall delay the call output up to 63 seconds after the vehicle enters the loop. The timer shall be adjustable, from 0 to 30 seconds, into no more than 1.0 second increments.

2) Extension Timing Function. This timing function shall carry over (i.e., extend) the call output up to 15.75 seconds after the vehicle leaves the loop. The timer shall be adjustable, from 0 to 15.75 seconds, in not more than .25 second increments.

When any of the preceding special functions are specified, then that special function shall be furnished on all channels of the same loop detector module.

(d) Sensitivity. Each of the channels shall have a minimum of three sensitivity settings per detection mode. The settings shall be selectable from the front panel. The highest sensitivity setting shall consistently respond to a loop inductance change of 0.02 percent. The lowest sensitivity setting shall respond to nominal loop inductance changes of from 0.15 to 0.4 percent. All modules must have sensitivities which differ by not more than ± 0.05 percent change in inductance from the nominal

value chosen. A channel shall not respond to loop inductance changes less than 0.1 percent in the lowest sensitivity setting.

(e) Response Time. The channel response time in the lowest sensitivity setting shall be less than 20 milliseconds. For any negative inductive change which exceeds the sensitivity threshold, the channel shall output a ground true logic level within 20 milliseconds. When such inductance change is removed, the output shall become an open circuit within 20 milliseconds.

For test purposes, a negative change of inductance shall be maintained for a minimum of 100 milliseconds and a maximum of 600 milliseconds after it is applied. When the response time differences are averaged over ten trials, the value of that average difference shall not exceed 10 milliseconds.

The response time of the channel for the highest sensitivity setting shall be less than 250 milliseconds for a 1.0 percent inductance change.

(f) Operating Frequency. Each channel shall have a minimum of three operating frequencies. The frequency switch shall be either on the front panel or on the circuit board. Frequency selection shall be possible without the use of tools.

(g) Detection Holding Time. The channel, in the least sensitive position, shall maintain the presence detection of a vehicle for a minimum of three minutes while the vehicle is over the loop and is causing an inductance change of 1.0 percent or greater.

The channel, in the highest sensitivity position, shall maintain the presence detection of a vehicle for a minimum of three minutes while the vehicle is over the loop and is causing an inductance change of 0.02 percent or greater.

(h) Interference. Each channel shall not cause crosstalk with any other channel either within the same detector amplifier or within any other detector amplifier that is mounted in the same cabinet. A channel shall not detect vehicles, moving or stopped, at distances of 3 feet (900 millimeters) or more from the loop perimeter to which it is connected.

(i) Failsafe Operation. Each channel shall have a failsafe design such that if the loop detector circuit is open, the channel shall output a continuous vehicle call.

(j) Isolation Transformers. Each loop detector shall be coupled to the channel input by isolated transformers. The isolated input shall provide continued operation of the channel if the loop detector becomes grounded or has resistive leakage to ground.

(H) External Detector Inputs. Each pedestrian push button, bicycle push button, or remote vehicle detector call input to the controller shall be isolated from the controller's logic ground by an auxiliary isolation relay. The isolation relay will be provided and installed by the Agency. The size of the relay will be 1.6 inches (*40 millimeters*) wide by 2 inches (*50 millimeters*) long.

The terminal strip shall be the Type 141 with terminals in multiples of 4. The size shall be 1-1/8 inches (*28 millimeters*) wide by 1/2 inch (*13 millimeters*) deep. The terminal spacing shall be 7/16 inch (*11 millimeters*). The screw size shall be 3/16 inch (*5 millimeters*).

(1) Terminal Strip - A Side.

The isolation relay shall be mounted on the A side of the terminal strip. The A side shall be the left hand side when the terminal strip is mounted vertically or the top side when the terminal strip is mounted horizontally. Terminal No. 1 shall be the top terminal when mounted vertically or the first terminal from the right when mounted horizontally. A field terminal shall be provided to connect the detector call field inputs to the A terminal strip.

(2) Terminal Strip - B Side. The B side of the terminal shall be wired as follows for each relay required:

Terminal	Function
1	+12 or +24 V (DC or AC)
2	Logic ground
3	(N.O.) Det. Call (for specified phase)
4	Det. call field input (for specified phase)

A power supply external to the controller shall be provided for the isolation relays. The controller power supply shall not be used for this purpose.

(I) Additional Panels.

(1) The main panel shall be fully wired in the following configuration:

12 Load Switch Sockets
6 Flash Transfer Relay Sockets
1 Flasher Socket
2 Bus Interface Units Slots
Wiring for 1 type 2 Detector rack and a type 16 Malfunction Management Unit

(2) The following items shall be installed at the noted height: on the left side (from the front).

(a) 34440 GX BIU adder assembly and BIU 53 1/4 inches (1.3 meters) form the bottom of the cabinet and wired for the Agency to install the RCU cables.

(b) 34440 GX BIU adder assembly and BIU 34 1/2 inches (*875 millimeters*) from the bottom of the cabinet and wired for the Agency to install the RCU cables.

(c) Wire in cabinet 44975 GX MIL 108-4 panel wired for autoscope 16 1/4 inches (*410 millimeters*) from the bottom.

(d) DLP-2062V2 Suppression Panel assembly 32 inches (810 millimeters) from the bottom of the cabinet under the second shelf.

(3) The following items shall be installed in the middle of the cabinet at the noted height:

(a) Real panel 12 inches (*300 millimeters*) up from the bottom of the cabinet.

(b) Top shelf 63 1/2 inches (*1.6 meters*) from the bottom of the cabinet

(c) Second shelf 52 inches (*1.3 meters*) from the bottom of the cabinet.

(4) The following items shall be installed at the noted height on the right side (from the front):

(a) 45010 G8 Load Resistor Panel 22 inches (550 millimeters) from the bottom.

(b) DLP-2062V2 Suppression Panel assembly 12 inches (300 millimeters) from the bottom of cabinet.

(5) Emergency Vehicle Preempt Rack. One emergency vehicle preempt rack panel shall be provided in each cabinet and wired for Agency furnished discriminators. The rack shall support two channel preemption devices, and one BIU.

734-2.04 Auxiliary Control Equipment.

(A) Malfunction Management Unit (MMU). Cabinets shall be equipped with a NEMA TS-2 Type 16 Malfunction Management Unit (MMU). When a component is of such special design (proprietary) that it precludes the purchase of identical component from a parts distributor or component manufacturer, one spare duplicate component shall be furnished with each unit.

(B) Load Switch. All load switches shall comply with NEMA TS-2, Section 6 requirements and shall be EDI model 510 or approved equal.

(C) Flasher Unit. All flasher units shall comply with NEMA TS-2 1992, Section 6 requirements and shall be EDI model 810 or approved equal.

(D) Bus Interface Unit. Bus interface units (BIUs) shall comply with TS2, Section 8 requirements. BIUs shall provide a separate front panel indicator light emitting diode (LEDs) Valid Data. When a component is of such special design (proprietary) that I precludes the purchase of identical component from a parts distributor or component manufacturer, one spare duplicate component shall be burnished with each unit.

(E) Flash Load Relays. Flash load relays shall be for the purpose of providing special circuitry or operational requirements. The relays shall be NEMA type.

The relay shall be covered with a clear dust cover which shall be secured to the relay base with a fastening device.

The relay contact points shall be of fine silver or silver alloy, or a superior alternate material, and shall be capable of carrying a load of 20 amperes per contact, unless otherwise specified, at 120 volts AC.

The relay shall show no failure while making, carrying, and breaking a 20 ampere, 120 volt, traffic signal lamp load through 10,000 cycles at the rate of 10 cycles per minute and a 50 percent duty cycle. Each relay shall be capable of making, breaking, and carrying all the current for a 1,000 watt tungsten lamp load without burning, pitting, or otherwise failing for at least one million operations.

The relay shall be electrically and mechanically operative after a momentary current of 100 amperes at 120 volts is applied to the set of closed contacts at least five times with a minimum of two minutes between applications of current. The relay shall not break down or flash over while carrying a load of 20 amperes at 120 volts for at least 50 cycles at the rate of five cycles per minute. The duty cycle shall be 50 percent on and 50 percent off.

The relay shall withstand 1,500 volts at 60 Hz between insulated parts and between current carrying parts and grounded or non-current carrying parts.

(F) Auxiliary Control Relays. These types of relays shall be utilized in circuits to provide special operations.

Auxiliary control relays shall have a pin type connector on the base. The relay shall be removable without the use of tools.

The relay shall be covered with a removable dust cover. The relay coil shall be rated at 120 VAC, 28 volts AC/DC, or 12 volts AC/DC as required. The contacts shall be single or double pole. The number of contacts shall be as required by the relay's operational

functions. The contacts shall be properly rated for the circuit load and shall be constructed of gold and/or silver plated material.

(G) Street Lighting Control Contactor. A street lighting control contactor, meeting the requirements of 736-2.01 (C) (2), shall be provided in each controller cabinet.

734-2.05 Machine Vision Processing Video Vehicle Detection System.

(A) General. The machine vision processing video vehicle detection system monitors vehicles approaching an intersection via video images and provides detector outputs to a traffic controller or similar device.

In accordance with the provisions of Subsection 106-2, the contractor shall submit one copy of the following items to the Agency:

- A list of twenty non-beta site references. This list shall include site names, contacts and phone numbers.
- A materials list containing the manufacturers, model numbers, and technical information for all machine vision processing video detection system equipment proposed. All machine vision processing vehicle detection system components shall be furnished by manufacturers of established reputation and experience.
- Product technical information sheets for each principal component in the proposed system.
- A complete operations manual for the proposed system components.

The supplier shall provide a list of a minimum of fifty currently operating machine vision processing (MVP) vehicle detection systems which render satisfactory service.

All machine vision processing (MVP) vehicle detection system controls and components shall be supplied from one source. The supplier shall have a minimum of 5 years experience providing above ground machine vision video detection systems and be able to provide proof of product liability insurance of at least $9.0 million.

The manufacturer/supplier shall have a quality system that has been certified (registered as complying with ISO-9000 quality standards in effect at the time of award. Due to the non-product specific nature of the ISO-9000 standards, certification of any product manufactured by the supplier at the same location as the equipment to be supplied under this specification shall be deemed as complying with this requirement.

The system shall consist of image sensor(s), a machine vision processor (MVP) and all necessary miscellaneous cable and associated support equipment for a complete and operational system. Hardware proposed must have been tested and preapproved by the Agency prior to the time of submittal.

The system shall be able to detect either approaching or departing vehicles in multiple traffic lanes. A minimum of 100 detection zones shall be user-definable through interactive graphics by placing lines and or boxes in an image on a VGA monitor. The user shall be able to redefine previously defined detection zones. The MVP shall calculate traffic parameters in real-time and provide local non-volatile data storage for later downloading and analysis.

(B) Functional Capabilities.

(1) Real-Time Detection. The MVP shall be capable of simultaneously processing information from up to four (4) video sources including CCTV video image sensors and video tape players. The video sources may be, but are not required to be, synchronized or line locked. The video shall be digitized and analyzed at a rate of 30 times per second.

The system shall be able to detect the presence of vehicles in a minimum of 100 detection zones within the combined field of view of the image sensors.

Different detector types shall be selectable via software. Detector types shall include count detectors, presence detectors, directional presence detectors, speed detectors, station detectors, input detectors, and detector logical functions. The speed detectors shall report vehicle speed and vehicle classification based on length. Three length categories shall be user definable in the software.

Once the MVP has been properly set up using the supervisor computer, it shall be possible to disconnect the supervisor computer. The MVP shall detect vehicles as a stand-along unit, calculate traffic parameters in real-time, and store traffic parameters in its own non-volatile memory.

(2) Local Data Storage. The MVP shall count vehicles in real-time and compute the average of traffic parameter over user defined times intervals (or time slices), as follows:

(a) Volume
Number of vehicles detected during the time interval.

(b) Occupancy
Lane occupancy measure in percent of time.

(c) Vehicle Classification
Number of automobiles, single unit trucks or tractor trailers, as defined by length.

(d) Flow Rate
Vehicles per hour per lane.

(e) Headway
Average time interval between vehicles.

(f) Speed
Time mean and space mean vehicle speed in MPH or KM/H.

(g) Level of Service
Determined by user defined thresholds for average speed and flow rates.

(h) Space Occupancy
Sum of the vehicle lengths divided by average distance traveled during the time interval measured as percent.

(i) Density
Average flow divided by space mean speed expressed in vehicles/mile or vehicles/kilometer.

The duration of the time intervals (or time slices) shall be user selectable as 10, 20 or 30 seconds, 1, 5, 10, 30, or 60 minutes.

The time interval data shall be retained in non-volatile EEPROM flash memory within the MVP for later transfer to the supervisor computer or analysis. The amount of memory shall be 2 MB.

Retrieval of data stored in the non-volatile memory of the MVP shall be via a serial communications port. The MVP shall be capable of downloading data via direct connection to another computer. It shall also be capable of downloading data via a modem and dial-up telephone line, private cable, fiber optic network wireless microwave network to the traffic operations command center.

(3) Operation With Supervisor On-Line

(a) When the detector configuration is downloaded form the supervisor computer into the MVP, the video detection system shall operate with the supervisor computer disconnected or on-line.

(b) When the supervisor computer is on-line, vehicle detections shall be able to be viewed in real-time as they occur on the supervisor's color VGA display.

(c) The time-interval traffic data on the supervisor computer hard disk shall be able to be saved. The traffic data shall be that described in Subsection 734-2.05(B)(2). The complete time data or actuation data for each vehicle detection shall also be able to be saved on disk. The collected traffic and

detection data shall be made available in readily accessible ASCII format. The supervisor computer software shall provide tile management routines for efficiently filing, retrieving and reporting of the collected traffic data.

(d) The captured traffic data shall be capable of being displayed on the VGA screen of the supervisor computer in numeric format. The data displayed shall be for the last complete interval. Selection of the data to be displayed shall be by pull-down menus and shall be in for form compatible with the Microsoft Windows 95 graphics operating system.

(e) The MVP shall include the capability to capture a video image (still image) from a selected image sensor input and transmit the image to the supervisor computer for display. The captured video image shall be compressed to minimize the time needed to transmit the image. An option shall be provided to allow continuing or suspending detection while the video image is being compressed and transmitted.

(f) The system shall be capable of capturing and storing as a file, the video image currently being displayed at the supervisor computer.

(g) Communications with the supervisor computer shall be via either a point-to-point or multi-drop communications architecture. An error-checking and retransmission protocol shall be used for file transfer operations.

(C) Vehicle Detection.

(1) Detection Zone Placement

The video detection system shall provide flexible detection zone placement anywhere and at any orientation within the combined field of view of the image sensors. Preferred presence detector configuration shall be lines placed across lanes of traffic or lines placed in-line with lanes of traffic. A single detector line shall be able to replace one or more conventional detector loops connected in series. Detection zones shall be able to be overlapped. In addition, detection zones shall have the capability of implementing logical functions including AND, OR, NAND, N of M and delay/extend timing.

(2) Detection Zone Programming

Placement of detection zones shall be by means of a supervisor computer and mouse operating in the Microsoft Windows 95 or newer graphics environment. The VGA monitor shall show images of the detection zones superimposed on the video image of traffic.

The detection zones shall be created by using the mouse to draw detection lines on the supervisor computer's VGA monitor. The detection zones shall be capable of being sized shaped and overlapped to provide optimal road coverage and detection. The system shall be capable of saving the detector configurations on disk, to download detector configurations to the MVP, and to retrieve the detector configuration that is currently running in the MVP.

The supervisor computer's mouse shall be capable of editing previously defined detector configurations so as to fine-tune the detection zone placement size and shape. Once a detection configuration has been created, the supervisor computer system shall provide a graphic display of the new configuration on its own VGA screen.

When a vehicle is within a detection zone, the detection zone shall change in color or intensity on the VGA monitor thereby verifying proper operation of the detection system. Color changes shall also be sued to indicate detection delay and extension timing.

(3) Optimal Detection

The video detection system shall reliably detect vehicle presence when the image sensor is mounted 30 feet (10 meters) or higher above the roadway, when the image sensor is adjacent to the desired coverage area, and when the length of the detection area or field of view (FOV) is not greater than then times the mounting height of the image sensor. The image sensor shall not be required to be mounted directly over the roadway. A single image sensor, place at the proper mounting height with the proper lens, shall be able to monitor six to eight traffic lanes simultaneously.

(4) Detection Performance

Overall performance of the video detection system shall be comparable to inductive loops. Using standard image sensor optics and in the absence of occlusion, the system shall be able to detect vehicle presence with 98% accuracy under normal conditions, day and night, and 96% accuracy under adverse conditions (i.e. fog, rain, snow).

(D) Machine Vision Processing (MVP) Hardware

(1) MVP Mounting

The MVP shall be shelf mountable. The nominal outside dimensions, excluding connectors, shall be 5 inches x 11.5 inches x 7 inches (*130 millimeters x 293 millimeters x 180 millimeters*) height, width and depth, respectively.

(2) MVP Environmental.

The MVP shall be designed to operate reliably within the environmental conditions typically found in roadside traffic cabinets. The MVP shall meet the environmental requirements established by NEMA (National Electrical Manufacturers Association) TS2 standards as well as the environmental requirements for Type 170 and Type 179 controllers. Operating temperature shall be from -30° F to +165° F (*-35 °C to +74 °C*) at 0% to 95% relative humidity, non-condensing.

(3) MVP Electrical

The MVP shall be modular in design and provide at a minimum, a processing capability equivalent to the Intel 486SX microprocessor. The bus connections used to interconnect the modules of the MVP shall be gold-plated DIN connectors.

The MVP shall be powered by 89 - 135 VAC, 60 Hz, single phase, and draw 0.12 amps. The power supply shall automatically adapt to the input power level. Surge ratings shall be as set forth in the NEMA TS2 specifications.

Serial communications to the supervisor shall be through an RS-232/RS-422 serial port. This port shall be able to download traffic data stored in non-volatile memory as well ads the real-time detection information needed to show detector actuations. A 9-pin "D" subminiature connector on the front of the MVP shall be used for serial communications.

The MVP shall be equipped with a NEMA TS2 detector interface for 32 detector outputs. Output level shall be compatible with the NEMA TS2 Type 2, 170 and Type 179 standards. A 37-pin "D" subminiature connector on the front of the MVP shall be used for interfacing to these outputs.

The MVP shall be available with a NEMA TS2 Type 2 detector interface, where detector information is transmitted serially via an RS-485 data path. A 15- pin "D" subminiature connector meeting the requirements of the TS2 standard shall be used for the serial detector output.

NEMA red-green inputs for up to 16 phases shall be available as inputs to provide controller state information for detection and Extend/Delay timing functions. A 37-"D" subminiature connector on the front of the MVP shall be used for these inputs.

The MVP shall be equipped with up to four RS-170 black and white composite video inputs, so that signals from up to four image sensors or other synchronous or nonsynchronous video sources can be processed in real-time. A fifth video input on four camera units shall be provided to allow connections of a local surveillance camera or other non-detection video source.

The Video from this auxiliary video input shall not be processed for detection. BNC connectors on the front of the MVP shall be used for all video inputs.

The MVP shall be equipped with a single RS-170/NTSC composite video output. This output shall be capable of being switched to correspond to any of the video inputs, as selected remotely via the supervisor computer or front panel switch. Multiple video outputs requiring external cable connections to create a combined single video output shall not be acceptable. A BNC connector on the front of the MVP shall be used for video output.

As an alternative to RS-170/NTSC video format, the MVP shall be available with video inputs and outputs in the CCIR (B&W)/PAL format.

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video outputs requiring external cable connections to create a combined single video output shall not be acceptable. A BNC connector on the front of the MVP shall be used for video output.

As an alternative to RS-170/NTSC video format, the MVP shall be available with video inputs and outputs in the CCIR (B&W)/PAL format.

The MVP software shall be stored in flash memory within the MVP. This software shall be capable of being updated without the removal of modules or memory devices.

The MVP software and/or supervisor shall include diagnostic software to allow testing the MVP functions. The software shall include the capability to set and clear individual detector outputs and display the status of inputs to enable setup and troubleshooting in the field.

(E)Video Storage & Transmission.

The contractor shall provide a fast scan video/data transmission system. The system capable of uploading/downloading data and providing video transmission through a variety of communication systems including public switched and private telephone networks, ISDN networks, cellular networks, and RF link to the Agency's traffic operations command center. The system shall comply with the following provisions.

- Video Inputs: 10 video channel inputs. 1 volt p/p video input, 75 ohm or high impedance (switchable).
- Video Output: 1 video output designed to drive a 75 ohm load.
- Video Input/Output: Bi-directional audio communication between the Transmitter to Receiver on links greater than 38.4 kbps, 300 Hz to 3.3 kHz bandwidth, 1 volt p/p (typ), 2 volts p/p (max).
- Receiver: AS-VST 10-CA-T or approved equal.
- Transmitter: AS-VST 10-CA-T or approved equal.
- Modem: AS-Modem-PSTN fastest compatible baud rate available.

The number of transmitter(s), receiver(s), and modem(s) to be supplied shall be as specified on the bid schedule sheet. The modem(s) shall be the "fastest" available at the time of the bid for transmission over voice grade telephone lines.

734-3 CONSTRUCTION DETAILS

734-3.01 General Requirements. All traffic controller assembly equipment shall be furnished and installed as shown on the plans, and in accordance with the Special Provisions and these

specifications. Cabinet wiring, connecting cables, support bases, and shelves shall be provided to allow for future installation and use. An outdoor silicone caulking shall be applied around the base of the cabinet.

New cabinets shall be installed such that the doors face away from the street. The exact siting of all control and lighting cabinets shall be closely coordinated with the Engineer. The contractor shall contact the Engineer 48 hours prior to siting.

734-3.02 Test Requirements. All specified traffic controller assembly items shall meet the applicable environmental and testing standards of NEMA Publication TS-2. All traffic signal controller units tested shall utilize the procedures required by these specifications.

The manufacturer shall ensure that the cabinet and controller is fully tested prior to being delivered.

734-3.03 Field and Tiepoint Terminal/Wiring.

(A) Controller Cabinet.

All field terminals shall be installed on a terminal support which shall be located at the rear of the lower portion of the controller cabinet and not less than 5 inches (*130 millimeters*) from the base of the cabinet.

Field terminals shall be located at the bottom of the backboard. The order of the field terminals shall be left to right beginning with phase one green, phase one yellow, phase one red, phase one flash and following the order of the load switches. Field terminals shall be of the Screw type per NEMA TS2 5.3.6.

All connectors for field terminals shall be connected to barrier type terminal blocks. Each terminal block position shall have two No. 10/32 screw connectors (not less than 3/8 inches (*10 millimeters*) in length), and a removable shorting bar. Each terminal shall accommodate at least three No. 12 AWG conductors. The terminal block shall have a labeling strip for each position.

All controller assembly wiring tie points on the front side of the terminal blocks shall be the spade type. Tie points of the back side of terminal blocks shall be soldered to a lug. All crimp style connectors shall be applied with the proper tool. The tool's handles shall not open until the crimp is completed. Each terminal position shall be permanently labeled at the terminal position. Tie points shall be required for all controller unit and auxiliary control equipment circuits.

(B) Pre-emption Cabinet Wiring.

The pre-emption cabinet shall include a load switch circuit to operate the pre-emption "No Right Turn" illuminated message signal (120 VAC output). The field terminals shall include the following terminal positions:

- To railroad (120 VAC)
- From railroad (not wired)
- "No Right Turn" signal

734-3.04 Cabinet Wiring Diagrams. Each controller cabinet assembly shall have a complete set of wiring diagrams which shall show the intersection plan, signal phasing layout, and all control device connections.

Each wiring diagram set shall include a mylar and two sets of blueprints.

These diagrams shall also be provided on computer disk. Computer aided drafting program used by manufacturer shall be AutoCAD Release 14 or newer.

Each controller cabinet shall be furnished with a sheet metal wiring diagram print holder. The minimum size of the print holder shall be not less than 9 inches (*230 millimeters*) wide x 8 inches (*200 millimeters*) high x 1-1/4 inches (*30 millimeters*) deep, mounted inside.

734-4 METHOD OF MEASUREMENT

Unless otherwise specified, each traffic signal controller assembly will be measured as a unit and shall include the following, by the contractor:

(A) Pickup, from the Agency, and install the Agency supplied controller cabinet.

(B) Furnish and deliver to the Agency the traffic signal controller, including the appropriate cables. When required by the plans and/or special provisions, this shall also include a factory-wired, traffic signal controller backpanel and any other materials specified in this section and so required.

Service pedestal cabinets will be measured as a unit for each service pedestal cabinet furnished and installed.

734-5 BASIS OF PAYMENT

The accepted quantities of traffic signal control cabinets and service pedestal cabinets, measured as provided above, will be paid for at the contract unit price each for the type traffic signal controller assembly or service pedestal cabinet designated in the bidding schedule, complete in place, which price shall be full compensation for the work described and specified herein and on the plans, including service terminal boxes, meter sockets when specified, breaker panels, auxiliary signal controls, external logic modules and all other components necessary to complete the work and delivery of the required materials.

SECTION 735

DETECTORS

735-1 DESCRIPTION

The work under this section shall consist of furnishing and installing vehicular and pedestrian detectors at the locations shown on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

735-2 MATERIALS

735-2.01 Vehicle Detectors.

(A) General. Detectors shall conform to the minimum acceptable design and operating requirements of these specifications for detecting the presence and passage of vehicles.

(B) Loop Detectors. The detector loop dimensions shall be as specified on the plans.

(1) Saw Cut Loop Detectors.

The conductors for the inductive loop detector and the loop detector lead-in cable shall be as specified in Section 732-2.01.

(2) Preformed Loop Detectors.

(a) General. The purpose of the preformed modular loop detector is to provide a long life induction loop which will have a much higher reliability and resistance to ground. Preformed modular loops shall be of the shape and size indicated on the plans.

The contractor is required to submit to the Engineer written certification of compliance from the manufacturer that the product meets or exceeds all the following requirements.

(b) Assembly. Preformed modular detector loops shall be factory assembled. Home-runs and interconnect units shall be pre-wired, injected modular and shall be supplied as a complete assembly with each detector loop. The design of the assembly shall be for the specific application. The designs shall be applicable for use with hot asphalt, asphalt overlays, routed asphalt, concrete, and light-rail installations along with burial in dirt and gravel.

The loop wire to be used in the loop assembly shall be #16 TFFN stranded. It shall be color coded for the appropriate lane use as specified herein. Conductors from loop to loop or from loop to termination pull box shall be twisted a minimum of four turns per foot (*13 turns per meter*). All of the loop cable system shall be completely sealed inside the protective conduit with asphalt rubber sealant. Water blockage shall be assured by the factory.

Color Coding

Lane 1	Blue:	Left Turn Lanes, or Fast Lane
Lane 2	Black:	Fast Lanes
Lane 3	Red:	Middle Lane, or Curb Lane
Lane 4	Yellow:	Curb Lane (where 3 or more through lanes exist)

Inter-loop splicing will not be permitted, but fold points may be provided to facilitate shipping, handling, and installation. Fold points shall occur at not more than every 20 feet (*6 meters*).

Preformed modular loop hermetic assemblies shall have four layers of moisture protection utilizing asphalt-rubber filled Polypropylene construction. The loops shall be built with flexible/foldable expansion-contraction joints providing at least 1 inch *(25 millimeters*) of movement.

Joints shall be located for convenience in shipping and installation. A nominal 5 inch (*130 millimeters*) space shall be provided in the 3/8 inch (*10 millimeters*) Polypropylene. A sleeve that slides over the space in the 3/8 inch (*10 millimeters*) Polypropylene shall be a 10 inch (*250 millimeters*) length of 3/4 inch (*19 millimeters*) Polypropylene schedule 80. Expansion-Contraction joints shall be used at all fold points as specified herein.

A Tee shall be used at the center connections on quadrapole shaped loops. All Tees shall be CPVC heavy wall injection molded.

In new asphalt or concrete installations, the flexible Tee section shall be made of heavy wall CPVC and have a non-metallic cover also made of CPVC with extended skirts and ribbed reinforcing. The side outlets on the Tee body shall be 1 inch (*25 millimeters*) deep and join with 1/2 inch (*13 millimeters*) trade size PVC or CPVC conduit. The center outlet of the Tee shall accept a 3/4 inch (*19 millimeters*) trade size conduit. The cover shall be glued onto the Tee body upon completion of the assembly. The completely assembled Tee shall be able to withstand the weight of fully loaded dump and concrete trucks, the tracks of paving machines, etc. It shall not crack, break, or crush when subjected to compressive loading of heavy contractor equipment.

All material for assembling and installing the interconnects and home-runs shall be provided directly by the manufacturer. The loop feeder shall be run from the loop to the conduit stub out in either a rigid Polypropylene conduit or a high pressure hydraulic hose capable of supporting construction equipment. Either material shall be sealed in its entirety with rubberized asphalt sealant, identical to the material used in the loop housing. The selection of the material type

shall be at the discretion of the Engineer. This "protected" feeder shall be of sufficient length to be inserted 3 to 5 inches (*75 to 130 millimeters*) into the pull box stub out.

All preformed loops shall withstand pavement temperatures which occur as the result of ambient temperatures of -35° F to 165° F (*-37 °C to 74 °C*).

(C) Image Sensor.

(1) The video detection system shall use high resolution, monochrome, image sensors as the video source for real-time vehicle detection. As a minimum, each image sensor shall provide the following capabilities:

(a) Images shall be produced with a CCD sensing element with horizontal resolution of at least 500 lines and vertical resolution of at least 350 lines. Images shall be output:

1) As a video signal conforming to RS170, RS170A or NTSC specifications.

2) As a video signal conforming to CCIR specifications.

(b) Useable video and resolvable features in the video image shall be produced when those features have luminance levels as low as 0.1 lux at night.

(c) Useable video and resolvable features in the video image shall be produced when those features have luminance levels as high as 10,000 lux during the day.

(d) Useable video and resolveable features in the video image shall be produced when the ratio of the luminances of the resolved features in any single video frame is 300:1.

(e) Automatic gain, automatic iris, and absolute black reference controls shall be furnished:

1) Automatic iris shall operate in a damped manner with a time constant of 0.25 seconds or longer.

2) Automatic gain shall operate in a damped manner with a time constant of one second, and automatic gain shall not be applied to the video signal until the lens aperture is fully opened by the automatic iris control.

3) Automatic gain, automatic iris, and sensitivity shall be factory adjusted and/or modified as required for proper performance with the video detection system.

4) The black level shall be adjusted to 0 IRE units.

5) The iris video level shall be adjusted so that a no-contrast image has 50 IRE units of video.

6) The lens ALC shall be adjusted to average.

a) An optical filter and appropriate electronic circuitry shall be included in the image sensor to suppress "blooming" effects at night.

b) It is preferred that the image sensor video signal be crystal synchronized. Line lock synchronization, however, is acceptable.

c) Gamma for the image sensor shall be preset at the factory to a value of 1.0.

(2) The image sensor shall be equipped with an auto-iris lens with adjustable focal length. The maximum aperture of the lens shall be prefocused at infinity at the factory shall not be smaller than f1.8 and the minimum aperture of the lens shall not be larger than f300.

(3) The image sensor and lens assembly shall be housed in an environmental enclosure that provides the following capabilities:

(a) The enclosure shall be waterproof and dust-tight to NEMA-4 specifications, and shall be pressurized with an inert gas to 5 ± 1 psi (*35 ± 7 kilopascals*).

(b) The enclosure shall allow the image sensor to operate satisfactorily over an ambient temperature range from 29° F (*-34 °C*) to 140° F (*+60 °C*) while exposed to precipitation as well as direct sunlight.

(c) The enclosure shall allow the image sensor horizon to be rotated in the field during installation.

(d) The enclosure shall include a provision at the rear of the enclosure for connection of power and video signal cables fabricated at the factory. Input power to the environmental enclosure shall be 115 VAC 60 Hertz, with240 VAC 50 Hertz as an option.

(e) The enclosure shall be heated to prevent the formation of ice and condensation in cold weather, as well as to assure proper operation of the lens iris mechanism. The heater shall not interfere with the operation of the image sensor electronics, and it shall not cause interference with the video signal.

(f) The enclosure shall be white and shall include a sun shield to minimize solar heating. The front edge of the sun shield shall protrude beyond the from edge of the environmental enclosure and shall include provision to divert water flow to the sides of the sun shield. The amount of overhang of the sun shield shall be adjustable to prevent direct sunlight from entering the lens. The shield shall be installed fully extended.

(g) The total weight of the image sensor in the environmental enclosure with sun shield shall be less than 5 pounds (*2 kilograms*).

(h) When operating in the environmental enclosure with power and video signal cables connected, the image sensor shall meet FCC class B requirements for electromagnetic interference emissions.

(4) The video output of the image sensor shall be isolated from earth ground. All video connections from the image sensor to the video interface panel shall also be isolated from earth ground. The image sensor shall be connected to the MVP such that the video signal originating form the image sensor is not attenuated more than 3 dB when measured at the cabinet.

(5) Connections for both video and power shall be made to the image sensor using a single 18 pin circular metal shell connector (Bendix PTO7C-14-18P or equivalent). The mating cable shall use a right angle shell and shall be available in lengths of 5 (*1.5 meters*), 10 (*3 meters*), 30 (*9.1 meters*), and 60 feet (*18.2 meters*) to accommodate various installations.

A video isolation amplifier panel shall be available for installation inside of the traffic cabinet.

(6) The system shall be a MIL-LEKTRON Model ML 108 or approved equivalent and be fully compatible with the image processor, camera, and camera cable. One spare isolation cable shall be provided with each isolation unit.

The system shall meet the following specifications:

(a) Video: 75 ohm

(b) Connector type: BNC

(c) Common mode rejection ratio: 100 dB @ 60 Hz minimum.

(7) The isolation system panel shall buffer the video signal and provide transient suppression via connection to earth ground.

Video shall be transmitted from the camera to digital image processor over Belden 8281 coaxial cable, and shall meet all related industry specifications.

(8) Wire and Cable. Power cable shall be Carol model Super VU-TRON III Black Jacket SJ00W-A P/N85263, 3 conductor bundled cable or approved equivalent and meeting all agency standards for electrical conductors. Wire gauge to be determined by contractor for each specific job site but not smaller than #16 AWG in diameter.

The contractor shall install conduit, cable, and wire according to plans. Conduit fill shall not exceed 40%. Separate power from coax where possible.

After installation, and before termination, all wiring and cabling shall be checked and tested by the contractor to insure there are no grounds, opens, or shorts on any conductors or shields. A megohmeter (megger) shall be utilized to accomplished these tests and a reading of greater than 20 megohms shall be required to successfully complete the test. The contractor is to contact the Agency 48 hours prior to testing and perform all testing in the presence of an Agency representative.

The contractor is to visually inspect wire and cable for faulty insulation prior to installation and protect cable ends at all times with acceptable end caps except during actual termination. At no time shall any coaxial cable be subjected to a bend less than a 6 inch (*150 millimeters*) radius.

735-2.02 Pedestrian Push Button Detectors. The pedestrian detector shall be a push button switch mounted inside an approved push button housing. The switch shall be the phenolic enclosed SPST type with momentary contacts. The contacts shall be rated at 15 amps and 125 VAC. The switch shall have screw type terminals and shall have a rated life of not less than one million operations. The switch shall operate in the normally open position.

Pedestrian push buttons shall be mounted 42 inches (*1.1 meter*) above finished grade. Finished grade is defined as the surface upon which the pedestrian will be standing when pushing the button. Maximum side reach over obstructions shall be 24 inches (*600 millimeters*).

Pedestrian push button detectors shall comply with June 20th, 1994 Interim Final Ruling on the Americans with Disabilities Act Accessibility Guidelines.

The housing of the push button station shall be of substantial tamper-proof construction made of cast aluminum alloy. The assembly shall be weather-proof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. The housing shall be shaped to fit the curvature of the pole to which it is attached and shall provide a rigid installation. The housing body shall contain a direct push-type actuator button, microswitch-type or approved equal. The housing cover shall contain the push button sign as described below or as specified in the special provisions.

The microswitch component shall be dustproof, water resistant type. It shall be a precision, snap acting type. It shall also be U.L. listed and SCA certified and meet requirements for NEMA TS-1 and TS-2 as applicable.

Pedestrian push button signs shall be made with porcelain enameled 20 gauge (*0.91 millimeter*) sheet steel, 9-1/2 inches (*243 millimeters*) by 12 inches (*300 millimeters*) in size. Corners of the sign shall be finished round for safety and neat appearance. Each hole shall be provided with a brass grommet. Instructions on the signs shall be black enameled letters or symbols on a white enamel background. The legend shall be as shown on the plans or as specified in the special provisions.

Pole installation bolts, sign screws and washers shall be furnished with unit.

The plunger, actuator surface shall have a minimum diameter of 2 inches (*50 millimeters*). It shall be made of polished stainless steel and assembled with all stainless steel components so as not to be corrosive. The actuator shall be conical in shape.

Operating force shall be a maximum 5 pounds (*22 Newtons*).

735-2.03 Saw Cut Sealant. Saw cut sealants shall be a flexible encapsulant intended for sealing and protecting vehicle detector loop wires installed in saw cuts.

(A) Emulsified Crack Filler Sealant. Emulsified crack filler sealant may be used to seal saw cuts in asphaltic concrete base and leveling courses and in lean concrete base courses. The emulsified crack filler sealant shall conform to the requirements of the following table:

EMULSION (FOR CRACK FILLING)

Test on Emulsion	ASTM Test Method Except as Shown	Requirements
Viscosity, Saybolt Furol, 25 °C., Seconds, Range	D 244	25-150
Retained on No. 20 Sieve, Percent, Maximum	D 244 (1)	0.10
Particle Charge	D 244	Positive

EMULSION (FOR CRACK FILLING)

Test on Emulsion	ASTM Test Method Except as Shown	Requirements
Pumping Stability	(2)	Passes
Settlement, 5 Days Percent, Maximum	D 244	5.0
Residue, Percent Minimum	D 244 (3)	60.0

Test on Residue

Viscosity, 60° F. Centistokes, Range	D 2170	100-9500
Maltene Distribution, Ratio, Range	D 2006-70 (4)	0.7-1.4
PC/S, Ratio, Minimum	D 2006-70 (4)	0.50
Asphaltenes, Percent Maximum	D 2006-70	11.0

(1) Distilled water will be used instead of the two percent sodium oleate solution.

(2) 450 ml. of emulsion will be charged into a one liter beaker and circulated through a gear pump (Roper 29 B 22621) having a 1/4 inch (*6 millimeters*) inlet and outlet. The pumping stability is acceptable if there is no significant oil separation after a circulation of ten minutes.

(3) ASTM D 244 is modified by heating a 50-gram sample to 149 °F (*65 °C*) until foaming ceases, then cooling it immediately.

(4) PC + Polar Compounds; A Sub 1 = First Acidaffins; S = Saturated Hydrocarbons; A Sub 2 = Second Acidaffins. Maltene Distribution = ratio of PC + A Sub 1 to S + A Sub 2.

The emulsified crack sealant shall remain homogeneous within 30 days of delivery and shall be homogeneous after thorough mixing. The emulsified crack sealant shall be freeze stabilized and if freezing has occurred, a homogeneous mixture shall be obtained when the material has thawed and been thoroughly mixed.

(B)One Part Elastomeric Sealant. One part elastomeric sealant may be used to seal saw cuts in portland cement concrete pavement, asphaltic concrete pavement and lean concrete base.

The sealant shall provide compressive yield strength to withstand normal vehicular traffic as well as sufficient flexibility to withstand normal movement in concrete pavements, while protecting the loop wire from moisture penetration.

The encapsulant shall be a one-part elastomeric compound requiring no mixing, measuring or application of heat prior to or during this installation.

The encapsulant shall, within its stated shelf life in original undamaged packaging, cure only in the presence of moisture. The rate of cure will, therefore, depend upon temperature and relative humidity at the time of installation. Cool dry weather will slow curing whereas warm, humid weather will accelerate curing.

The encapsulant shall be designed to enable vehicular traffic to pass over the properly filled saw cut immediately after installation without tracking or stringing of the material. The encapsulant shall form a surface skin allowing exposure to vehicular traffic within 30 minutes at 75° F (*24 °C*). and completely cure to a tough, rubber-like consistency in two to seven days after installation.

Properly installed and cured encapsulant shall exhibit resistance to effects of weather, vehicular abrasion, motor oils, gasoline, anti-freeze solution, brake fluid, deicing chemicals and salt normally encountered, in such a manner that the performance of the vehicle detector loop wire is not adversely affected.

The cured encapsulant shall be temperature stable and exhibit no degradation in performance throughout the ambient pavement temperature ranges experienced within Pima County, Arizona.

The encapsulant shall exhibit minimal shrinkage during or after its installation, and in no manner affect the performance characteristics of the material.

The encapsulant shall be designed to permit clean-up of material and application equipment with non-flammable solvents such as 1,1,1 trichloromethane or Scotch-Grip Brand Solvent No. 4 (prior to curing of encapsulant). Should any encapsulant material be allowed to cure in the application nozzle, it shall be able to be pulled out as a solid plug.

The encapsulant shall have a minimum 12-month shelf life in undamaged original containers when stored in a cool, dry environment.

The encapsulant shall be designed for roadway installation when the surface temperature is between 40° F (*4 °C*) and 140° F (*160 °C*).

The encapsulant shall have the following physical properties in its uncured and cured states.

Physical properties of the uncured (wet) encapsulant:

Property	**Requirement**	**Test Procedure**
Weight	10.1 lbs/gal (*1.2 Kg/l*) +/-0.3 lbs (*0.14 kg*)	Weight/Gallon (*weight/liter*)
Total Solids Weigh	75 - 85%	Determination of No-by Volatile Content
Viscosity	10,000 - 85,000 CPS	Viscosity
Drying Time	Touch: 24 hrs. max. Complete: 30 hrs. max.	Tack-Free Time

Physical properties of the cured encapsulant:

Property	**Requirement**	**Test Procedure**
Hardness (Indentation)	65 - 85	Rex Hardness
Tensile Strength	500 psi min. (*3.5 megaPascals*)	Tensile & Elongation
Elongation	300%	Tensile & Elongation

(C) Hot Applied Rubberized Sealant. Hot applied rubberized sealant may be used to seal saw cuts in portland cement concrete pavement, asphaltic concrete pavement and in lean concrete base. Hot rubberized asphalt sealant shall be formulated specifically to be flexible. It shall be suitable for use as a sealant for traffic loop saw cuts and be non-tracking under traffic. At application temperatures, the traffic loop sealant shall be a thin, free flowing fluid which penetrates saw cuts and self-levels permitting uniform application. The sealant shall be melted and applied to pavements using a pressurized application unit. The sealant shall be a relatively stiff sealant but shall remain flexible at low pavement surface temperatures. The test results shall conform to the following specifications of the loop detector sealant.

Test	**Specification**
Penetration, 77° F (25 °C)	25 - 35 max.
Flow, 140° F (60 °C)	0 mm - 5 mm max.
Resilience, 77° F (25 °C)	40% min.
Softening Point	180° F min.
Ductility, 77° F (25 °C)	30 cm min.
Mandrel Bend, 0° F (-18 °C), 180 deg., 5 sec, 1/2" dia.	Pass
Rec. Pour Temp.	380° F (*193 °C*)
Safe Heating Temp.	410° F (*210 °C*)
375° F (190 °C) Viscosity	30 Poise
Unit Weight	10.0 lbs/gallon (*1.20 kg/liter*)
Coverage, 1/2" x 1/2" (13 mm x 13 mm) Crack	13.0 lbs per 100 ft. (*5.8 kg/30m*)

(D)Acrylic Loop Sealant. Acrylic loop sealant may be used to seal saw cuts in asphaltic concrete.

The sealant shall be one part polysulfide acrylic water base sealant.

The sealant shall have the following properties:

Test	Specification
Viscosity	Gardner hold 25 to 29
% Solids by wt.	80 - 85
Elongation	1000% ATSM D-638
Tensile Strength	600 psi (*4.1 mpa*)
Gel Time	5 - 15 minutes

735-3 CONSTRUCTION DETAILS

735-3.01 Vehicle Detector Installation.

(A)General. Vehicle detectors shall be installed as shown on the project plans and the Agency's standard drawings or Standard Details, and as directed by the Engineer. The installation of the vehicle detectors shall be such that the operation shall not be affected by temperature changes, water, ice, rain, snow, chemicals, or electromagnetic noise.

All loops placed in areas to be paved or overlayed shall be installed prior to the final pavement course. Saw cutting of new pavement is prohibited unless prior written permission is granted by the Engineer.

If a new vehicle detector loop is to be installed in a pavement in which an obsolete loop currently exists and a portion of the new loop will encroach into the area bounded by the existing obsolete loop, the contractor shall cut the existing obsolete loop as many times as needed to effectively destroy potential paths through which current could travel. The number and location of the cuts shall be approved by the Engineer. This procedure shall be used whether the existing obsolete loop is located in the riding surface or in a pavement lift other than the riding surface or if the existing surface will be overlayed with a new pavement. This same procedure shall be used if any part of an existing obsolete loop is within four feet of a new loop.

(B)Saw Cut Loop Detector Installation. Saw cuts shall be sealed with an approved sealant. All slots cut in the pavement shall be blown out and dried before installing conductors. After the conductors are installed in the slots, the slots shall be filled to within 1/8 inch (*3 millimeters*) of the pavement surface with sealant. Before the sealant sets up, the surplus sealant shall be removed from the road surface without the use of solvents.

The handling of the sealant and the filling of the saw cut shall be in accordance with the directions of the manufacturer. Sand blotter shall be applied as directed by the Engineer.

(C) Preformed Loop Detector Installation.

(1) General.

Preformed modular loops shall be installed in the roadway subgrade unless otherwise as specified in the plans or special provisions.

Conduit used for the loop assembly shall be 3/8-inch (*10 millimeters*) polypropylene copolymer PP SDR-9 molded to the shape required. Typical corner radius on quadrapole, diamond, and square shaped loops shall be 3 inches (*75 millimeters*). The corners shall be hot molded 90 degree bends which are all integral to the loop conduit. A Tee shall be used at the center connections on quadrapole shaped loops.

A flexible 1/2 inch (*13 millimeters*) schedule 80 PVC section shall be used to connect the pull Tees to the body of the loop assembly and to the home-run or interconnect. The length of the flexible section shall be as required for proper assembly and to maximize the physical strength of the loop.

The loop assembly shall be capable of withstanding the weight of fully loaded dump and concrete trucks, the tracks of paving machines, etc. It shall not crack, break, or crush when subjected to compressive loading of heavy equipment.

Factory sealed home-runs and interconnects shall be used unless otherwise specified (i.e. the loop assembly shall be a completely sealed unit into the first pull box). The loop feeder shall run from the loop to the conduit stub out in either a rigid polypropylene conduit or a high pressure hydraulic hose capable of supporting construction equipment. Either material shall be sealed in its entirety with rubberized asphalt sealant, identical to the material used in the loop housing. The selection of the material type shall be at the discretion of the Engineer. This protected feeder shall be of sufficient length to be inserted 3 to 5 *inches (75 to 130 millimeters*) into the pull box stub out.

From the conduit stub out into the pull box the wire shall be in a flexible polyethylene tube of 3/8 inch (*10 millimeters*) diameter, filled with rubberized asphalt sealant identical to that used in the rigid type feeder. This flexible feeder shall be capable of being fished through the conduit between the curb and the pull box. All wire in the feeder portion of the assembly shall be twisted throughout its length at not less than 4 turns per foot (*13 turns per meter*).

Where two loops are connected by a common feeder, each loop shall have a separate twisted pair of conductors to the pull box. Where multiple small loops are used as a substitute for a

long loop, the manufacturer shall tag each pair to identify current flow (S = start and F = finish) as well as which loop is 1st, 2nd, 3rd, etc. in the series.

Performed loops installed prior to placement of an asphaltic concrete overlay shall not suffer any degradation as a result of the temperature experienced during the paving operations.

(2) Installation.

The field installation of the preformed modular loops shall consist of the routing and placement in existing asphalt pavement, placement during the applications of hot asphalt, placement prior to concrete paving or decking, or placement under light-rail tracks.

Installation shall proceed according to manufacturer's specifications as outlined below:

(a) Existing Pavement

A routed groove shall be cut into the existing pavement in conformance with the manufacturer's specifications. The frames and home-runs shall be placed into the routed cuts. The routed cuts shall then be filled with hot-melted asphalt-rubber slot sealant conforming to the manufacturer's recommendations.

(b) Hot Asphalt

The preformed loop shall be secured on top of the base rock according to manufacturers specifications and be covered with a layer of hot asphalt at least 2.5 inches (*65 millimeters*) thick. Paving equipment shall not be allowed to spin their wheels or turn on the exposed loop.

(c) Hot Asphalt Overlay

A slot shall be cut into the existing pavement. The preformed loop detector framework shall be secured to the pavement according to manufacturers specifications. A minimum of 2.5 inches (*65 millimeters*) of pavement cover is required at finished grade.

(d) Concrete

The preformed loop detector shall be installed in concrete pavements using a method that conforms with manufacturers specifications and is approved by the Engineer. The completed assembly shall be approximately 2.5 inches (*65 millimeters*) below finished grade unless otherwise specified.

The contractor shall order preformed loops only after the pull box adjacent to the loop has been set or its exact location is known. This will ensure that loops will fit actual field conditions. Loops shall consist of 3 turns of

wire except where total cover exceeds 6 inches (*150 millimeters*) in which case 4 turns will be required. Where loops are to be installed near structural steel 5 turns of wire are required. Loops that are located further than 300 feet (*90 meters*) from the stop bar shall require 2 additional turns.

The contractor shall test for electrical continuity before installation. Any loop failing this test shall be replaced by the manufacturer. Any loop that fails after installation shall be replaced by the contractor at his own expense.

Pull box stub out sizes shall be as follows:

Number of Cables	Conduit Stub Out Size
1	1.0 inch (*25 millimeters*)
2	2.0 inch (*50 millimeters*)
3-4	2.5 inch (*65 millimeters*)
5-6	3.0 inch (*75 millimeters*) or 2 x 2.0 inch (*50 millimeters*)

(D) Splices. The detector sensor conductors shall be spliced to the detector lead-in cable in the adjacent pull box. Detector lead-in cables shall run continuous and unspliced to the controller cabinet.

All detector wire splices shall be soldered using resin core solder with 60 percent tin and 40 percent lead. The splices shall be sealed from moisture with self encapsulating shrink tubing. When heated the inner thermoplastic adhesive shall temporarily melt and the outer wall shall shrink. A weather proof bond shall form with a dielectric strength of 500 volt/mil and water absorption shall be less than 6.5 percent. The detector lead-in cable shield shall only be grounded on one end in the controller cabinet.

(E) Detector Loop Installation Field Tests. Before and after the saw cut sealant has been installed, the contractor shall perform an insulation resistance-to-ground test at the pull box on the detector leads. The insulation resistance-to-ground of the loop detector shall be at least 200 megohms when measured at a voltage of 500 D.C. with a megger. When the loop detector sensor conductors have been spliced with the detector lead-in cable, a test shall be conducted on the detector lead-in cable at the controller cabinet which shall provide a minimum resistance-to-ground of 50 megohms. Such test shall be conducted with the presence of the Engineer.

Any loop detector that does not meet the above requirement or cannot be tuned to the Engineer's satisfaction shall be replaced by the contractor at no cost to the Agency.

735-3.02 Pedestrian Detector Installation. Pedestrian push button detectors shall be installed as shown on the plans in conformance with the Agency's standard drawings or standard details.

735-4 METHOD OF MEASUREMENT

Loop detectors and pedestrian detectors will be measured as a unit for each type of detector furnished and/or installed.

Video Detection System will be measured as a unit each for each completely installed video detection system, which includes the installation of all mountings, cameras, hardware, software, and any associated material required for a complete and operational system. Agency shall supply complete system unless otherwise stated on the plans or Special Provisions.

735-5 BASIS OF PAYMENT

Loop detectors and pedestrian detectors, measured as provided above, will be paid for at the contract unit price each for the type detector designated in the bidding schedule, complete in place, which price shall be full compensation for the work described and specified herein and on the plans.

Video Detection system measured as provided above will be paid for at the contract unit price each for each complete intersection video detection system complete in place, which will be full compensation for the work and material described and specified herein and on the plans.

SECTION 736

STREET AND SIGN LIGHTING

736-1 DESCRIPTION

The work under this section shall consist of furnishing, installing and/or modifying street lighting systems, sign illumination systems, or internally illuminated street name signs at the locations shown on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

The work as described above shall include furnishing and installing all materials and equipment designated on the project plans necessary for the installation of future systems.

736-2 MATERIALS

736-2.01 Street Lighting Materials. Street lighting materials shall conform to the requirements of this section and be of the type and size specified. All lighting fixtures shall be supplied complete with lamps.

(A) Horizontally Mounted High and Low Pressure Sodium Luminaires. High pressure sodium (HPS) luminaires shall be 100 watt, 150 watt, 250 watt or 400 watt, as specified, of the horizontal burning type. Low pressure sodium (LPS) luminaires shall be 18 watt, 35 watt, 55 watt, 90 watt, 135 watt or 180 watt, as specified, of the horizontal burning type. Unless otherwise specified, HPS luminaires shall be the cobra head style. LPS luminaires shall be of the style required in the special provisions or as shown in the plans and/or the Agency's Standard Drawings or Standard Details. The housing, together with the reflector, shall be of sufficient size to properly utilize the high or low pressure sodium lamps designated. The light distribution shall be Type III medium cutoff unless otherwise specified and shall conform to the Illumination Engineering Society (IES) Standards and to any other codes, standards, or ordinances which apply.

Each luminaire shall be furnished with an instruction sheet which clearly shows installation procedures and instructions for adjusting the lamp socket. This instruction sheet shall include complete information on all socket positions and the IES light distribution produced from each setting.

(1) Luminaire Housing.

The luminaire housing shall be fabricated from a noncorrosive material. The lower portion of the luminaire shall be composed of two parts. One part shall contain the optical assembly and the other part shall be the ballast assembly. The ballast module door shall contain all the major electrical components and shall be capable of being lowered after loosening a fastening device. The HPS fastening device shall be a single stainless steel captive screw with an automatic safety latch. The LPS fastening device shall be a latch. The ballast module door shall have separable hinges. The ballast shall be pre-

wired to the lamp socket and terminal board. The ballast module door assembly shall be removable and replaceable by the use of quick disconnect plugs. The HPS optical assembly holder shall have an automatic latch with a safety catch on the house side. The HPS optical assembly holder shall be forced upward at the street side by spring pressure against the gasket seal when in the closed and latched position. The LPS optical assembly shall be held in place by either a latch or retaining clips. The luminaire shall have a slipfitter for mounting on a 2 inch *(50 millimeter)* nominal mast arm tenon and shall be adjustable for leveling ±3 degrees from the horizontal. The optical assembly size and the housing size shall be the same for 250 and 400 watt HPS luminaires. The optical assembly size and the housing size shall be the same for 100 and 150 watt HPS luminaires. The optical assembly size and the housing size shall be the same for 35 and 55 watt LPS luminaires.

Unless otherwise specified, the housing exterior shall be unfinished non-reflective aluminum or painted a light gray enamel in conformance with Subsection 1002-4.

(2) Optical Assembly and Gaskets.

The HPS optical assembly shall incorporate a snap-on, high specular, anodized aluminum reflector and shall contain a charcoal filter which effectively absorbs gaseous contaminates and particulate matter. The LPS reflector shall be formed of aluminum and factory painted white for very wide distribution.

The HPS optical assembly shall be the 90 degree cut-off flat glass type, manufactured of high quality, heat resistant glass. The LPS refractor shall be of prismatic molded acrylic and shall be sealed in the door.

A gasket of an approved neoprene material that will maintain a watertight and dust-tight seal throughout the temperature ranges inherent with the type of lamps specified shall be securely fastened to the reflector in the HPS luminaire and to the housing in the LPS luminaire. The gasket between the lamp socket and the reflector of the HPS luminaire shall be polyester fiber that will maintain a dust-tight seal throughout the above specified temperature ranges.

The lamp socket shall be of rugged, high grade porcelain securely mounted to a support bracket which is adjustable in both the vertical and the horizontal directions. Each adjustment shall be clearly and permanently coded for each light distribution setting. The coding shall directly re-late to the instruction sheet furnished with each luminaire.

(3) Ballast.

The HPS ballast shall be a three winding lag type magnetic regulator and shall be capable of starting lamps at -40° F *(-40 °C)* degrees Fahrenheit and operating the lamps within the limits specified by the lamp manufacturer. The starting amperes shall be less than operating amperes. The HPS ballast shall provide the lamp voltage shown in the lamp table of Subsection 736-2.01 (B). The HPS ballast shall be prewired to the lamp socket and terminal board. The HPS ballast shall be rated to the circuit voltage and size of the lamp specified. The HPS ballast shall be capable of operating for a six month period during a short circuit failure, lamp open, or end of life cycle without any measurable deterioration to the ballast.

The HPS ballast shall have the following characteristics:

	Initial (Percent)	End of Lamp Life (Percent)
Power Factor	99	90
Lamp Regulation Spread	14	18
Input Voltage Dip Tolerance	60	30
Lamp Wattage Regulation	0.8 for each one percent of line voltage	--
Line Voltage Variation	±10	--

The LPS ballast shall have a line voltage of 480 volts for use with LPS lamps and shall be capable of starting lamps at -20° F *(-7 °C)* and operating the lamps within the limits specified by the lamp manufacturer. The starting amperes shall be less than the operating amperes. The LPS ballast shall either be the high-reactance or reactor type with a power factor corrected to 90 percent with lamp wattage regulation of -5% to +3% with a line voltage fluctuation of -10% to +5%. The LPS ballast shall be prewired to the lamp socket and terminal board. The LPS ballast shall be rated to the circuit voltage and size of lamp specified.

(B) Lamps. Each luminaire shall be equipped with the specified lamp. The lamps shall be universal burning, clear, high or low pressure sodium type, as specified. Each lamp shall be clearly and permanently marked, giving the wattage and the American Standard Association number or the manufacturer's reference number and labeled with the date installed. Lamps of the wattage specified shall conform to the following:

HPS LAMPS

Wattage	Lamp Voltage	Minimum Initial Lumens	Rated Life (Hours)
100	55	9,500	24,000
150	55	16,000	24,000
250	100	30,000	24,000
400	100	50,000	24,000

LPS LAMPS

Wattage	ANSI Code	Minimum Initial Lumens	Rated Life (Hours)
18	L69RA-18	1,800	12,000
35	L70RB-35	4,800	18,000
55	L71RC-55	8,000	18,000
90	L72RD-90	13,500	18,000
135	L73RE-135	22,500	18,000
180	L74RF-180	33,000	18,000

(C) Lighting Controls.

(1) Photo Electric Controls.

The photo electric controls, hereinafter referred to as PEC, shall have a supply voltage rating of 105 to 285 volts AC, 60 Hz.

The nominal dimensions shall be 3.078 inches *(78.2 millimeters)* outside diameter and 2.219 inches *(56.4 millimeters)* maximum height. The operating temperature range shall be from -65° F *(-54 °C)* to +158° F *(70 °C)* and 100 percent relative humidity. A time delay shall be incorporated into the circuit to prevent the lights from being turned off at night by transient lights which might be focused on the control. The PEC shall be a conventional glass faced, hermetically sealed cell.

When the north sky illumination in the area falls to the preset value, the lighting load shall be turned on.

A switch to permit manual operation of the lighting circuit shall be provided for each PEC.

The PEC shall work in conjunction with an external auxiliary load relay for handling the required lighting loads unless specified otherwise.

The PEC shall have a built-in lightning arrester. The encapsulated surge protector shall have a spark-over value of 2,000 volts and shall interrupt up to 10,000 amperes of follow-through current without affecting the operating characteristics.

The PEC shall meet the following electrical requirements:

Supply Voltage	105-285 volts, 50/60 Hz, AC
Photo cell coil	120 volts, AC
Inrush current	120 amperes at 110 volts 60 amperes at 240 volts

Lamp Loads:

Incandescent	1000 watts
Mercury vapor	1800 volt-amperes
Fluorescent	1800 volt-amperes
HPS	1800 volt-amperes
LPS	1800 volt-amperes
Relay contacts:	Single pole, single throw
Operating levels:	Normally closed
Turn on:	1.0 $\pm$ 0.2 foot-candles (10.8 $\pm$2.1 lux)
Turn off maximum:	1.8 foot-candles (19.4 lux)
Life at rated load:	5000 on-off operations minimum
In rush current:	130 amperes @ 120 VAC
Operating levels:	65 amperes @ 240 VAC
Ratio average	3.0 foot-candles (32.3 lux)
Control power	0.65 watts maximum (120 VAC) 3.2 maximum (240 VAC)

(2) Auxiliary Contactor.

Unless otherwise specified, an auxiliary contactor shall be used in conjunction with a PEC to control the required lighting loads. The contactor shall have contacts rated to switch the specified lighting loads and shall be normally open. The contactor shall be single pole or double pole as required. The contactor shall be installed as shown on the plans.

The contactor shall be of the mechanical armature type and shall consist of a 120 volt operating coil, a laminated core, a laminated armature, contacts, and terminals. The contacts shall be fine silver, silver-alloy, or other superior low contact resistance metal.

(3) Manual-Off-Photo Switch.

A manual-off-photo switch shall be installed to manually activate the contactor to turn the lights on or off. The switch shall be the toggle type having double pole, double throw contacts with the center position being the "off" position, and be rated at 10 amperes at 250 volts A.C. The switch shall be manually activated in the up position and shall be activated by the PEC in the down position.

(D) Testing. Each luminaire shall be subjected to an initial test period of 100 hours.

736-2.02 Sign Lighting Materials.

(A) General. Sign lighting fixtures and all necessary hardware shall conform to these specifications, and shall be UL listed. Fixtures shall either be high pressure sodium or fluorescent type, as specified on the plans. Each sign lighting fixture shall be designed for mounting at the top of the sign panels as shown on the plans on an overhead sign structure. The mounting and number of fixtures required per sign shall be as shown on the project plans. All sign lighting fixtures shall be supplied complete with lamps.

(B) High Pressure Sodium Fixtures. High pressure sodium sign lighting fixtures shall be designed for mounting at the top of the sign panel on an overhead sign structure. The fixture shall be of an enclosed design and shall be watertight and corrosion resistant. Each fixture shall consist of a housing with uplight shield, door, reflector, refractor, lamp, socket assembly, ballast, terminal block, quick connect harness and all necessary hardware. The fixture shall be UL listed and shall conform to the following:

(1) Housing.

The housing shall have a door designed to hold a refractor. Housings and doors shall be fabricated of die cast aluminum. All external bolts, screws, hinges, hinge pins and door closure devices shall be stainless steel.

Each housing shall be drilled and tapped for 1-1/4 inch *(32 millimeters)* conduit at the center of the fixture nearest the sign panel.

Each housing shall be provided with holes as recommended by the manufacturer to permit condensed water to drain. Each hole shall be countersunk to a depth appropriate for the thickness of the housing.

The door shall be hinged to the housing on the side of the fixture away from the sign panel and shall be provided with two captive latch bolts or other closure devices. The door shall include an integral glare shield.

The juncture of the door and the housing shall be gasketed to provide a watertight and dust-tight joint. The gasket material shall be a minimum 3/8 inch *(10 millimeter)* seamless closed cell sponge EPDM meeting UL specification requirements for tensile strength and elongation after 7 days aging at 235° F (*113 °C*).

(2) Reflector.

The reflector shall be one piece hydroformed and shall be made from specularly finished aluminum protected with an electrochemically applied anodized finish. The reflector shall be designed so that water deposited on it due to condensation will drain away. The reflector shall be contoured to match the refractor design.

(3) Refractor.

The refractor shall be made from borosilicate heat resistant glass. The outer surface of the refractor shall be smooth and the inner surface shall contain the splitting and bending prisms. A single piece weather resistant gasket shall seal the refractor to the housing. The refractor shall be so designed or shielded that no fixture luminance is visible when the fixture is approached directly from the rear and the viewing level is the bottom of the fixture. When a shield is used, it shall be an integral part of the door casting.

(4) Lamp.

Each fixture shall be furnished with a 150 watt high pressure sodium lamp, ANSI code: S55SC-150, in accordance with the lamp table of Subsection 736-2.01 (B).

(5) Lamp Socket.

Each lamp socket shall be a porcelain enclosed mogul type. The socket shell shall contain integral lamp grips to assure electrical contact under conditions of normal vibration. The center contact shall be spring-loaded. Shell and center contact shall be nickel plated brass. The socket shall be rated for 1,500 watts, 600 volts.

(6) Ballast.

The ballast for the HPS sign fixture shall meet the requirements of Subsection 736-2.01 (A) (3). The ballast for each HPS sign fixture shall be 100 percent copper wound and shall be designed for the characteristics and wattage of the lamp it is to operate and it shall provide the proper starting voltage and operating waveforms, voltage and current.

Ballasts shall be of high power factor lag circuit design, capable of starting and operating the high pressure sodium lamp required within the limits specified by the lamp manufacturer.

Ballasts shall be 100 percent copper wound and have a Class H insulation system. Core laminations shall be M6 magnetic steel.

A ± 10 percent line voltage variation will not result in more than a ± 10 percent variation in wattage. Input wattage shall not exceed 188 watts. The power factor shall be over 90 percent throughout the life of the lamp.

The core-coil, starting aid and capacitor shall have a minimum ambient starting temperature of -40° F *(-40 °C)* and be capable of operating for a six month period during a short circuit failure, lamp open, or end of life cycle without any measurable deterioration to the ballast.

Ballasts shall have a design life of not less than 100,000 hours.

The input voltage for ballasts shall be as shown on the plans or as specified in the special provisions.

Each ballast shall consist of separate components, each of which shall be capable of being easily removed. Each component shall be provided with screw terminals, NEMA tab connectors or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they connect.

Heat generating components shall be mounted so as to use the portion of the sign lighting fixture upon which they are mounted as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the case temperature to 167° F *(75 °C)*.

Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors shall be metal cased and hermetically sealed.

(7) Terminal Block.

Each fixture shall be provided with a barrier type terminal block for terminating field connections. The terminal block shall be secured to the housing and shall be provided with protection from water due to condensation. Means shall be provided for both fusing and disconnecting the input circuit. Fuses shall be 12/32 inch *(10 millimeter)* diameter, 1 1/2-inch *(40 millimeter)* long ferrule type and shall be UL listed. Fuses shall be rated for the type of fixtures specified. A quick connect wire harness shall be included for internal wiring.

(8) Performance.

When the fixture with its specified lamp is located so that the light center of the lamp is 4 feet *(1.2 meters)* in front of, 1 foot *(300 millimeters)* above and centered on a sign panel 8 feet *(2.4 meters)* high and 16 feet *(4.9 meters)* wide, the ratio of the maximum to minimum illuminance level on the panel shall not exceed 4.65 to 1 and the average to minimum illumination

ratio shall not exceed 2.75 to 1. In addition, the illuminance gradient shall not exceed 2 to 1. The illuminance gradient is defined as the ratio of the minimum illuminance per one square foot *(one square meter)* of panel to that on any adjacent square foot *(square meter)* of panel. The average maintained illumination level on the panel shall be 20 foot candles *(215 lux)*.

(9) Uplight Shield.

The fixture shall be provided with an uplight shield that eliminates light above the horizontal plane. The shield shall be of the same manufacturer as the fixture, constructed of 0.060 inch *(1.5 millimeter)* aluminum sheet material and shall be mounted with a minimum of eight stainless steel screws. The shield shall be finished inside and outside with a baked polyester powder paint with a minimum 60 percent reflectance to match the luminaire. The shield shall be configured to provide zero light above the horizontal plane, as shown by independent laboratory test reports. The contractor shall furnish the Engineer with certified copies of the results of the independent laboratory test reports. The shield shall flare at 45 degrees from the fixture housing to a point 1/4 inch *(6 millimeters)* below the lowest horizontal plane of the refractor.

(C) Fluorescent Fixtures. The fixture shall be the fully enclosed type, watertight and dust-tight with drainage provided at the bottom of the in-place fixture. The fixture shall consist of aluminum framing, reflectors, two fluorescent lamps, two associated ballasts, fuse holders, and terminal blocks.

The fixture base and the cover frame shall be fabricated from a minimum 14 gauge aluminum alloy. Mounting holes shall be provided in the bottom of the fixture for slip-bolt attachment to the channel mounting framework. The fixture and cover shall have a toggle action lock for quick and easy access so that the lamps and the reflectors may be removed and replaced without the use of tools. A piece of clear acrylic plastic, a minimum of 1/8 inch *(3 millimeters)* thick, shall be inserted in the cover frame.

Reflectors shall be constructed of aluminum with a minimum thickness of 0.020 inches *(0.5 millimeters)*. The aluminum shall have a specular Alzak processed finish.

The lamps shall be F-72T12/CW/HO, recessed double contact base, high output type. The lamps shall have an average current rating of 800 milliamperes and shall have an initial lumen rating of 6650 lumens, and a rated life of 12,000 hours. The lamp holder socket shall have silver plated, heavy duty contacts designed for outdoor operations and shall have a neoprene seal to prevent the entrance of moisture at the contacts.

The ballast shall be the single tube, high output, instant start type. The ballast shall be weatherproof for outdoor use and shall have a minimum noise level rating. The ballast shall operate on 120 volt, 60 Hz, AC and shall be rated for satisfactory operation down to 20° F *(-29 °C)*. The internal ballast components shall be locked in place with a thermosetting compound that will not heat-soften at elevated temperatures. Each ballast shall be independently fused with a two ampere, slow-blow fuse.

The fuse holder shall have an insulating base and number 8/32 screw terminals. Slow-blow glass fuses shall be used and shall be 1/4 inch *(6 millimeters)* in diameter and 1-1/4 inches *(30 millimeters)* in length.

Fixture terminal blocks shall be the heavy duty, open top, and side barrier type and shall have number 8/32 screw terminals.

(1) Dry Type Transformers.

On those sign structures connected to 480-volt lighting circuits, dry type transformers shall be installed as required on the plans. The transformer shall be rated for outdoor use and shall meet the NEMA 3R requirements. The transformer shall step the 480 volts down to 120/240 volts, 3 wire. The transformer shall be sized as required on the project plans.

(2) Mounting Channel.

The 1-5/8 inch x 1-5/8 inch *(41 millimeters x 41 millimeters)* mounting channel shall be as designated on the plans and shall be fabricated from sheet steel having a minimum thickness of 0.105-inches *(2.7 millimeters)* conforming to the coating requirements of ASTM A 153 or A 386. The channel shall be attached to the tubing furnished on the sign structure by machine bolts. The machine bolts shall be at least 3/8 inch *(10 millimeters)* in diameter.

(3) Electrical Requirements.

The electrical power to each sign light fixture shall be 3-or 4-wire, 120 volts, as specified on the plans.

736-2.03 Load Center Cabinets. Load center cabinets, including pole mounted cabinets, shall have photoelectric controls and shall also include the concrete foundation, conduit stub-outs, meter socket (if specified), rigid metal conduit riser, concrete encased PVC-coated rigid metallic conduit, cabinet housing, panel, breakers, contactor, selection switch, fuses, dry transformer, internal wiring and other incidentals in accordance with the project plans and these specifications.

Pre-cast foundations shall not be used. All foundations shall be poured in place.

The load center cabinet housing shall be fabricated from 10 gauge (*3.4 millimeters*) sheet steel and shall be of a NEMA 3 weather resistant construction. The steel cabinet housing and accessories shall be treated on the inside and outside with one coat of zinc chromate primer and painted with two coats of white enamel in accordance with Section 1002. Cabinets shall have continuous welded outside seams.

Circuit breakers shall be molded case, thermal magnetic, bolt-on or plug-in type and shall be U.L. listed.

Load center cabinets shall have a dead front panel to isolate all live electrical circuitry. The panel shall be fabricated from 14 gauge *(1.9 millimeter)* sheet steel and shall be painted the same as the cabinet. The dead front panels shall be hinged on one side and securely fastened on the other with bolts. The dead front shall be hinged with lift up and out type hinge pins. Switches, breakers and other components shall have openings to operate from the front panel.

736-2.04 Internally Illuminated Street Name Signs. Internally illuminated street name sign fixtures and all necessary hardware shall conform to these specifications and shall be UL listed. Each street name sign fixture shall be designed for mounting on a traffic signal mast arm. The mounting and number of street name sign fixtures shall be as shown on the project plans. All street name sign fixtures shall be supplied complete with lamps.

The street name sign fixture housing shall be constructed entirely of aluminum, except for the two translucent street name sign panels. The aluminum shall not be painted. The upper and lower housing shall be constructed of 0.078 inch *(2 millimeter)*, minimum thickness, extruded aluminum. The end casting shall be 356 aluminum with a low copper content. The gaskets used shall be closed cell neoprene or extruded neoprene. All fasteners, external bolts, screws, hinges, hinge pins, door closure devices, and other hardware shall be made of stainless steel.

Each of the two translucent street name sign panels shall be constructed of a single piece of tuflite fiberglass. The minimum thickness shall be 0.060 inches *(1.5 millimeters)*. Applied to the fiberglass panel shall be an Interstate green Fascal overlay with the lettering cut out. The sign panel upper case letters and numbers shall be:

8 inches *(200 millimeters)* high for the street name (Standard Alphabet Series E or C)
5 inches *(130 millimeters)* high for the suffixes (Standard Alphabet Series E or C)
3 inches *(75 millimeters)* high for the block numbers (Standard Alphabet Series E or C)

The standard alphabet series used will be based on the current U.S. Department of Transportation specifications for alphabets for highway signs. The alphabet series selected will depend on the number of letters comprising the street name. The letter and word spacing shall vary according to the length of the street name.

Each panel of the street name sign fixture shall be internally illuminated using a single lamp unit equipped with a 200 MA, T-12 lamp. The reflector shall be die-formed with a baked white enamel finish and have a minimum thickness of 0.40-inches *(10 millimeters)*. The reflector shall evenly distribute the light across the entire translucent panel.

The ballast shall be 120 volts, 60 Hz, 0 degree starting used in combination with the 200 MA, T-12 lamp in order to increase the rated life of the lamp to 18,000 hours.

The dimensions of the sign panel and fixture will be governed by the sign legends. Sign legends are as provided in the special provisions. The exact sign legend and dimensions of the sign panels shall be approved by the Engineers prior to the fabrication.

Block numbers shall be confirmed by the Contractor prior to ordering.

The sign colors, street names and suffix shall appear on both panels of the sign.

The sign shall have three 1/4 turn airlock fasteners per door to secure it to the housing. A continuous aluminum hinge 0.040 inch *(1 millimeter)* x 1 1/16 inch *(27 millimeter)* installed between the door and luminaire housing.

The internally illuminated sign shall be installed on the mast arm via contractor supplied mounting bracket as directed by the Engineer, and shall be wired to the intersection lighting circuit (120v). Brackets shall have the ability to swing 360 degrees.

The top and side panels shall not be drilled or otherwise have their watertight integrity compromised.

The mounting brackets shall be manufactured from 6061-T6 aluminum or better with all hardware stainless steel. The bolts shall be Nylock or equal. The bracket assembly shall be configured in such a manner so that the centerline of the pole is on the centerline of the sign itself. The entire unit will be able to swivel to 75 degrees in both directions, have hinges that are self lubricating and with anti-rotation for pivot bolts and assemblies.

Internally Illuminated Pedestrian Crossing signs shall be provided as indicated on the plans and shall be black on yellow background and read "Pedestrian Crossing." Letters shall be 8 inches *(200 millimeters)* in height. Signs shall have 1-1/2 inches *(40 millimeter)* black border.

736-3 CONSTRUCTION DETAILS

Conduit shall be installed between the load center cabinet foundation and the service pole and shall be the PVC coated, rigid metallic type.

Field adjustments of the lamp sockets shall not be made for horizontally mounted type luminaires. The lamp socket shall be adjusted at the factory to achieve the light distribution as specified on the plans and in the special provisions.

The contractor shall maintain full nighttime operation of the existing lighting system during the duration of the construction project.

736-4 METHOD OF MEASUREMENT

Luminaires will be measured as a unit for each luminaire furnished and/or installed.

Photo electric controls shall be measured as a unit for each photo electric control furnished and/or installed.

Load center cabinets will be measured as a unit for each load center cabinet furnished and/or installed.

Sign lighting fixtures and internally illuminated street name signs will be measured as a unit for each fixture furnished and installed.

736-5 BASIS OF PAYMENT

The accepted quantities of luminaries, photo electric controls, load center cabinets, sign lighting fixtures and internally illuminated street name signs, measured as provided above, will be paid for at the contract unit price each, for the types of luminaires and load center cabinets designated in the bidding schedule, complete in place, which price shall be full compensation for the work described and specified herein and on the plans.

The accepted quantities of photo electric controls, measured as provided above, will be paid for at the contract unit price each, complete in place, which price shall be full compensation for the work described and specified herein and on the plans, including incidentals such as mounting hardware and any other equipment necessary to complete the work.

The accepted quantities of sign lighting fixtures, measured as provided above, will be paid for at the contract unit price each, complete in place, which price shall be full compensation for the work described and specified herein and on the plans, including incidentals such as mounting hardware, electrical wiring, conduit, circuit breaker disconnects, transformers and any other equipment necessary to complete the work.

SECTION 737

INCIDENTAL ELECTRICAL WORK

737-1 DESCRIPTION

The work under this section shall consist of maintaining existing traffic signals and lighting systems, furnishing and installing complete and functioning temporary traffic signal systems, and removing and salvaging or reinstalling electrical equipment, all in accordance with the project plans and the requirements of these specifications.

737-2 MATERIALS

737-2.01 Maintaining Existing Traffic Signals and Lighting Systems. Replacement items necessary for maintaining existing traffic signal and lighting systems shall be of similar make and manufacture and meet the minimum material requirements of those items they are to replace.

737-2.02 Temporary Traffic Signals.

(A) General. Agency approved pole-line hardware shall be utilized in the installation of poles, messenger cable, pole anchors, etc.

(B) Wood Poles. Wood poles shall be 40 feet *(12.2 meters)* in length, Class 3, unless otherwise specified, and meet the requirements of Section 731 of these specifications. Holes for poles shall be dug at an angle with the vertical to allow for proper raking of the top of the pole. Poles shall be set 10 feet *(3 meters)* deep in the ground, be well tamped, and raked 1 foot *(300 millimeters)* out from the vertical position and in line with the pull of the cable.

The wood poles for temporary signals and their associated cables, wires, supports, etc. shall be located so as to provide clearance for all permanent construction.

(C) Messenger Cable. The messenger cable used for aerial signals and anchoring shall be 1/2 inch *(13 millimeters)* minimum, 7-strand, high-strength grade, galvanized steel messenger cable securely attached to the poles and anchors in an approved manner.

(D) Agency Furnished Material. The Agency will be responsible for any changes required in the control cabinet. The existing pedestrian units shall be used on the temporary traffic signals. The existing controller cabinet shall be used. All other equipment and materials necessary for the temporary signals shall be furnished by the contractor, unless otherwise specified.

737-2.03 Removing and Salvaging or Reinstalling Electrical Equipment. Replacement parts for salvaged or reinstalled electrical equipment shall meet the material requirements for like items as herein before specified, as directed by the Engineer, or as designated in the special provisions.

737-3 CONSTRUCTION DETAILS

737-3.01 Maintaining Existing Traffic Signals and Lighting Systems. The contractor shall furnish the name and telephone number of the designated, licensed, qualified electrician who is to be contacted by the Police, Department of Public Safety, Engineer, Agency communication's center, or Agency personnel in case of maintenance requirements. The response time for the contractor designated electrician is to be 20 minutes during normal work hours and 1 hour for all other times.

All existing traffic signal and lighting systems, or other designated electrical systems, shall be kept in effective operation for the benefit of the traveling public during the progress of the work, except when shutdown is permitted by the Engineer to allow for alterations or final removal of the systems. The contractor shall provide to the Agency, for approval, a schedule of operations for maintaining existing traffic signals and street lighting during construction. The contractor shall follow the approved schedule of operations. Wherever possible, the contractor shall construct temporary traffic signals or relocate existing traffic signals to clear the construction area prior to beginning construction on the roadway. The work shall also include the relocation and/or modification of existing traffic signals and lighting systems as required during construction.

The traffic signal system removals and shutdowns shall be limited to the normal working hours as directed, in advance, by the Engineer. During periods of shutdown, off-duty police officers shall be employed by the contractor to manually direct traffic. At all times, the traffic signal systems shall remain operational.

All traffic signal heads not in use shall be covered with burlap only and shall be unmistakably out of service when observed by an approaching driver.

During construction, the maintenance, care and control of the existing traffic signal control cabinet will be the responsibility of the Agency. All other maintenance of the existing traffic signal system shall be accomplished by the contractor.

The contractor shall maintain full nighttime operation of the existing lighting system for the duration of the construction project. The contractor shall designate a person who will be available for emergency maintenance calls after normal working hours. The contractor shall furnish this person's name and telephone number to the Engineer. The contractor shall have labor and the necessary equipment available at all times for such emergency maintenance.

The contractor shall maintain telephone service to the central monitoring system when such service exists.

737-3.02 Temporary Traffic Signals. Messenger cable shall have a maximum sag of five percent of the distance of spans. The lowest point of any backplate shall initially be 18 feet (*5.5 meters*) above the roadway to allow for settling of poles and anchors. Backplates shall be maintained so that the clearance between the lowest point of any backplate and the future finished roadway grade shall not be less than 17 feet (*5.2 meters*). The contractor shall check each day to insure that the minimum clearance is maintained and shall take corrective measures if necessary.

Cable rings, on 24 inch (*600 millimeters*) maximum spacing, shall be used to secure the signal wires to the messenger cable. The wires shall also be taped to the cable if necessary to prevent excessive and unsightly slack in the line(s).

The continuous operation of traffic signals shall be in accordance with the requirements of Subsection 737-3.01.

The contractor shall maintain the electrical systems for the duration of the construction project. The contractor shall designate a person who will be available for emergency maintenance calls after normal working hours. The contractor shall furnish this person's name and telephone number to the Engineer. The contractor shall have labor and the necessary equipment available at all times for such emergency maintenance.

When required, the contractor shall remove and salvage all material associated with the temporary traffic signal. All salvaged material shall be the property of the Agency and shall be dismantled and stockpiled as directed by the Engineer. Material broken or damaged by the contractor shall be replaced with new and like material at the contractor's expense. It shall be the responsibility of the contractor to remove and dispose of all traffic signal equipment and materials not salvaged.

Cavities resulting from the removal of pull boxes, foundations or other material shall be backfilled and compacted with material equivalent to or better than the surrounding material.

737-3.03 Removing and Salvaging or Reinstalling Electrical Equipment. The contractor shall remove and salvage all existing traffic signal and lighting equipment not reused as specified in the special provisions, project plans, or as directed by the Engineer. The work shall also include the removal and disposal of foundations. All equipment and materials to be salvaged shall be the property of the Agency. Salvageable material shall be dismantled and stockpiled, prior to project completion, as directed by the Engineer, and shall be delivered to the Agency by the contractor upon 48 hour prior notice to the Engineer.

All equipment damaged or destroyed by improper care or handling shall be replaced with new equipment. Unless otherwise specified, it shall be the responsibility of the contractor to remove and

dispose of all discarded materials not salvaged. Holes resulting from removal of pull boxes, foundations, and other material shall be backfilled and compacted with material equivalent to the surrounding area as designated by the Engineer.

When salvaged equipment is to be reinstalled, the contractor shall furnish and install all necessary materials, equipment, and hardware as required to complete the new installation. Reinstalled poles, pull boxes and cabinets shall be relocated as shown on the plans, with conduit and conductors installed, and all circuit connections complete and operational. Signal faces, mounting assemblies and backplates shall be cleaned and repainted when reinstalled. All traffic signal faces, either to be reinstalled or part of a modified system, shall be relamped. Luminaires to be reinstalled shall be cleaned and relamped.

Existing materials to be relocated and found to be unsatisfactory by the Engineer shall be replaced with new material and will be paid for in accordance with the requirements of Subsection 109-4.

737-4 METHOD OF MEASUREMENT

Maintaining existing traffic signals and lighting systems will be measured as a single, complete unit of work.

Temporary traffic signal will be measured as a single, complete unit of work.

Removing and salvaging or reinstalling electrical equipment will be measured as a single, complete unit of work.

737-5 BASIS OF PAYMENT

The accepted quantities of maintaining existing traffic signals and lighting systems, measured as provided above, will be paid for at the contract lump sum price, which price shall be full compensation for the work, complete, as specified and described herein, and as shown on the project plans.

The accepted quantities of temporary traffic signal, measured as provided above, will be paid for at the contract lump sum price, which price shall be full compensation for the work, complete in place, as specified and described herein, and as shown on the project plans.

The accepted quantities of removing and salvaging or reinstalling electrical equipment, measured as provided above, will be paid for at the contract lump sum price, which price shall be full compensation for the work, complete in place, as specified and described herein, and as shown on the project plans.

SECTION 801

LANDSCAPE EXCAVATION

801-1 DESCRIPTION

The work under this section shall consist of excavating areas to be landscaped, hauling and satisfactory disposal of surplus excavated material in accordance with the details shown on the project plans and the requirements of these specifications.

801-2 MATERIALS (None Specified)

801-3 CONSTRUCTION DETAILS

All landscape contouring shall be performed in reasonably close conformity to the lines, grades, dimensions, and cross section(s) established by the Engineer or shown on the project plans.

The hauling and disposal of surplus excavated material shall be in accordance with the requirements of Subsection 203-3.03 (D).

801-4 METHOD OF MEASUREMENT

Landscape excavation will be measured by the cubic yard (*cubic meter*).

Landscape excavation measured by the cubic yard (*cubic meter*) will be measured in its original position by the Engineer, and the volume will be computed in accordance with the requirements of Subsection 109-1.

801-5 BASIS OF PAYMENT

The accepted quantities of landscape excavation, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*).

When landscape excavation is not included as a contract item, full compensation for any landscape excavation necessary to perform the construction operations specified on the project plans and the Special Provisions will be considered as included in the unit price paid for other contract items in the bidding schedule.

SECTION 802

LANDSCAPE GRADING

802-1 DESCRIPTION

The work under this section shall consist of grading, contouring, compacting, smoothing or otherwise shaping areas at the locations designated on the project plans.

802-2 MATERIALS (None Specified)

802-3 CONSTRUCTION DETAILS

Roadway shoulders and soil areas left exposed after planting or prior to placement of decomposed granite shall be graded as required to leave a generally smooth appearance conforming to the general shape and cross section indicated on the project plans. The final surfaces shall be raked. All objectionable material, trash, brush, weeds, and stones larger than 2 inches (*50 millimeters*) in diameter shall be removed from the site and disposed of in a manner acceptable to the Engineer.

802-4 METHOD OF MEASUREMENT

Landscape grading will be measured either by the square yard (*square meter*) of area actually graded or as a single complete unit of work.

802-5 BASIS OF PAYMENT

The accepted quantities of landscape grading, measured as provided above, will be paid for at the contract unit price per square yard (*square meter*) or at the contract lump sum price specified in the bidding schedule.

When landscape grading is not included as a contract item, full compensation for any landscape grading necessary to perform the construction operations specified on the project plans and the Special Provisions will be considered as included in the unit price paid for other contract items in the bidding schedule.

SECTION 803

LANDSCAPE BORROW AND PLATING MATERIAL

803-1 DESCRIPTION

The work under this section shall consist of grading surfaces, eradicating grasses, weeds and undesirable vegetation; furnishing, hauling, placing and compacting imported material for establishing the required elevations and grades in landscape areas and for plating embankment slopes, dikes and other designated areas in accordance with the details shown on the project plans and the requirements of these specifications.

803-2 MATERIALS

803-2.01 Landscape Borrow and Plating Material. Landscape borrow and plating material shall be secured from commercial sources or from contractor furnished sources unless otherwise designated in the Special Provisions. The material shall be in accordance with the requirements of Subsection 804-2.

803-2.02 Decomposed Granite. Decomposed granite shall be free of lumps or balls of clay and shall not contain calcareous coatings, caliche, organic matter or foreign substances. All material shall be from a single production source and shall present a uniform appearance on each project. The gradation and color of the decomposed granite shall be as indicated on the plans or in the Special Provisions.

803-2.03 Rock Mulch. Rock mulch shall be free of calcareous coating, caliche, organic matter or other foreign substances.

803-3 CONSTRUCTION DETAILS

803-3.01 Landscape Borrow and Plating Material. Prior to placing material, the areas shall be cleared of all weeds, brush, trash, rock 2 inches (*50 millimeters*) or larger in diameter and other objectionable material. Undesirable vegetation, grasses and weeds shall be eradicated by the use of both an approved herbicide and mechanical methods.

Landscape borrow shall be placed in horizontal layers not exceeding 8 inches (*200 millimeters*) in depth prior to compaction. Water shall be added or removed in order to obtain the required density. Each layer of landscape borrow shall be compacted to a density of not less than 85 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Plating material shall be spread and shaped to conform to the lines, grades and cross sections as shown on the project plans or as established by the Engineer. The material shall be watered and compacted in accordance with the requirements of the Special Provisions.

803-3.02 Decomposed Granite. Decomposed granite shall not be placed until the required irrigation system(s), preliminary weed control, if specified, and acceptable finish grading and planting operations have been completed within the area.

The surfaces upon which the decomposed granite is to be placed shall be graded smooth and compacted to a density of not less than 85 percent of the maximum density as determined in accordance with the requirements of the ADOT Materials Testing Manual, as directed and approved by the Engineer. The area of the planting pits shall be "water settled". No mechanical compaction of the planting pit area(s) shall be allowed.

All deleterious material and rocks larger than 1 inch (*25 millimeters*) in diameter shall be removed and disposed of by the contractor.

The contractor shall provide a sample of the decomposed granite to the Engineer for approval prior to hauling any quantity of the material to the site.

The decomposed granite shall be evenly distributed over the designated areas to the depths as detailed on the project plans. The compacted depth of the decomposed granite shall be within 1/2 inch (*13 millimeters*) of the depth shown on the project plans. The finished surface of the decomposed granite shall be 1/2 inch (*13 millimeters*) minimum and 1 inch (*25 millimeters*) maximum below the surface of adjacent sidewalk or concrete foundations and the tops of adjacent curbs. All areas to receive decomposed granite shall be approved by the Engineer prior to placement of the decomposed granite.

Vehicles used for spreading, grading, and raking the decomposed granite shall have one set of wheels with floatation tires having a minimum width of 18 inches (*450 millimeters*) to provide uniform compaction of the decomposed granite.

All equipment operations for spreading and grading, raking, chemical application, water settling, and any other operations shall be conducted in a manner that uniformly maximizes the wheel compaction of the vehicle over the entire surface.

After placing, spreading and grading, the contractor shall apply water to saturate the decomposed granite sufficient to achieve the optimum moisture content to aid compaction and remove the fine material from the surface.

The contractor shall apply one application of an approved pre-emergent herbicide on all decomposed granite areas following placement of the granite. Water to activate the pre-emergent herbicide shall be applied to the areas of herbicide application in accordance with the manufactures recommendations.

The contractor shall notify the Engineer and obtain prior approval for the use of any herbicides for weed eradication. The contractor shall keep a record of all applications; the type of herbicides

used; the rate and method of application; and the date and location of such applications. A copy of this record shall be submitted to the Engineer after each application.

Erosion which occurs within the decomposed granite areas shall be corrected by the contractor and approved by the Engineer prior to final acceptance.

803-3.03 Rock Mulch. The surfaces upon which the rock mulch is to be placed shall be excavated or filled to the grades and elevations shown on the plans, fine graded and compacted to 85 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer. All deleterious material shall be removed and disposed of by the contractor at no additional expense to the Agency.

The size, gradation, type and/or coloration of the rock mulch shall be as specified on the plans or in the Special Provisions.

The contractor shall provide a sample of the rock mulch to the Engineer for approval prior to hauling any quantity of the material to the site.

The contractor shall stake out or paint the boundary of all areas to receive rock mulch. The Engineer shall approve the boundary prior to placement of the rock mulch.

A pre-emergent herbicide shall be applied to staked areas and watered in accordance with the manufacturer's printed instructions and with the approval of the Engineer.

The rock shall be placed in an even application, tightly packed, to provide complete coverage of the area shown on the project plans so that soil will not be visible between rocks.

After placing and grading the rock mulch, the contractor shall water the mulch with a light spray to remove fine material from the surface to an extent satisfactory to the Engineer. Any regrading that is necessary after placement of the rock mulch shall be at no additional cost to the Agency.

Care shall be taken in the placement of the rock mulch so as not to disturb or damage any plant material, adjacent surfaces or irrigation equipment.

803-4 METHOD OF MEASUREMENT

Decomposed granite will be measured by the square yard (*square meter*) in place as determined by the areas where the decomposed granite is placed to the minimum thickness or by the cubic yard (*cubic meter*) of material in place.

Rock mulch will be measured by the cubic yard (*cubic meter*) of material in place as determined by the areas where the rock mulch is placed to the minimum thickness.

Landscape borrow and plating material will be measured either by the cubic yard (*cubic meter*) or square yard (*square meter*) or by the ton (*metric ton*).

Landscape borrow and plating material measured by the cubic yard (*cubic meter*) will be measured in the hauling vehicle, and the volume will be computed by methods approved by the Engineer.

Landscape borrow and plating material measured by the square yard (*square meter*) will be measured in its final position as determined by the areas where it has been placed.

Landscape borrow and plating material measured by the ton (*metric ton*) will be measured in accordance with the requirements of Subsection 109-1. The weight of the material will be determined by deducting the difference in weight between the average in-place moisture content of the material prior to any prewetting in accordance with the requirements of Subsection 206-3 and the average moisture content of the material at the time of weighing.

803-5 BASIS OF PAYMENT

The accepted quantities of decomposed granite, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) or square yard (*square meter*) for the unit specified in the bidding schedule, complete-in-place.

The accepted quantities of rock mulch, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*), complete-in-place.

The accepted quantities of landscape borrow and plating material measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) or ton (*metric ton*) for the unit specified in the bidding schedule, complete-n-place.

SECTION 804

TOPSOIL

804-1 DESCRIPTION

The work under this section shall consist of furnishing, hauling and placing topsoil in accordance with the details shown on the project plans and the requirements of these specifications.

804-2 MATERIALS

When a source of topsoil is not designated, the contractor shall furnish a source within 50 miles (*80 kilometers*) of the project site and complying with the requirements of Section 1001. Topsoil from sources furnished by the contractor shall conform to the following requirements:

Prior to the delivery of any topsoil to the project site, the contractor shall furnish a written soil analysis prepared by an accredited soil analyst for each source of topsoil proposed for use. The soil analysis shall indicate the pH, total soluble salts, percent calcium carbonate, exchangeable sodium in both percent and parts per million, plasticity index, and size gradation. A minimum of three samples per each 10,000 cubic yards (8,000 cubic meters), with a minimum of three samples per source, shall be tested. All tests shall be performed in accordance with the procedures provided in Table 804-1. The soil analysis shall not be more than one year old.

Topsoil shall be fertile, friable soil obtained from well drained arable land which has or is producing healthy crops, grasses or other vegetation. It shall be free draining, non-toxic and capable of sustaining healthy plant growth.

Topsoil shall be reasonably free of subsoil, refuse, roots, heavy clay, clods, noxious weed seeds, phytotoxic materials, coarse sand, large rocks, sticks, brush, litter, and other deleterious substances.

Certificates of Analysis conforming to the requirements of Subsection 106-5(C) shall be submitted to the Engineer for each source of topsoil proposed for use. The Engineer's approval shall be obtained prior to each delivery of topsoil to be used on the project.

For acceptance purposes, each approximate 20,000 cubic yards (*16,000 cubic meters*) of topsoil material delivered from a given source to the project site shall be considered a lot. For each lot of topsoil, 6 representative samples shall be taken at random locations designated by the Engineer. Topsoil shall be sampled after final placement. Each source of topsoil shall be tested separately. The samples from each lot shall be tested by the Engineer for pH, soluble salts, calcium carbonate,

exchangeable sodium in percentage and parts per million, P.I., and gradation in accordance with the test procedures listed in Table 804-1.

The average test result obtained for each characteristic from each lot shall meet the following requirements.

TABLE 804-1

Characteristics	Test Method	Requirement Average of 6 Samples
PH	ARIZ. 237	6.0 – 8.3
Soluble Salts (PPM)	ARIZ. 237	2000 Max.
Calcium Carbonate (%)	ASTM D 4373	8% Max.
Exchangeable Sodium (%)	ARIZ. 729	5% Max.
Exchangeable Sodium (PPM)	ARIZ. 729	300 Max.
P.I.	AASHTO T 90	5 – 20
Gradation: 2 inch (*50 mm*) 1/2 inch (*12.5 mm*) No. 40 (*425 micrometers*)	ARIZ. 201	% Passing 100 85 – 100 35 – 100

If the average test result for a lot fails to meet all the specifications listed above, the material from that lot shall be rejected. In lieu of removal and replacement, the contractor may propose for the Engineer's consideration a method of treatment of the in-place material to obtain specification compliance. Provided the Engineer approves, the topsoil shall be treated at no additional cost to the Agency. The lot shall then be resampled and tested for specification compliance by the Engineer.

If the pH of the topsoil for a lot exceeds 8.3, the topsoil shall either be removed and replaced, or be treated as provided for in the preceding paragraph. Any treatment for pH shall be sufficient to obtain an average pH between 6.0 and 8.0, inclusive. The treatment for pH shall follow the recommendations of a recognized soil analyst and shall be subject to the approval of the Engineer. Any treatment for pH shall be at no additional cost to the Agency. Additional acceptance testing after treatment for pH will not be required.

804-3 CONSTRUCTION DETAILS

Topsoil shall be spread uniformly on the designated areas to the required depths and contours shown on the plans. When necessary, the area shall be cultivated to a sufficient depth to break up any materials which may have been compacted as a result of the spreading operations.

The finished surface shall be free of all rocks larger than 1 inch (*25 millimeters*) in diameter.

804-4 METHOD OF MEASUREMENT

Topsoil will be measured by the cubic yard (*cubic meter*).

Topsoil will be measured in its final position, and the volume will be computed as the product of the surface area of the topsoil and the nominal depth of the topsoil as specified on the project plans or by other methods approved by the Engineer.

804-5 BASIS OF PAYMENT

The accepted quantities of topsoil, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*), complete-in-place.

SECTION 805

SEEDING

805-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, preparing the soil and applying the seed to all areas designated on the project plans or established by the Engineer. Seeding shall be Class I, Class II, or Class III, and shall be performed where indicated on the project plans and in accordance with the requirements of these specifications.

805-2 MATERIALS

805-2.01 General. Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

805-2.02 Seed. The species, strain or origin of seed shall be as designated herein unless the species, strain or seed origin is otherwise noted on the project plans or in the Special Provisions in which case that seed shall be used.

(A) Seed Mix No. 1: High Growing Mix

Botanical Name	Common Name	PLS/ACRE
Grasses		
Aristida purpurea	Purple Threeawn	3.0
Bouteloua curtipendula "Vaughn"	Sideoats Grama	3.0
Setaria macrostachya	Plains Bristle Grass	2.0
Sporobolus cryptandrus	Sand Drop Seed	1.0
Forbs		
Baileya multiradiata	Desert Marigold	1.5
Cassia covesii	Desert Senna	2.0
Eschscholtzia mexicana	Mexican Poppy	3.0
Helianthus annus	Sunflower	3.0
Linum lewisii	Blue Flax	2.0
Sphaeralcea ambigua	Globe Mallow	2.0
Shrubs		
Altriplex caneseens	Fourwing Saltbush	3.0
Antriplex lentiformus	Quail Brush	2.0
Atriplex polycarpa	Desert Saltbush	2.0
Celtis pallida	Desert Hackberry	2.0
Encelia farinosa	Brittlebush	3.0
Trees		
Acacia constricta	White Thorn Acacia	1.0
Acacia greggii	Cat Claw Acacia	1.5
Cercidium floridum	Blue Palo Verde	1.5
Prospis velutina	Velvet Mesquite	1.0

(B) Seed Mix No. 2: Low Growing Mix

Botanical Name	Common Name	PLS/ACRE
Aristida purpurea	Purple Threeawn	3.0
Atriplex semibacata	Australian Saltbush	1.5
Baileya multiradiata	Desert Marigold	1.5
Bouteloua curtipendula "Vaughn"	Sideoats Grama	3.0
Cassia covesii	Desert Senna	2.0
Dyssodia acerosa	Scrubby Dogweed	1.0
Encelia farinosa	Brittlebush	2.0
Eragrostis intermedia	Plains Lovegrass	2.0
Eriogonum fasciculatum	Shrubby Buckwheat	1.5
Eschscholtzia california	California Poppy	2.0
Eschscholtzia mexicana	Mexican Poppy	2.0
Lupinus sparsiflorus	Desert Lupine	2.0
Linum lewisii	Blue Flax	1.5
Phacelia campanularia	Bluebells	2.0
Sphaeracea ambigua	Globe Mallow	2.0

No substitution of species, strain, or origin of seed will be allowed unless evidence is submitted in writing by the contractor to the Engineer showing that the specified materials are not reasonably available during the contract period. The substitution of species, strains, or origins shall be made only with the written approval of the Engineer, prior to making said substitution.

The seed shall be delivered to the project site in standard, sealed, undamaged containers. Each container shall be labeled in accordance with Arizona Revised Statues and the U.S. Department of Agriculture rules and regulations under the Federal Seed Act. Labels shall indicate the variety of strain of seed, the percentage of germination, purity and weed content, and the date of analysis which shall not be more than 9 months prior to the delivery date.

Legume seed shall be inoculated with appropriate bacteria cultures approved by the Engineer, in accordance with the culture manufacturers' instructions.

Seed that has become moldy, wet, or otherwise damaged, will not be acceptable. Seed shall be called for in pounds of pure, live seed (PLS), where PLS is defined as the product of seed germination (G) and seed Purity (P) all divided by 100.

805-2.03 Mulch.

(A) General. The type and application rate of mulch shall be as specified in the Special Provisions.

(B) Irrigated Areas. The slurry mix of seed, fertilizer, and wood cellulose fiber mulch for irrigated areas shall consist of or meet the following proportions:

Material	Rate
Seed	As noted on list
Fertilizer	300 lbs./acre (*335 kg/ha*)
Wood Fiber Mulch	1,800 lbs./acre (*2,020 kg/ha*)
Tacking Agent	120 lbs. Active ingredient/acre (*135 kg/ha*)
Gro-Power or equal	1,000 lbs./acre (*1,120 kg/ha*)

(C) Unirrigated Areas: The slurry mix and soil amendments for unirrigated areas shall be as follows:

(1) Site Preparation

Gro-Power: 5-3-1 slow
Release fertilizer1,000 lbs./acre (*1,120 kg/ha*)
Ammonium phosphate: 16-20-0200 lbs./acre (*225 kg/ha*)

(2) Slurry Mix

Hydrofiber: Cellulose fiber-mulch,
Silva or equal 800 lbs./acre (*900 kg/ha*)
Tackifier: 80 lbs./active ingredient/acre (*90 kg/ha*)
Starter
Fertilizer: Ammonium Phosphate
16-20-0 100 lbs./acre (*120 kg/ha*)
Seed Mix: as specified

(3) Straw Mulch

Straw: Clean barley or wheat straw 1.5 tons/acre (*3.4 Mg/ha*)
Hydrofiber: 400 lbs./acre (*450 kg/ha*)
Tackifier 150 lbs./active ingredient/acre (*170 kg/ha*)

(D) Wood Cellulose Fibers. Natural wood cellulose fiber shall have the property of dispersing readily in water and shall have no toxic effect when combined with seed or other materials. A colored dye which is noninjurious to plant growth may be used.

The wood cellulose fibers shall be manufactured such that:

After addition and agitation in slurry tanks containing fertilizers, seed, water, and other approved additives the fibers in the material will become uniformly suspended to form a homogeneous mixture.

When hydraulically sprayed on the ground the material will form a blotterlike cover which is uniformly impregnated with seed.

The cover will allow the absorption of moisture and allow rainfall or applied water to percolate to the underlying soil.

(E) Straw. Straw shall be from oats, wheat, rye or other grain crops of current season as approved by the Engineer and shall be free from noxious weeds, molds or other objectionable material.

Straw mulch shall be from the current season's crop and in an air-dry condition suitable for placing with mulch blower equipment.

805-2.04 Water. Water shall be free of oil, acid, salts or other substances harmful to plants. The source shall be approved by the Engineer prior to use.

805-2.05 Tacking Agent. Unless the tacking agent is specified in the Special Provisions, the contractor shall submit the type and specifications of the tacking agent to the Engineer for approval. An approved tacking agent will have strong adhesive characteristics as well as imparting lubrication to the mixture to allow for the uniform dispersion of the hydroseed slurry. The tacking agent shall also have gelling properties to inhibit the tendency of water and fiber to move downhill as they are sprayed on steep slopes. The stabilizer should be soluble and readily disperse in water without the formation of gel balls or other coagulation or sedimentation. The tacking agent shall contain a plantago organic mucilard base with the active ingredient comprising 70% to 80% of the agent. The properties of the tacking agent shall not be adversely affected by the addition of fertilizers or other additives to the slurry mix.

805-2.06 Chemical Fertilizer. Chemical fertilizer shall be a commercially produced, pelleted, granular form derived from inorganic sources. Chemical fertilizer shall be furnished in standard containers with the name, weight, and analysis of the contents clearly marked. Chemical fertilizer shall be State inspected to meet 16-20-0 percentages where the first number represents the minimum percent of soluble nitrogen, the second number represents the minimum percent of available phosphoric acid, and the third number represents the minimum percent of water soluble potash.

805-2.07 Soil Conditioner. Soil conditioner (Gro-Power or equal) shall be derived from organic materials such as decomposed animal, vegetable, and mineral matter; shall be composted, relatively dry, friable, and pass a 1 inch (*25 millimeters*) sieve; shall not contain poultry, animal or human waste, pathogenic viruses, fly larvae, insecticides, herbicides, fungicides, or poisonous chemicals that would inhibit plant growth, and shall have the following guaranteed chemical analysis:

Ingredient	Percentages (Minimum)
Nitrogen	5
Phosphoric Acid	3
Water Soluble Potash	1
Humus	50
Humic Acids	15
Soluble Metallic Iron	1

805-3 CONSTRUCTION DETAILS

805-3.01 General. Seed shall be of the class and variety specified, and shall be applied at the rate specified in the Special Provisions.

The contractor shall notify the Engineer at least 2 days prior to commencing seeding operations.

Seeding operations shall not be performed when wind would prevent uniform application of materials or would carry seeding materials into areas not designated to be seeded.

Preparation of the areas for seeding shall be as specified herein and in the Special Provisions.

Equipment and methods of distributing seeding materials shall be such as to provide an even and uniform application of the seed, mulch and/or other materials in accordance with the specified rates.

Unless specified otherwise in the Special Provisions, seeding operations shall not be performed on undisturbed soil outside the clearing and grubbing limits of the project or on steep rock cuts.

805-3.02 Classes of Seeding.

(A) Seeding (Class I). Seeding (Class I) shall consist of furnishing and planting lawn seed.

Immediately before seeding, the surface area shall be raked or otherwise loosened to obtain a smooth friable surface free of earth clods, humps and depressions. Loose stones having a dimension greater than 1/2 inch (*13 millimeter*) and debris brought to the surface during cultivation shall be removed and disposed of by the contractor in a manner approved by the Engineer.

Where indicated on the project plans or specified in the special provisions, topsoil shall be placed and allowed to settle for at least 1 week prior to seeding. The topsoil shall be thoroughly watered at least twice during the settlement period.

Seed shall be uniformly applied in 2 directions at right angles to each other with one-half the specified application rate applied in each direction.

Immediately after seeding, the area shall be uniformly covered with screened manure at the rate of 1 cubic yard per 1,000 square feet (*0.8 cubic meter per 100 square meters*) and then watered until the ground is wet to a minimum depth of 2 inches (*50 millimeters*).

Seeding areas flooded or eroded as a result of irrigation shall be repaired, reseeded and refertilized by the contractor at his expense.

(B) Seeding (Class II). Seeding (Class II) shall consist of furnishing and planting range grass seed, flower seed and/or shrub seed, and includes mulching.

Where equipment can operate, the area to be seeded shall be prepared by disking, harrowing or by other approved methods of loosening the surface soil to an average depth of 6 inches (*150 millimeters*). On slopes too steep for equipment to operate, the area shall be prepared by hand raking to the specified depth. On sloping areas, all disking, harrowing and raking shall be directional along the contours of the areas involved. Loose stones having a dimension greater than 4 inches (*100 millimeters*) brought to the surface during cultivation shall be removed and disposed of in a satisfactory manner prior to grading and seeding. All areas which are eroded shall be restored to the specified condition, grade and slope as directed prior to seeding.

On cut and fill slopes the operations shall be conducted in such a manner as to form minor ridges thereon to assist in retarding erosion and favor germination of the seed.

The contractor shall submit a batch (tank) mix for the Engineer's approval prior to mixing any seed/mulch slurry. Batch mixing and coverage will be monitored throughout seeding operations.

Care shall be taken during the seeding operations to prevent damage to existing trees and shrubs in the seeding area in accordance with the requirements of Subsection 107-12. Seed shall be drilled, broadcast or otherwise planted in the manner and at the rate specified in the Special Provisions.

The type of mulch, and the manner and rate of application shall be as specified in the Special Provisions.

Mulch material which is placed upon trees and shrubs, roadways, structures and upon any areas where mulching is not specified or is placed in excessive depths on mulching areas shall be removed as directed. Mulch materials which are deposited in a matted condition shall be loosened and spread uniformly over the mulching areas to the specified depth.

During seeding and mulching operations, care shall be exercised to prevent drift and displacement of materials. Any unevenness in materials shall be immediately corrected by the contractor.

Mulch shall be immediately affixed by crimping and tacking after application. The Engineer shall determine which areas are not conductive to anchoring by crimping and will direct the contractor to anchor such mulch by tacking only. No mulch shall be applied to seeding areas which cannot be crimped and/or tacked by the end of each day. Any drifting or displacement of mulch before crimping and/or tacking shall be corrected by the contractor, at no additional cost to the Agency.

If a tacking agent is specified in order to bind the straw and mulch in place, the type, rate and manner of application shall be as specified in the Special Provisions. Prior to the application of a tacking agent, protective covering shall be placed on all structures and objects where stains would be objectionable. All necessary means shall also be taken to protect the traveling public and vehicles from damage due to drifting spray.

Unless otherwise specified in the special provisions, Class II seeding areas shall not be watered after planting.

(C) Seeding (Class III). Seeding (Class III) shall consist of furnishing and planting range grass seed, flower seed and/or shrub seed, all without mulching.

Seeding (Class III) shall conform to the requirements specified under Subsection 805-3.02 (B), except that mulching will not be required.

Unless specified in the special provisions, Class III seeded areas shall not be watered after planting.

805-3.03 Hydroseeding. Hydroseeding (hydraulic seeding), using 1500 pounds per acre (*680 kilograms per hectare*) of wood cellulose fiber, shall be an acceptable alternate for planting and mulching Seeding (Class I, II or III).

All machines used for hydroseeding shall be an approved type capable of continuous agitation of the slurry mixture during the seeding operation. Pump pressure shall be such as to maintain a continuous nonfluctuating spray capable of reaching the extremities of the seeding area with the pump unit located on the roadbed. The sprayer shall be equipped to use the proper type of nozzles to obtain a uniform application on the various slopes and at the distance to be covered.

The seed, fertilizer, mulch, tacking agent (when required) and water shall be combined in the proportions of the various materials as provided in the special provisions and allowed to mix a minimum of 5 minutes prior to starting the application of the slurry. Seed shall be applied within 30 minutes after mixing with water.

Hydroseeding deposited on adjacent trees and shrubs, roadways, in drain ditches, on structures and upon any areas where seeding is not specified or is placed in excessive depths on seeding areas shall be removed.

805-3.04 Preservation of Seeded Areas. The contractor shall protect seeded areas from damage by traffic or construction equipment. Surfaces eroded or otherwise damaged following seeding and prior to final acceptance shall be repaired by regrading, reseeding and remulching as directed by the Engineer.

805-4 METHOD OF MEASUREMENT

Seeding (Class I), Seeding (Class II) and Seeding (Class III), will be measured either by the square yard (*square meter*) of ground surface to the nearest 100 square yards (*100 square meters*) seeded or by the acre (*hectare*) to the nearest 0.1 acre (*0.1 hectare*).

805-5 BASIS OF PAYMENT

The accepted quantities of seeding, measured as provided above, will be paid for at the contract price for the pay unit specified in the bidding schedule, complete-in-place.

No direct measurement or payment will be made for the preservation of seeded areas.

SECTION 806

TREES, SHRUBS AND PLANTS

806-1 DESCRIPTION

The work under this section shall consist of furnishing and planting trees, palms, shrubs, vines, cacti, and other plants (nursery stock) and transplanting trees, palms, shrubs, vines, cacti, and other plants (collected stock and/or local stock), all as designated on the project plans. The work shall also include the layout and preparation of planting pits, trenches and beds, including excavating and backfilling; the storage and protection of all planted and unplanted stock and other materials; amendments, all mulching, fertilizing, watering, staking, guying, pruning and wrapping; the cleanup of the area, application of pre-emergent herbicide; removal of grass, weeds and undesirable vegetation; application of rodent repellent or barriers; disposal of unwanted and deleterious materials; and care and maintenance all in accordance with the details shown on the project plans and the requirements of these specifications.

806-2 MATERIALS

806-2.01 General. Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted to the Engineer for all contractor furnished materials, unless otherwise specified.

806-2.02 Nursery Stock. All plants shall be grown in a nursery and shall conform to the applicable requirements as specified in the current edition of "American Standard for Nursery Stock" as approved by the American National Standards Institute, Inc., and sponsored by the American Association of Nurserymen, Inc., subject to certain variations in size and measurement when specified on the project plans or in the Special Provisions.

Botanical plant names shall be in accordance with the current edition of "Standardized Plant Names" prepared by the American Joint Committee on Horticultural Nomenclature.

All plants shall be true to type and species shown on the project plans and at least one plant in each group of plants of the same species delivered to the project shall be tagged with a weatherproof label stating both the botanical and common name of the plants in that group.

Within thirty working days after the pre-construction conference, the contractor shall supply the Engineer with written verification that all the plant material necessary to complete the work as specified has been located and reserved. This verification will serve as proof of availability for all plant material required.

All plants shall be in healthy condition with normal symmetrical form, well-developed foliage, branches and cane systems at the time of delivery to the project. Plants shall be free from disease, insect eggs or infestations, disfiguring knots, bark abrasions, broken tops, branches or canes, damaged roots, sun,

wind or frost injury, or other objectionable features. Plants pruned from larger sizes to meet specified sizes will not be accepted.

Plants which are furnished in containers shall have been growing in the containers for a sufficient period of time for uniform root development throughout the plants' ball, but the roots shall show no evidence of having been restricted or deformed.

The presence of grass, weeds, or any undesirable organism in the soil surrounding the plants, or any of the before mentioned conditions, may be cause for rejection of the plants.

No substitution of species and/or sizes of specified plants shall be made unless evidence is submitted in writing to the Engineer that plants in the species, quantity and/or sizes specified are not available during the contract period. The substitution of species and/or sizes shall be made only with the written approval of the Engineer prior to making said substitution.

Substitution of a larger size of the same species may be made by the contractor without written approval. However, the contractor shall be responsible for any additional cost of the plants or for any additional planting costs.

All plants shall comply with Federal and State laws requiring inspection for diseases and infestations.

All shipments or deliveries of plant material grown out of state will be inspected at the nursery or growing site by the authorized State of Arizona authorities prior to delivery to the project. A copy of the state inspection record shall accompany all plant material grown out of state showing the plant material has been inspected for plant diseases and insects.

All rejected plants shall be removed from the project immediately upon rejection by the Engineer.

806-2.03 Collected Stock. Collected stock shall be secured from sources outside the project limits for transplanting, and shall comply with the size, type and species requirements designated on the project plans or in the Special Provisions. When sources for collected stock are not designated, the contractor shall furnish the source.

Collected stock shall be healthy, free from weeds, grasses, insects, disease, defects and disfigurements, and shall be approved by the Engineer before transplanting operations are begun. Palm trees shall be free of scars and damage considered unsightly or unhealthy as determined by the Engineer.

The contractor shall comply with all State and Federal laws regarding the removal, sale, and transplanting of native plants.

806-2.04 Local Stock. Local stock shall be secured from within the project limits for transplanting and will be designated on the project plans, the Special Provisions or by the Engineer. All plants shall be approved by the Engineer before transplanting operations are begun.

806-2.05 Prepared Topsoil. Prepared topsoil shall consist of prepared soil mixed as specified under Subsection 806-2.06 Prepared Soil, except the existing soil shall be replaced with topsoil. The existing soil excavated from the planting pits shall be removed and disposed of by the contractor. Soil conditioner shall be as specified under Subsection 806-2.06.

Topsoil shall conform to the requirements of Subsection 804-2. Soil excavated from existing planting pits, trenches, and beds which meets the requirements of Subsection 804-2 may be used as topsoil.

806-2.06 Prepared Soil. Prepared soil material for backfill at tree pits, plant pits, planting trenches and bedding shall consist of a uniform mixture by volume, loose measure, of the following components per cubic yard (*cubic meter*): 18 cubic feet (*0.5 cubic meters*) of existing soil, 9 cubic feet (*0.25 cubic meters*) of mulch, 3 pounds (*1.4 kilograms*) sulphur. Prepared soil shall be blended on-site prior to deposition.

Prepared soil shall be produced, prior to use in the planting pits, by combining the approved component materials into a homogeneous mixture. The Engineer shall be notified prior to the production of the prepared soil.

Backfilling mix for ocotillo and other cacti shall be a ratio of 1 part mulch to 3 parts clean site soil free of stones and lumps.

Should any unforeseen or unsuitable planting conditions arise, they shall be called to the attention of the Engineer. Backfill shall be well worked about the roots and settled by watering and tamping and shall provide the required depth as shown for watering basins. Root hormone, B-1 or Superthrive, shall be added in accordance with the recommendations immediately upon completion of backfilling.

Soil sulphur shall be granular or prilled agricultural grade, containing 99.5 percent sulphur and 0.5 percent inert ingredients ("Dispersion" or approved equal).

806-2.07 Mulch. Mulch shall consist of composted, ground, or shredded fir or Ponderosa pine bark shavings with at least 85 percent able to pass through a 1/4 inch (*6.3 millimeter*) screen. The pH shall not exceed 7.5. The mulch shall be hygroscopic or contain a wetting agent, and shall be nitrogen stabilized with a .5 percent nitrogen content.

806-2.08 Water. Water shall conform to the requirements of Subsection 805-2.04.

806-2.09 Chemical Fertilizer. Fertilizer for trees, shrubs, etc., shall be a slow release commercial fertilizer in a packet or tablet form such as "Agriform" 21 gram, 20-10-5 plant tablets or equal and of recent manufacture.

806-2.10 Lumber and Tree-Stakes. Tree-stakes and braces shall be sound, straight construction grade treated Douglas fir, lodge pole pine or of other species approved by the Engineer. Douglas fir stakes and braces shall have nominal dimensions of 2 inches by 2 inches and lodge pole pine stakes shall have a diameter of 2 inches (*50 millimeter*) or greater. Tree-stakes and braces may be furnished either rough or dressed. Stakes shall be a minimum of 8 feet (*2.4 meters*) in length and shall be of a "Wolmanized" type, chamfered at one end, or approved equal.

Lumber stored at the project site shall be neatly stacked on skids a minimum of 12 inches (*300 millimeters*) above the ground and shall be protected from the elements to prevent damage or warping.

806-2.11 Hardware. Nails, lag screws, staples, and other hardware shall be of galvanized commercial quality. All bolts and lag screws shall be furnished with galvanized malleable washers.

Wire shall be new 12 gauge soft annealed galvanized steel wire. Covers for guying wires shall be new, 3/4 inch (*19 millimeters*) minimum diameter vinyl or two-ply fabric-bearing rubber hose.

806-2.12 Existing Plant Material. The contractor shall be responsible for maintaining all existing plants and providing adequate water supply to any existing plants affected by construction activities. Existing plants that are removed, damaged or destroyed during construction shall be replaced with trees and shrubs of the same species at the contractor's expense. Large existing plants removed will require large size replacements as directed by the Engineer.

806-3 CONSTRUCTION DETAILS

806-3.01 Planting Season. All planting shall be done during the time specified in the Special Provisions.

806-3.02 Excavation. The contractor shall be responsible for laying out all planting areas and staking all plant locations in reasonably close conformity to the dimensions and locations shown on the project plans. The Engineer shall approve all planting areas and locations prior to any excavating of planting pits, trenches or beds.

In the event that existing field conditions such as subsurface utilities, pipes, structures, impervious materials or inadequate drainage necessitate relocation of planting areas, the Engineer will designate new locations. Adequate drainage for planting pits shall be based on a minimum percolation rate for the pit of 6 inches (*150 millimeters*) per hour.

Prior to excavating planting pits, planting trenches or beds for plants, these areas shall be graded as designated on the project plans, or as approved by the Engineer.

Planting pits and trenches shall be excavated to the dimensions indicated on the project plans or in the Special Provisions and shall have vertical sides and horizontal bottoms. When dimensions are not specified, the pits and trenches shall be excavated to a depth equivalent to the depth of the root ball and to a width five times the root ball diameter.

When excavated material does not meet the requirements for topsoil as specified in Subsection 804-2, it shall be disposed of in a manner approved by the Engineer.

When excavation of any planting pit is difficult and the Engineer determines that poor drainage may result, the pit shall be filled with water twice in order to check the drainage. Any pit which has not fully drained after each filling within a twelve hour period shall be deepened until proper drainage is achieved. If proper drainage cannot be achieved, the pit shall be moved or deleted, as determined by the Engineer. If required, this work shall be paid for in accordance with Subsection 104-2.

Excavation of planting pits, trenches and beds shall not be done when, in the opinion of the Engineer, the moisture content of the soil is excessive with respect to accepted horticultural practice.

806-3.03 Shipping and Handling Plants. Prior to shipping, all plants shall be dug, handled, prepared and packed for shipment with care and skill, in accordance with recognized standard practice for the kind of plant involved. The root systems of all plants shall not be permitted to dry out at any time. Plants shall be protected at all times against freezing temperatures, the sun and the wind while in transit. During transportation in closed vehicles, plants shall receive adequate ventilation to prevent "sweating". Plants delivered in a wilted condition will be rejected.

The contractor shall notify the Engineer at least 24 hours prior to the date of arrival of plants from a single Arizona plant source at the project site. The Engineer will inspect all plants for conformity with the specifications, and upon his acceptance, planting may begin. The Engineer may select at random no more than 3 container-grown plants of each species in every delivery to the site for root development inspection. Plants of the same species from different growers shall be considered as separate shipments. If upon inspection of root development of plants so selected the Engineer determines the roots have become restricted or deformed in their containers, all plants of that species in that shipment, including the inspected plants, will be rejected and shall be removed from the site. The contractor's project supervisor shall be at all plant inspections.

Plants shall be furnished in containers, or as specified in the Special Provisions or on the project plans.

Plants delivered, inspected, and found acceptable for planting shall normally be planted within 24 hours after delivery to the project site. Plants which cannot be planted within 24 hours after delivery shall be stored as specified herein.

All temporarily stored plants shall be protected from extreme weather conditions and roots shall be kept moist.

806-3.04 Planting.

(A) General. On landscaping projects with irrigation systems, no planting shall be done until installation and acceptance of the irrigation system in total or in increments. The initial watering and all subsequent watering of the planting(s) shall be done using the newly constructed irrigation system. The plant material may require temporary irrigation systems acceptable to the Engineer for the initial watering of large plant material which are in addition to the designed irrigation system.

(B) Nursery Stock. Planting shall not be done in soil that is excessively moist or otherwise in a condition not satisfactory for planting in accordance with accepted horticultural practice.

Plants in containers, bear root, balled and burlapped shall be planted and watered the same day the container, wrap or moisture protection is cut.

The contractor shall adequately water plants to maintain a healthy and vigorous growing condition during the planting period.

Plants shall be removed from containers in such a manner that the root ball is not broken. Plants with broken root balls or with root balls that fall apart while being planted shall be rejected.

Plants shall be planted plumb and shall be centered in the planting pit or trench. All planting pits shall have slanted sides and flat bottoms.

Backfill material shall be prepared soil conforming to the requirements of Subsection 806-2.06 or as otherwise noted in the Special Provisions and shall be carefully firmed around the root ball of the plant so as to eliminate all air pockets. Backfill shall not be compacted around the roots or ball of the plants during or after planting operations.

Clods or stones exceeding 2 inches (*50 millimeters*) in diameter and foreign matter deemed objectionable by the Engineer will not be allowed. All excess soil that has objectionable stones shall be disposed of off the project site in a manner acceptable to the Engineer. No additional payment will be made for the removal and disposal of objectionable stone, or soil containing foreign matter.

Any excess soil which is not used in the backfill of the planting pits may be evenly distributed in the landscape areas if it will not interfere with the final grading of these areas.

All planting areas shall be graded as specified to facilitate proper watering of all material, and leave a generally smooth appearance after completion of planting.

Plants shall be set to such depth that, after backfilling and watering, the top of the root ball and the level of the backfill will be at the surrounding grade as shown on the project plans. Any plant that settles more than 1-1/2 inches (*40 millimeters*) below the specified grade shall be reset or replaced. Any additional backfill material required shall be as specified in the Special Provisions and on the project plans.

Immediately after planting, all plants shall be thoroughly irrigated until the backfill soil around and below the root ball of each plant is saturated.

(C) Collected Stock and Local Stock. If slings or cables are used to support stock during transporting and planting, the trunk shall be protected at the points of contact with the slings or cables by the use of burlap, canvas, sections of automobile tire casing, or other suitable protective material.

Cables shall be so placed as to maintain proper support and balance at all times.

A tree spade is an acceptable method for digging and moving the stock.

Dead fronds, certain live fronds, and flower stalks and seed pods shall be removed on palm trees leaving a minimum crown of 6 to 8 tiers of live fronds on each tree. Crown fronds shall be pulled together and loosely, but securely, tied in an upward position to protect the heart of the tree. The material shall be light manila rope or multiple strands of binder twine. Frond ties shall remain in place a minimum of 60 days after planting.

The contractor shall be responsible for preventing damage or death of the stock being moved both during the moving operation and after the planting operation is completed. Should sufficient damage occur to stock, the contractor shall replace the stock with the same species of equal size.

After planting, the contractor shall maintain all collected stock and local stock in established positions during construction and landscaping establishment periods.

The contractor shall ensure that palms have been chemically sprayed with an approved preventative treatment to inhibit development of bud rot during the planting operation and during periods of high humidity and warm temperatures. The treatment shall be applied to allow deep penetration into the palm tree hearts.

Care shall be taken such that no palm tree is dropped or mishandled during the planting operations. Bending the palm tree trunk or causing uneven contact of the tree trunk with another surface may damage the palm tree heart and eventually kill the tree.

806-3.05 Pruning and Staking. All plants shall be pruned at the direction of the Engineer and in accordance with accepted horticultural practices. Pruning shall consist of removing all dead and damaged twigs and branches in order to form each type of plant to the standard shape for its species. All pruning cuts 3/4 inch (*19 millimeters*) and over in diameter shall be treated with an approved tree wound dressing.

Trees shall be supported in the manner detailed on the project plans or as specified in the Special Provisions.

Tree-stakes shall be driven vertically, unless otherwise indicated on the plans, at least 6 inches (*150 millimeters*) in firm, undisturbed ground at the bottom of the planting pit or trench. Stakes shall be positioned so as to clear the root system without disturbing the integrity of the roots.

Guying shall be as detailed on the project plans or as directed by the Engineer. The ends of all tree ties and guy wires shall be securely stapled to the stakes, braces or supports to prevent them from becoming a hazard.

Tree ties and guy wires shall be periodically inspected and adjusted as necessary to prevent "girdling" or injury to tree trunks or branches.

Trees shall be secured to the stakes with tree ties after backfilling and prior to irrigating in the manner detailed on the project plans or as specified in the special provisions.

All wire ties used on plant staking shall be stapled to stakes in a manner acceptable to the Engineer. Rubber hoses on tree ties shall be a minimum of 1 foot (*300 millimeters*) in length at each wire loop. All tie wire exposed to tree trunks shall be covered with hose or other material approved by the Engineer.

806-3.06 Care and Protection of Trees, Shrubs and Plants. Prior to the beginning of work under Section 807 - Landscaping Establishment; the contractor shall be responsible for maintaining and protecting all planting areas, as specified in Subsection 807-3.02, including the care and protection of trees, shrubs, and plants planted under this Section. Such care and protection shall include, but not be limited to, the watering of stock, removal of construction trash and debris, eradicating and removing weeds and undesirable vegetation as specified in the Special Provisions, repairing, adjusting, or replacing stakes and guying, repairing weather damage or damage caused by the public, furnishing and applying sprays, dust, and/or cages to combat vandalism, disease, insects, rodents and pests and taking such precautions as

necessary to prevent damage from cold, frost, sunburn or other hazards. All undesirable grasses and weeds shall be eradicated with herbicides or manual methods during Phase I, and disposed of by the contractor in accordance with Subsection 807-3.02.

The contractor shall remove and replace, at no additional cost to the Agency, all dead plants and all plants that show signs of failure to grow or which are so injured or damaged as to render them unsuitable for the purpose intended, as determined by the Engineer. The Agency shall replace plants injured or damaged by frost when such injury or damage was caused despite the contractor's efforts to protect the plants. The contractor may, with the approval of the Engineer, delay replacement of plants killed by frost until such time that frost is not imminent.

Plants shall be staked in accordance with Subsection 806-3.05 and as detailed on the project plans.

Any person or persons applying pesticides will be considered as doing so for hire and shall be required to be licensed in accordance with the requirements of Title 3, Chapter 2, Arizona Revised Statutes, Article 6, Section 3-377.

The contractor shall notify the Engineer and obtain prior approval of the use of any chemicals for weed eradication or control. The types of herbicide to be used and the methods of application shall be in conformity with the Environmental Protection Agency requirements, labeling instructions, and shall be approved by the Engineer. The contractor shall keep a record of all applications, the type of herbicide used such as pre- or post-emergent, the rate and method of application and the date and location of such applications on forms acceptable to the Engineer. A copy of this record shall be submitted to the Engineer after each application.

Pre-emergent herbicides or manual weed control shall be used on noxious weeds in planting areas located within the project limits; but noxious weed control within granite mulch, decomposed granite, or rock mulch shall be as specified under those items of work. All areas shall be kept free of noxious weeds. All planting areas within the project limits shall receive an approved pre-emergent herbicide, as specified under Subsection 803-3.02. The application of herbicide shall include all areas not covered under other items of the specifications.

The contractor shall pay special attention to the infestation of nut and bermuda grasses. Either of these items found in the planting pits of that material shall be grounds for immediate removal, disposal, and replacement of that item. The planting pit shall be excavated and inspected to assure complete eradication of any roots or rhizomes which may have grown into the area. All this work and material shall be the responsibility of the contractor, at no additional cost to the Agency.

806-4 METHOD OF MEASUREMENT

Planting trees, shrubs and plants, and transplanting trees, shrubs and plants will be measured on a lump sum basis, except that when the bidding schedule~~s~~ sets forth specific items under this section on a unit basis, measurement will be made by the unit for each item designated in the bidding schedule.

806-5 BASIS OF PAYMENT

The accepted quantities of trees, shrubs and plants, measured as provided above, will be paid for at the contract lump sum price or contract unit price each for the pay unit designated in the bidding schedule, complete-in-place.

No measurement or direct payment will be made for plants selected for inspection and not planted or for the care and protection of trees, shrubs and plants prior to the beginning of the Landscaping Establishment period, the costs being considered as included in the prices paid for plants accepted and paid for under the various contract bid items.

SECTION 807

LANDSCAPING ESTABLISHMENT

807-1 DESCRIPTION

The work under this section shall consist of the care of all planted stock in accordance with accepted horticultural practices; keeping all horticultural and related areas free of weeds, grasses and construction related debris; replacing dead, dying or diseased plant material, applying all irrigation water; repairing, adjusting or replacing stakes and guys; furnishing and applying sprays and dust to combat disease, insects and other pests; pruning as required by the Engineer; and the testing, adjusting, repairing and operating of the irrigation system; as shown on the project plans and in accordance with the requirements of these specifications and the Special Provisions.

807-2 MATERIALS

Materials necessary for the establishment of the seeding and planted stock, and the operations of the irrigation system(s) shall be furnished by the contractor and shall conform to the requirements of these specifications and the Special Provisions. The contractor shall notify the Engineer and obtain prior approval for the use of any chemicals for weed control or eradication.

Office, equipment and storage areas, and irrigation water during the landscape establishment period will be the contractor's responsibility with no separate payment being made under the Contract.

All electrical power and water used in conjunction with temporary and/or permanent irrigation or lighting will be obtained and supplied by the contractor during landscaping establishment. Electrical power used for electrical equipment and tools, and/or for the contractor's temporary offices shall also be paid for by the contractor.

807-3 CONSTRUCTION DETAILS

807-3.01 General. The time period for landscaping establishment shall be the number of calendar days specified in the Special Provisions. The time period shall begin after written notice from the Engineer of substantial completion of the landscape portion of the project and when the Engineer is assured that the work can be performed in a continuous and consistent manner without restricting the use of any facilities by the traveling public.

The contractor shall submit a work schedule of operations for approval by the Engineer each month with the dates of work to be completed. Such work shall include: replanting, weed control program, pruning, staking and guying, furnishing and applying sprays and dust to combat diseases and insects, irrigation repairs, clearing debris, sweeping or raking landscape areas or other work required by the Engineer.

Each calendar day, during which the Engineer determines that no work under landscaping establishment is required, and the contractor is so advised, regardless of whether or not the contractor performs landscaping establishment work, will serve to reduce the total number of calendar days specified.

Each calendar day, during which the Engineer determines that work under landscaping establishment is required, and the contractor is so advised, and the contractor fails to accomplish the required work, will not serve to reduce the total number of calendar days specified.

Thirty calendar days after the beginning of the landscaping establishment period and at the end of every 30 calendar days the Engineer, accompanied by the contractor, will inspect all landscaping items, planted stock and the irrigation system. The Engineer will notify the contractor at least 1 week in advance of the date for each inspection. The final inspection will be made approximately 7 calendar days from the expected termination of the landscaping establishment period.

A special inspection will be required at anytime during the landscaping establishment period when, in the opinion of the Engineer, conditions justify such action.

The contractor will be required to keep the planted areas cleared of trash and debris.

The contractor's responsibility for landscaping establishment shall conform to the requirements of Subsection 107-19.

All erosion within landscaped areas, seeded or turf areas, decomposed granite areas and/or rock mulch areas shall be immediately repaired by the contractor to maintain the final grade in reasonably close conformity with the lines and grades as shown on the project plans or as established by the Engineer. The erosion repair work shall be completed before the next monthly inspection at the contractor's expense. Consideration shall be made by the Engineer of erosion caused by an unusually heavy rainfall event.

807-3.02 Planted Stock and Seeding Establishment. All dead or unhealthy plant stock shall be removed and replaced, as directed, at the contractor's expense, within 7 days from the date of the inspection and the contractor shall notify the Engineer in writing when the replacement work has been performed. Stock furnished for replacement shall be of the same size and species as originally specified. Unhealthy plant material may be corrected by the use of chemical and fertilizer applications where and when approved by the Engineer.

After the final inspection, and removal of all dead or unhealthy stock and, if directed, its replacement, and the termination of the landscaping establishment period, the contractor will then no longer be responsible for the replacement of plant stock.

In case of certain plant stock found to be dead or unhealthy at the inspections specified above, the contractor may be ordered to remove certain dead or unhealthy plant stock and may be ordered not to replace such plant stock when nonreplacement would not adversely effect the planting design. The initial furnishing and planting, and the subsequent removal of such plant stock ordered removed and not replaced shall be at no additional cost to the Agency.

Seeded areas, exclusive of lawn areas, receiving irrigation shall yield an average of 5 healthy germinated plants per square foot (*0.1 square meter*) within 90 days of seeding.

All unpaved areas within the right-of-way shall be kept cleared of weeds and other undesirable vegetation unless otherwise specified in the Special Provisions.

The control of weeds shall be accomplished either by the use of herbicides or by manual means. The types of herbicides to be used and the methods of application shall be in conformity with the Environmental Protection Agency requirements, labeling instructions, and shall be approved by the Engineer. The contractor shall keep a record of all applications; the type of herbicides used, such as pre- or post-emergent; the rate and method of applications; and the date and location of such applications. A copy of this record shall be submitted to the Engineer every month.

Any person or persons applying pesticides will be considered as doing so for hire and shall be required to be licensed in accordance with the requirements of Title 3, Chapter 2, Arizona Revised Statutes, Article 6, Section 3-377.

Seeded areas receiving irrigation shall be maintained by fertilizing, weeding, trimming, and such other operations as rolling, regrading, and replanting, as required to provide an acceptably graded area free from erosion damage or other bare areas.

Seeded areas shall not be overwatered to induce rapid growth.

Lawn areas shall be mowed, weeded, edged and trimmed at the time and in accordance with standard horticultural procedures. The first mowing shall not be attempted until the stolons are firmly rooted and can withstand a brief period of drying. Mowing equipment shall be well maintained with sharp blades set at a mowing height of 2 inches (*50 millimeters*). Watering and fertilizing of lawns shall be done at intervals as necessary to maintain a uniform, healthy, desirable green color and sturdy growth.

The contractor shall water and maintain the seeded area to provide a uniform and satisfactory stand of grass. To be acceptable, lawns shall have a good, uniform color and sturdy growth. At least 98 percent of the area designated to be planted shall have an acceptable lawn.

807-3.03 Irrigation System Establishment. Once completed, an initial inspection of the irrigation system will be conducted by the contractor and the Engineer. This inspection shall determine the systems acceptability as well as the need for component modification or replacement.

A final inspection of all system components will be conducted after all required modifications or replacements have been satisfactorily completed.

The irrigation system shall be tested, adjusted, repaired, and operated in the manner in which it was designed to function. Components such as backflow prevention units and pressure reducing valves as well as all other appurtenances shall function properly in accordance with the requirements of the design and the special provisions, together with the recommendations of the manufacturer. No change in the system as it was accepted under the contract shall be made without written approval of the Engineer.

Precautions shall be taken to avoid soil erosion by the irrigation system. Soil eroded by the irrigation system shall be replaced with soil meeting the requirements specified in the plans or specifications, regraded and reseeded as per plans and specifications.

The entire irrigation system shall be maintained by the contractor to insure balanced and necessary watering. This shall include but not be limited to the following:

(1) Removal of sand and debris causing restriction within sprinkler, bubbler, and emitter discharge orifices.

(2) Necessary timing adjustments to the automatic electric controllers.

(3) Repairing and/or replacing any broken or malfunctioning component of the system.

During landscaping establishment, emission points of emitters shall be repositioned as directed by the Engineer. Additional tubes shall be installed where necessary, as determined by the Engineer. Staking of the additional tubes shall be in accordance with the details shown on the project plans.

The irrigation system shall be tested within one week prior to each scheduled inspection. Testing of the various components shall be as specified in the special provisions or as directed by the Engineer. The contractor shall keep a record of the results of all testing and shall submit a copy of these results to the Engineer upon completion of each test.

The irrigation system establishment period shall run concurrently with the landscape establishment time period and shall commence once the contractor has complied with the following requirements:

(1) The automatic control system must be fully functioning.

(2) Each emitter must be performing to specification.

(3) The pressure regulator must be properly adjusted.

(4) The filter elements must be clean.

(5) The emitters shall be at the grades and locations indicated on the plans.

(6) The sprinkler heads shall be properly adjusted.

807-4 METHOD OF MEASUREMENT

Landscaping establishment will be measured as a single lump sum unit of work.

807-5 BASIS OF PAYMENT

Landscaping establishment, measured as provided above, will be paid for at the contract lump sum price specified in the bidding schedule.

Partial payments may be made for landscaping establishment. Payment will be based upon the length of the landscaping establishment period, as specified in the special provisions, and the contract lump sum price for the item. Partial payment will be made only when the following work is completed prior to submittal of the monthly estimate:

(1) The Engineer's list of necessary work from the prior inspection.

(2) The contractor's list of proposed operations from their monthly work schedule.

The contractor shall furnish water used for landscaping establishment. The cost of the water and its application shall be considered as included in the lump sum price bid for this item.

Payment for work not covered by the Specifications or noted on the project plans or in the Special Provisions will be made in accordance with the requirements of Subsection 104-2.

SECTION 808

LANDSCAPE IRRIGATION SYSTEM

808-1 DESCRIPTION

The work under this item shall consist of furnishing all materials and installing a complete and functioning irrigation distribution system, including but not limited to, potable and nonpotable systems both buried and above ground, temporary systems, and all irrigation equipment specified herein, at the locations shown on the plans, and in accordance with the requirements of these specifications.

Irrigation distribution plans are, in general, diagrammatic. The exact location of component units of the irrigation distribution system will be approved by the Engineer.

For the purpose of definition, main lines and/or pressure mains shall be defined as those pipes under constant pressure. Lateral lines are those lines which are located on the discharge side of the control valves and are not under constant pressure.

808-2 MATERIALS

Equipment, materials, or patented processes, noted on the plans or in the Special Provisions, are so designated to establish a standard of quality, finish, appearance, or performance. The use of an alternative or substitute article or equipment, material, or process shall be in accordance with the requirements found in Section 106.

Any warranty or guarantee normally provided by the manufacturer for any item shall, when received, be furnished to the Engineer. At the final acceptance of the irrigation system, the contractor shall furnish the owner with one irrigation manual. This manual shall include a complete list of all materials used including model numbers, sizes, etc., and complete instructions for the annual operation and maintenance of the system. The manual shall be submitted in a protective notebook and shall be suitable for reproduction.

808-2.01 Pipe and Fittings. Pipe and fittings furnished shall be galvanized steel and/or polyvinyl chloride, hereinafter called PVC.

(A) Galvanized Steel Pipe. Galvanized steel pipe and fittings shall conform to the requirements of ASTM A 120. Pipe and fittings shall be threaded, standard weight, Schedule 40.

Joint compounds shall be compatible with, and of a recognized standard for use with the pipe and fittings specified.

(B) Polyvinyl Chloride PVC Pipe. All plastic and fittings used for the transportation of potable water shall comply with the requirements of, and bear the stamp of, the National Sanitation Foundation.

SECTION 808

Materials used in the manufacture of pipe and fittings shall conform to the requirements of ASTM D 1784, Class 1254-B.

All pipe 1/2 inch (*DN 15*) through 2 inches (*DN 50*) in diameter shall be bell-end or plain end, solvent weld type.

All pipe greater than 2 inches (*DN 50*) in diameter shall conform with ASTM D 2241 and shall be provided with rubber "O" ring gaskets. Rubber "O" rings shall conform with ASTM D 3130.

All rigid PVC pipe for lateral lines shall be solvent weld PVC pipe unless otherwise noted.

Cements, solvents, thinners and joint compounds shall be compatible with and/or of a kind recognized by the industry as proper for use with plastic pipe and fittings.

PVC pipe shall conform to the requirements of ASTM D 2241 for SDR 21 and SDR 26 pipe and ASTM C 1785 for Schedule 40 and Schedule 80 pipe.

The pipe classification and the pressure rating will be specified on the project plans or in the Special Provisions.

Pipe for use with elastomeric joint fittings shall be either plain-end or with thickened integral bell.

Bell-end, solvent weld PVC pipe shall conform to the requirements of ASTM D 2672. Bell-end, solvent weld pipe shall be used only on irrigation laterals.

Socket type fittings for use of PVC pipe shall be solvent weld.

Elastomeric seals for use in elastomeric ring joint fittings shall conform to the requirements of ASTM D 3139. All elastomeric joint fittings used with PVC pipe shall be factory fabricated, shall bear the manufacturer's fabrication mark, and shall be shipped with gaskets factory installed.

The twin gasket coupling body shall be extruded from a material identical to that of the pipe with which it is to be used. The push-on type coupling shall have a smooth outside diameter and be internally machined to receive square bottom elastomeric seal and shall have machined-in pipe stops.

Seal for twin gasket couplings shall have a square bottom with the leading edge concealed to prevent interference with the tapered pipe end during assembly.

All elastomeric seal couplings shall meet or exceed the performance requirements of the pipe with which it is to be used.

Plastic pipe shall be delivered to the site in unbroken, banded or tied bundles, and shall be so packaged as to prevent damage to pipe barrels or ends. If pipe is delivered from a local warehouse, the pipe need not be bundled or wrapped.

Upon delivery to the site, the contractor shall inspect all pipe for possible shipping damage. Following delivery and receipt of the pipe, the contractor shall certify, in writing to the Engineer, that the pipe and fittings, as received, are in good condition and all damaged material has been removed.

Plastic pipe shall be handled and stored in the manner directed by the manufacturer.

Prior to beginning trench excavation, the contractor shall lay out the irrigation distribution system for the approval of the Engineer by providing necessary indicators at the locations of all pipe lines, pumps, tanks, valves, irrigation heads, and related structures.

Mainline pipe 3 inches *(DN 80)* or greater in diameter shall have concrete thrust blocks installed at specific filling locations as per the project plans and/or pipe manufacturer's recommendations and instructions.

(C) PVC Fittings. PVC pipe shall be coupled, as specified, by the following methods:

(1) Solvent weld, socket-type coupling. (Primer shall be used on all solvent weld joints.)

(2) Elastomeric seal coupling.

All PVC fittings shall conform to one or more of the following requirements:

(1) ASTM D 2466 for Schedule 40 socket-type fittings.

(2) ASTM D 3139 for elastomeric seal-type fittings.

Fittings shall be installed in accordance with the manufacturer's recommendations and these specifications.

808-2.02 Emitter Hose. The flexible emitter hose, which shall deliver water to the emitter assembly shall be manufactured from virgin polyethylene material having the following physical characteristics:

CHARACTERISTICS	VALUE
O.D.	.704 inch (*17.9 millimeters*)
I.D.	.600 inch (min) (*15.2 millimeters*)
Wall	.0052 inch (*.13 millimeters*)
Carbon Black	1.5 - 3.5
Density	.92 - .93
Melt	210° F (*99 °C*) to soften
Environmental	
Stress Crack Resistance	0/100/100

Fittings for use with flexible emitter hose shall be of the compression, internal barb type, constructed of virgin PVC or glass-filled polypropylene materials, and as detailed on the project plans.

808-2.03 Gate Valves. Gate valves shall be bronze, in the sizes specified on the project plans or in the Special Provisions.

The body of bronze valves shall be of heavy duty bronze conforming to the requirements of ASTM B 62, or approved equal. Valves shall have a service rating for non-shock, cold water, of 200 psi (*1.4 megapascals*). Valves shall be of the double disc, taper seat type with nonrising stem, union bonnet and handwheel. Identification of valves by trade name, manufacturer, etc., shall be stamped or cast on the valve case. Valves shall be assembled as detailed on the plans.

The valve box, as detailed, shall be a two-piece box consisting of a top and bottom section with a cover imprinted "IRRIGATION WATER". Box assemblies shall be manufactured of a rigid combination of polyolefin and a fibrous inorganic component or concrete. The bottom section shall have an integral formed bell, 9 inches (*230 millimeters*) in diameter and 6 inches (*150 millimeters*) in height, unless otherwise specified on the plans. The top section shall accommodate the lid as supplied by the manufacturer. Top and bottom sections shall be threaded to facilitate field adjustment as required.

808-2.04 Electric Control Valves. Control valves shall be of the types and sizes specified on the plans or "as equal" as determined by the Engineer. The manufacturer's name and identification shall be cast or stamped on the valve. Valves shall have a minimum service rating of 150 psi (*1.0 megapascals*), non-shock cold water. Valve bodies, bonnets, and packing nuts shall be brass, bronze, or a glass-filled nylon construction.

Springs, where required, shall be of stainless steel. All valves shall have accurately machined valve seat surfaces and internal parts. End connections shall be machined female pipe thread unless otherwise specified. Electrically operated valves shall be of the same manufacturer as the automatic controller unless otherwise specified.

The remote control valves shall be electrical solenoid type.

The valve box, cover and necessary extension shall be as specified and detailed on the project plans.

The electric solenoid actuated type valve shall be a normally closed, slow acting diaphragm type, hydraulically operated of the globe or angle type. The solenoid shall be for 24-volt, 60 cycle operation with running current of 2.0 watts. The solenoid shall be completely epoxy encapsulated for positive waterproofing with a stainless steel shunt band.

The valve shall be slow opening and closing by means of a potential fluid resistor to avoid damage from surge pressures. Opening and closing speed shall not be less than 5 seconds.

The inlet port to the diaphragm chamber shall have a removable screen, and shall be accessible without removing the bonnet from the valve body. The outlet port from the diaphragm chamber shall discharge into the downstream side of the valve. The solenoid plunger shall be spring-loaded so that the valve may be operated when installed in any position, and shall be constructed of stainless steel with a neoprene seat and a grit filter to protect against solenoid plunger hang-up. The diaphragm shall be nylon-reinforced neoprene. The valve bonnet shall have a bleed screw or petcock for manual operation of the valve. The valve bonnet shall be secured to the valve body by stainless steel bolts.

Valves shall have a flow control stem and wheel handle for regulating or shutting off the flow of water.

808-2.05 Pressure Reduction Riser. The pressure reduction riser shall consist of the pressure reducing valve, union, valve box and all appurtenances.

The pressure reducing valve shall be a self-contained, single-seat, direct-acting, spring-loaded, diaphragm-actuated type. The valve shall be of all plastic construction, stainless steel body seat, composition seat discs, BUNA-N diaphragm with nylon insert and stainless steel springs. The valve shall have a maximum working pressure rating of 150 psi (*1.0 megapascals*) and shall be capable of regulating outlet pressure from 5 (*35 kilopascals*) to 20 psi (*140 kilopascals*), and have an adjustment screw for setting the pressure. The downstream pressure variance shall not exceed a rate of 0.44 psi (*3.0 kilopascals*) for every 10 psi (*70 kilopascals*) variance (increase or decrease) in upstream or source pressure. The valve shall have an integral "Shrader" pressure test valve. When shown on the project plans, the valve shall have a 1/2 inch (*DN 15*) MPT inlet and 3/4 inch (*DN 20*) MHT female outlet.

The valve box, cover, and necessary extensions shall be as shown on the plans, and shall be manufactured of concrete or a molded, virgin plastic materials conforming to the following ASTM requirements and having the following physical characteristics:

CHARACTERISTIC	ASTM	VALUES
Tensile Strength	D-638-72	3400 psi (*23.4 mega pascals*) Minimum
Deflecting Temperature 66 psi Stress	D-648-72	230° F (*110 °C*)

The valve box shall be 12 inches (*300 millimeters*) high. Valve box lids shall be bolt locking. Lids shall be hinged to permit access without removal of the lid.

The threaded in line spring check valve shall have a body constructed of Type 1 PVC. The valve stem shall be 18-8 stainless steel with BUNA-N poppet seal. The half pound (*0.23 kilopascal*) spring shall be 18-8 stainless steel. The valve shall have male x female threads, 3/4 inch (*DN 20*) NPT.

808-2.06 Backflow Prevention Unit. Backflow prevention units shall be of the reduced pressure type and size as specified on the plans.

Backflow prevention units and component fittings shall conform to applicable state and local health department regulations, local plumbing codes, and the performance requirements of the applicable ASSE Standards or Foundation for Cross Connection Control Research, University of Southern California. Field tests shall be performed by personnel approved by the Engineer, and at no additional cost to the Agency. All tests shall be as specified by the Foundation for Cross Connection Control Research, University of Southern California. Under no circumstances shall shutoff valves of any type be installed downstream from any atmospheric type backflow prevention device.

In the event of a malfunction of the unit, construction shall be such that in the normal operation of the device, the level of water in the zone between the two check valves shall be lowered to create, within the inlet, an air gap greater than the diameter of the inlet pipe.

The backflow prevention unit shall conform to the applicable standards of AWWA, ASSE, and IAPMO.

The reduced pressure backflow preventer shall consist of two independently operating check valves, an independent relief valve, resilient seat inlet and outlet, full port ball type shut-off valves and test cocks. The unit shall be designed for installation in a normal horizontal flow attitude. The independent relief valve shall be located between the two check valves.

The backflow preventer shall include an integral sensing system that will automatically open the relief valve whenever the pressure upstream of the first check valve drops below 3 psi (*21 kilopascals*) greater than the pressure in the zone between the two check valves. The relief valve shall remain open until a positive pressure differential of 3 psi (*21 kilopascals*) is reestablished. The sensing passage shall be located within the unit housing to protect against accidental damage or crimping. To assure maximum size passageway, snubber or other restrictive elements shall not be used.

In the event that pressure upstream of the first check valve drops to atmosphere or below, the construction of the unit shall be such that during the normal operation of the device, the level of water in the zone between the two check valves shall be lowered to create within the unit an internal air gap which is greater than the diameter of the inlet pipe.

Both check valves and the relief valve shall be spring loaded poppet type of modular design such that the complete assembly including valve, spring and seat may be removed and replaced using low cost replacements kits.

All parts shall be made from corrosion resistant materials.

The design shall place the sensing diaphragm and passage within the unit housing to eliminate danger of malfunction due to mechanical or vandalism damage.

The backflow preventer shall conform to the following material pressure and temperature range requirements:

Body	Bronze
Check Valve Enclosures	Glass Filled Noryl
Valve Disc	EPT Rubber
Diaphragm	Buna N and Nylon
"O" Rings	Buna N
Springs	Stainless Steel
Screws	Stainless Steel
Maximum Working Pressure	150 psi (*1.0 MPa*)
Hydrostatic Test Pressure	300 psi (*2.1 MPa*)
Temperature Range	32° F – 210° F (*0 °C – 99 °C*)

Construction of the backflow prevention unit shall be such that any minor leakage at the second check valve will result in a visible flow from the relief valve even if the first check valve is totally disabled.

Each reduced pressure backflow prevention unit shall be factory assembled and tested prior to delivery.

The backflow prevention unit shall be protected form damage due to freezing temperature and from vandalism.

808-2.07 Emitter Assembly. Unless otherwise specified in the Special Provisions, emitters shall be of pressure compensation and continuous flushing type known as a Groove and Flap Short Path Emitter. The case of the emitter shall be made of durable black, plastic material. It shall be resistant to temperature variation, ultraviolet radiation, smog (ozone), common liquid fertilizer and weed spray. The case shall completely encompass the diaphragm, protecting it from potentially harmful environmental factors.

The emitter shall be capable of continuous, self-flushing, clog free operation with 200 mesh (minimum) filtration for 1/2 GPH (*2 liters/hour*), and 150 mesh for 1 and 2 GPH (*3.8 and 7.5 liters/hour*) emitter. The emitter shall be capable of being installed in any position and maintain its given flow characteristics. The emitter shall be non-adjustable and the flow regime shall be maintained by a flexible silicon rubber diaphragm.

The emitter shall function with a system pressure range of 20 psi (*138 kilopascals*) minimum to 50 psi (*345 kilopascals*) maximum. The emitter flow variation shall not exceed 10 percent within this pressure range.

The 2 GPH (*7.5 liters/hour*) emitter shall be capable of delivering 2.05 GPH (*7.75 liters/hour*) at 20 psi (*130 kilopascals*) and 1.75 GPH (6.6 *liters/hour*) at 50 psi (*345 kilopascals*).

The 1 GPH (*3.8 liters/hour*) emitter shall be capable of delivering 1 GPH (*3.8 liters/hour*) at 20 psi (*130 kilopascals*) and 1 GPH (*3.8 liters/hour*) at 50 psi (*345 kilopascals*).

The 1/2 GPH (*2 liters/hour*) emitter shall be capable of delivering 0.5 GPH (*2 liters/hour*) at 20 psi (*130 kilopascals*) and 0.45 GPH (*1.7 liters/hour*) at 50 psi (*345 kilopascals*).

The emitter distribution tubing between the emitter and the .580 inch (*14.7 millimeters*) ID emitter house shall be .187 inch (*4.7 millimeters*) ID, .250 inch (*6.4 millimeters*) OD. The tubing between the emitter outlet and the point of discharge shall be vinylized .150 inch (*3.8 millimeters*) ID, .220 inch (*5.6 millimeters*) OD. All tubing shall fit tightly with the corresponding emitter barbs, adapters, and discharge outlet opening.

808-2.08 Filter. The filter housing shall be constructed of glass reinforced polypropylene, and the removable filter cylinder shall be manufactured of 200 mesh stainless steel with an effective filter area of 27 square inches (*17 420 square millimeters*). The cartridge housing shall have an integral 3/4 inch (*DN 20*) ball valve for flushing of the filter without removal of the cartridge. Threads shall be 1 inch (*DN 25*) MPT.

The valve box, cover and necessary extension shall be termed standard meter. Box and extensions shall be 6 1/2 inches (*165 millimeters*).

808-2.09 Full or Part Circle Pop-up Rotor Sprinkler. Unless otherwise specified in the special provisions, the full or part circle pop-up rotor sprinkler shall be a single nozzle turbine drive type, capable of covering 33 feet (*10 meters*) radius at 45 psi (*310 kilopascals*) with a discharge rate of 1.9 GPM (*7.2 liters/minute*) for part circle, and 42 foot (*13 meters*) radius with 3.7 gallons per minute (*14 liters/minute*) for full circle heads. The sprinkler shall have an infinitely adjustable arc of coverage from 30° to 360°.

The sprinkler case and internal assembly, except for bearing spring, wiper seal, and bearing washers shall be constructed of durable plastic. The rotation of the sprinkler shall be accomplished by turbine drive rotor, actuated by the flow of water through the sprinkler.

The sprinkler shall have a valve to prevent low sprinkler drainage.

The sprinkler shall have an adjustable diffuser pin for distance and distribution control and shall be capable of full or part circle operation. The sprinkler nozzle outlet trajectory shall be 23 degrees.

The sprinkler shall have a strong stainless steel retract spring for positive pop-down. Pop-up height shall be no less than 3-5/8 inches (*92 millimeters*). The sprinkler shall have a co-molded bypass wiper seal for low pressure operation and for cleaning debris from riser as it retracts into case. The pop-up portion of the case diameter shall not exceed 1-3/4 inches (*44 millimeters*) diameter.

The sprinkler shall have a bottom inlet and an inlet screen to protect nozzle from clogging.

808-2.10 Controller (Automatic). Automatic controllers shall be solid-state electronic type, capable of fully automatic operation of the system. The controller cabinet and pedestal, where specified, shall be constructed of heavy gauge steel. The cabinet shall be UL listed, rain and dust proof. All cabinets shall be locking and keyed alike.

The automatic controller shall have the number of stations as shown on the project plans.

Each of the controller stations shall be programmable to operate from one minute to nine hours and 50 minutes, in one minute increments. The controller shall have two independent programs with four automatic starts per day for each. Each controller shall have, at a minimum, a 14 day programming capability. During operation, the controller shall provide a monitoring readout indicating station in operation and time remaining.

The automatic controller shall be compatible with 2 watt V.A.C. solenoid valves.

A master on/off button shall provide for system shutdown while maintaining programming. Electrical surge protection and lightning protection shall be an integral part of the controller and shall be provided on both the primary and circuit lines.

The controller shall be capable of being operated manually at any desired time during operation. A manual single station operation for programmed time or new setting shall be possible without affecting the original program. The controller shall have a factory preset back-up program for standby operation in the event of program loss and a rechargeable battery back-up to maintain the program for up to 6 hours in the event of a power loss.

All programming shall be accomplished via keyboard entry with all readouts LED displayed.

Electrical characteristics shall be as follows:

Input	117 V.A.C., 60 Hz
Output	24.0 V., 60 Hz 1.1 AMP
Fuse	1.0 A slow blow

Construction details shall conform to the applicable requirements of the General Specifications for Traffic Signal and Highway Lighting System, the Traffic Signal Standard Drawings, the National Electrical Code, latest edition, and as specified on the project plans.

All wiring to be used for connecting the electric remote control valve to the automatic controllers shall be UL approved, 600 volt, Type UF single conductor wire. Wire shall be solid copper, AWG sizes 12 or 14 as specified on the plans. Insulation shall be 60 mils thick PVC ICC-100 compound. Wire shall be color-coded as approved by the Engineer.

Installation procedures shall be as specified.

Wire connections to remote control valves and at wire splices shall be made with UL approved, sealant-filled (cycohexanone), water-tight wire connectors installed as recommended by the manufacturer.

Services (120 VAC) shall be placed at the locations indicated on the project plans. The contractor shall provide for any deviations between the final locations and those indicated on the plans.

Circuit breaker requirements shall be 20A, 1P, 120VAC and have a 10,000 AIC rating.

Concrete for the cabinet base shall have a 28-day compressive strength of 2,500 psi (*17.3 megapascals*) and shall conform to the requirements found in Section 1006.

808-3 CONSTRUCTION REQUIREMENTS

808-3.01 General. Within 30 days after the date of the preconstruction conference, the contractor shall submit to the Engineer 5 copies of a list of the materials and equipment he proposes to use. This list shall show the manufacturer's name, model number, size, capacity, and complete specifications to determine whether or not each piece of material or equipment is acceptable and to assure that all such materials and equipment, when incorporated into the work, will be in accordance with the requirements of the project plans.

The contractor shall not begin work until the material and equipment have been approved in writing by the Engineer.

The use of potable water by the contractor shall require the installation of an approved backflow prevention device. All backflow prevention devices shall be in place, tested and approved for use by the water utility prior to the contractor using any water from the municipal water system.

Prior to beginning trench excavation, the contractor shall lay out the system or systems for the approval of the Engineer by providing approved indicators at the location(s) of major components such as piping runs, valves, pumps, backflow preventers and tanks.

The contractor shall locate any existing water distribution system piping and appurtenances within the limits of the project which will be affected by new system construction and/or revisions.

Utility connections, both water and electrical, shall be as shown on the project plans or as determined by the utility company. Unless specifically exempted in the plans or specifications, the contractor shall be responsible for all costs to provide these services.

The contractor shall assume full responsibility for the correct installation of the water distribution system, as herein specified, and unless it can show past experience of installing this type of system, it shall arrange with the manufacturer for the services of a qualified manufacturer's representative to be on hand at the start of the installation and as necessary during the installation and testing of the system.

All materials and fittings shall be new, of manufacturer's most current design, and shall bear the appropriate national association's seal of approval; for example, NSF and UL. Similar parts shall be procured from the same manufacturer, and internal parts shall be common and interchangeable. Parts listing and source of supply for replacement parts shall be furnished to the Engineer. The contractor shall provide two complete manuals of all materials, equipment, parts, and manufacturer's installation, maintenance and owner manuals, to the Engineer prior to final project acceptance.

All enclosures shall remain closed and locked, and all valve box covers shall be in place throughout the construction and landscaping establishment period, except when actual work is in progress on the respective unit.

The contractor shall furnish sufficient numbers of pressure gauges with tire chucks, which shall be used in the testing and necessary adjustment of the emitter system during construction and landscaping establishment.

All pressure regulators shall be tested at 90 days intervals throughout the contract and establishment period. Regular tests shall be performed at a minimum of three working days prior to regularly scheduled project inspections.

Upon delivery to the site, the contractor shall inspect all pipe for possible shipping damage. Shipping straps shall be removed to prevent damage due to expansion in hot weather.

All copper pipe required to install the backflow prevention unit or fertilizer injector assembly shall be type "K", hard drawn, of the size shown on the project plans. Copper fittings shall be wrought or cast, and of the configuration and size shown on the project plans.

All PVC pipe and fittings shall be stored as recommended by the manufacturer and as directed by the Engineer. All PVC pipe shall be covered to prevent exposure to sunlight. Sufficient air space shall be provided between the opaque covering material and the pipe to prevent undue heat buildup and retention.

PVC pipe which has been discolored by exposure to sunlight or has been scratched, scored or otherwise damaged in handling will not be acceptable.

Plastic pipe and fittings shall be installed in accordance with the requirements specified herein and the manufacturer's recommendations.

Any PVC fitting or nipple marks from any device other than a strap tightening wrench shall be removed and replaced with a new component. Any system replaced shall be retested as herein specified.

No water distribution system main piping, laterals, other piping, or other components shall be installed through or beneath new or existing plant pits or plant material. The minimum distance between the plant pit and piping shall be 12 inches (*300 millimeters*) the plant pit and piping shall be determined by maximum supply lengths as specified on the project plans.

808-3.02 Trenching and Piping. Trenches shall be excavated to a uniform grade which shall not cause undue deflection of pipe and shall be no wider than is necessary for proper installation of the pipe, fittings and other required incidentals. The bottom of the trench shall be firm and free from large or sharp rocks.

The first 3 inches (*75 millimeters*) over the pipe shall be backfilled with dirt or sand fine enough to pass a 1/2 inch (*13 millimeters*) sieve and compacted to approximately 85% of the maximum density. The remainder of the trench shall be backfilled with excavated soil, free of rocks larger than 2 inches (*50 millimeters*) in diameter. Compaction shall be to approximately 85% of the maximum density. If additional backfill material beyond that generated by the trenching operations is required, it shall be select material obtained at the contractor's expense. Pipe joints shall not be backfilled until the system has been tested and accepted. Backfill must be capable of supporting healthy plant growth.

Where pavement or other impervious material is encountered in the excavation of trenches, such material shall be removed and disposed of in a satisfactory manner.

The quick term burst test shall be conducted in accordance with ASTM 1599. Reference to other quick term burst tests shall be deleted.

Solvent welding shall be accomplished by applying primer to the pipe end (spigot) and to the coupling socket (bell). Solvent cement shall then be applied to the male spigot of the pipe only. All other manufacturing recommendations shall be followed.

Solvent-weld PVC within sleeves shall be of the size indicated, assembled, and tested as specified prior to placement in the sleeve. The above pressure test shall be in addition to the specified water system test.

All sleeves shall be installed a minimum of 30 inches (*760 millimeters*) below pavement, or as directed by the Engineer, at the locations indicated. The cut ends of the pipe shall be reamed smooth and, at the time of inspection, both ends of pipe shall be visible and shall extend 1 foot (*300 millimeters*) beyond paving or curbs into a planting area. Where sleeving is provided for irrigation control wire and a pull box is indicated, the sleeve shall be extended and terminate in the pull box.

Sleeves shall be capped or plugged in a manner acceptable to the Engineer following installation and prior to placement of water piping.

Plastic pipe and fittings shall be installed in accordance with the requirements specified herein and the manufacturer's recommendations.

Any socket type fitting for use with water piping shall conform to the tolerances of the appropriate ASTM Specification for materials specified for the water piping.

Where threaded plastic to metal or plastic to plastic connectors are required, the metal connections shall be worked first. A non-hardening manufacturer recommended sealant/lubricant compatible with plastic fittings and/or components shall be used and the joint shall be handtightened with final tightening not to exceed one turn with a strap wrench.

Threaded polyvinyl chloride adapters into which pipe may be solvent welded shall be used where threaded plastic connectors are required.

The contractor shall be responsible for protecting irrigation lines from freezing. Irrigation lines damaged as a result of freezing shall be repaired or replaced at the contractor's expense.

Gate valves will be installed as shown on the project plans and shall conform to the requirements detailed in these Special Provisions.

808-3.03 Bedding and Cover Material. When required, bedding and cover material for PVC piping, flexible emitter hose and 24 volt wiring shall be sand conforming to the gradation requirements of Subsection 1006-2.03 (B) with the following exceptions:

SAND BEDDING SIEVE SIZE	PERCENT PASSING
No. 4 (*4.75 millimeters*)	100
No. 16 (*1.18 millimeters*)	30-80
No. 50 (*300 μm*)	0-30
No. 100 (*150 μm*)	0-25
No. 200 (*75 μm*)	0-20.0

808-3.04 Pressure Reduction Riser. At the initial installation, the pressure reducing valve shall be field adjusted to 25 psi (*172.4 kilopascals*) and maintained at 24 to 26 psi (*165.5 to 179.3 kilopascals*) at the adjacent pressure check point.

Immediately prior to the initial operation of any of the pressure reducing valves on a continuous basis, all valves shall be retested and reset if necessary. The contractor shall, at the completion of the entire irrigation system, test and record the pressure readings at all pressure reducing valves. If any readings are not within the recommended pressure, necessary devices shall be reset and retested by the contractor.

808-3.05 Emitter Assembly. The emitter and distribution tubing shall be assembled using the manufacturer's recommended tools and accessories.

The maximum length of the distribution tubing shall be as detailed on the project plans. In the event the distance in the field exceeds the maximum length, the contractor shall extend the .600 inch (*15.2 millimeters*) ID emitter hose or PVC header as required by adding a tee and shall add a flush valve at the end of each extension. This work if necessary will be performed at the contractor's expense.

The emitter assembly, as detailed on the plans, shall consist of the emitter unit, flexible polyethylene emitter distribution tubings (length as required), and molded polyethylene adapter.

808-3.06 Emitter Hose. The contractor shall assume full responsibility for the correct installation of the emitter system, as herein specified, and unless he can show past experience of installing this type of system, he shall arrange with the manufacturer for the services of a qualified manufacturer's representative to be on hand at the start of the installation and as necessary during the installation and testing of the system.

All emitter hose shall be flushed prior to and after installation of emitter assemblies. A manual self closing flush valve shall be installed at the end of each line.

808-3.07 Filter. The filter shall be installed in a manner that allows removal of the cartridge for visual inspection.

808-3.08 Full or Part Circle Pop-Up Rotor Sprinkler. Sprinkler heads shall be installed as detailed on the plans or as directed by the Engineer. Minor adjustments may be made as needed to avoid guardrails and other obstructions from interfering with the intended coverage. The installed angle of the head may be adjusted relative to vertical to maximize intended coverage and minimize erosion.

808-3.09 Programming of Controller to Minimize Erosion. The irrigation controller shall be programmed to operate the sprinklers for a duration and at a frequency such that erosion during and after seed establishment is minimized. Any erosion damage shall be repaired by the contractor at no cost to the Agency.

808-3.10 Water Meter. This work shall be performed by the appropriate local water department or company, and shall consist of furnishing all materials (including meters, meter boxes, covers, and valves), equipment, tools, and labor necessary to provide the specified size water service where indicated on the plans.

It shall be the contractor's responsibility to notify the appropriate water department or company immediately following award of contract, requesting the installation of the required water services. It shall be the contractor's responsibility to coordinate his landscape and irrigation work with the schedule of appropriate water department or company.

The contractor shall be responsible for paying the water department or company for the installation of the water service and appurtenant equipment.

The contractor shall be responsible for providing all water necessary during the construction and plant establishment periods.

At the completion of the installation of piping, pumps, valves, tanks, and other irrigation system components and after all solvent welded joints have cured for 24 hours, the water distribution system shall be tested in accordance with the requirements indicated in this section.

808-4 TESTING

Prior to backfilling, the irrigation distribution system shall be tested in accordance with the requirements of these specifications.

The contractor shall flush and bleed all lines prior to testing. Metal or plastic caps or adjustable irrigation heads may be used to facilitate flushing and testing. Backfill material placed on the lines shall be limited to the quantity required to stabilize the lines under pressure and to serve as insulation during testing in hot weather. During testing, all fittings and couplings shall be visible for inspection. Any failure evident during the test shall be repaired and the system retested before backfilling. The contractor shall furnish the necessary equipment required to perform the testing.

The main lines and/or pressure mains shall be subjected to 150 psi (*1 035 kilopascals*) pressure for a minimum period of 2 hours. The contractor shall furnish all necessary pumps and test equipment at no additional cost to the Agency. All lateral lines shall be subject to test at static pressure, or proposed operating pressure, whichever is greater, for a period of 2 hours. During this time, all solvent-welded elastomeric seal joints, threaded connections, and other component parts shall be inspected to determine that no leaks exist.

All pressure testing shall be done following removal of entrapped air. Under no circumstances shall air be used to develop the test pressure.

Upon satisfactory completion of the main line and/or pressure main test, the water pressure shall then be reduced to static water pressure for a period of 2 hours. The system shall be checked for leaks at the end of this 2 hour period and all necessary repairs shall be made.

All valves shall be tested in sequence starting at the valve most remote from the source of water supply in order to subject the main lines to surge pressure. Testing on this phase shall be done at static water pressure. All valves shall be operated manually. All electric remote control valves shall be tested to the satisfaction of the Engineer prior to burial of wiring.

Any mechanical failures or leaks which may occur during testing shall be repaired. Defective materials shall be removed and replaced. After replacement or repairs have been made, the entire testing procedure shall be repeated until it is determined that there are no leaks or failures in the irrigation distribution system.

808-5 RECORD AND AS-BUILT DRAWINGS

The contractor shall provide and keep up to date a complete "as-built" record set of blue line prints which shall be corrected daily and show every change from the original drawings and specifications and the exact as-built locations, size, and kind of equipment. This set of drawings shall be kept on the site and shall be used only as a record set.

The as-built drawings shall also serve as work progress sheets. The contractor shall make neat and legible annotations thereon, daily as the work proceeds, showing the work as actually installed. These drawings shall be available at all times for inspection, and shall be kept in a location acceptable to the Engineer.

The contractor shall dimension, from two permanent points of reference, building corners, sidewalk, road intersections, road station points, etc., and the location of the following items:

Connection to existing water lines and backflow prevention unit.

Connection to existing electrical power and controller.

Gate valves.

Routing of primary and lateral irrigation lines (dimension maximum 200 feet (*60 meters*) along routing).

Electric control valves and filters.

Routing of control wiring.

Quick coupling valves.

Other related equipment as directed by the Engineer.

All lettering on drawings shall be a minimum 1/8 inch (*3 millimeters*) in size.

Master control valves, flow meter and wiring.

Vacuum release valves.

Mainline pressure reduction valves.

On or before the date of final inspection, the contractor shall deliver the corrected and approved "as-built" record set of prints to the Engineer. Delivery of the "as-built" prints will not relieve the contractor of the responsibility of furnishing required information that may have been omitted.

808-6 METHOD OF MEASUREMENT

The landscape irrigation system will be measured on a lump sum basis or as individual unit prices as noted on the bid schedule for the work complete in place.

808-7 BASIS OF PAYMENT

Payment will be made at the contract lump sum price, or unit price(s), for the item(s) called for in the Bidding Schedule, which price shall be full compensation for the item(s) complete-in-place as described herein and on the project plans.

SECTION 810

EROSION CONTROL AND POLLUTION PREVENTION

810-1 DESCRIPTION

The work under this item shall include furnishing, installing, maintaining, removing and disposing of temporary erosion control measures such as silt fences, check dams, straw barriers, and other erosion control devices or methods as shown in the Storm Water Pollution Prevention Plan (SWPPP) and in the Special Provisions.

The work shall also include furnishing, installing, and maintaining permanent erosion control measures such as pipe inlet and outlet protection, cut and fill slope transitions, headwall and wingwall treatments, and other permanent erosion control devices or methods as shown in the SWPPP.

810-1.01 Erosion Control. Erosion controls, both temporary and permanent, shall be installed in accordance with phasing provisions in the approved SWPPP and coordinated with the related construction.

All work specified in this subsection will be temporary for use during construction, unless designated otherwise.

The contractor shall be responsible for maintaining all erosion and pollution control devices in proper functioning condition at all times.

When deficiencies in the erosion control devices or other elements of work listed herein are noted by inspection or other observation, specified corrections shall be made by the contractor by the end of the day or work shift, or as directed by the Engineer.

Work specified herein which is lost, destroyed, or deemed unacceptable by the Engineer as a result of the contractor's operations shall be replaced by the contractor at no additional cost to the Agency. Work specified herein which is lost or destroyed as a result of natural events, such as excessive rainfall, shall be replaced by the contractor and be paid for in accordance with the requirements of Subsection 109-3.

In cases of serious or willful disregard for the protection of the waters of the U.S. and/or natural surroundings by the contractor, the Engineer will immediately notify the contractor of such non-compliance. If the contractor fails to remedy the situation within 24 hours after receipt of such notice, the Engineer may immediately place the erosion and/or other pollution control elements in proper condition and deduct the cost thereof from moneys due the contract.

810-1.02 Other Pollutant Controls. The work shall include implementing controls to eliminate the discharge of pollutants, such as fuels, lubricants, bitumens, dust palliatives, raw sewage, wash water, silt laden water, and other harmful materials; into

storm and other off-site waters. The work shall include the implementation of spill prevention and material management controls and practices to prevent the release of washoff of pollutants. These controls and practices shall be specified in the SWPPP and shall include storage procedures for chemicals and construction materials, disposal and cleanup procedures, the contractor's plans for handling of potential pollutants, and other pollution prevention measures as required.

Handling procedures for potential pollutants shall also be include in the contractor's "good housekeeping" practices, as specified in Subsection 107-15 and in the Special Provisions.

810-2 MATERIALS

810-2.01 Silt Fence. Material requirements for silt fences, including posts, wire support fencing, and fasteners, shall be in accordance with Section 915. Geotextile fabric shall conform to the requirements of Subsections 1014-1 and 1014-8, except that the filter cloth shall be woven polypropylene, and the fabric Apparent Opening Size shall be between numbers 20 and 50 U.S. Standard sieve sizes (*850 μm and 300 μm metric sieve size*), when tested in accordance with ASTM D 4751.

810-2.02 Straw Bales. Straw shall be in three-tie bales approximately 40 inches long by 24 inches wide by 14 inches high (*1000 millimeters x 600 millimeters x 360 millimeters*). Straw shall be well compacted with a low seed content. Ties shall be nylon string.

Stakes shall be wooden stakes, two-by-two inches by four feet (*50 X 50 millimeters X 1.2 meters*).

810-2.03 Riprap and Rock Mulch. Riprap for cut and fill transitions designated on the plans shall conform to the requirements of Section 913 and shall be in accordance with the following table, unless otherwise specified. Riprap for cut and fill transitions shall conform to gradation A or B as designated on the project plans.

Sieve Size		Percent Passing
Gradation A	**Gradation B**	
6 inch (*150 millimeters*)	12 inch (*305 millimeters*)	90-100
4.24 inch (*106 millimeters*)	9 inch (*230 millimeters*)	70-85
3 inch (*75 millimeters*)	6 inch (*150 millimeters*)	30-50
2 inch (*50 millimeters*)	4 inch (*100 millimeters*)	5-15
1 inch (*25 millimeters*)	2 inch (*50 millimeters*)	0-5

Rock mulch for pipe inlet and outlet protection, headwall and wingwall treatment, and rock check dams shall conform to the requirements of Section 803 and shall be in accordance with gradation C below, unless otherwise specified. Section 803 requirements for use of pre-emergent herbicide and for post-placement watering of rock mulch shall not apply to rock mulch applied under Section 810.

Gradation C	
Sieve Size	**Percent Passing**
3 inch (*75 millimeters*)	100
2 inch (*50 millimeters*)	50-75
1 inch (*25 millimeters*)	10-20

810-2.04 Sand Bags. Sand bags, when filled shall measure approximately 24 inches (*600 millimeters*) long by 16 inches (*400 millimeters*) wide by 4 inches (*100 millimeters*) thick. Bags shall be manufactured from polyproplylene, polyethylene, or polyamide woven fabric with the following characteristics:

Unit Weight, Minimum, oz. Per sq. yd.	4 (*136 g/m^2*)
Mullen Burst Strength, Exceeding, p.s.i.	300 (*2 MPa*)
Ultraviolet Stability, Exceeding, %	70

Material used to fill sand bags shall be clean sand or a clean sandy soil free of silt, as approved by the Engineer.

810-3 CONSTRUCTION REQUIREMENTS

The contractor shall implement the SWPPP throughout the project, as specified in Subsection 107-15 and in the Special Provisions.

Erosion control features shall be temporary or permanent, as designated herein. Temporary erosion control features specified for removal at the end of the project shall become the property of the contractor, unless designated by the Engineer to be left for permanent use.

810-3.01 Silt Fences. Installation and maintenance requirements for silt fences shall be accordance with Section 915, unless otherwise specified.

810-3.02 Straw Bales.

(A) General. Straw bales shall be installed in accordance with the project plans and details or as directed by the Engineer. The bottom of all bales shall be embedded 4 to 6 inches (*100 to 150 millimeters*) into the ground. In locations where rows of bales are installed, joints between bales in adjacent rows shall be staggered.

Straw bales shall be staked as shown on the project plans and details. Stakes shall be driven flush with the top of the bale, skewed in directions opposite to the skew of adjacent stakes, and perpendicular to the direction of flow. In areas where straw bales may be allowed to remain in place, wood stakes must be used. In other areas, No. 4 (No. 13) steel bars may be used. A minimum of two stakes shall be used for each bale.

Straw bales shall be installed tightly together to form a cohesive unit without gaps or voids. Joints between bales shall be hand packed with straw to maintain a uniform density throughout the unit and to eliminate voids.

The Contractor shall maintain all straw bales in a functional condition. Accumulated sediment shall be removed and disposed of by the contractor when approximately 75 percent of the original capacity has been filled with silt, or as directed by the Engineer.

Straw-bale features shall remain in service until disturbed areas have been stabilized, as directed by the Engineer.

When the use of a straw bale feature is discontinued, all materials shall be removed and become the property of the contractor. During removal, all sediment shall be disposed of, and the area restored to a finished condition as shown on the plans, or as directed by the Engineer.

(B) Straw-Bale Check Dams. Check-dam bales shall extend from the flow line into the cut or fill slopes. Rows of one or more bales on each side of the flow line shall overlap laterally at the flow line.

(C) Straw-Bale Barriers. Unless otherwise shown on the plans, there shall be a minimum distance of 6 inches (*150 millimeters*) between straw bale barriers and the toe of cut and fill slopes.

810-3.03 Riprap and Rock Mulch. Riprap used in cut and fill transitions; and rock mulch treatments for pipe inlets and outlets, headwalls and wingwalls, and rock check dams; shall be installed in accordance with the project plans and details or as directed by the Engineer.

Rock shall be installed so as to conform to and completely cover the treatment area shown on the plans with a uniform, cohesive rock unit. The rock shall no impede flow into the treatment area and shall be feathered at the outflow.

Accumulated debris shall be removed and disposed of by the contractor after each rain storm, or as directed by the Engineer.

Pipe treatments, headwall and wingwall treatments, and cut and fill transitions are permanent project features which shall remain in continuous service after installation and project completion.

Rock check dams shall remain in service until the seeding work commences or until they are no longer needed, as approved by the Engineer. When use of a rock check dam is discontinued, the materials shall be removed and wasted on site in a manner that will not impede designed drainage flows, as approved by the Engineer.

810-3.04 Sand bags. The work shall include furnished sand bags and sand, preparing the filled bags, and installing filled sand bags where shown on the plans or as approved by the Engineer.

Sand bags in the vicinity of curbs and catch basins shall be installed to 2 inches (*50 millimeters*) below the height of the adjacent curb to allow drainage into the catch basin. When sediment depth behind the sand bags reaches 3 inches (*75 millimeters*) the sediment shall be removed and disposed of in accordance with local, state, and federal laws and permit requirements.

Sand bag features shall remain in service until disturbed areas have been stabilized, as directed by the Engineer.

When the use of a sand bag feature is discontinued, all materials shall be removed and become the property of the contractor. During removal, all sediment shall be disposed of, and the area restored to a finished condition as shown on the plans, or as directed by the Engineer.

810-4 METHOD OF MEASUREMENT.

Silt Fence will be measured in accordance with Subsection 915-5.

Straw Bale check dams and barriers will be measured per each bale.

Pipe Inlet/Outlet Treatment, Headwall and Wingwall Treatment, and Rock Check Dams will be measured per cubic yard (*cubic meter*) of rock mulch. Cut and Fill transitions will be measured per cubic yard (*cubic meter*) of riprap.

Sand bags will be measured per each filled sand bag placed into service.

810-5 BASIS OF PAYMENT.

Silt Fence will be paid for in accordance with Subsection 915-6, except that no separate measurement and payment will be made for removal of sediment the cost being considered a part of contract items.

The accepted quantities of straw bale check dams and barriers, measured as provided above, will be paid for at the contract unit price per each bale, which price shall be full compensation for the work, complete in place, including all excavation; preparation; and furnishing, installing, maintaining, final removal, and disposal of temporary straw bale check dams and barriers, including returning the area to a natural condition, as approved by the Engineer.

The accepted quantity of rock check dams, measured as provided above, will be paid for at he contract unit price per cubic yard (*cubic meter*) of rock mulch, which price shall be full

compensation for the work, complete in place, including all excavation; preparation; and furnishing, installing, maintaining, final removal, and disposal or dispersion, including returning the area to a natural condition, as approved by the Engineer.

The accepted quantity of Pipe Inlet/Outlet Treatment, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) of rock mulch, which price shall be full compensation for the work, complete in place, including all excavation; preparation; and furnishing, installing, and maintaining of Pipe Inlet/Outlet Treatment, as approved by the Engineer.

The accepted quantity of Headwall and Wingwall Treatment, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) of rock mulch, which price shall be full compensation for the work, complete in place, including all excavation; preparation; and furnishing, installing, and maintaining of Headwall and Wingwall Treatment, as approved by the Engineer.

The accepted quantity of Cut and Fill Transitions, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) of riprap, which price shall be full compensation for the work, complete in place, including all excavation; preparation; and furnishing, installing, and maintaining of Cut and Fill Transitions, as approved by the Engineer.

The accepted quantities of sand bags, measured as provided above, will be paid for at the contract unit price per each sand bag, which price shall be full compensation for the work, complete in place, including all excavation; preparation; and furnishing, installing, maintaining, final removal, and disposal of temporary sand bags, including returning the area to a natural condition, as approved by the Engineer. No separate measurement and payment will be made for removal of sediment, the cost being considered a part of contract items.

No additional measurement or payment will be made of temporary features subsequently designated by the Engineer as permanent, the cost being considered as included in the unit bid price.

No additional measurement or payment will be made for associated earthwork, ground preparation, stakes, silt and debris removal and disposal, or maintenance, the cost being considered as including the unit bid price.

SECTION 901

MOBILIZATION

901-1 DESCRIPTION

The work under this section shall consist of preparatory work and operations, including but not limited to, the movement of personnel, equipment, supplies and incidentals to the project site; the establishment of all offices, buildings and other facilities necessary for work on the project, and for all other work and operations that must be performed and costs incurred prior to beginning work on the various items on the project site.

901-2 MATERIALS (None Specified)

901-3 CONSTRUCTION DETAILS (None Specified)

901-4 METHOD OF MEASUREMENT

Mobilization will be measured for payment by the lump sum as a single complete unit of work.

901-5 BASIS OF PAYMENT

Payment for mobilization, measured as provided above, will be made at the contract lump sum price, which shall be full compensation for supplying and furnishing all materials, facilities and services and performing all the work involved as specified herein.

Partial payments under this item will be made in accordance with the following provisions. Reference herein to the original contract amount shall mean the original contract amount exclusive of mobilization:

The first payment of the lump sum price for mobilization will be paid after issuance of the Notice to Proceed provided that all submissions required under Subsection 108.03 are submitted by the contractor. The amount paid for the first partial payment will be 30% of the lump sum price.

The second payment of the lump sum price for mobilization will be made on the first estimate following completion of 5 percent of the contract. The amount paid for the second payment will be 30% of the lump sum price.

The third payment of the lump sum price for mobilization will be made on the first estimate following completion of 10 percent of the contract. The amount paid for the third payment will be 40% of the lump sum price.

The total sum of all payment(s) shall not exceed the original contract amount bid for mobilization, regardless of the fact that the contractor may have, for any reason, shut down work on the project or moved equipment away from the project and back again.

The adjustment provision of Section 104 and the retention of funds provision of Section 109 shall not apply to the item of Mobilization.

When other contract items are adjusted as provided in Subsection 104-2, and if the costs applicable to such items of work include mobilization costs, such mobilization costs will be considered as recovered by the contractor in the lump sum price paid for mobilization, and will be excluded from consideration in determining compensation under Section 104

When mobilization is not included as a contract item, full compensation for any necessary mobilization required will be considered as included in the prices for the various contract items involved and no additional compensation will be made.

SECTION 902

CHAIN LINK FENCE

902-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing chain link fence and gates at the locations and in accordance with the details shown on the plans. Unless otherwise noted on the project plans, chain link fence shall be either Type 1 or Type 2 as shown in the Standard Construction Drawings of the Arizona Department of Transportation and shall be constructed in accordance with the requirements of these specifications.

The type and height of chain link fence to be constructed will be shown on the project plans.

Chain link fence shall be constructed of either zinc coated steel fabric, posts, hardware and fittings or aluminum coated steel fabric and zinc coated steel posts, hardware and fittings. The option used shall be the same on any one project.

The work under this section shall also include constructing chain link fence and gates from salvage.

902-2 MATERIALS

902-2.01 General. Certificates of Compliance conforming to the requirements of Subsection 106-5 of the Standard Specifications shall be submitted for all materials except for Subsection 902-2.08 Barbed Wire. Barbed wire will be sampled and tested in accordance with methods used by the Agency and will require written approval by the Engineer prior to being incorporated into the work.

902-2.02 Posts.

(A) General. Posts shall be round pipe, H-section or roll-formed and shall conform to the nominal dimensional requirements shown on the plans. In addition, the material of which posts are fabricated shall have a nominal thickness, before galvanizing, of not less than 0.111 inch (*2.8 millimeters*). The option of post type used shall be the same on any one project.

Posts shall have provisions to securely hold the top tension wire in position and allow for removal and replacement of a post without damaging the top tension wire. Tubular posts shall be fitted with rain-proof tops.

(B) Round Pipe. Pipe shall be zinc coated (galvanized) round steel pipe conforming to the requirements of ASTM A 53, Type E or S, Grade A, Standard Weight, Schedule 40 or shall be round pipe conforming to all of the requirements of AASHTO M 181 for Grade 2 pipe. In addition, Grade 2 pipe furnished with an organic topcoat shall have a separate chromate chemical treatment of 15 micrograms per square inch (*23 milligrams per square meter*) applied to the zinc coating prior to application of the organic topcoat.

(C)H-Section Posts. H-sections posts shall be manufactured from steel conforming to the requirements of AASHTO M 223, Grade 42 and shall meet the zinc coating, strength and dimensional requirements of AASHTO M181 for Type I, Grade 1 steel posts.

(D)Roll Formed Posts. Roll formed posts shall be manufactured from steel sheet and strip conforming to the minimum requirements of ASTM A 570, Grade 45 and shall meet the strength and dimensional requirements of AASHTO M181 for Type I roll formed posts. The required coating shall be a hot-dip zinc coating in accordance with the requirements of AASHTO M181 for Grade 1 steel posts or a coating system meeting the exterior coating requirements of AASHTO M181 for Grade 2 round steel posts consisting of a hot-dip zinc coating, chromate chemical treatment, and organic topcoat.

902-2.03 Concrete. Concrete for post footings shall be utility concrete conforming to the requirements of Section 922.

902-2.04 Fence Fabric. Steel wire constituting the fence fabric shall meet the minimum breaking strength requirements of AASHTO M181, Table 2 for Type I or II wire when tested in accordance with AASHTO Method T68.

Chain link fabric shall be either zinc coated or aluminum coated steel wire fence fabric. Zinc-coated steel fabric shall conform to the requirements of ASTM A 392, Class 1 coating. Aluminum coated steel fabric shall conform to the requirements of ASTM A 491, with a minimum weight of coating of 0.40 ounces per square foot (*122 grams per square meter*) of wire surface area. The wire used for aluminum coated chainlink fence fabric shall be coated prior to weaving into fabric. The wire used in the manufacture of the fabric shall be 11 gauge (*3.05 millimeters*) for all fence fabric 60 inches (*1.5 meters*) or less in height and shall be 9 gauge (*3.76 millimeters*) for fabrics greater than 60 inches (*1.5 meters*) in height. Wire meeting the dimensional requirements for 10 gauge (*3.40 millimeters*) wire may be substituted for a 9 gauge (*3.76 millimeters*) wire provided the minimum breaking strength for 9 gauge (*3.76 millimeters*) wire as stipulated in AASHTO M181, Table 2, is maintained.

Chain link fence fabric shall be woven throughout in the form of approximately two inch (*50 millimeters*) square mesh. Fabric 60 inches (*1.5 meters*) or less in height shall be furnished with knuckling on one selvage and barbing on the other. Fabric over 60 inches (*1.5 meters*) shall be furnished with barbing on both selvage(s).

902-2.05 Tension Wire and Fabric Fasteners. Tension wire shall be 7 gauge (*4.5 millimeters*) coil spring steel wire of good commercial quality with a minimum tensile strength of 75,000 pounds per square inch (*517 mega pascals*), and shall be zinc coated or aluminum coated. Zinc coated steel wire shall have a minimum coating of 0.8 ounce per square foot (*244 grams per square*

meter) of uncoated wire surface. Aluminum coated steel wire shall have a minimum coating of 0.4 ounce per square foot (*122 grams per square meter*) of uncoated wire surface.

Tie wires, hog rings and post clips shall be zinc coated or aluminum coated steel of good commercial quality and shall be of the same gauge as the fence fabric being fastened.

The minimum weight of zinc coating shall conform to the requirements of ASTM A 392, Class 1 coating. The minimum weight of aluminum coating shall be 0.4 ounces per square foot (*122 grams per square meter*) of wire surface area.

902-2.06 Truss Rods and Tighteners. Truss rods and tighteners shall be fabricated from commercial quality steel and shall be zinc coated in accordance with the requirements of AASHTO M 111. Truss rods shall be 3/8 inch (*9.5 millimeters*) diameter adjustable rods. Truss tighteners shall have a strap thickness of not less than 1/4 inch (*6.35 millimeters*).

902-2.07 Miscellaneous Fittings and Hardware. Structural bars, stretcher bar bands, post caps and miscellaneous hardware shall be fabricated from commercial quality steel and shall be zinc coated in accordance with the requirements of AASHTO M 111. Stretcher bars shall be 3/16 inch (*4.76 millimeters*) by 3/4 inch (*19 millimeters*) steel flat bars. Stretcher bar bands shall be 1/8 inch (*3.2 millimeters*) by 1 inch (*25.4 millimeters*) preformed steel bands.

902-2.08 Barbed Wire and Barbed Wire Support Arm. Barbed wire for use with Type 2 chain link fence shall conform to the requirements of Subsection 903-2.04 (A).

Barbed wire support arm shall be of the type shown on the plans, shall be fabricated from commercial quality steel, and shall be zinc coated in accordance with the requirements of AASHTO M 111.

902-2.09 Gates. Gates shall be of the sizes shown on the plans. Gates greater than 8 feet (*2.45 meters*) in width shall have a vertical member installed at the midway point of the gate.

Gate frames shall be constructed of not less than 1-1/2 inch (*38 millimeters*) steel pipe and interior vertical members shall be constructed of not less than 1 inch (*25.4 millimeters*) pipe. Pipe shall be zinc coated steel pipe conforming to the requirements of ASTM A 53, Standard Weight, Schedule 40, or shall be round pipe conforming to all of the requirements of AASHTO M 181 or Class 2 pipe.

Gate frames shall be fastened together at the corners by welding. Welding shall be performed in accordance with the requirements of the American Welding Society, Structural Welding Code, D1.1 and as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

Truss rods and tighteners for the gate frames shall conform to the requirements specified herein under Subsection 902-2.05.

Fabric for the gates shall be of the same kind used for the adjoining chain link fence and shall be attached to the gate frame by the use of stretch bars, stretcher bands and tie wires as specified under Subsection 902-3.03.

Gates shall be hung by at least two steel, ductile iron or malleable iron hinges not less than 3 inches (*76 millimeters*) in width, so designed as to securely clamp to the gate post and permit the gate to be swung back against the fence.

Gates shall be provided with a combination steel, *ductile iron* or malleable iron catch and locking attachment which will not rotate around the latch post. Stops to hold gates open shall be provided where required.

902-3 CONSTRUCTION DETAILS

902-3.01 General. In areas where there is livestock, the contractor shall take all measures necessary to restrict the livestock to the land where it is being kept when such measures are made necessary by the removal of existing fences, gates, or cattle guards during the performance of the contractor's work. The contractor shall furnish all materials and construct temporary fence, gates and cattle guards as may be necessary to restrict the livestock as specified.

Existing fences that are to remain in place and which have been damaged by the contractor's operations shall be replaced or restored by the contractor at no additional cost to the Agency in accordance with the provisions of Subsection 107-12.

Unless otherwise directed by the Engineer, the contractor shall clear the fence lines of all earth, trees, brush, and other obstructions which interfere with the proper construction of the fences. Disposal of removed material shall be in accordance with the requirements of Subsection 201-3.01. Clearing for the fence line shall be kept within any right-of-way or easement. Fence shall be constructed within the public rights-of-way or easements as shown on the plans.

902-3.02 Setting Posts. Line posts shall be spaced at not more than 10 foot (*3 meters*) intervals, measured from center to center of posts, and such measurement shall be made parallel to the slope of the natural ground.

End, intermediate, and corner post assemblies shall be as shown on the plans. Intermediate post assemblies shall be spaced at 500 foot (*150 meters*) intervals or midway between pull posts when the distance between such posts is less than 1,000 feet (*300 meters*) and more than 500 feet (*150 meters*).

All posts shall be placed in a vertical position, except in unusual locations where the Engineer may direct that the posts be set perpendicular to the ground surface. All posts shall be set in concrete footings conforming to the details shown on the plans and crowned at the top to shed water.

Fence fabric or wire shall not be attached to the posts until the concrete has cured a minimum of 72 hours.

At locations where a change in the vertical alignment of the fence line forms an angle of deflection of 10 degrees or more, a corner post assembly shall be provided. A change in the horizontal alignment of the fence line where the angle of deflection is 30 degrees or more shall be considered as a corner and a corner post assembly shall be installed.

902-3.03 Installing Fence Fabric. Chain link fence fabric shall be fastened on the outward facing side of the posts, unless otherwise specified by the Engineer. The fabric shall be stretched taut and fastened to the posts. Between posts, the top and bottom edges of the fabric shall be fastened to the tension wires. The tension wires shall be stretched tight and installed on a straight grade between posts. The distance from the top of the fabric to the top tension wire shall be 2 inches (*50 millimeters*) maximum.

The fabric shall be fastened to end, corner, latch, gate and pull posts with stretcher bars and stretcher bar bands. Stretcher bar bands shall be spaced at intervals not exceeding 14 inches (*355 millimeters*). The fabric shall be fastened to the line posts with the wires or post clips spaced at intervals not exceeding 14 inches (*355 millimeters*) and to the tension wire with the wires or hog rings spaced at 18 inches (*455 millimeters*) center to center.

Selvage at the bottom of chain link fence fabric shall be cut, unless otherwise specified. Selvage at the top of chain link fence fabric shall be cut for heights of 6 feet (*1830 millimeters*) and over, and shall be knuckled for heights less than 6 feet (*1830 millimeters*).

902-3.04 Barbed Wire. Barbed wire for Type 2 fence shall be pulled taut before being permanently attached to the barbed wire extension arms and to the posts. Barbed wire across the top of a gate frame shall be made taut by means of eye bolts or ratchet bands at each end.

A maximum of two splices on barbed wire will be allowed between post assemblies but not on the same wire. No splicing will be allowed within 100 feet (*30 meters*) of a pull post.

902-3.05 Construct Chain Link Fence from Salvage. Portions of the existing chain link fence, including gates, designated for removal and salvage shall be constructed at the new locations shown on the project plans and shall be constructed in accordance with the provisions specified herein for new chain link fence.

The contractor may, at its option and at no additional expense to the Agency, construct new chain link fence in lieu of constructing chain link fence from salvage. If the contractor elects to construct new chain link fence, the fence materials originally designated for construction from salvage shall become the property of the contractor.

All posts, pipe, fabric or hardware which are deemed by the Engineer to be unsuitable for use in reconstructing the chain link fence shall be removed and disposed of as directed by the Engineer. If any of these materials require replacement to complete the quantity of chain link fence to be constructed, the materials shall be furnished by the contractor and will be paid for as specified in Subsection 109-5.

902-4 METHOD OF MEASUREMENT

Chain link fence will be measured by the linear foot (*meter*) of each type and size of fence specified. Measurement will be made along the top of the completed fence from outside to outside of end posts, excluding the widths of gate openings. Gate posts and latch posts will be considered as included in the measurement of the completed fence.

Gates will be measured by the unit of each type and size of gate specified. A gate unit complete in place shall include the necessary fittings, hardware, and gate bracing.

Constructing the various types of chain link fence or gates from salvage will be measured by the linear foot (*meter*) or by the unit each, using the limits of measurement specified for new construction.

902-5 BASIS OF PAYMENT

The accepted quantities of chain link fence and gates or construct chain link fence and gates from salvage, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*) for the type and size of fence and per each for the type and size of gates designated in the bidding schedule, complete-in-place.

The accepted quantities of reconstruct chain link fence from salvage, measured as provided above, will be made at the contract unit price per linear foot (meter), complete-in-place, including excavation, footing concrete, backfill, and disposal of surplus material. Any new posts, pipe, fabric, or hardware furnished by the contractor to replace salvaged chain link fence components deemed by the Engineer to be unsuitable for use, will be measured and paid for in accordance with the provisions of Section 104-2.

No payment will be made for furnishing materials and constructing temporary fence, gates and cattle guards as may be necessary to restrict livestock.

SECTION 903

WIRE FENCE

903-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing barbed wire fence, woven wire fence, game fence, antelope fence, and gates at the locations and in accordance with the details shown on the plans. Fences and gates shall be of the types and sizes shown on the plans and shall be constructed in accordance with the requirements of these specifications.

The type of fence to be constructed will be shown on the project plans.

903-2 MATERIALS

903-2.01 General. Certificates of Compliance conforming to the requirements of Subsection 106-5 of the Standard Specifications shall be submitted for all materials except Subsection 903-2.02 Posts and Braces and Subsection 903-2.04 Fencing Wire. Posts, braces and fencing wire will be sampled and tested in accordance with methods used by the Agency and will require written approval by the Engineer prior to being incorporated into the work.

903-2.02 Posts and Braces. Line posts shall conform to the requirements of ASTM A 702. Lengths of posts shall be as shown on the plans. Packaging of posts will not be required. The type of post furnished, tee, channel, or U or Y type, shall be the same on any one project.

End, corner, pull, latch, and gate posts and braces shall conform to the requirements of ASTM A 702, for uprights and braces.

Posts and braces shall be painted green.

903-2.03 Concrete. Concrete for post footings shall be utility concrete conforming to the requirements of Section 922.

903-2.04 Fencing Wire.

(A) Barbed Wire. Barbed wire shall be 12-1/2 gauge (*2.51 millimeters*) steel wire with 4 point, 14 gauge (*2.03 millimeters*) barbs, spaced five inches (*127 millimeters*) apart and shall be either zinc coated or aluminum coated. Zinc coated steel wire shall conform to the requirements of ASTM A 121, Class 1 coating. Aluminum coated steel wire shall conform to the requirements of ASTM A 585, Type I, Class 1 coating.

(B) Barbless Wire. Barbless wire shall meet the same requirements as barbed wire, except that the barbs shall be omitted.

(C) Woven Wire Fabric. Woven wire fabric shall be either zinc coated or aluminum coated. Zinc coated woven wire shall conform to the requirements of ASTM A 116 for No. 11 (*3.05 millimeters diameter*) Farm, Class 1 coating with fabric stay wires 6 inches

(*150 millimeters*) apart. Aluminum coated woven wire shall conform to the requirements of ASTM A 584, for No. 11 (*3.05 millimeters diameter*) Farm, Class 2 coating with fabric stay wires 6 inches (*150 millimeters*) apart.

903-2.05 Stays and Fasteners. Stays shall be 9-1/2 gauge (*3.6 millimeters*) twisted wire designed for screw-on type installation. Stays shall be zinc coated steel of good commercial quality. The minimum weight of zinc coating shall be 0.3 ounce per square foot (*92 grams per square meter*) of uncoated wire surface.

Tie wires, hog rings and post clips shall be zinc coated steel of good commercial quality and shall be of the same gauge as the fence fabric being fastened.

The minimum weight of zinc coating shall be 0.3 ounce per square foot (*92 grams per square meter*) of uncoated wire surface.

903-2.06 Gates.

(A) Type 1 Gate. Gates shall conform to the requirements of Subsection 902-2.09, except as specified herein.

Gates greater than five feet (*1.5 meter*) in width shall have a vertical member installed at the midway point of the gate.

Fabric for the gates shall be either chain link fence fabric or woven wire fabric. Chain link fence fabric shall conform to the requirements of Subsection 902-2.04 for fabric using 11 gauge (*3.05 millimeters*) wire. Woven wire fabric shall be of the same kind used for the adjoining woven wire fence. When the adjoining fence is barbed wire fence, gate fabric shall be of the kind used with Type 2 woven wire fence.

Gates shall be hung by at least two steel, ductile iron or malleable iron hinges, so designed as to securely clamp to the type of gate post furnished and permit the gate to be swung back against the fence.

Gates shall be provided with a combination steel, ductile iron or malleable iron catch and locking attachment which will not rotate around the latch post. Stops to hold gates open shall be provided where required.

(B) Type 2 Gate. Type 2 gates shall be constructed so that each line of wire will be securely attached to the gate post and to the latch board. The three vertical wire stays, placed within the gate, shall be equally spaced. Above the top fence wire and below the bottom fence wire, a double strand of steel wire shall be placed around the latch post forming loops of such size that they will accept the ends of the latch board. A pry stick shall be sewed to the gate post so as to draw the fence to a taut condition when closed.

The latch board and pry stick assembly shall be made of wood or of steel. Wood shall be clear select Douglas fir, 1-1/2 inch (*38 millimeters*) by 1-1/2 inch (*38 millimeters*) by 4 feet (*1.2 meters*) for the latch board and 1-1/2 inch (*38 millimeters*) by 1-1/2 inch (*38 millimeters*) by 2 feet (*600 millimeters*) for the pry stick. Steel latch board and pry stick shall be fabricated from the same type of steel utilized for line posts. The dimensions for wood products are the minimum actual dimensions, not nominal.

903-3 CONSTRUCTION DETAILS

903-3.01 General. Wire fence and gates shall conform to Arizona Department of transportation Standard Drawing C-12.10. The type of wire fence and gate(s) shall be as shown on the project plans.

In areas where there is livestock, the contractor shall take all measures necessary to restrict the livestock to the land where it is being kept when such measures are made necessary by the removal of existing fences, gates or cattle guards during the performance of the contractor's work. The contractor shall furnish all materials and construct temporary fence, gates and cattle guards as may be necessary to restrict the livestock, as specified.

Existing fences that are to remain in place and which have been damaged by the contractor's operations shall be replaced or restored by the contractor at no additional cost to the Agency, in accordance with the provisions of Subsection 107-12.

The contractor shall clear the fence lines of all earth, trees, brush and other obstructions which interfere with the proper construction of the fences, unless the Engineer orders certain trees to remain in place. Clearing the fence line shall be within any right-of-way or easement. Disposal of removed material shall be in accordance with the requirements of Subsection 201-3.01.

Fence shall be constructed within the public rights-of-way or easements as shown on the plans.

903-3.02 Setting Fence. Fence posts shall be spaced at the intervals and set to the depths shown on the plans.

In determining the post spacing, measurements shall be made parallel to the ground slope, and all posts shall be placed in a vertical position, except in unusual locations where the Engineer may direct that the posts be set perpendicular to the ground surface.

Line posts may be driven into undisturbed earth provided driving does not injure the posts. All voids around the post shall be backfilled and the material thoroughly tamped.

End, corner, pull, latch and gate posts and braces shall be set in concrete footings, crowned at the top to shed water.

Any high points which interfere with the placing of wire fence fabric shall be excavated to provide the clearance shown on the plans.

Changes in the horizontal alignment of the fence line where the angle of deflection is 15 degrees or more shall be considered as corners and a corner post assembly shall be installed. Changes in fence alignment where the angle of deflection is less than 15 degrees, but more than 5 degrees, shall be considered as alignment angles and diagonal tension wires shall be installed. The diagonal tension wires shall consist of two twisted steel wires and shall be attached to the adjacent line posts.

Where the fence line intersects a cross fence, the wires of the existing cross fence shall connect to an end post assembly as shown on the plans.

Connecting fence assemblies, with braces for every direction of strain, shall be placed at the junction with new fences.

Intermediate post assemblies shall be installed at not more than 650 foot (*200 meters*) intervals between other braced posts, but for woven wire fence, the spacing shall be such as to use standard rolls of fabric with a minimum of cutting and waste. After post assemblies have been placed, the barbed wire and woven wire fabric shall be pulled taut to the satisfaction of the Engineer, and each longitudinal wire shall be cut and securely fastened to the braced post with devices customarily used for the purpose. Barbed wire or woven wire fabric shall not be carried past a post assembly, but shall be cut and fastened to the post independently of the adjacent spans. A maximum of two splices on barbed wire will be permitted between post assemblies, but not on the same wire. No splice shall be placed closer than 100 feet (*30 meters*) to any post assembly.

Where fence lines are interrupted by openings for gates and cattle guards, intermediate post assemblies shall be installed at both sides of the opening, at a distance of one panel width from the end of the opening.

After the tensioning of the barbed wire or woven wire fabric between two posts assemblies, all longitudinal wires shall be attached to each intervening line post at the height and spacing shown on the plans. The distance from the bottom wire to the ground may vary, at any one point from that shown on the plans, 4 inches (*100 millimeters*) plus or minus for barbed wire fence and game fence, and 1 inch (*25 millimeters*) plus or minus for woven wire fence. Where abrupt changes occur in the fence line grade, intermediate line posts may be required to maintain proper distances between the bottom wire and the ground.

Spacing of the twisted vertical wire stays shall be as shown on the plans for each type of fence. The vertical wire stays shall be woven into every horizontal wire for each type of fence.

At all grade depressions, where stresses tend to pull the posts from the ground, the affected fence posts shall be anchored in concrete or the fence wires shall be weighted with concrete sag weights. The volume of concrete required to anchor the posts shall be not less than 1 cubic foot (*0.03 cubic meter*). Fence sag weights shall weigh not less than 100 pounds (*45 kilograms*) and shall be made with a wire loop hanger embedded in the concrete. A double strand of wire shall be attached to each horizontal line of barbed wire and to the top and bottom wire of the woven wire fabric and tied to the wire loop hanger of the sag weight.

903-3.03 Flood Gates. Flood gates shall be constructed at the locations specified on the project plans or where designated by the Engineer and in accordance with the details shown on the project plans. If the length of the flood gate is such that the Engineer determines that line posts are needed, the posts shall be placed as necessary and driven to the depth required to keep the flood gate upright.

Flood gates shall be constructed to the same requirements specified for barbed wire fence construction, except that the concrete sag weights shall weigh 35 pounds (*16 kilograms*).

903-4 METHOD OF MEASUREMENT

Wire fence will be measured by the linear foot (*meter*) of each type of fence specified. Measurement will be made along the top of the completed fence from outside to outside of end posts, excluding the widths of gate and cattle guard openings. Gate posts and latch posts will be considered as included in the measurements of the completed fence.

Type 1 gates will be measured as a complete unit, in place, by the width of the gate opening. Double gates will be measured as one complete unit by the width of the gate opening. A gate unit, complete-in-place, shall include the gate with all necessary fittings, hardware, and gate bracing.

Type 2 gates will be measured as a complete unit, in-place, of the width of the gate opening. A gate unit complete-in-place shall include the wire gate with vertical stays, latch board and pry stick.

Flood gates will be measured by the linear foot (*meter*). Measurement will be made on the fence line along the top wire from gate post to gate post as shown on the plans, but exclusive of any Type 2 gates.

903-5 BASIS OF PAYMENT

The accepted quantities of wire fence and flood gates, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*) for the type of fence and gate designated in the bidding schedule, complete-in-place.

Type 1 and Type 2 gates, measured as provided above, will be paid for at the contract unit price per gate for the type designated in the bidding schedule, complete-in-place.

No payment will be made for furnishing materials and constructing temporary fence, gates and cattle guards as may be necessary to restrict livestock.

SECTION 905

GUARDRAIL

905-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing new guardrail, reconstructing existing guardrail, or constructing guardrail from salvage, all at the locations and in accordance with the details shown on the plans and the requirements of these specifications.

905-2 MATERIALS

Materials for guardrail shall conform to the requirements of Section 1012.

Prismatic guardrail reflector tabs and prismatic guard-rail-mounted barrier markers shall conform to the requirements of Section 1008. The body of the prismatic guardrail reflector tabs shall have a minimum thickness of 3/16 inch (*5 millimeters*) and be either galvanized steel or ultraviolet-resistant plastic. Prismatic reflectors shall be 3-1/4 inches (*85 millimeters*) in diameter, and shall be secured to the body in accordance with the manufacturer's recommendations. Prismatic guard-rail-mounted barrier markers shall be ultraviolet-resistant, and shall have a trapezoidal-shaped body in accordance with ADOT Standard Drawing 4-M-10.01.

Post-mounted L-shaped barrier markers, and flexible guardrail markers shall be made of a high quality, impact and ultraviolet resistant, flexible, white-colored plastic or similar material with a minimum thickness of 3/16 inch (*5 millimeters*). This material shall be configured into a rectangular body that is flat, curvilinear or tubular with a width between 3 and 4 inches (*75 and 100 millimeters*). The minimum reflective area for L-shaped post-mounted barrier markers shall be 10 square inches (*645 square millimeters*). The reflectorized surface for flexible guardrail markers shall be 3 inches wide by 5 inches long (*75 millimeters by 125 millimeters*).

Guardrail delineator material shall be specifically manufactured to provide roadside delineation. All delineators shall consist of complete units that are precut, pre-drilled as applicable, and ready to be installed in the field. The delineators shall be packaged in such manner as to prevent damage and deterioration during shipping and storage.

905-3 CONSTRUCTION DETAILS

905-3.01 General. Guardrail types and details shall conform to those found in the Arizona Department of Transportation Standard Drawings. The construction of the various types of guardrail shall include the assembly and erection of all component parts complete at the locations shown on the project plans. The same type of post shall be used in any one continuous length of guardrail.

All metal work shall be fabricated in the shop. No punching, drilling, cutting or welding shall be done in the field, except as provided for under Subsections 905-3.04 and 905-3.05. All metal cut in the field shall be cleaned and painted in accordance with Section 1002.

Where field cutting or boring of wood posts and blocks is permitted, the affected areas shall be thoroughly swabbed with at least two applications of the same type of wood preservative as initially used.

Where wood posts with rectangular sections are used, the posts shall be set so that the longest dimension is perpendicular to the rail.

Where post is to be set in concrete, the concrete shall be placed against undisturbed material in the excavated hole. Before the post is set in the hole, a 1-1/2 inch (*13 millimeters*) thickness of polystyrene material shall be placed to cover all sides and corners of the embedded portion of the post for the full depth of the concrete. The polystyrene material shall not be nailed or clipped to the post, but shall be held against the post in a manner approved by the Engineer.

All bolts shall extend beyond the nuts a minimum of two threads, except that bolts on posts adjacent to pedestrian traffic shall be cut off flush to the nut. Bolts extending more than 2 inches (*50 millimeters*) beyond the nut shall be cut off so as to be less than 1/2 inch (*13 millimeters*) beyond the nut.

Unless otherwise shown on the plans, bolts shall be torqued as follows:

Diameter of Bolt, Inches	(*Metric*)	Torque, Foot – Pounds	(*Newton Meters*)
5/8	(*M 16*)	45 – 50	(*61–68*)
3/4	(*M 20*)	70 – 75	(*95–102*)
7/8 or larger	(*M 22*)	120 – 125	(*163–169*)

All bolts, other than those specified to be torqued, shall be securely tightened.

Guardrail elements shall be spliced by lapping in the direction of traffic in the nearest adjacent lane.

Reflectorized tabs shall be installed on posts at the locations shown on the plans and spaced at a maximum interval of 37-1/2 feet (*11.4 meters*). The slotted part of the tab shall be installed under the mounting bolt head so that the reflectorized surface of the tab faces oncoming traffic. The exposed ends of the slotted part of the tab shall be bent up against and then over the top of the bolt head. Silver faced tabs shall be installed on the right hand side of all roadways and yellow faced tabs shall be installed on the left hand side of both one-way roadways and divided roadways.

When guardrail is being constructed, or reconstructed under traffic, the contractor shall conduct his operations so as to constitute the least hazard to the public. All guardrail work shall be performed in the direction of traffic flow. Traffic control shall be provided in accordance with the requirements of Section 701.

905-3.02 Roadway Guardrail. Guardrail posts shall be set to the line and grade established by the Engineer and spaced as shown on the plans.

Wood and steel posts shall either be driven, or placed in manually or mechanically dug holes; however, driven posts will not be permitted at locations where damage to the curb, gutter, sidewalk, buried items, shoulders or pavement might occur. The Engineer will be the sole judge as to whether driving of posts will be allowed. Driving of posts shall be accomplished in a manner which will prevent battering, burring, separation of the galvanizing from the steel or distortion of the post. Any post which is bent or otherwise damaged to the extent it is unfit for use in the finished work, as determined by the Engineer, shall be removed and replaced at no additional cost to the Agency.

Pre-punched pilot holes may be required where wood posts are driven. Pilot holes will not be required where steel posts are driven.

Where pavement is disturbed in the construction of guardrail, the damaged surfacing shall be repaired as approved by the Engineer. Where the top surface of a culvert or other item is at an elevation which would interfere with full depth post placement, the post shall be placed and anchored in accordance with the requirements of Subsection 905-3.06.

Except where a concrete foundation for a post is required, the space around and under the posts placed in manually or mechanically dug holes shall be backfilled with moist soils placed in compacted lifts as approved by the Engineer.

Wood blocks shall be toenailed to the wood post with one 16 penny galvanized nail on each side of the top of the block. Wood or steel blocks shall be set so that the top of the block is no more than 1/2 inch (*13 millimeters*) above or below the top of the post, unless otherwise shown on the project plans.

Rail elements shall be spliced at 25 foot (*7.6 meters)* intervals or less. Rail elements shall be spliced at posts unless otherwise shown on the project plans. Where steel posts and blocks are used, back-up plates shall be installed at each post, except at posts where splices are made. Rail elements at joints shall have full bearing. When the radius of curvature is 150 feet (*46 meters*) or less, the rail elements shall be shop curved.

905-3.03 Guardrail Anchor Assembly. Installation of guardrail anchor assembly shall be as shown on the plans. Concrete footings shall be poured against moist, undisturbed earth. The top of all footings shall be flush with the ground line and shall be steel troweled to a smooth finish with a slope to drain away from the post. Immediately after placing concrete footings, at least 4 inches (*100 millimeters*) of loose moistened earth which is free of clods or gravel shall be placed over the footing or the footing shall be sprayed with an approved liquid membrane curing compound. After the footing has cured, earth material together with any excess excavated material shall be removed and disposed of as approved by the Engineer.

905-3.04 Construct Guardrail from Salvage. Salvaged guardrail, guardrail transitions, anchor assemblies, and other guardrail systems shall be constructed at the locations shown on the project plans and in accordance with the provisions specified herein for new guardrail.

If any salvaged materials are deemed by the Engineer, to be unsuitable for reuse or if the quantities of salvaged materials are insufficient to complete the work, the contractor shall furnish new materials in sufficient quantities to complete the work and the cost of furnishing such materials will be paid for in accordance with the provisions found in Subsection 109-5.

Where new bolt holes in rail elements are required, the holes shall be made by drilling or punching. Flame-cut bolt holes will not be permitted.

905-3.05 Reconstruct Guardrail. Existing guardrail, guardrail transitions, anchor assemblies and other guardrail systems shall be removed as required, and reconstructed at the locations shown on the project plans, and in accordance with the provisions specified herein for new guardrail.

All guardrail components requiring removal shall be removed in such a manner as to prevent damage to and minimize the loss of the components.

If any materials designated for reconstruction are deemed by the Engineer to be unsuitable for reuse or if the quantities of existing materials are insufficient to complete the work, the contractor shall furnish new materials in sufficient quantities to complete the work and the cost of furnishing such materials will be paid for in accordance with the provisions of Subsection 109-5.

Items designated to be reused which are lost, damaged or destroyed as a result of the contractor's operations shall be repaired or replaced by the contractor at no additional cost to the Agency.

Existing posts, blocks, rail elements or hardware which are not required for guardrail reconstruction or which the Engineer deems unsuitable for reconstruction, shall be removed and disposed of as directed by the Engineer.

Where new bolt holes in rail elements are required, the holes shall be made by drilling or punching. Flame-cut bolt holes will not be permitted.

905-3.06 Bolted Guardrail Anchors.

Bolted guardrail anchors shall consist of bolting two steel brackets to the shortened post and to the box culvert roof as shown on the plans.

Where the elevation of the top surface of a culvert or other similar installation prevents the placement of a post of the specified length, the posts shall be shortened and anchored in accordance with the details shown on the plans.

905-3.07 Rub Rail. Rub rail shall be installed in accordance with the details shown on the plans.

905-3.08 Guardrail Transitions. Guardrail transitions to concrete barriers shall be constructed in accordance with the details shown on the plans.

905-4 METHOD OF MEASUREMENT

The limits of measurement for the various guardrail items are shown on the plans. Guardrail, of the type shown on the project plans, will be measured by the linear foot (*meter*) along the face of the rail element from center to center of end posts, exclusive of guardrail anchor assemblies, and guardrail transitions.

Guardrail anchor assemblies, and guardrail transitions will be measured by the unit each.

Bolted guardrail anchors will be measured by the unit for each post anchored as shown on the plans. One unit will consist of the cut and fitted guardrail post, brackets and hardware.

Rub rail will be measured by the unit for each rail installed.

Constructing the various types of guardrail from salvage will be measured by the linear foot (*meter*) or by the unit each, using the limits of measurement specified for new construction.

Reconstructing the various types of guardrail will be measured by the linear foot (*meter*), or by the unit each, using the limits of measurement specified for new construction.

905-5 BASIS OF PAYMENT

The accepted quantities of guardrail, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*) for the types of guardrail installation designated in the bidding schedule, complete in place, including excavation, backfill and disposal of surplus material.

The accepted quantities of guardrail anchor assemblies, measured as provided above, will be paid for at the contract unit price for the type designated in the bidding schedule, complete in place, including excavation, backfill, disposal of surplus material, and furnishing and placing concrete for post footings.

The accepted quantities of construct guardrail from salvage, or reconstruct guardrail, measured as provided above, will be paid for at the contract unit price, complete in place, including excavation, backfill and disposal of surplus or unusable materials.

The contractor will be paid in accordance with the provisions of Subsection 109-5 for furnishing new posts, blocks, rail elements or hardware to replace components deemed by the Engineer unsuitable for reuse, or to supplement insufficient existing quantities for reconstructing the various types of guardrail, or for constructing the various types of guardrail from salvage.

The accepted quantities of bolted guardrail anchors, measured as provided above, will be paid for at the contract unit price each. The unit price paid for bolted guardrail anchors shall be for the work, complete-in-place, including excavation, backfill, removing and replacing surfacing, cutting and fitting steel beam posts or timber posts, and drilling anchor bolt holes in steel and timber posts, and disposal of surplus materials.

The accepted quantities of rub rail, measured as provided above, will be paid for at the contract unit price each, complete in place, including rub rail terminal, splice plate, blocks and hardware as required.

The accepted quantities of guardrail transitions to concrete barriers, measured as provided above, will be paid for at the contract unit price, complete in place, including guardrail, posts, blocks, hardware and terminal connection and excavation, backfill and disposal of surplus material.

SECTION 906

CATTLE GUARDS

906-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing new cattle guards or reconstructing existing cattle guards at the locations and in accordance with the details shown on the project plans or designated by the Engineer, and the requirements of these specifications.

906-2 MATERIALS

906-2.01 Concrete. Concrete shall be Class B and shall conform to the requirements of Section 1006.

906-2.02 Steel. Reinforcing bars and structural steel shall conform to the requirements of Section 1003 and Section 1004, respectively. ASTM A570/570M, Grade 40 steel may be used as an alternate to ASTM A36A 36M steel for fabrication of cattle guard rails.

906-2.03 Fencing. Fence posts and braces shall conform to the requirements of Sections 902 and 903.

906-2.04 Backfill. Backfill material shall conform to the requirements of Subsection 203-5.

906-2.05 Wood. Wooden shims shall conform to the requirements shown on the plans.

906-3 CONSTRUCTION DETAILS

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5.

Completed cattle guards shall be well drained and shall minimize collecting or ponding runoff.

Cattle guards shall be cast-in-place concrete or, at the option of the contractor, may be precast units. The requirements for precast units may be found in the Special Provisions.

Cattle guards shall be constructed in accordance with the details shown on the plans and in reasonably close conformity to the lines and grades established or shown on the project plans. All fence and steel gates required shall be constructed as specified under Section 902 or Section 903, as applicable.

Painting of structural steel shall be in accordance with the requirements of Section 610. Structural steel shall be painted with one coat of Paint No.1. Painting of fence posts and gates shall be in accordance with the requirements of Section 902 or Section 903, as applicable.

Existing cattle guards designated on the project plans for reconstruction shall be dismantled to the extent required and in such a manner as to preserve all materials or portions of the existing structure that are acceptable for use in the reconstructed structure. All removed concrete shall be disposed of in accordance with the requirements of Subsection 202-3.03 (A).

Cattle guards to be reconstructed shall be constructed as specified herein, except that the materials required shall be salvaged to the extent possible from the existing cattle guards designated on the plans to be reconstructed or removed.

Steel angles providing a bearing surface for each grille unit of a roadway cattle guard and wooden shims under railroad cattle guards shall be set to the required elevations with sufficient accuracy that no rocking, under load, of a grille unit or tread assembly can be observed and that no gap greater than 1/32 of an inch (*1 millimeter*) exists between any pair of bearing surfaces when the unit or assembly is not under load and is not spiked, welded or otherwise held in place.

The fabrication and connections of grille units, angle units, and other steel elements shall conform to the requirements of Section 604. Either H-10 (M-9) or H-20 (M-18) loading will be designated on the project plans.

906-4 METHOD OF MEASUREMENT

Cattle guard, and reconstruct cattle guard will be measured as a unit for each structure.

Cattle guards consisting of a different number of grille units, different "H" ("M") loadings, different widths, or being new instead of reconstructed will be measured separately.

906-5 BASIS OF PAYMENT

The accepted quantities of cattle guards and reconstruct cattle guards, measured as provided above, will be paid for at the contract unit price each, complete-in-place, including excavation, grading to drain, structure backfill, structural steel, reinforcing steel, grilles, concrete, painting, wood shims and concrete slabs where required.

Payment for fence or gates will be made as specified under Section 902 or 903, except that posts and braces attached to the cattle guard shall be considered as included in the cost of the cattle guard.

SECTION 908

CONCRETE CURBS, GUTTERS, SIDEWALKS AND DRIVEWAYS

908-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing Portland cement concrete curb, curb and gutter, ramp curb, wedge curb, sidewalk, driveways, and valley gutters at the locations in accordance with the details shown on the project plans and the requirements of these specifications.

Work under this item shall also include furnishing all materials and constructing portland cement concrete handicap ramps, cut-off walls and headers in accordance with the locations and details indicated on the project plans and the requirements of these specifications.

908-2 MATERIALS

908-2.01 Concrete. Concrete shall conform to the requirements of Section 1006 for Class B concrete.

908-2.02 Expansion Joint Filler. Expansion joint filler shall be 1/2-inch (*13 millimeters*) bituminous or nonbituminous preformed strips conforming to the requirements found in Section 1011.

908-2.03 Welded Wire Fabric. Welded wire fabric shall conform to the requirements found in Section 1003.

908-2.04 Concrete Curing Compound. Curing compound shall be liquid membrane-forming compound conforming to the requirements of AASHTO M 148, Type I, Class A, or as otherwise approved by the Engineer.

908-3 CONSTRUCTION DETAILS

The subgrade shall be constructed in reasonably close conformity to the lines and grades established or shown on the project plans.

Prior to placing concrete curb, curb and gutter, wedge curb, sidewalk, driveway, valley gutter, handicap ramp, cut-off wall, or header, the material on which they are to be placed shall be compacted to a depth of at least 6 inches (*150 millimeters*) and to a density of not less than 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual as directed and approved by the Engineer.

All unstable or unsuitable material shall be removed to a depth of not less than 6 inches (*150 millimeters*) below subgrade and replaced with material approved by the Engineer.

Single curb, curb and gutter, wedge curb, and sidewalk shall be constructed either by the use of conventional fixed forms or by slip-form curb and sidewalk placing machines.

Weather and temperature limitations for the placement of concrete shall be in accordance with the requirements of Subsection 1006-5.

Forms shall be maintained at all times in good condition as to accuracy of shape, strength, rigidity, and smoothness of surface. The depth of face forms for concrete curbs shall be equal to the full face height of the curb. All other forms shall be set to form the full depth of all edges not formed by adjacent concrete. Forms unsatisfactory in any respect shall not be used.

Forms shall be set in reasonably close conformity to the dimensions, lines, and grades shown on the project plans or established by the Engineer and be securely staked in position. Clamps, spreaders, and braces shall be used where required to insure rigid forms.

When the roadway section slopes away from the gutter, the slope of the gutter shall be formed to match the roadway cross slope.

Unless otherwise indicated on the plans or in the special provisions, concrete sidewalks in pedestrian areas shall be 4 inches (*100 millimeters*) in thickness while concrete sidewalks which parallel depressed curbs or cross driveway entrances shall be 6 inches (*150 millimeters*) in thickness.

When specified on the plans or in the special provisions, welded wire fabric shall be used in driveways and in sidewalk areas which parallel depressed curbs or cross driveway entrances.

The subgrade and forms shall be watered immediately in advance of placing concrete. Concrete shall be placed in the forms and thoroughly consolidated, working the coarse aggregate away from the faces of the forms. The concrete shall be consolidated by means of approved mechanical vibrators or by tamping or spading by hand. The fresh concrete shall be struck off so the surface will be at the proper elevation when the concrete is consolidated. Concrete shall be thoroughly worked so that the coarse aggregate is below the surface and the mortar comes to the top. The surface shall then be finished to grade and cross-section with a float, troweled smooth and then given a final fine brush finish. The exposed edges shall be tooled to a 1/4 inch (*6 millimeters*) radius unless a larger radius is indicated on the plans. When concrete placed in curb forms has set sufficiently so that it will not slump, the front face form shall be removed. The gutter, front face, and top of curb shall be troweled smooth and then given a final fine brush finish with brush strokes parallel to the lines of curb and gutter. The exposed edges shall be tooled to a 1/4 inch (*6 millimeters*) radius.

The contractor shall form the uppermost 6 inches (*150 millimeters*) of concrete headers and 12 inches (*300 millimeters*) of concrete cut-off walls which do not abut pavement. Where headers and cut-off walls abut existing pavement, the pavement shall be sawed to its full depth to provide a straight, uniform, vertical surface

against which the concrete will be placed. All other requirements for forming and finishing headers and cut-off walls shall comply to those of concrete curbing as specified herein.

Expansion joints shall be constructed at tangent points or curb returns, at structures, and at a maximum of 40 foot (*12 meters*) intervals for sidewalks and 60 foot (*18 meters*) intervals for curb and curb and gutter. Expansion joints shall be constructed between sidewalks and driveways, between sidewalks and abutting structures, around poles, posts, boxes, and other fixtures that protrude through the sidewalk. Expansion joints shall match as nearly as possible the joints in the adjacent pavement or existing concrete curb and sidewalk. Joint filler shall be placed vertically and extend full depth beginning 3/16 inch (*5 millimeters*) below the surface of the concrete being placed. During the placing and tamping of concrete, the filler shall be restrained in its proper position. Edges of the concrete at expansion joints shall be tooled to a 1/4 inch (*6 millimeters*) radius.

Contraction joints (weakened-plane joints) shall be constructed at a maximum of 15 foot (*4.6 meters*) intervals in curb and gutter and sidewalks and shall coincide with contraction joints in adjacent pavement or existing concrete curb and sidewalk. A contraction joint shall be constructed along the center of driveway entrances 20 feet (*6 meters*) in width or greater. Longitudinal contraction joints shall be constructed in the center of sidewalk having a width greater than 7 feet (*2 meters*). Contraction joints shall either be formed or sawed. Formed contraction joints shall be constructed by parting the large aggregates in the fresh concrete with a straightedge to a depth of 2 inches (*50 millimeters*). The final joint finishing shall be accomplished with a jointer tool having a radius of 1/4 inch (*6 millimeters*) and leaving a finished joint depth of a minimum of 3/4 of an inch (*19 millimeters*). Sawed joints shall be sawed to a depth of 2 inches (*50 millimeters*) or one-third the thickness of the concrete, whichever is greater.

Scoring lines, where required, shall have a minimum depth of 1/4 inch (*6 millimeters*) and a radius of 1/8 inch (*3 millimeters*). Where longitudinal scoring lines are required, they shall be parallel to, or concentric with, the lines of the work.

Forms shall be thoroughly cleaned each time they are used and shall be coated with a light oil as required to prevent the concrete from adhering to them.

If slip-form equipment is used to construct curb and gutter and sidewalk, such equipment shall be designed specifically for the work. The Engineer may require the contractor to demonstrate that the specific equipment he proposes to use is capable of satisfactorily placing the concrete mix. If at any time, the placement results are not satisfactory to the Engineer, the use of the slip-form equipment shall be discontinued. All applicable requirements of construction by use of fixed forms shall apply to the use of slip-form equipment.

The slip-form equipment shall be controlled as to line and grade by means of automatic sensing and control devices such that the machine automatically senses and follows either a taut guide line or other reference, performing any necessary corrective maneuvers required to establish the proper grade and alignment. The contractor shall set the guide line from survey marks provided by the Engineer.

Immediately following the required finishing operations, one or more applications of curing compound shall be applied to all exposed surfaces. The curing compound shall be applied at the rate of not less than 1 gallon per 150 square feet (*0.3 liters per square meter*) of surface area, and in such manner as to entirely cover and seal all exposed surfaces of concrete with a uniform film.

The surface of concrete sidewalk shall be tested with a 10 foot (*3 meters*) straightedge. Any deviation in excess of 1/4 of an inch (*6 millimeters*) shall be corrected at no additional expense to the Agency.

The face, top, back, and flow line of the curb and gutter shall be tested with a 10 foot (*3 meters*) straightedge or curve template, longitudinally along the surface. Any deviation in excess of 1/4 of an inch (*6 millimeters*) shall be corrected at no additional expense to the Agency.

No vehicular traffic will be allowed on driveways until the concrete has reached at least 60 percent of the required 28-day strength.

Before acceptance of the work, all concrete curb, curb and gutter, wedge curb and sidewalk shall be cleaned of all discolorations resulting from the contractor's operations, including, but not limited to, dirt, stains, bitumens, and equipment tire marks. Cleaning may be by abrasive blast methods or by other methods approved by the Engineer.

908-4 METHOD OF MEASUREMENT

Concrete single curb, wedge curb and curb and gutter will be measured by the linear foot (*meter*) along the flow line. Lengths occupied by catch basins will be excluded from the measurement.

Concrete sidewalks, driveways, and valley gutter will be measured by the square foot (*square meter*) of area constructed. Areas occupied by catch basins will be excluded from the measurement.

Concrete handicap ramps will be measured by the unit, complete-in-place.

Concrete headers and cut-off walls will be measured by the linear foot (*meter*) of length for each depth or width of cut-off wall.

908-5 BASIS OF PAYMENT

The accepted quantities of concrete single curb, curb and gutter, valley gutter, sidewalk, driveway, handicap ramp, header, and cut-off wall, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), square foot (*square meter*), or each, which price shall be full compensation for the item, complete-in-place, including furnishing and placing embankment material, excavating, backfilling, grading, and compacting.

The removal of unstable or unsuitable subgrade material, as directed by the Engineer, shall be paid for in accordance with the provisions of Subsection 109-5.

SECTION 909

SURVEY MONUMENTS

909-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and installing concrete monuments, including solid brass, one-piece, monument markers; cast iron frames and covers; furnishing cast iron frames and covers; or removing and resetting existing frames and covers at the locations and in accordance with the details shown on the plans and the requirements of these specifications.

909-2 MATERIALS

909-2.01 Concrete. Concrete shall be utility concrete conforming to the requirements of Section 922.

909-2.02 Frames and Covers. Frames and covers shall conform to the requirements of Subsection 505-2.05.

909-2.03 Standard Markers. Markers shall be as shown on Standard Detail 103 and shall be furnished by the contractor. When applicable, markers shall be stamped with the registration number of the responsible surveyor registered in the State of Arizona. Markers shall also be stamped with a brief description of the point being marked.

909-3 CONSTRUCTION DETAILS

909-3.01 Survey Monuments. Excavation for new monuments shall be at the locations and the depths designated on the plans. The monuments shall then be set, backfilled with suitable material and the fill tamped into place to provide a stable, secure installation. The concrete base, cast iron frame, bituminous mix and cover shall then be placed as detailed on the plans. The frame and cover shall be installed in a manner similar to that required under Subsection 505-3.01.

909-3.02 Frames and Covers. New frames and covers shall be installed as specified under Subsection 909-3.01.

909-3.03 Reset Frames and Covers. Existing frames and covers to be reset shall be carefully removed and reset as specified under Subsection 909-3.01; however, at the contractor's option and with approval of the Engineer, adjustable extension rings conforming to the requirements of Subsection 505-3.03 may be used. Frames and covers broken or damaged in removing and resetting shall be replaced at the contractor's expense.

909-4 METHOD OF MEASUREMENT

Survey monuments will be measured as a unit for each survey monument, including frame and cover; for each frame and cover; or for each existing frame and cover removed and reset as specified in the project plans.

909-5 BASIS OF PAYMENT

The accepted quantities of survey monuments, frame and cover for survey monument, and reset frame and cover for survey monument, measured as provided above, will be paid for at the contract unit price each, complete-in-place, including excavation and backfill.

SECTION 910

CONCRETE BARRIERS

910-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing portland cement concrete barriers at the locations and in accordance with the details shown on the project plans and the requirements of these specifications.

910-2 MATERIALS

910-2.01 Concrete. Unless otherwise shown on the plans, concrete shall be Class S portland cement concrete conforming to the requirements of Section 1006 with a compressive strength of at least 3000 pounds per square inch (*20.7 mega pascals*) at 28 days.

910-2.02 Reinforcing Steel. Reinforcing steel shall be in accordance with the requirements of Section 1003.

Dowels for the joints of cast-in-place barrier with fixed forms and those for precast barrier shall be corrosion resistant coated dowel bars conforming to the requirements of AASHTO M 254, Type A.

910-2.03 Grout. Grout for pressure grouting the joints of precast barrier shall conform to the requirements of Subsection 602-2.03.

Grout for the bedding of precast barrier shall conform to the requirements of Subsection 913-2.04.

910-2.04 Joint Sealant. Joint sealant for slip-formed or extruded barrier shall be a latex sealing compound conforming to the requirements of ASTM C 834, applied as recommended in ASTM C 1193.

910-3 CONSTRUCTION DETAILS

910-3.01 General. Unless otherwise required by the project plans and specifications, concrete barrier shall be constructed by any of the following methods or combinations thereof, at the contractor's option:

Cast-in-place by slip-form or extrusion

Cast-in-place by fixed forms

Precast

Concrete barriers shall present a smooth, uniform appearance in their final position, and conform to the horizontal and vertical lines shown on the project plans or ordered by the Engineer.

When concrete barriers are to be constructed on recently completed bridges, the barriers shall be placed after falsework has been released and as long after superstructure construction as the progress of the work will permit, unless otherwise ordered by the Engineer.

Concrete barriers and concrete barrier transitions which are constructed on bridge structures and retaining walls shall be constructed by cast-in-place, fixed-form methods. Precast or slip-form methods will not be allowed.

Where concrete barrier is not placed on pavement, the supporting material shall be shaped and finished in reasonably close conformity to the lines, grades, and dimensions established by the Engineer or shown on the project plans. The material shall be compacted to at least 95 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

All exposed surfaces shall be given a Class II finish in accordance with the requirements of Subsection 601-3.05. Curing of concrete shall be in accordance with the requirements of Subsection 1006-6.

Barrier markers shall be installed in accordance with the details shown on the plans.

910-3.02 Cast-In-Place by Slip Form or Extrusion.

(A) General. Concrete barriers constructed by using an extrusion machine or similar equipment, shall be well compacted and dense. At the option of the contractor, concrete may be produced using materials continuously batched by volume and mixed in a continuous mixer, in accordance with the requirements of AASHTO M 241, except that sampling, testing, and acceptance of the concrete will be in accordance with the requirements of Section 1006. The contractor may be required to furnish evidence of successful operation of the extrusion machine or other equipment.

Slip form or extruded barrier will be considered not to require additional finishing if the surface meets the requirements for a Class II finish, as described in Subsection 601-3.05, and the alignment is satisfactory. If the extruded barrier does not meet these requirements, operations shall be stopped until adjustments are made to the equipment or the concrete mix that will result in an acceptable finished product. Barrier that cannot be refinished to meet the specifications for a Class II finish shall be removed and replaced at no additional cost to the Agency. Barrier that has unsatisfactory alignment and straightedge tolerance shall be subject to penalty or replaced in accordance with these specifications.

The concrete shall be vibrated, rammed, tamped or worked with suitable equipment until the concrete has been consolidated in order to eliminate voids such as honeycombed surfaces. In

conjunction with said methods of consolidation, the equipment shall be operated under sufficient uniform restraint to the forward motion so as to produce the required consolidation.

The concrete shall be of such consistency that after extrusion it will maintain the shape of the barrier without support.

The grade for the top of the concrete barrier shall be indicated by an offset guide line, set by the contractor from survey marks established by the Engineer. The forming portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine so as to conform to the predetermined grade line. A grade line gauge or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the barrier being placed and the established grade line as indicated by the offset guide line.

In lieu of the above method for maintaining the barrier grade, the extrusion machine may be operated on rails or forms or on existing pavement.

(B)Dimensional Tolerances:

(1) The top of the exposed faces of the barrier shall comply with the following tolerances to be accepted at 100 percent of the unit price bid per linear foot (*meter*).

(a) When a 10 foot (*3 meters*) long straightedge is placed on the top surface of the barrier it shall not vary by more than 1/4 inch (*6 millimeters*) from the straightedge.

(b) When a 10 foot long (*3 meter*) straightedge is placed along the face of the barrier it shall not vary by more than 1/2 inch (*13 millimeters*) from the straightedge.

All other barrier dimensions shall not deviate by more than 1/2 inch (*13 millimeters*) from plan's alignment.

(2) The top and exposed faces of the barrier shall comply with the following tolerances to be accepted at 75 percent of the unit price bid per linear foot.

(a) When a 10 foot (*3 meters*) long straightedge is placed on the top surface of the barrier it shall not vary by more than 1/2 inch (*13 millimeters*) from the straightedge.

(b) When a 10 foot (*3 meters*) long straightedge is placed along the face of the barrier it shall not vary by more than 3/4 inch (*19 millimeters*) from the straightedge.

All other barrier dimensions shall not deviate by more than 3/4 inch (*19 millimeters*) from plan's alignment.

910-3.03 Cast-in-Place by Fixed Forms. Concrete barrier, cast-in-place with fixed forms, shall be constructed and cured in accordance with the requirements of Section 601. If new or like

new metal or wood forms are used and it is apparent, after the forms are stripped, that special care has been taken to produce uniformly textured surfaces with pleasing appearance, the Engineer may waive the additional finishing specified to produce a Class II finish.

The barrier shall be cast in sections of the length shown on the project plans.

After the concrete has cured for 7 days, the joint shall be filled to a depth of at least 1 inch (*25 millimeters*) with joint sealant.

When a 10 foot (*3 meters*) long straightedge is place on the top and along the faces of the barrier, the surface shall not vary more than 1/4 inch (*6 millimeters*) from the straightedge.

910-3.04 Precast. Precast concrete barrier shall be cast in accordance with the requirements of Section 601.

After precast barrier has been approved for use on the project, no additional concrete finishing will be required. Should the finish of precast barrier be marred or damaged as a result of transporting or handling, the Engineer may reject it or allow refinishing to his satisfaction. If refinishing is allowed, the resulting surface shall be of uniform texture and appearance and shall match the adjoining sections.

Each section of barrier shall be set on a layer of fresh and plastic grout at least 1 inch (*25 millimeters*) deep, so that grout is exuded for the full length on both sides of the base as the section is slid and worked to the true line and grade.

After adjacent sections of barrier have been doweled and set firmly in final position, the joint between them shall be filled with joint sealant to a depth of 1 inch (*25 millimeters*), up both sides but not across the top. After the joint sealant has set firmly enough to withstand the grouting pressure, grout shall be forced into the pressure grout hole until it flows from the top of the joint.

When a 10 foot (*3 meters*) long straightedge is placed on the top and along the faces of the barrier, the surface shall not vary more than 1/4 (*6 millimeters*) inch from the straightedge.

910-4 METHOD OF MEASUREMENT

Concrete barrier will be measured by the linear foot (*meter*) along the center line of its top surface.

Concrete barrier transitions will be measured as a unit for each transition constructed in accordance with the project plans.

The measurement of the total length of the concrete barrier will not include any portion noted on the project plans as being within a guardrail transition, or part of the structure of a bridge extending between the stations of the ends of the bridge wing walls located on the same side of the roadway.

910-5 BASIS OF PAYMENT

The accepted quantities of concrete barrier, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*).

The acceptance quantities of concrete barrier transitions, measured as provided above, will be paid for at the contract unit price each, complete-in-place, including excavation and backfill.

No measurement or direct payment will be made for barrier markers, the cost being considered as included in the cost of the concrete barrier, paid either by linear foot (*meter*) or as part of a structure.

SECTION 912

SHOTCRETE

912-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and applying shotcrete on prepared surfaces of channels, ditches, slopes under bridge structures and to other similar construction at the locations and in accordance with the details shown on the plans and the requirements of these specifications.

Shotcrete shall be mortar or concrete conveyed through a hose and pneumatically applied using either the dry mix process or the wet mix process.

The dry mix process shall consist of thoroughly mixing a proportional combination of dry fine aggregate and portland cement; conveying the mixture through a delivery hose to a special nozzle where water is added and mixed with the other materials immediately prior to its discharge from the nozzle. The wet mix process shall consist of premixing by mechanical methods a proportional combination of portland cement, aggregate, and water required to produce mortar or concrete; conveying the mortar or concrete through the delivery hose to the special nozzle where additional compressed air is added at the nozzle prior to its discharge.

912-2 MATERIALS

912-2.01 Portland Cement and Water. Portland cement and mixing water shall conform to the requirements of Subsection 1006-2.

912-2.02 Aggregate.

(A) Fine Aggregate. Fine aggregate shall conform to the requirements of Subsection 1006-2.03(B), except that it shall conform to the following gradation:

Sieve Size	Percent Passing
3/8 inch (*9.5 millimeters*)	100
No. 4 (*4.75 millimeters*)	95-100
No. 8 (*2.36 millimeters*)	80-100
No. 16 (*1.18 millimeters*)	50- 85
No. 30 (*600 micrometers*)	25- 60
No. 50 (*300 micrometers*)	10- 30
No. 100 (*150 micrometers*)	2- 10

(B) Coarse Aggregate. Coarse aggregate shall conform to the requirements of Subsection 1006-2.03 (C), except that it shall conform to the following gradation:

Sieve Size	Percent Passing
1/2-inch (*12.5 millimeters*)	100
3/8-inch (*9.5 millimeters*)	85-100
No. 4 (*4.75 millimeters*)	10- 30
No. 8 (*2.36 millimeters*)	0- 10
No. 16 (*1.18 millimeters*)	0- 5

912-2.03 Admixtures. Admixtures may be used with the premixed mortar or the concrete and shall conform to the requirements of Subsection 1006-2.04.

912-2.04 Reinforcing Steel. Reinforcing steel bars or welded wire fabric shall conform to the requirements of Section 1003.

912-2.05 Expansion Joint Filler. Materials furnished for expansion joint filler shall conform to the requirements of Section 1011.

912-2.06 Water Stops. Materials furnished for water stops shall conform to the requirements of Section 1011.

912-3 CONSTRUCTION DETAILS

912-3.01 Equipment. Equipment for use with the dry mix process shall be capable of metering the fine aggregate-cement mixture into the delivery hose under close control and delivering a continuous, smooth stream of uniformly mixed material at the proper velocity to the discharge nozzle. The nozzle shall be equipped with a manually operated water ring for directing an even distribution of water through the fine aggregate-cement mixture. The water ring shall be capable of ready adjustment to vary the quantity of water.

Equipment for use with the wet mix process shall be the pneumatic feed type; however, a positive displacement type may be used if permitted, in writing, by the Engineer. The pneumatic feed type shall be capable of discharging the premixed mortar accurately, uniformly and continuously through the delivery hose and to the gunning nozzle. The nozzle shall be fitted with an air ring for injecting additional compressed air into the premixed material flow. The size of the delivery hose shall be within the range of 1-1/4 to 2-1/2 inches (*32 to 64 millimeters*).

912-3.02 Air Supply. The air compressor shall have ample capacity to furnish an adequate supply of clean dry air for maintaining sufficient nozzle velocity for all phases of the work while simultaneously operating a blow pipe for clearing away the rebound. The air hose shall be equipped with a filter to prevent any oil or grease from contaminating the shotcrete.

A constant air pressure of not less than 80 pounds per square inch (*550 kilopascals*) shall be maintained in the placing machine when using the dry mix process or at the nozzle when using the wet mix process and when the delivery hose length is 100 feet (*30 meters*)

or less. The pressure shall be increased at least five pounds per square inch (*35 kilopascals*) for each additional 50 feet (*15 meters*) of hose or fraction thereof.

912-3.03 Proportioning and Mixing.

(A) Dry Mix Process. Dry mix material shall consist of one part portland cement to not more than four parts fine aggregate measured either by weight or by volume. The fine aggregate shall contain not less than three percent nor more than six percent moisture by weight.

The cement and fine aggregate shall be thoroughly mixed before being charged into the delivery equipment. If the contractor uses a drum-type mixer, the mixing time shall be not less than one minute. The mixed material shall be utilized promptly after mixing and any material that stands more than 45 minutes will be rejected and removed from the work site.

(B) Wet Mix Process.

(1) Premixed Mortar.

Premixed mortar shall consist of not less than 6.0 sacks of portland cement per cubic yard (*335 kilograms per cubic meter*), fine aggregate and water mixed to a desired consistency, generally to a slump in the range of 1-1/4 to 4 inches (*32 to 100 millimeters*).

The material may be mixed at a central mixing plant or at the project site. If mixing is done at the project site, the mixer shall be capable of thoroughly mixing the specified materials in sufficient quantity to maintain continuous placing of the mortar.

(2) Concrete.

Unless otherwise specified in the Special Provisions, the contractor shall determine the mix proportions and shall furnish concrete for pneumatic placement which contains a minimum of 658 pounds of portland cement (i.e. 7.0 sacks) per cubic yard (*390 kilograms per cubic meter*) of concrete and which attains a minimum 28-day compressive strength of 3,000 psi (*20.7 megapascals*). Fine aggregate and coarse aggregate shall conform to the requirements of Subsection 912-2.02. The total mix shall contain, by weight, 15 to 20 percent coarse aggregate. In no case shall the slump be greater than 4 inches (*100 millimeters*).

If ready-mixed concrete is used, it shall conform to the requirements of ASTM C 94.

912-3.04 Preparation of Surfaces. The surfaces on which shotcrete is to be placed shall be finely graded to the lines and grades shown on the project plans or established by the Engineer.

The surfaces shall be thoroughly compacted and shall be uniformly moistened so that water will not be drawn from the freshly placed shotcrete.

912-3.05 Forms and Ground Wires. Forms shall be of plywood sheathing or other suitable material and shall be true to line and grade and sufficiently rigid to resist deflection during placement of the shotcrete. Forms shall be constructed to permit the escape of air and rebound during the gunning operation.

Ground or gauging wires shall be installed where necessary to establish the thicknesses, surface planes and finish lines of the shotcrete.

912-3.06 Steel Reinforcement. Steel reinforcement shall be as shown on the project plans and shall conform to the requirements of Section 605.

912-3.07 Placement. The velocity of the shotcrete as it leaves the nozzle shall be maintained uniform and at a rate approved by the Engineer for the given job conditions. The nozzle shall be held as nearly perpendicular to the working surface and at a proper distance, generally between 2 and 5 feet (*600 and 1500 millimeters*), to insure maximum compaction with minimum rebound of the shotcrete.

Rebound or previously expended material in the shotcrete mix shall not be used in any portion of the work. All rebound shall be removed prior to final set and before placement of the shotcrete on adjacent surfaces.

Shotcrete shall not be applied during any precipitation which is of sufficient intensity to cause the in-place shotcrete to run. Shotcrete shall not be applied during wind conditions that cause separation of the nozzle flow.

Shotcrete shall not be applied when a descending ambient air temperature falls below 40° F (*4.5 °C*) nor until an ascending air temperature rises above 35° F (*1.6 °C*). Temperature shall be taken in the shade away from artificial heat.

912-3.08 Quality Control Testing. Tests to determine the physical quality of the shotcrete will be performed by the Engineer periodically during the work, as required. Test panels and cores shall be prepared by the contractor.

Test panels at least 12 inches (*300 millimeters*) square and as thick as the structure being constructed but not less than 3 inches (*75 millimeters*) shall be prepared by gunning shotcrete mix on a piece of plywood that is true and not warped, bowed or deformed in any way. Cores shall be taken from the panels for compressive strength tests and for visual examination. Cores shall have a minimum diameter of 3 inches (*75 millimeters*) and an L/D of at least 1. Test panels shall be cured in the same manner as the production work.

Cores shall be obtained and tested in accordance with the requirements of AASHTO T 24. The cores will be tested for a minimum compressive strength of 3,000 psi (*20.7 megapascals*) at 28 days.

The cut surfaces of the test specimens will be carefully examined for soundness and uniformity of the material and shall be free from laminations and sand pockets.

912-3.09 Construction Joints. One-half (1/2) inch (*13 millimeters*) premolded expansion joint material, conforming to the requirements of Subsection 1011-6, shall be placed at 60 foot (*18 meters*) intervals on all shotcrete or concrete bank protection. Weakened plane joints, or scoring, shall be at 15 foot (*4.5 meters*) intervals between expansion joints.

All expansion joint material shall extend the full depth of the concrete being placed, and shall be flush with the top of the finished surface; furthermore, expansion joint material shall be so supported, prior to placement of concrete, as to ensure tight joints. Reinforcing material shall be cut at all expansion joints.

912-3.10 Finishing. After the shotcrete has been placed as nearly as practicable to the required thickness and shape outlined by forms and ground wires, the surface shall be checked with a straightedge and any low spots or depression shall be brought up to proper grade by placing additional shotcrete in such a manner that the finished surface shall be smooth and uniform.

Unless otherwise specified in the special provisions, the surface of the shotcrete shall have a natural gun finish.

912-3.11 Curing. The shotcrete surfaces shall be kept continuously moist for at least seven days, beginning immediately after finishing, by means of either a water spray or fog system capable of being applied continuously, or by liquid membrane-forming compound, or by polyethylene sheeting conforming to the requirements specified in ASTM C 171. If polyethylene sheeting is used, it shall be white opaque and adjoining sheets shall overlap at least 12 inches (*300 millimeters*) and the laps secured to provide an airtight and windproof joint. If liquid membrane-forming compound is used it shall be Type I conforming to the requirements of ASTM C 309 and the application rate shall be 100 square feet per gallon (*0.4 liter per square meter*).

912-4 METHOD OF MEASUREMENT

Shotcrete will be measured by the square yard (*square meter*) of surface areas placed to the required thickness.

No measurement will be made of unexposed surfaces such as support slabs or joints, integral curb faces or cut-off walls.

912-5 BASIS OF PAYMENT

Payment for shotcrete will be made at the contract unit price per square yard (*square meter*), complete-in-place, including excavating, backfilling, fine grading, reinforcement and joint material.

SECTION 913

BANK PROTECTION

913-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing bank protection in accordance with the details shown on the plans and the requirements of these specifications. Bank protection shall be dumped riprap, grouted riprap, wire tied riprap, riprap in wire baskets or gabions, and other types of bank protection and shall be constructed in accordance with the locations and details shown on the project plans and the requirements of these specifications.

913-2 MATERIALS

913-2.01 Rock.

(A) General. Rock shall be sound and durable, free from clay or shale seams, cracks or other structural defects. The Bulk Specific Gravity (SSD) shall be determined in accordance with the requirements of AASHTO T-85 and shall be a minimum of 2.60. Rock used to construct dumped riprap shall be angular in shape. Rock used to construct other types of bank protection may be rounded stones or boulders. Rock shall have a least dimension not less than one-third of its greatest dimension and a gradation in reasonable conformity with that specified in the Special Provisions or shown herein for the various types of bank protection. Control of the gradation will be by visual inspection.

No source of rock is designated. It shall be the contractor's responsibility to secure a source of rock, and, as applicable negotiate for the material, obtain the right-of-way and pay all royalties and damages.

The source from which the rock will be obtained shall be selected well in advance of the time when the rock will be required in the work. The acceptability of the rock will be determined by the Engineer. If testing is required, suitable samples of rock shall be taken in the presence of the Engineer at least 25 days in advance of the time when the use of the rock is expected to begin. The approval of some rock fragments from a particular quarry site shall not be construed as constituting the approval of all rock fragments taken from that quarry.

(B) Grouted Riprap. Gradation of the rock for grouted riprap shall be as specified in the Special Provisions or as shown on the project plans.

(C) Wire Tied Riprap. Rock for wire tied riprap shall be well graded with at least 95 percent, by weight, exceeding the least dimension of the wire mesh opening. The maximum size stone, measured normal to the mat, shall not exceed the mat thickness.

(D) Dumped Riprap. Gradation of the rock for dumped riprap shall be as shown on the project plans or as specified in the Special Provisions.

The contractor shall provide two samples of rock of at least 5 tons (*4.5 metric tons*) each, meeting the gradation specified above. The sample at the construction site may be a part of the finished riprap covering. The other sample shall be provided at the quarry. These samples shall be used as a frequent reference for judging the gradation of the riprap supplied. Any difference of opinion between the Engineer and the contractor shall be resolved by dumping and checking the gradation of two random truck loads of stone. Mechanical equipment, a sorting site, and labor needed to assist in checking gradation shall be provided by the contractor at no additional cost to the Agency.

(E) Gabions. Rock for gabions shall be well graded, varying in size from 4 to 8 inches (*100 to 200 millimeters*).

(F) Riprap (Slope Mattress). Rock for slope mattress shall be well graded with 70 percent, by weight, exceeding 4 inches (*100 millimeters*). The maximum dimension of a single stone shall not exceed the least dimension of the gabion enclosure.

Broken concrete may be used upon approval of the Engineer.

(G) Rail Bank Protection. Rock used to construct rail bank protection shall be as specified in the Special Provisions or as shown on the project plans.

913-2.02 Metal Items.

(A) Wire Fabric. Welded wire fabric shall be galvanized and shall conform to the requirements of AASHTO M 55, except that the minimum weight of the zinc coating shall be 0.15 of an ounce per square foot (*46 grams per square meter*) of actual surface.

Woven wire fabric shall conform to the requirements of ASTM A 116, except that the minimum weight of zinc coating shall conform to the requirements of ASTM A 641M, Class 3.

Wire fabric shall be of the gauge (*diameter*), spacing, pattern, and dimensions shown on the plans. The selvedge on each sheet of mesh shall be galvanized steel wire two gauges heavier (*approximately 25 percent longer*) than that used in the body of the mesh.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

(B) Miscellaneous Fittings and Hardware. Miscellaneous fittings and hardware shall be of the type and size specified for the use indicated on the project plans by the manufacturer of the major item to which they apply. Miscellaneous fittings shall be galvanized in accordance with the requirements of AASHTO M 232.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

(C) Tie Wires. Tie wires shall be of good commercial quality and the gauge (size) shall be as shown on the project plans, except that the minimum weight of the zinc coating shall conform to the requirements of ASTM A 614M, Class 3. At the option of the contractor, approved wire fasteners may be used on gabions slope matresses, or wire fabric in lieu of tie wires.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

(D) Steel Cable. Steel cable shall be zinc-coated steel structural wire rope conforming to the requirements of ASTM A 475, 7-wire strand, Class A for the diameter shown on the plans.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

(E) Railroad Rail. Railroad rails may be new or used. If used rails are furnished, they shall be equal to at least 95 percent of the original section.

(F) Soil Anchor Stakes. Soil anchor stakes shall be steel and of the length called for on the plans. When not specified to be railroad rails, the following items may be used: crane rails with a weight of at least 40 pounds per linear foot (*60 kilograms per linear meter*), 2-3/8 inch (*60.3 millimeters*) outside diameter steel pipe conforming to the requirements of ASTM A 53, or 3 inch by 3 inch by 3/8 inch (*76 by 76 by 10 millimeters*) structural steel angles conforming to the requirements of ASTM A 36/A 36M. Used rails, pipe, or angles may be used provided the material is not rusted or damaged to the extent that the strength of the item is reduced to less than 90 percent of a new item of the same type and nominal size.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

913-2.03 Granular Filter Material and Bedding Material. Unless otherwise indicated in the project plans or Special Provisions, the filler material or bedding material shall consist of granular material having a maximum dimension of 2 inches (*50 millimeters*) and shall be free of clay or organic material.

914-2.04 Grout. Grout shall consist of one part portland cement, three parts fine aggregate and one-fifth part hydrated lime, by volume. These materials shall be thoroughly dry mixed and sufficient water shall be added to provide a mixture of thick workable consistency.

Portland cement, fine aggregate, and water shall conform to the requirements of Section 1006. Hydrated lime shall conform to the requirements of ASTM C 207, Type N.

Grout that has been mixed more than one hour shall not be used. Retempering of grout will not be permitted.

913-2.05 Filter Fabric. Filter fabric shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-5 respectively. Special attention shall be given to the required survivability of the filter fabric.

The identification, packaging, handling, and storage of the geotextile fabric shall be in accordance with ASTM D 4873. Fabric rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Rolls will be stored on the site or at another identified storage location in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof, light colored, opaque cover. At no time, shall the fabric be exposed to sunlight for a period exceeding 14 days.

913-2.06 Sacked Concrete. Sacked concrete shall be utility concrete conforming to the requirements of Section 922, except that the minimum cement content shall be 376 pounds per cubic yard (*223 kilograms per cubic meter*); the slump shall be from 3 to 5 inches (*75 to 125 millimeters*); and the aggregate shall conform to the following gradation when tested in accordance with the requirements of Arizona Test Method 201:

Sieve Size	Percent Passing
2-inch (*50 millimeters*)	100
1/4-inch (*6.3 millimeters*)	45-89
No. 200 (*75 micrometers*)	0-12

Sacks for sacked concrete riprap shall be made of at least AASHTO M 182 Class 3 burlap and shall be approximately 19-1/2 inches x 36 inches (*500 millimeters by 900 millimeters*) measured inside the seams when the sack is laid flat, with an approximate capacity of 1.25 cubic feet (*0.035 cubic meters*). Sound, reclaimed sacks may be used.

913-3 CONSTRUCTION DETAILS

913-3.01 General. Areas on which bank protection is to be constructed shall be cleared, grubbed, and excavated or backfilled in accordance with the requirements of the appropriate sections of these specifications so as to produce a ground surface in reasonable conformance with the lines and grades shown on the project plans or established by the Engineer.

Fill areas shall be compacted in accordance with the requirements of Subsection 203-9.

Placement through water will not be permitted unless otherwise approved by the Engineer.

913-3.02 Filter Fabric. When filter fabric is required, it shall be placed in the manner and at the locations shown on the project plans. The surface to receive the fabric shall be free of obstructions, depressions and debris. The filter fabric shall be loosely laid and not placed in a stretched condition.

The strips of fabric shall be placed to provide a minimum 24 inches (*600 millimeters*) of overlap for each joint. On horizontal joints, the uphill strip shall overlap the downhill strip. On vertical joints, the upstream strip shall overlap the downstream strip. The fabric shall be protected at all times during construction from extensive exposure to sunlight.

When the maximum size of the rock to be placed on filter fabric exceeds 18 inches (*450 millimeters*), the fabric shall be protected during the placement of the rock by a layer of bedding material. The bedding material shall be spread uniformly on the fabric to a depth of 4 inches (*100 millimeters*) and shall be free of mounds, dips or windrows. Compaction of the bedding material will not be required.

Rock shall be carefully placed on the bedding material and filter fabric in such a manner as not to damage the fabric. If, in the opinion of the Engineer, the fabric is damaged or displaced to the extent that it cannot function as intended, the contractor shall remove the rock, regrade the area, if necessary, and replace the filter fabric.

913-3.03 Dumped Riprap. The rock shall be placed for its specified thickness in one operation and in a manner which will produce a reasonably well graded mass, with a minimum amount of voids and with the larger rock evenly distributed throughout the mass.

No method of placing the rock that will cause segregation will be allowed. Hand placing or rearranging of individual rock may be necessary to obtain the specified results.

913-3.04 Wire-tied Riprap. After installation of the lower portion of the wire mesh, rock shall be placed in accordance with the requirements of Subsection 913-3.03. After placement of the rock, the upper portion of the wire mesh shall be placed, laced, and tied in accordance with the details shown on the project plans.

913-3.05 Grouted Riprap. Rock for grouted riprap shall be placed in accordance with the requirements of Subsection 913-3.03. The rock shall be thoroughly moistened and any excess of fines shall be sluiced to the underside of the stone blanket before grouting.

The grout may be delivered to the place of final deposit by any means that will insure uniformity and prevent segregation of the grout. If penetration of grout is not obtained by gravity flow

into the interstices, the grout shall be spaded or rodded to completely fill the voids in the rock blanket. Pressure grouting shall not unseat the rock; and during placing by this method, the grout shall be spaded or rodded into the voids. Penetration of the grout shall be to the depth specified on the project plans. When a rough surface is specified, stone shall be brushed until from one-fourth to one-half of the depth of the maximum size stone is exposed. For a smooth surface, grout shall fill the interstices to within a 1/2 inch (*13 millimeters*) of the surface.

Grout shall not be placed when the descending air temperature falls below 40° F (*4.5 °C*) nor until the ascending air temperature rises above 35° F (*1.6 °C*). Temperatures shall be taken in the shade away from artificial heat.

Curing of the grout shall be in accordance with the requirements of Subsection 912-3.11.

At the option of the contractor, shotcrete conforming to the requirements of Section 912 may be furnished in lieu of grout.

913-3.06 Slope Mattress Riprap. The mattress shall be excavated to the width, line and grade as shown on the plans. The mattress shall be founded on this bed and laid to the lines and dimensions required.

Excavation for toe or cut-off walls shall be made to the neat lines of the cut-off wall.

Mattresses shall be fabricated in such a manner that the sides, ends, lid and diaphragms can be assembled at the construction site into rectangular units of the specified sizes. Mattresses are to be of single unit construction, the base, ends and sides either to be woven into a single unit or one edge of these members connected to the base section of the unit in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

All perimeter edges of the mattresses are to be securely selvedged or bound so that the joints formed by tying the selvedges have at least the same strength as the body of the mesh.

Mattresses shall be placed to conform with the details shown on the project plans. Rock shall be placed in close contact within the unit so that maximum filling is obtained. The units may be filled by machine with sufficient hand work to accomplish the requirements of this specification.

Slope mattresses shall be filled with at least two layers of stone. Broken concrete may be placed in the bottom layer with approval of the Engineer.

Before the mattress units are filled the longitudinal and lateral edge surfaces of adjoining units shall be tightly connected by means of wire ties placed every 4 inches (*100 millimeters*) or by a spiral tie having a complete loop every 4 inches (*100*

millimeters). The lid edges of each unit shall be connected in a similar manner to adjacent units. The slope mattress shall be anchored as shown on the project plans. Each anchor stake shall be fastened to the cover mesh with a tie wire.

913-3.07 Gabions. The gabion bed shall be excavated to the width, line and grade as shown on the plans. The gabions shall be founded on this bed and laid to the lines and dimensions required.

Excavation for toe or cut-off walls shall be made to the neat line of the wall.

Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular units of the specified sizes. Gabions are to be of single unit construction, the base, ends, and sides either to be woven into a single unit or one edge of these members connected to the base section of the unit in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

Where the length of the gabion exceeds its horizontal width, the gabion is to be equally divided by diaphragms, of the same mesh and gauge as the body of the gabions, into cells whose length does not exceed the horizontal width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base section in such a manner that no additional tying at this juncture will be necessary.

All perimeter edges of gabions are to be securely selvedged or bound so that the joints formed by tying the selvedges have at least the same strength as the body of the mesh.

Gabions shall be placed to conform to the project plan details. Rock shall be placed in close contact in the unit so that maximum filling is obtained. The units may be filled by machine with sufficient hand work to accomplish the requirements of this specification. The exposed face or faces shall be hand placed using selected stones to prevent bulging of the gabion cell and to improve appearance. Each cell shall be filled in three lifts. Two connecting tie wires shall be placed as shown on the project plans between each lift in each cell. Care shall be taken to protect the vertical panels and diaphragms from being bent during filling operations.

The last lift of rock in each cell shall be level with the top of the gabion in order to properly close the lid and provide an even surface for the next course.

All gabion units shall be tied together, each to its neighbor, along all contacting edges in order to form a continuous connecting structure.

Empty gabions stacked on filled gabions shall be laced to the filled gabion at the front, side and back.

913-3.08 Sacked Concrete Riprap. The sacks shall be filled with concrete, loosely packed so as to leave room for folding or tying at the top. Approximately 1 cubic foot (*0.03 cubic meter*) of concrete shall be placed in each sack. Immediately after filling, the sacks shall be placed according to the details shown on the project plans and lightly trampled to cause them to conform with the earth face and with adjacent sacks in place.

The first two courses shall provide a foundation of double thickness. The first foundation course shall consist of a double row of stretchers laid level and adjacent to each other in a neatly trimmed trench. The trench shall be cut back into the slope a sufficient distance to enable proper subsequent placement of the riprap. The second course shall consist of a row of headers placed directly above the double row of stretchers. The third and remaining courses shall consist of stretchers and shall be placed in such a manner that joints in succeeding courses are staggered.

All dirt and debris shall be removed from the top of the sacks before the next course is laid thereon. Stretchers shall be placed so that the folded ends will not be adjacent. Headers shall be placed with the folds toward the earth face. Not more than four vertical courses of sacks shall be placed in any tier until initial set has taken place in the first course of any such tier.

When there will not be proper bearing or bond for the concrete because of delays in placing succeeding layers of sacks, a small trench shall be excavated in back of the row of sacks already in place, and the trench shall be filled with fresh concrete before the next layer of sacks is laid. The size of the trench and the concrete used for this purpose shall be approved by the Engineer. The Engineer may require header courses at any level to provide additional stability to the riprap.

Sacked concrete riprap shall be cured by being covered with a blanket of wet earth or by being sprinkled with a fine spray of water every 2 hours during the daytime for a period of 4 days.

913-3.09 Rail Bank Protection. Excavation, where required for rock fill, shall be performed in reasonably close conformity to the lines and grades established or shown on the project plans.

Rails shall be driven at the locations and to the minimum penetrations shown on the plans. Driving equipment shall be capable of developing sufficient energy to drive the rails to the specified minimum penetration and be approved by the Engineer.

If hard material is encountered during driving before minimum penetration is reached and it has been demonstrated to the satisfaction of the Engineer that additional attempts at driving would result in damage to the rails, the Engineer may order

additional work to be performed, such as jetting or drilling, in order that minimum penetration may be obtained or he may order the minimum penetration to be reduced as required by the conditions encountered.

Wire fabric shall be securely fastened to the rails, placed in the trenches and laid on the slopes. The rock backfill shall then be carefully placed so as not to displace the wire fabric or rails. The wire fabric shall entirely enclose the rock backfill.

The completed rock fill shall be backfilled as necessary and the waste material disposed of as directed by the Engineer.

913-4 METHOD OF MEASUREMENT

Riprap, except gabions and sacked concrete, will be measured by the cubic yard (*cubic meter*) of protection constructed by computing the surface area measured parallel to the protection surface and the total thickness of the riprap measured normal to the protection surface.

Riprap (gabions) will be measured by the cubic yard (*cubic meter*) by computing the volume of the rock filled wire brackets used.

Riprap (sacked concrete) will be measured by the cubic yard (*cubic meter*) of concrete placed in the completed work. The measurement will be based on mixer volumes less any wasted material.

Rail bank protection will be measured by the linear foot (*meter*). Rail bank protection will be measured along the bank protection control line from end rail to end rail.

913-5 BASIS OF PAYMENT

The accepted quantities of riprap and rail bank protection, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) or liner foot (*meter*), as designated in the bidding schedule, which price shall be full compensation for the work, complete-in-place, including excavation, preparing the ground area and furnishing and installing the rock, filter fabric, bedding material, metal items, concrete, sacks and grout, and backfilling as required.

Materials, labor and equipment necessary to perform additional work such as jetting or drilling, as specified under Subsection 913-3.09, will be paid for in accordance the provisions of Subsection 109-5.

SECTION 914

MASONRY CONSTRUCTION

914-1 DESCRIPTION

The work under this section shall consist of furnishing all labor, equipment, and materials to construction concrete masonry unit (CMU) walls and retaining walls in accordance with the project plans. The work will include the construction of concrete footers on compacted subgrade and the construction of walls to the specified heights as depicted on the project plans.

914-1.01 Codes and Standards. Construction of masonry unit walls shall comply with provisions of the following codes, specifications, and standards, except when otherwise noted on the project plans or in the Special Provisions.

Uniform Building Code (current approved edition)
IBO Research Reports (current approved edition)

914-2 MATERIALS

913-2.01 General. Free access shall be provided to material stockpiles and facilities. Tests, not specifically indicated to be conducted by the Agency including retesting of rejected materials and installed work, shall be conducted by the contractor at no additional cost to the Agency.

The contractor shall be required to submit manufacturer's product data for each type of masonry unit, accessory, and other manufactured products.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted for each type of masonry unit.

The contractor will be required to submit samples of each exposed masonry unit and colored masonry mortar in the full range of colors and textures for selection and verification.

914-2.02 Masonry Units. Masonry units shall be from one manufacturer. The masonry units shall be of uniform texture and color for each type required for each continuous and/or visually related area.

The masonry units shall comply with the standards and requirements indicated on the project plans and Special Provisions.

Concrete masonry units (CMU) shall be manufacturer's standard units with nominal face dimensions and widths as indicated below:

Standard units:	
16"x8"x8"high (*390 x 190 x 190 millimeters*)	Standard
16"x12"x8" high (*390 x 300 x 190 millimeters*)	color
Standard units:	
16"x8"x8" high (*390 x 190 x 190 millimeters*)	Integral
16"x12"x8" high (*390 x 300 x 190 millimeters*)	color

Split face (rock face) units:	
16”x8”x8” high (*390 x 190 x 190 millimeters*)	Standard
16”x12”x8” high (*390 x 300 x 190 millimeters*)	color

Special shapes where required for lintels, corners, jambs, sash, control joints, headers, bonding, and other special conditions shall be provided.

Hollow loadbearing CMU shall conform to the requirements of ASTM C 90 and Grade N-I.

The weight classification shall be normal weight units unless otherwise indicated.

Curing of units shall conform to the requirements of ASTM C 90, Type I.

Linear shrinkage is to be limited from 0.03 percent to 0.045 percent at a moisture absorption of 30 percent during delivery and until time of installation.

Masonry units shall match the sample, approved by the Engineer, for color and texture.

914-2.03 Mortar and Grout.

(A)Materials. Portland Cement shall conform to the requirements of ASTM C 150 for Type I or Type II.

The freezing point of mortar shall not be lowered by use of admixtures or anti-freeze agents.

Calcium chloride shall not be used in mortar or grout.

Cementitious materials in mortar shall be limited to Portland cement-lime.

The Contractor shall use Type M mortar for masonry below grade and in contact with earth and Type S mortar for all other reinforced masonry.

Grout for unit masonry shall comply with ASTM C 476 for grout for use in construction of reinforced and non-reinforced unit masonry. Grout shall be of the consistency indicated on the project plans or in the Special Provisions or, if not otherwise indicated, of a consistency (fine or coarse) at time of placement which will completely fill all spaces intended to receive grout without segregation. Grout shall have a minimum compressive strength of 2,000 psi (*13.8 mega pascals*) at 28 days.

Mortar for masonry unit construction shall comply with the current edition of the Uniform Building Code or ASTM C 270, Proportion Specification, for types of mortar required, to produce mortar with a minimum compressive strength of 1800 psi (*12.4 megapascals*) at 28 days.

Water shall be clean and potable.

Colored pigmented mortars shall be pre-mixed color masonry cements of the formulation required to produce color indicated, or if not indicated, as selected from manufacturer's standard formulations.

Hydrated lime shall conform to the requirements of ASTM C 270, Type S.

Aggregate for Mortar shall conform to the requirements of ASTM C 144.

Aggregate for Grout shall conform to the requirements of ASTM C 404.

Colored mortar pigments shall be selected and proportioned with other ingredients to produce the color require. A pigment-to-cement ratio of 1:10, by weight shall not be exceeded.

Colored mortar pigments shall be natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes. Only pigments with record of satisfactory performance in masonry mortars shall be used.

(B) Testing. Mortar shall be sampled and tested in accordance with the requirements of ASTM C 780. Grout shall be sampled and tested in accordance with the requirements of ASTM C 1019. Samples shall be representative of all materials and mixes to be used in the field. All mixes and materials shall be tested prior to commencing any masonry work, with acceptance tests performed during the progress of the work, as directed by the Engineer.

Representative samples of the concrete masonry units shall be selected from initial deliveries to the project and shall be tested for conformance in accordance with the requirement of ASTM C 90, Grade NI units, for both compressive strength and shrinkage requirements. The Frequency of additional testing or retesting, shall be at the discretion and direction of the Engineer.

914-2.04 Masonry Accessories.

(A) Horizontal Joint Reinforcing and Ties for Masonry. Joint reinforcing and ties shall be welded wire units, prefabricated in straight lengths of not less than 10 feet (*3 meters*), with matching corner ("L") and intersecting ("T") units. Joint reinforcing shall be fabricated from cold-drawn steel wire conforming to the requirements of ASTM A 82. Deformed continuous side rods and plain cross rods shall be fabricated into units with widths of approximately 2 inches (*50 millimeters*) or less than the nominal width of walls and partitions as required to position side rods for full embedment in mortar. Mortar coverage shall not be less than 5/8 inch (*16 millimeters*) on joint faces exposed to exterior and not less than 1/2 inch (*13 millimeters*) elsewhere. The following types of joint reinforcing shall be provided unless otherwise indicated in the project plans or Special Provisions:

Ladder type with perpendicular cross roads spaced not more than 16 inches (*400 millimeters*) center to center.

A single pair of side rods shall be used for single wire masonry.

Wire sizes shall be fabricated with 9-gauge (*3.8 millimeters*) side and cross rods.

A manufacturer's standard mill galvanized wire finish shall be applied.

(B) Anchors and Ties. Straps, bars, bolts and rods fabricated form not less than 16-gauge (*1.5 millimeters*) sheet metal or 3/8-inch (*10 millimeters*) diameter stock, shall be provided unless otherwise indicated in the project plans or Special Provisions.

(C) Concrete Embeds for Masonry. Steel weld plate anchors shall be furnished and installed as indicated on the project plans.

(D) Miscellaneous Masonry Accessories. Premolded control joint strips shall be solid rubber strips with a Shore A durometer hardness of 60 to 80, designed to fit a standard sash block and maintain lateral stability in a masonry wall. The size and configuration shall be as indicated on the project plans.

914-2.05 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 1003. Unless otherwise shown on the project plans, reinforcement bars of following grades shall be provided:

Grade 40 for bars No. 3 (*No. 10M*) and No. 4 (*No. 13M*)
Grade 60 for bars No. 5 (*No. 16M*) to No. 18 (*No. 57M*)

Reinforcing bars which are shown to be bent or hooked shall be shop fabricated.

914-2.06 Concrete. Concrete shall be Class S portland cement concrete conforming to the requirements of Section 1006.

914-2.07 Mortar Wash. Mortar wash shall be a light gray mortar slurry.

914-2.08 Stucco.

(A) Application. Stucco application is to be applied directly over the concrete or masonry surface using a suitable bonding agent. The bonding agent shall be applied by the manufacturer. The surface to receive the stucco shall be evenly dampened to obtain uniform suction. The stucco shall be applied to an approximate thickness of 3/8 inch (*10 millimeters*). The surface shall be made true and even by floating or rodding. The surface shall be left rough in order to receive the finish coat.

The finish stucco coat shall not be applied sooner than 7 days after application of the preceding coats. Before applying, the surface of the preceding coat shall be dampened to obtain uniform suction. The thickness of the finish coat shall be sufficient to secure the required texture troweling. The finish, shall be applied such that the entire wall can be completed at one time to eliminate joining marks. Corners can serve as breaking points.

(B) Curing. Each application of stucco shall be kept damp for a minimum of 72 hours after application. Moistening of each application shall begin as soon as the stucco has hardened sufficiently so as not to be damaged. Water shall be applied in a fine fog spray. Care shall be taken to avoid soaking the stucco. Water shall be applied only to the point that it can be readily absorbed. The stucco shall be protected from uneven and excessive evaporation during hot, dry weather and also from strong gusts of wind.

(C) Patching. Stucco containing cracks, blisters, pits or discoloration is not acceptable. Patching inherently defective work will be permitted only when approved by the Engineer and such patching shall match the existing work in texture and color. Repair of defects shall be commenced after other trades have finished their work in the area.

914-2.09 Paint. Stucco shall be painted as noted on the project plans. Paint shall be applied per the manufacturer's specifications. Paint shall be exterior quality conforming to the requirements of Section 610. Unless otherwise specified in the project plans or Special Provisions, the color shall be Sherwin Williams Pink Beige, SW2018 or approved equal. A surface sealer, conforming to the requirements of Section 611-2.04 and 611-3.12, shall be applied prior to painting.

914-3 CONSTRUCTION DETAILS

914-3.01 Shop Drawings. Shop drawings shall be submitted for fabrication, bending, and placement or reinforcement bars. Shop drawings shall comply with the "*Manual of Standard Practice for Detailing Reinforced Concrete Structures*", latest edition. Bar schedules, diagrams of bent bars, stirrup spacing, lateral ties, and other arrangements and assemblies as required for fabrication and placement of reinforcement of unit masonry work shall be shown.

The contractor shall furnish shop drawings in accordance with Subsection 105-2.

914-3.02 Installation.

(A) General. Masonry construction shall be built to the actual width of the masonry units, using units of nominal width as shown on the project plans or specified by the Special Provisions.

Mortar wash shall be applied 1/4 inch (*6 millimeters*) thick to the CMU block.

Pilasters shall be constructed in accordance with the details shown in the project plans.

Masonry units shall be cut with a motor-driven saw designed to cut masonry with clean sharp, unchipped edges. Units shall be cut as required to provide the pattern shown on the project plans and to fit adjoining work neatly. Full units shall be used wherever possible. Dry cutting saws shall be used to cut concrete masonry units.

Concrete masonry units shall not be wetted.

Exposed masonry shall be laid in the bond pattern shown on the project plans or, if not shown, laid in running bond vertical joint with each course centered on units in courses above and below.

The contractor shall layout walls in advance for accurate spacing of surface bond patterns with uniform joint widths, and to properly locate openings, movement-type joints, returns, and offsets. The use of less-than-half size units at corners, jambs, and at other locations is to be avoided.

Lay-up walls shall be plumb and with courses level, accurately spaced, and coordinated with other work.

When stopping and resuming work the contractor shall rake back one-half masonry unit length in each course, do not tooth. All exposed surfaces of set masonry shall be cleaned. Units shall be lightly wetted and loose masonry units and mortar shall be removed prior to laying fresh masonry.

CMU cores under bearing plates, beams, lintels, posts, and similar conditions shall be filled with grout unless otherwise indicated.

The joint widths shown on the project plans shall be maintained, except for minor variations required to maintain bond alignment. If not otherwise indicated, walls shall be laid with 3/8 inch (*10 millimeters*) joints. For masonry walls which are to be concealed or to be covered by other materials cut joints flush. The Contractor shall tool expose joints slightly concave using a jointer larger than joint thickness and rake out mortar in preparation for application of caulking or sealants where required.

Masonry units disturbed after laying shall be removed, cleaned, and relaid in fresh mortar.

Collar joints between wythes shall be solidly filled with grout.

The contractor shall maintain vertical continuity of core or cell cavities which are to be reinforced and grouted to provide the minimum clear dimensions indicated and to provide the minimum

clearance and grout coverage for vertical reinforcement bars. Cavities shall be kept free of mortar. Webs shall be solidly bedded in mortar where adjacent to reinforced cores or cells.

Formwork and shoring as required for temporary support of reinforced masonry elements, shall be provided. Formwork shall be maintained until the reinforced masonry members have hardened sufficiently to carry their own weight and all other reasonable temporary loads that may be placed on it during construction.

(B) Low-lift Grouting. A minimum clear dimension of 2 inches (*50 millimeters*) and a clear area of eight square inches (*5160 square millimeters*) shall be provided in vertical cores to be grouted.

Vertical reinforcement shall be placed prior to laying the CMU. Vertical reinforcement shall extend above the elevation of the footing to allow for spicing. Vertical reinforcement shall be supported in position at vertical intervals not exceeding 192 bar diameters or 10 feet (*3 meters*).

The CMU may be laid to the maximum grout pour height but shall not exceed 5 feet (*1.5 meters*) in height.

Grout shall be poured using a container with a spout or by a chute. Grout shall be rodded during placement. Grouting shall be continuous and pouring shall not be interrupted. Grout pours shall be terminated 1 1/2 inches (*38 millimeters*) below the top course.

Grout pours in vertical cells shall be stopped 1-1/2 inches (*38 millimeters*) below the bond beam course. Horizontal reinforcement shall be placed in the bond beams. Horizontal reinforcement shall be lapped at corners and intersections as shown on the project plans. Grout shall be placed in the bond beam course before filling vertical cores above the bond beam.

(C) Placing Reinforcing Steel. Reinforcing steel shall be cleaned of loose rust, mill scale, earth, or other material which will reduce the bond to the mortar or grout. Reinforcing bars with kinks or bends not shown on drawings or final shop drawings, or bars with reduced cross section due to excessive rusting or other causes shall not be used.

Reinforcing steel shall be placed accurately at the spacing indicated on the project plans or shop drawings. Vertical bars shall be supported and secured against displacement.

Horizontal reinforcement may be placed as the masonry work progresses. Where vertical bars are shown in close proximity, a clear distance between bars of not less than the nominal bar diameter or 1 inch (*25 millimeters*), whichever is greater shall be provided.

Masonry shall not be grouted if the reinforcing steel placement exceeds the following tolerances:

Vertical: Variation in spacing from face of masonry plus or minus 1/4 inch (*6 millimeters*).

Variation in spacing in longitudinal run of masonry plus or minus 2 inches (*50 millimeters*).

Horizontal: Variation in spacing perpendicular to the face of masonry plus or minus 1/4 inch (*6 millimeters*).

Masonry grouted in violation of this specification shall be removed at the contractor's expense.

Reinforcing steel shall be spliced in accordance with the provisions of Subsection 605-3.02.

(D) Horizontal Joint Reinforcing. Continuous horizontal joint reinforcing shall be provided as shown in the project plans and specified. Longitudinal side roads shall be fully embedded in mortar for their entire length with a minimum cover of 5/8 inch (*16 millimeters*) on exterior side of walls, and 1/2 inch (*13 millimeters*) at other locations. Reinforcing steel shall be lapped in accordance with Subsection 605-3.02. Control and expansion joints shall not be bridged with reinforcing, unless otherwise indicated. Prefabricated "L" and "T" sections shall be used to provide continuity at corners and wall intersections. Units shall be cut and bent as directed by manufacturer for continuity at returns, offsets, and other special conditions.

Reinforcing steel for single-wythe walls shall be placed at 16 inches (*400 millimeters*) vertically, unless otherwise indicated.

(E) Anchoring Masonry Work. Anchoring devices of the type indicated in the project plans or Special Provisions shall be provided.

(F) Lintels. Loose lintels of steel and other materials shall be installed where shown on the project plans.

Masonry lintel shall be provided where shown and wherever openings of more than 1 foot (*300 millimeters*) without structural steel or other supporting lintels.

Formed-in-place lintels shall be temporarily supported.

For hollow concrete masonry unit walls, specially formed "U" shaped lintel units with reinforcing bases placed as shown on the project plans and filled with grout of consistency required to completely fill space between reinforcing bars and masonry unit shall be used.

A minimum bearing of 16 inches (*400 millimeters*) shall be provided at each jamb, unless otherwise indicated.

(G) Control and Expansion Joints. Vertical masonry expansion joints shall be provided where shown on the project plans. Control joints shall be located at 20 foot (*6 meters*) maximum intervals. Expansion joints shall be preformed PVC with caulking at the outsides of the joints. Masonry accessory items shall be built in as the masonry work progresses.

914-3.03 Placing and Finishing.

(A) General. During erection, the tops of walls shall be covered with waterproof sheeting at the end of each day's work. Partially completed structures shall be covered when work is not in progress.

The cover shall extend a minimum of 24 inches (*600 millimeters*) down both sides of the wall and be held securely in place.

Backfill shall not be placed against masonry retaining walls for at least 7 days after completing the masonry walls or columns.

Concentrated loads shall not be applied for at least three days after completion of the masonry wall or column.

Sills, ledges, and projections shall be protected from droppings of mortar.

(B) Staining. The face of masonry shall be protected to prevent staining from grout, mortar or solid. Grout or mortar in contact with masonry shall be immediately removed. The base of walls shall be protected from rain-splashed mud and mortar splatter by means of coverings spread on the ground and over wall surface.

(C) Repair, Pointing, and Cleaning. Masonry units which are loose, chipped, broken, stained, or otherwise damaged, or do not match adjoining units as intended shall be removed and replace. New units which match adjoining units shall be provided and installed in fresh mortar, or grouted and pointed and to eliminate any evidence of replacement.

During the tooling of joints, voids or holes, except weep holes, shall be enlarged and completely filled with mortar. All joints at corners, openings and adjacent work shall be pointed to provide a neat uniform appearance that is properly prepared for application of caulking or sealant compounds.

Exposed CMU masonry shall be cleaned by dry brushing at the end of each day's work and after final pointing to remove mortar spots and droppings.

914-3.04 Cold Weather Protection. The following construction procedures shall be followed when temperature ranges, as indicated below, exist at the time of installation. Temperatures are air temperatures at the time of installation except in the case of grout when temperature ranges apply to anticipated minimum night temperatures.

40° F (4 °C) to 32° F (0° C)

Mortar: Heat mixing water to produce mortar temperature between 40° F (4 °C) and 120° F (49° C).

Grout: Follow normal masonry procedures.

32° F (0 °C) and below:

No masonry construction shall be performed.

Completed masonry and masonry not being worked shall be protected in the following manner when the temperatures indicated are reached. Temperature ranges indicated apply to mean daily air temperatures except for grouted masonry. For grouted masonry temperature ranges apply to anticipated minimum night temperatures.

40° F (4 °C) to 32° F (0 °C)

Protect masonry from rain or snow for at least 24 hours by covering with weather-resistive membrane.

32° F (0 °C) and below:

No masonry construction shall be performed.

914-4 Method of Measurement

Walls shall be measured by the square foot (*square meter*) along the front face of the wall, from the top of the footing to the top of the wall cap. When indicated in the bidding schedule, walls may be measured by the linear foot (*meter*) along the front face of the wall. The linear foot (*meter*) measurement shall include all of the actual area between the top of the footings to the top of the wall cap.

914-5 Basis of Payment

The accepted quantities of masonry noise wall, screen wall and sign wall, measured as provided above, will be paid for at the contract unit price per square foot (*square meter*) as noted in the bid schedule, complete in place, including all excavation, backfill, compaction, concrete, reinforcement, stucco and sign wall treatments, stone wall veneers, graphics, copper letters, boulders, stepped footings, nitches, grout, PVC control joints, labor, equipment, materials and incidentals necessary to complete the work.

SECTION 915

TEMPORARY SILT FENCE

915-1 DESCRIPTION

The work under this section shall consist of furnishing, installing, maintaining, and removing a geotextile barrier-fence designed to remove suspended particles from the water passing through it.

The temporary silt fence shall be installed in accordance with the details and at the locations as shown on the project plans. The installation shall be in accordance with the requirements of these specifications except as otherwise directed or approved by the Engineer. The quantity of temporary silt fence to be installed will be affected by the actual conditions which occur during the construction of the project.

915-2 MATERIALS

915-2.01 Geotextile Fabric: The silt fence geotextile fabric shall be supplied in accordance with the material requirements of sections 1014-1 and 1014-8.

This specification provides criteria for wire supported geotextile silt fence as well as a self supporting geotextile silt fence.

915-2.02 Fabric Packaging, Handling, and Storage: The identification, packaging, handling, and storage of the geotextile fabric shall be in accordance with ASTM D 4873. Fabric rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Rolls will be stored on the site or at another identified storage location in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof, light colored, opaque cover.

915-2.03 Posts: Posts shall be a minimum of 3 feet (*1 meter*) plus the burial depth in length and may be made of either wood or steel. Soft wood posts shall be at least 3 inches (*75 millimeters*) in diameter, or nominal 2 inch by 4 inch (*50 millimeters by 100 millimeters*) and straight enough to provide a fence without noticeable misalignment. If oak posts are used, the size may be reduced to 1-1/2 inch by 1-1/2 inch (*38 millimeters by 38 millimeters*) with a minus tolerance of 1/8 inch (*3 millimeters*), provided that the cross sectional area is a minimum of 2.25 square inches (*1450 square millimeters*). Steel posts shall have a minimum weight of 1.3 pounds per linear foot (*1.95 kilograms per meter*), and have projections for fastening the wire and fabric to the fence.

915-2.04 Wire Support Fence: Wire support fence shall be a minimum of 2.75 feet (*830 millimeters*) high and shall be 7/64 inch (*2.8 millimeters*) diameter steel wire mesh.

915-2.05 Fasteners for Wooden Posts: Wire staples shall be 3/64 inch (*1.2 millimeters*) diameter and shall have a crown at least 3/4 inch (*19 millimeters*) wide and legs at least 1/2 inch (*13 millimeters*) long. Staples shall be evenly spaced with at least five per post.

Nails shall be 1/16 inch (*2 millimeters*) in diameter, 1 inch (*25 millimeters*) long with 3/4 inch (*19 millimeters*) button heads. Nails shall be evenly spaced with at least four per post.

915-3 CONSTRUCTION REQUIREMENTS

915-3.01 Silt Fence Installation: The contractor shall install a temporary silt fence as shown on the plans, and at other locations as directed or approved by the Engineer. Fence construction shall be adequate to handle the stress from sediment loading. Geotextile at the bottom of the fence shall be buried a minimum of 6 inches (*150 millimeters*) in a trench so that no flow can pass under the barrier. The trench shall be backfilled and the soil compacted over the geotextile. Fence height shall be as specified by the Engineer but in no case shall exceed 3 feet (*900 millimeters*) above ground surface.

915-3.02 Geotextile Fabric Post Attachment: The geotextile fabric shall be attached on the upstream side of the posts by wire, cord, button head nails, pockets, staples, or other acceptable means. The geotextile fabric shall be installed in such a manner that 8 to 10 inches (*200 to 250 millimeters*) of fabric is left at the bottom to be buried. The fabric shall be installed in the trench such that 6 inches (*150 millimeters*) of fabric is against the side of the trench and 2 to 4 inches (*50 to 100 millimeters*) of fabric is across the bottom of the trench in the upstream direction. The trench shall then be backfilled and compacted so that no flow can pass under the barrier.

A minimum overlap of 18 inches (*450 millimeters*) shall be provided at all splice joints with posts at the ends of each fabric roll.

At the time of installation, the fabric will be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, storage or installation.

915-3.03 Silt Fence Maintenance: The contractor shall be responsible to maintain the integrity of silt fences as long as necessary to contain sediment runoff in accordance with Subsection 107.15, or as directed by the Engineer.

915-3.04 Sediment Deposit Removal: Sediment deposits shall be removed when the deposit reaches approximately one-half of the height of the silt fence. The Engineer may also direct the contractor to install any additional silt fence.

915-3.05 Fence Removal: The silt fence shall remain in place until the Engineer directs that it be removed. Upon removal, the contractor shall remove and dispose of any excess silt accumulations, grade the area to leave a generally smooth appearance.

915-4 METHOD OF MEASUREMENT

Temporary silt fence will be measured per linear foot (*linear meter*). No allowance will be made for extra material used in overlapping at splice joints.

When no bid item is provided and removal of sediment is directed by the Engineer it shall be paid for in accordance with the provisions of Subsection 109-5. Removal of sediment will be measured by the cubic yard (*cubic meter*) in the hauling vehicle.

915-5 BASIS OF PAYMENT

The accepted quantity of temporary silt fence, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), complete in place, including all labor, materials, and equipment connected with placing the temporary silt fence as shown on the project plans or as directed by the Engineer. No payment will be made for rejected temporary silt fence, or patching, due to contamination or damage by the contractor. No payment shall be made for removal of the silt fence.

The removal of sediment will be paid for at the contract unit price per cubic yard (*cubic meter*), including the removal and disposal of silt accumulations as provided for in the erosion control plan for the project.

When no bid item is provided and removal of sediment is directed by the Engineer it shall be paid for in accordance with the provisions of Subsection 109-5.

SECTION 916

EMBANKMENT CURB

916-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing portland cement concrete embankment curbs at the locations and in accordance with the details shown on the project plans and the requirements of these specifications.

Embankment curb is a non-traffic control curb.

916-2 MATERIALS

916-2.01 Concrete. Portland cement, water and admixtures shall conform to the requirements of Section 1006 for Class B concrete.

Fine aggregate and coarse aggregate shall conform to the requirements found in Section 1006. The designated size of coarse aggregate shall be No. 7, No. 67 or No. 57. At the option of the contractor, aggregate conforming to the requirements for Aggregate Base, as shown in Subsection 303-2 may be furnished.

The contractor may add additional fine aggregate to the aggregate for the curb in order to facilitate finishing. Fine aggregate for this purpose shall be nonplastic and shall conform to the following grading requirements:

Passing No. 4 sieve (*4.75 millimeters*):	100 percent
Passing No. 200 sieve (*75 micrometers*):	0-10.0 percent

Fine aggregate added for this purpose shall not exceed 25 percent of the total aggregate for the concrete curb.

916-2.02 Concrete Curing Compound. Liquid membrane-forming compound shall conform to the requirements of AASHTO M 148, Type I, Class A.

916-3 CONSTRUCTION DETAILS

The contractor shall be responsible for furnishing the various ingredients and for proportioning and mixing them; however, approval of the proposed materials and proportioning and mixing shall be obtained prior to any concrete operations.

No field tests will be required on the concrete mixture.

The requirements for mixing and placing concrete in cold weather shall conform to the requirements of Subsection 1006-5.03. There is no maximum temperature limitation on the concrete mixture immediately before placement.

Embankment curb shall be constructed either by the use of conventional fixed forms or by slip-form curb placing machines. The surface on which the curbs are to be placed shall be cleaned of all loose dirt and debris prior to placing.

The work shall be performed so as not to mar the roadway surface. Concrete placed in fixed forms shall be thoroughly consolidated.

If slip-form equipment is used to construct embankment curb, such equipment shall be designed specifically for the work. The Engineer may require the contractor to demonstrate that the specific equipment he proposes to use is capable of satisfactorily placing the concrete mix. If the curb produced by such machines is not acceptable, the use of such machines shall be terminated.

Curbs shall present a neat appearance. The finish normally associated with the use of slip-form curb placing machines, including the use of moveable forms, will be considered as acceptable for the finishing of concrete embankment curb. When bituminous material is being applied to the adjacent roadway, curbs shall be protected so that they are not spattered or discolored.

Embankment curb shall be cured by the application of liquid membrane-forming compound. The timing and rate of application shall be approved by the Engineer.

916-4 METHOD OF MEASUREMENT

Embankment curb will be measured by the linear foot (*meter*) of curb placed. Lengths occupied by spillway inlets will be excluded from the measurement.

916-5 BASIS OF PAYMENT

The accepted quantities of embankment curb, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), complete-in-place.

SECTION 917

EMBANKMENT SPILLWAYS, EMBANKMENT DOWN-DRAINS, INLET AND OUTLETS

917-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing embankment spillways, embankment down-drains, inlets, and outlets at the locations designated on the project plans and in accordance with the details shown on the project plans and the requirements of these specifications.

917-2 MATERIALS

917-2.01 Concrete. Concrete shall be Class B and conform to the requirements of Section 1006.

917-2.02 Welded Wire Fabric, Reinforcing Bars and Miscellaneous Structural Steel. Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

Welded wire fabric and wire ties shall conform to the requirements of Section 1003.

Steel bars for reinforcing, anchor stakes and trash racks shall conform to the requirements of Section 1003.

Miscellaneous structural steel shall conform to the applicable requirements of Section 1004.

917-2.03 Corrugated Metal Pipe. Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted. Corrugated metal pipe shall conform to the requirements of Subsection 1010-2.01.

917-2.04 Expansion Joint Filler. Preformed bituminous joint filler shall conform to the requirements found in Section 1011.

917-3 CONSTRUCTION DETAILS

917-3.01 General. Embankment slopes and existing ground at outlets shall be excavated in reasonably close conformity to the lines, grades and cross sections shown on the plans or established by the Engineer.

Excess excavated material shall be removed from the site or disposed of by uniformly spreading on embankment slopes.

Backfill shall be placed and compacted in accordance with the requirements of Subsection 203-9 for embankment.

917-3.02 Concrete. Concrete spillways, inlets and outlets shall be constructed in accordance with the requirements of Section 601. Reinforcing with wire mesh or steel bars, as indicated on the plans, shall be placed in accordance with the requirements of Section 605.

Concrete surfaces shall be protected from discoloration.

Preformed bituminous joint material shall be placed around timber guardrail posts imbedded in concrete.

917-3.03 Metal. Each separate down-drain installation shall be assembled from one type of pipe only. Steel and aluminum shall not be used in the same installation.

Corrugated metal pipe utilized in construction of down-drains shall be installed in accordance with the applicable requirements of Section 501.

917-4 METHOD OF MEASUREMENT

917-4.01 Embankment Spillways and Embankment Down-Drains. Embankment spillways and embankment down-drains will be measured by the linear foot (*meter*) along the slope at the center line of the spillway and along the metal down-drain parallel to the center line of the pipe.

917-4.02 Inlets and Outlets. Inlets and outlets will be measured as a unit for each installation of the type specified.

Trash racks will not be measured for separate payment, but will be considered as included in the price bid for inlets.

917-5 BASIS OF PAYMENT

The accepted quantities of embankment spillways, embankment down-drains, inlets, and outlets, measured as provided above, will be paid for at the contract unit price, complete-in-place, including excavating and backfilling.

SECTION 920

SOIL-CEMENT FOR BANK PROTECTION, LININGS AND GRADE CONTROL STRUCTURES

920-1 DESCRIPTION

The work under this section shall consist of furnishing all materials and constructing soil-cement bank protection, linings and grade control structures at the locations and in accordance with the details shown on the project plans and the requirements of the specifications. The work shall include toe trench excavation, backfill, and dewatering.

920-2 MATERIALS

920-2.01 Portland Cement. Portland cement shall conform to the requirements of ASTM C 150 for Type II.

920-2.02 Fly Ash. Fly ash shall conform to the requirements of Subsection 1006-2.04 (D).

920-2.03 Water. Water shall conform to the requirements of Subsection 1006-2.02.

920-2.04 Aggregate. The soil used in the soil-cement mix shall not contain more than 5% material retained on a 2 inch (*50 millimeter*) sieve, nor any deleterious material. Soil for soil-cement lining shall be obtained from the required excavations or from borrow areas specified on the plans or approved by the Engineer and stockpiled on the job site as specified herein. The contractor shall be responsible for providing all the soil required for soil-cement production. Soil, meeting the gradation requirements specified herein, shall be obtained from the project excavations and/or from borrow areas specified on the plans or obtained by the contractor. Soil suitable for soil-cement shall be obtained from the required excavations, as shown on the project plans, before any borrow material is allowed to be used for this purpose. The contractor shall be responsible for locating and stockpiling suitable material from all project excavations in order to minimize the percentage of cementitious material necessary to achieve the required compressive strength. The actual soil to be incorporated into the soil-cement shall be analyzed by laboratory tests in order to determine the mix proportions to be used on the project. The distribution and gradation of materials in the soil-cement lining shall not result in lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from surrounding material. Soil shall conform to the following gradation:

Sieve Size	Percent Passing (Dry Weight)
2 inch (*50 millimeters*)	95% -100%
#4 (*4.75 millimeters*)	50% - 90%
#200 (*75 micrometers*)	3% - 15%

The Plasticity Index shall be a maximum of 5.

Clay and silt lumps larger than 1/2 inch (*13 millimeters*) shall be unacceptable, and screening, in addition to that previously specified, will be required whenever this type of material is encountered.

920-2.05 Design Procedures. The design requirements for the soil-cement shall be such that it achieves a compressive strength of 750 psi (*5170 kilopascals*) after 7 days.

Based on the design, the Engineer shall specify the percentage of cementitious material and moisture content. The design shall be performed in accordance with the Pima County Department of Transportation and Flood Control District's procedure, "Determination of Cement Content Required for Soil-Cement Mixtures" which is a modification of Arizona Test Method 220. Testing shall include 24 hour compressive strength results to evaluate the strength gained when compared to 7 day compressive strengths.

The cementitious portion of the soil-cement mix shall consist of one of the following alternates:

One hundred percent portland cement.

Eighty-five (85) percent portland cement and fifteen (15) percent fly ash.

When the option to incorporate fly ash into the cementitious portion of the mix is used, fly ash shall replace portland cement based on a ratio of one pound (*kilogram*) of fly ash added for each pound (*kilogram*) of portland cement removed.

The contractor shall allow a minimum of eight days for the determination of the content of cementitious material.

During the course of the work, the Engineer may adjust the cementitious content to assure that the required compressive strength is being attained. Changes to the mix shall be made promptly by the contractor when so directed by the Engineer.

For bidding purposes only, the estimated content of cementitious material in the soil-cement mix shall be as specified in the Special Provisions.

920-3 CONSTRUCTION DETAILS

920-3.01 Equipment. Soil-cement bank protection, linings or grade control structures may be constructed with any combination of machines and/or equipment, except as noted herein, that will produce a completed soil-cement lining or structure meeting the requirements for soil pulverization, cementitious material content and moisture content, mixing, transporting, placing, compacting, finishing, and curing as provided in these specifications.

920-3.02 Preparation. Before soil-cement processing begins, the area to be lined shall be graded and shaped to the lines and grades shown on the plans or as directed by the Engineer. The subgrade shall be compacted to a minimum of 90 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Immediately prior to placement of the soil-cement mixture, the underlying material shall be moistened if necessary. Soft or yielding native material shall be corrected and made stable in accordance with the requirements of Subsection 203-5.03(A).

920-3.03 Stockpiling of Aggregate. The aggregate stockpile(s) shall be constructed on level, firm ground free of brush, trees, stumps, roots, rubbish, debris and other objectionable or deleterious material and shall be located so as to provide a distance of not less than 15 feet (*4.5 millimeters*) from the outside bottom edge of any other existing stockpile. The stockpile shall be constructed in layers; each layer not exceeding 2 feet (*600 millimeters*) in thickness. Ramps formed for stockpile construction shall be of the same material as that being stockpiled, and will be considered a part of the stockpile. Before steepening a ramp, any contaminated surface material shall be removed.

Stockpiled material should be thoroughly mixed throughout its depth, width, and length before utilization. The material shall be homogeneous and uniform in color, gradation and moisture throughout.

The contractor shall be solely responsible for the construction of the stock pile(s), including monitoring for quality and uniformity of the material placed therein. To assure conformance with the requirements of this Subsection and Subsection 920-2.04, the Engineer will, at random intervals during construction of the stockpile, sample and test the material being placed therein. Results from these tests shall be compared against the test results obtained by the contractor to assure compliance with the requirements of Subsection 920-2.04.

Unless otherwise approved by the Engineer, final sampling for acceptance of the soil aggregate will be conducted after the required quantity of soil aggregate, necessary to complete soil-cement placement on a substantial portion of the project, has been stockpiled. After a stockpile has been sampled and accepted, no material will be added to it without the approval of the Engineer.

Stockpiled material shall also conform to the applicable requirements of Subsection 106-3 and Subsection 1006-2.06.

The stockpile(s) shall be completed and approved at least eight days prior to the start of soil-cement production, so as to provide sufficient time for verification of the mix proportions for the project.

The contractor may have to blend dissimilar soils in order to maintain the optimum soil properties and gradation specified in Subsection 920-2.04, and thus minimize overruns of cementitious material. Blending shall require constructing separate stockpiles for materials to be blended and shall be performed by the utilization of separate storage feed bins at the plant, to the satisfaction of the Engineer.

920-3.04 Blending of Cement and Fly Ash. The blending procedure shall be sufficient to provide a uniform, thorough, and consistent blend of cement and fly ash. The blending method and operation shall be approved by the Engineer prior to the commencement of soil-cement production. In the blending of the cementitious materials, the percent of fly ash content shall not vary by more than ± 2.0 percent of the contents specified by the Engineer.

Weighing or volumetric measuring devices are required at both the cement and fly ash feeds. At the direction of the Engineer, an additional measuring device may also be required when the cement and fly ash are pre-blended at the site. In the production of soil cement, the percent of cementitious material shall not vary by more than ± 0.3 percent of the contents specified by the Engineer.

Silos and feeders shall be equipped and operated so as to provide uniform rates of feed and prevent caking. Provisions shall be made to allow for ready sampling of the cementitious material(s).

920-3.05 Mixing Plant. Soil-cement shall be mixed in an approved central-type plant having a stationary twin shaft pugmill mixer of the continuous mixing type or an approved batch-type pugmill. The mixing plant shall be designed, coordinated and operated to produce a soil-cement mixture of the proportions specified within the required tolerances. The plant shall be equipped with positive means for controlling and maintaining a constant time of mixing. Twin shaft pugmills shall also be equipped with a positive means for maintaining a constant speed of rotation of the shafts. The plant shall be equipped with screening, feeding, and weighing, metering or volumetric measuring devices that will add the soil, cementitious material(s) and water into the mixer in the specified quantities. The blades of twin shaft continuous pugmill mixers shall be adjustable for angular position on the shaft and reversible to retard the flow of the mix.

When the quantity of water is controlled by metering, provisions shall be made by the contractor whereby the quantity of water delivered through the meter can be readily converted to weight. A water storage tank may be required to prevent the adverse effects created by surge drawdown.

The soil aggregate feed rate shall be controlled by a variable speed belt or a remotely operated gate, calibrated to accurately deliver any specified quantity of material. The feed rate shall

be readily adjustable from the control panel to compensate for changes in the moisture content of the soil or to change soil aggregate proportions when blending is required and separate bins are utilized. The combined aggregate belt feeding the mixer shall be equipped with an approved belt scale. The belt scale shall operate automatic controls which will govern the proportions of cementitious material and water as ratios of the total soil aggregate, with provisions for ready changing of the proportions.

When a continuous mixing plant with a fixed soil aggregate feed rate system is used, the belt shall travel at a constant speed. The feed system shall continuously deliver aggregate to the mixer at a constant feed rate, calculated on a dry weight basis, at any locked gate setting. The feed system shall be mechanically interlocked with all other feed devices. The soil aggregate feed monitoring system shall provide the rate of and total quantity of soil aggregate fed into the mixture.

The plant shall be equipped with a hydraulically or mechanically operated discharge holding-bin having a minimum capacity of 20 tons (*18 metric tons*).

Mixing shall be sufficient to secure a homogeneous, intimate, uniform mixture of the soil, cement, fly ash, and water within the specified tolerances. Soil and cementitious material shall be mixed sufficiently to prevent cementitious balls from forming when water is added.

Mixing shall not proceed when the soil aggregate or the area on which the soil-cement is to be placed is frozen. Soil-cement shall not be mixed or placed when the air temperature is below 45° F (*7 °C*), unless the air temperature is at least 40° F (*5 °C*) and rising.

Free and safe access to the plant must be provided to the Engineer at all times for inspection of the plant's operation, and for sampling the soil-cement mixture and its components.

920-3.06 Measuring Devices. Weighing, metering or volumetric measuring devices specified in Subsection 920-3.05 and 920-3.06 shall record the quantity of the material, and shall have a digital readout such that the total discharged quantity per hour and the cumulative total quantity are displayed.

Measuring devices shall be calibrated, at the contractor's expense, and approved by the Engineer.

Each measuring device shall be calibrated to an accuracy of $\pm$ 2 percent and shall be inspected and calibrated as often as the Engineer deems necessary to assure their accuracy.

920-3.07 Required Moisture. The moisture content of the mix shall be adjusted by the contractor as needed to achieve the compressive strength and compaction requirements specified herein.

920-3.08 Handling. The soil-cement mixture shall be transported from the mixing area to the embankment in clean equipment. Hauling equipment shall be outfitted with suitable covers to protect the mixture in unfavorable weather. The total elapsed time between the addition of water to the mixture and the start of compaction shall be the minimum possible. In no case should the total elapsed time exceed 30 minutes. This time may be reduced by the Engineer when the air temperature exceeds 90° F (*32 °C*), or when there is a breeze or wind which promotes rapid drying of the soil-cement mixture.

920-3.09 Placing. The mixture shall be placed on the moistened subgrade embankment, or previously completed soil-cement with spreading equipment that will produce layers of such widths and thicknesses as are necessary for compaction to the required dimensions of the completed soil-cement layers. The compacted layers of soil-cement shall not exceed 8 inches (*200 millimeters*), nor be less than four 4 inches (*100 millimeters*) in thickness.

Each successive layer shall be placed as soon as practicable after the preceding layer is completed and certified.

All soil-cement surfaces that will be in contact with succeeding layers of soil-cement shall be kept continuously moist by fog spraying until placement of the subsequent layer, provided that the contractor will not be required to keep such surfaces continuously moist for a period longer than 7 days.

The contractor shall take all necessary precautions to avoid damage to the completed soil-cement by equipment, and to avoid the deposition of raw earth or foreign materials between layers of soil-cement. Where ramps are constructed over soil-cement that is not to grade, all foreign materials and the uppermost 1 inch (*25 millimeters*) of the previously placed soil-cement mixture must be removed prior to continuation of the soil-cement construction.

920-3.10 Compaction. Soil-cement shall be uniformly compacted to a minimum of 98 percent of maximum density as determined by field density tests taken in accordance with the procedures of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer. Optimum moisture and maximum density shall be determined in accordance with Arizona Test Method 221, 222b and 223 procedures. Wheel rolling with only hauling equipment shall not be an acceptable method of compaction.

At the start of compaction, the mixture shall be in a uniform, loose condition throughout its full depth. Its moisture content shall be such that the required compaction can be achieved with a minimum of effort and manipulation of the mix. No section shall be left undisturbed for longer than 30 minutes during compaction operations. Compaction of each layer shall be conducted in such a manner as to produce a dense surface, free of compaction planes in

not longer than 1 hour from the time water is added to the mixture. Whenever the contractor's operation is interrupted for more than 2 hours, the top surface of the completed layer, if smooth, shall be scarified to a depth of at least 1 inch (*25 millimeters*) with a spike tooth instrument, or by other means acceptable to the Engineer, prior to placement of the next layer. The spacing of striations, produced by scarifying, shall not exceed 18 inches (*450 millimeters*) measured perpendicular to the length of the soil-cement being placed. The surface, after said scarifying, shall be swept using a power broom, or other method approved by the Engineer, to completely free the surface of all loose material prior to placement of the next layer of soil-cement.

920-3.11 Finishing. After compaction, the soil-cement shall be further shaped to the required lines, grades, and cross sections and rolled to a reasonably smooth surface.

920-3.12 Curing. Temporarily exposed surfaces shall be kept moist as directed by the Engineer.

Care must be exercised to ensure that no curing material, other than water, is applied to the surfaces that will be in contact with succeeding layers.

Permanently exposed surfaces shall be kept in a moist condition for 7 days, or they may be covered with a suitable curing material, subject to the Engineer's approval. Any damage to the protective covering within 7 days shall be repaired to the satisfaction of the Engineer.

When a curing material, other than water is used, the permanently exposed surfaces shall be kept moist until the curing material is applied. The curing material is to be applied as soon as practicable, with a maximum time limit of 24 hours between the finishing of the surface and the application of the protective cover or membrane.

When necessary, the soil-cement shall be protected from freezing for 7 days after its construction by a covering of loose earth, straw, or other suitable material approved by the Engineer.

920-3.13 Maintenance. The contractor shall be required, within the limits of his Contract, to maintain the soil-cement in good condition until all work is completed and accepted. Maintenance shall include immediate repairs of any defects that may occur. This work shall be done by the contractor at his own expense and repeated as often as necessary. Faulty work shall be replaced for the full depth of the layer.

920-3.14 Inspection and Testing. The Engineer, with the assistance and cooperation of the contractor, shall make such inspections and tests as he deems necessary to ensure the work conforms to the contract documents. These inspections and tests may include, but shall not be limited to: (1) the taking of test samples of the soil-cement and its individual components at all

stages of processing and after completion, and (2) the close observation of the operation of all equipment and methods used on the work. Only those materials and methods achieving the requirements specified herein shall be acceptable.

Testing during production shall typically consist of four sets of compressive strength samples per shift and a minimum of one belt sample. Plant scale readings shall be recorded a minimum of 4 times per shift.

All testing of soil-cement, its individual components, or the mix design unless otherwise provided specifically in the plans or Special Provisions, shall be in accordance with the latest applicable Agency specifications in effect as of the date of advertisement for bids on the project.

Testing for proper compaction shall be done on at least every other layer of compacted soil-cement, at any location chosen by the testing personnel. If the layer being tested does not achieve the minimum density, as specified in Subsection 920-3.10, the Engineer may direct the layer to be reworked providing that the time requirements to complete compaction are not exceeded, until it meets the minimum density. Layers not meeting the minimum density shall be removed at no additional cost to the Agency. The contractor shall not be permitted to continue placing subsequent layers of soil-cement on any layer which has failed to achieve the required compaction until such time as the deficient layer has been reworked, retested, and found to meet the density requirements specified.

The initial acceptance of the soil-cement shall in no way preclude further examination and/or testing at any time during the course of construction or the warranty period that the Engineer suspects that the material is not properly represented by the sample(s) obtained to date. The acceptance, at any time, of material incorporated into the work shall not bar its future rejection if it is subsequently found to be defective in quality or uniformity.

920-4 METHOD OF MEASUREMENT

The work shall be measured: (1) in cubic yards (*cubic meters*) of soil-cement bank protection, lining or grade control structure, as determined by the specified lines, grades, and cross sections shown on the plans or as calculated from the soil-cement plant scale readings, whichever is the lesser; and (2) in tons (*metric tons*) of cementitious material (i.e., portland cement or portland cement and fly ash) incorporated into the soil-cement used for bank protection, linings, or grade control structure(s) as indicated in the special provisions or in accordance with the instructions of the Engineer.

Cementitious material shall be computed in accordance with the example herein provided. Any waste of cementitious material and/or soil-cement material by the contractor during the handling, mixing, placing, etc., operations shall not be paid for.

920-4.01 Example Calculation For The Measurement of Cementitious Material Incorporated Into The Soil Cement.

Cementitious Material (Tons) = A x B x C

where:

A = Volume of soil cement as determined from the lesser of: (1) the specified lines, grades and cross-sections indicated on the plans, or (2) from the total plant scale readings for aggregate and cementitious material divided by "B", the average in-place dry density.

B = Average in-place dry density as determined from the compaction test results obtained through the course of construction.

C = Average content of cementitious material as determined from the plant scale readings and calculated by dividing the total weight of cementitious material by the total weight of dry aggregate and cementitious material.

Thus, if: A = 10,000 cubic yards; B = 135 pounds per cubic foot or 1.8225 tons per cubic yard; and C = 8.0%; the quantity of cementitious material, for the purpose of payment, would be 1,458 tons.

920-5 BASIS OF PAYMENT

The accepted quantities of soil-cement, measured as provided above, will be paid for at the contract unit price per cubic yard (*cubic meter*) of soil-cement bank protection, lining, or grade control structure and at the contract unit price per ton (*metric ton*) of cementitious material (i.e., portland cement or portland cement and fly ash). Such payment shall constitute full reimbursement for all work necessary to complete the soil-cement bank protection, linings, or grade control structures, including: dewatering; toe trench excavation; providing and stockpiling soil aggregate; watering; mixing; placing; compacting; shaping and finishing; curing; inspection; removal of screened material and excess stockpiled material; and testing assistance; and all other incidental operations.

Payment for additional excavation, where determined necessary by the Engineer to remove unsuitable material, in accordance with the requirements of Subsection 203-5.03(A), will be made in accordance with the provisions of Subsection 109-3.

No direct payment shall be made for excavating and hauling material from the project to the stockpile or blending dissimilar soils, if such blending is directed by the Engineer to make

unsuitable soils acceptable and/or to minimize the percentage of cementitious material incorporated in the mix. The cost of the blending, inclusive of hauling and stockpiling, shall be considered incidental to and included in the cost of producing and placing the soil cement.

Borrow, if required, shall be paid in accordance with Subsection 109-5.

SECTION 922

UTILITY CONCRETE FOR MISCELLANEOUS CONSTRUCTION

922-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, mixing and placing portland cement concrete for post foundations and anchors for barrier fences, line fences, chain link fences and miscellaneous signs; concrete foundations for depth gauges at fords; concrete for right-of-way markers and survey monuments; post barricades; safety barricade railing and handrails; concrete rings at ground surface for irrigation valves and gates; concrete fill at the base of electrical pull boxes; and for similar uses as specified on the project plans or in the special provisions.

922-2 MATERIALS

Portland cement, water, admixture, fine aggregate, and coarse aggregate shall conform to the requirements of Section 1006. The coarse aggregate size designation shall be chosen by the contractor and be approved by the Engineer and shall conform to the size designation and gradation requirements of AASHTO M 43.

922-3 CONSTRUCTION DETAILS

The Engineer will inspect and approve the facilities, materials, and methods for producing the concrete to insure that concrete of the quality suitable for use in the work will be obtained. Mixing and placing of the concrete shall conform to the requirements of recognized practice. Concrete may be mixed in approved mobile mixers.

Mixing and placing concrete in cold weather shall conform to the requirements of Subsection 1006-5.03. There is no maximum temperature limitation for the concrete mixture immediately prior to placement.

The minimum cement content per cubic yard of concrete shall be 615 pounds per cubic yard (365 *kilograms per cubic meter*).

All exposed concrete shall be finished to a smooth surface.

922-4 METHOD OF MEASUREMENT

No measurement will be made of the concrete used.

922-5 BASIS OF PAYMENT

No direct payment will be made for furnishing and placing utility concrete. The cost will be considered as included in the price bid for the item of work in which the concrete is incorporated.

SECTION 923

UTILITY INSTALLATIONS WITHIN PUBLIC RIGHTS-OF-WAY

923-1 DESCRIPTION

The work under this section shall consist of furnishing all labor, materials and equipment required for saw cutting, removal, and disposal of existing pavement, trench excavation, conduit installation, trench backfill, subbase preparation, pavement replacement, surface restoration, and cleanup as shown on the project plans at the locations and in accordance with the details.

923-2 MATERIALS

923-2.01 Native Material. Native material shall be defined as material, excavated from the trench that is acceptable for use as trench backfill. Native material shall be free from deleterious and organic substances, clay balls greater than 2 inches (*50 millimeters*) in diameter, concrete, asphaltic concrete, and debris of any nature. Native material shall not contain stone larger than 8 inches (*200 millimeters*) in greatest dimension for trench widths of 12 inches (*300 millimeters*) and above. For trenches less than 12 inches (*300 millimeters*) in width the stone size shall not exceed 3 inches (*75 millimeters*). Native material shall not have an excessive plasticity index or percentage of material passing the No. 200 (*75 µm*) sieve.

923-2.02 Imported Material. Imported material used for trench backfill is borrow material meeting the requirements of either native material as specified herein or as specified in Subsection 501-3.05.

923-2.03 Aggregate Base Course. Aggregate base course shall conform to the requirements of Subsection 303-2.

923-2.04 Controlled Low Strength Material (CLSM). Controlled low strength material shall conform to the requirements of Subsection 501-2.04.

923-2.05 Portland Cement Concrete. Portland cement concrete shall conform to the requirements for Class S, f'c = 3,000 psi (*20.7 mega pascals*), concrete set forth in Section 1006 and Table 1006-1.

923-2.06 Asphaltic Concrete. Asphaltic concrete shall conform to the requirements of Section 406.

923-2.07 Bituminous Surface Treatments. Bituminous surface treatments shall conform to the requirements of Section 404.

923-3 CONSTRUCTION DETAILS

923-3.01 Traffic Control. Traffic control shall conform to the requirements of Section 104-4.

923-3.02 Pavement Removal.

(A) Asphaltic Concrete. Cutting of asphaltic concrete at the patch width shall be done by full depth sawing. The patch width shall be a minimum of 2 feet (*600 millimeters*) wider than the top of trench width, with a minimum 1 foot (*300 millimeters*) shoulder on each side. Ripping, rooting or other methods which may damage the pavement beyond the patch width are prohibited. Asphaltic concrete shall be cut to its full depth before removal is begun.

If the pavement is sawed to full patch width prior to pavement removal, the contractor shall exercise care to prevent damage to the shoulders created during excavation, pipe laying and backfilling operations. Damaged shoulders shall be repaired by benching the trench at an elevation not to exceed 1 foot (*300 millimeters*) below the level of damage and a new shoulder established. The contractor may establish a new bench by sawing the pavement 1 foot (*300 millimeters*) wider on the side of the trench having the damaged bench.

Asphaltic concrete thus removed shall be properly disposed of off the job site and cannot be used in the trench backfill.

(B) Portland Cement Concrete Surfaces Including Curbs and Sidewalks and Portland Cement Concrete Bases with Asphaltic Concrete Surface Courses. Portland cement concrete or portland cement concrete with asphaltic concrete surface courses shall be sawed to their full depth prior to pavement removal. Concrete pavements shall be sawed to their patch widths prior to removal. Concrete curb and sidewalk removal shall conform to Standard Detail 211 and 203, respectively.

923-3.03 Trenches. All underground utility installations located within the public right-of-way shall have a minimum of 36 inches (*900 millimeters*) of cover, as measured from finish grade. Underground utilities shall be located a minimum of 24 inches (*600 millimeters*) below any existing or proposed drainage structure.

(A) Longitudinal Trenches. For utility installations longitudinal to the centerline, on roadways classified as arterials or collectors by the Major Streets and Routes Plan, or as otherwise required by the Engineer, the length of open trench shall not exceed the distance between the centerlines of adjacent cross streets or 750 feet (*230 meters*), whichever is less.

For installations occurring on local streets or alleys, the length of open trench may be 1,000 feet (*305 meters*) or the length of pipe which will be installed in one day, whichever is less. In no case, however, shall two adjacent cross streets be closed to traffic at the same time.

Should it become impossible to maintain access to private property, the property owner/occupant shall be given written notice a minimum of 24 hours prior to the closure of access. Access shall be restored at the end of each work day unless otherwise approved by the Engineer.

(B) Transverse Trenches. For utility installations transverse to the centerline on roadways classified as arterial or collector streets by the Major Streets and Routes Plan trench lengths shall not exceed one-half the roadway width, unless otherwise authorized by the Engineer. Emergency vehicle passage shall be maintained at all times.

In roadways containing median dividers traffic will be maintained on both sides of the median, unless otherwise authorized by the Engineer.

Local streets and alleys may be closed when authorized by the Engineer. Emergency vehicle access must be maintained on streets with a single outlet at all times.

923-3.04 Excavated Material. Material excavated from the trench, may be windrowed along the side of the trench in such a location that no collapsing soil loads are transmitted to the trench walls, and no hazard to traffic, motorist or pedestrian is created.

923-3.05 Shoring and Sheeting. When necessary, because of space limitations, or for trench safety and/or the protection of existing adjacent above or underground facilities, trench shoring and/or sheeting is installed, the shoring and/or sheeting shall comply with applicable, current State of Arizona and OSHA regulations.

923-3.06 Dewatering. Permits shall be obtained in conformance with Subsection 107-2. Water tables shall be kept below final trench grade. Trenches shall be kept free of water during the time period beginning prior to excavation and ending upon the Engineer's orders. The contractor shall construct and maintain the necessary facilities; such as pumps, wells, drains, dams, and channels; to keep the trench free of water.

Water removed from the site shall be conveyed to drainage facilities without causing any damage or disturbance to adjacent property. The contractor shall be responsible for and shall repair, at his expense, any damage caused by water or protective works. Water levels shall be changed slowly and uniformly so as not to impair the stability of slopes and soil properties. No direct payment shall be made for dewatering unless otherwise specified and provided for in the special provisions.

923-3.07 Trench Backfill. Trench backfill for purposes of this specification shall consist of filling the trench void from an elevation 1 foot (*300 millimeters*) above the pipe, conduit or appurtenance up to subgrade elevation. Bedding and shading from the bottom of the trench to a point 1 foot (*300 millimeters*) above the pipe shall conform to the requirements of the facility owner.

Trench backfill material shall meet the requirements of Section 923-2.01, 923-2.02, or 923-2.03.

Backfill shall be placed in uniform loose layers not exceeding 8 inches (*200 millimeters*) in depth before compaction unless otherwise approved by the Engineer.

Backfill material shall be compacted to 95% percent of the maximum dry density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual, as directed and approved by the Engineer.

Jetting and water settling of trench backfill material shall not be permitted. Jetting and water settling of bedding/shading material, if in accordance with the specifications of the appropriate utility, is acceptable.

With Agency approval, trenches may be backfilled with lean concrete, conforming to Section 923-2.04. No pavement patching shall commence until the lean concrete has cured for a period of 24 hours.

923-3.08 Surface Replacement. Pavement replacement shall be installed in accordance with Standard Detail 216.

Replacement of portland cement concrete pavement or base shall include load transfer dowels conforming to the requirements of Standard Detail 216.

Concrete curb and sidewalk replacement shall conform to the requirements of Standard Detail 209 and 200 respectively.

923-3.09 Boring and Jacking. When, due to the Agency's pavement cut moratoria or other cause, boring or jacking under pavement becomes necessary or advisable, the contractor shall comply with the requirements of Section 929 of these specifications.

923-3.10 Surface Restoration and Clean Up. Any damage done to public or private property as a result of the contractor's operations shall be restored in kind by the contractor at no additional cost to the Agency.

Protection and restoration of property and landscape shall be in accordance with Section 107-12. For projects on land controlled by the Forest Service, the contractor shall comply with the requirements of Section 107-13.

923-4 METHOD OF MEASUREMENT

Option 1 - Applicable in instances where unit prices are shown for the following quantities:

(1) Pipe and appurtenances
(2) Pavement removal
(3) Pavement patch

(A) Pipe installed under the terms of this contract shall be measured in accordance with Section 501-4.

(B) No direct measurement shall be made for trench excavation or backfill. The cost is considered to be included in the installed cost of the utility facility.

(C) Pavement removal shall consist of sawcutting, removal of asphaltic concrete pavement, portland cement concrete pavement, concrete curbs and gutters and concrete sidewalk. Pavement removal shall be measured by the square yard (*square meter*) as the product of the length measured along the pipe centerline and the width measured from the saw line on one side of the trench to the saw line on the opposite side of the trench, measured perpendicular to the pipe centerline measurement of concrete curbs and gutters shall be by the linear foot (*meter*). No measurement, unless approved by the Engineer, shall be made for removal of pavement beyond the limits shown on Detail 216.

When no bid item for sawcutting or removal of pavement, curbs and gutters and sidewalks is noted, the sawcutting and/or pavement removal shall be considered incidental to the pipe installation and its cost shall be included in the contract payment items provided.

(D) For trench widths in excess of 4 feet (*1.2 meters*), when pavement removal is required to one lane width or to a wider width specified by the Agency having jurisdiction over the right-of-way, the width shall be measured to the saw lines for the Agency width specified. No measurement shall be made for overbreakage beyond the saw lines specified above.

(E) Surface replacement of pavement, curbs and/or sidewalk shall be measured in square yards (*square meters*) or linear foot (*meters*), as noted in the bid schedule, to the limits specified in 923-4(C) and (D) above for the type of patch required. The patch shall be measured complete in place.

(F) No measurement shall be made for temporary or permanent striping required on pavement replaced over trenches.

(G) No measurement shall be made for surface restoration and clean-up.

Option 2 - Applicable in instances where only a unit price for pipe is shown.

Pipe installed under the terms of this contract shall be measured in accordance with Section 501-4 and shall include all items of work necessary to complete the facility installation to and including acceptance by the facility owners.

Methods of measurement and payment other than those shown above shall be set forth in the special provisions.

923-5 BASIS OF PAYMENT

(A) Pavement Removal. Pavement, concrete curb, and concrete sidewalk removal measured as described in Section 923-4(C) and (D) above shall be paid for at the contract unit price per square yard (*square meter*) or linear foot (*meter*) when specified by the special provisions or noted in the bidding schedule. This price shall be full and complete payment for removal of pavement and disposal off the job site. It shall include any dumping fees at a proper disposal site. Payment for pavement or curb removal shall include sawing to its full depth along the patch lines of the asphaltic or concrete pavement to be removed. No payment for overbreakage beyond the dimensions shown in Standard Detail 216 will be made.

(B) Surface Replacement. Surface replacement measured as described in Section 923-4 (E) shall be paid for at the specified contract unit price. This payment shall be full and complete payment for the installation, complete in place, of the base material and the surface course installed over a base course.

(C) No payment shall be made for the following items:

(1) Excavation and backfilling of trenches. The excavation and backfilling of trenches will be paid for as part of the unit price per lineal foot (*meter*) of pipe installed complete in place.

(2) Replacement of any necessary traffic line striping.

(3) Load transfer dowels or deformed tie bars. No separate payment will be made for load transfer dowels or deformed tie bars. The cost of these dowels and tie bars shall be included in the unit price for concrete pavement replacement.

(4) Dewatering of trenches and excavations.

SECTION 926

ENGINEER'S FIELD OFFICE

926-1 DESCRIPTION

The work under this section shall consist of providing and maintaining a furnished field office for the exclusive use of, and occupancy by Agency or Consultant field personnel in accordance with the requirements of these specifications.

The office shall be a building or mobile trailer, meeting the requirements specified, which shall be erected at a location convenient to the project. The office may be in the same building or mobile trailer as office space of the contractor, provided that such office is separated from the area used by the contractor by a wall or door with an adequate locking device and at least one door to the outside.

The contractor may furnish equivalent facilities in an existing building, provided such facilities and buildings are located to provide convenient service.

926-2 MATERIALS (None Specified)

926-3 CONSTRUCTION DETAILS

926-3.01 General. The field office shall be an approved, weatherproof building or mobile trailer meeting the specified requirements. The structure shall have a minimum ceiling height of 7 feet (*2.1 meter*), and shall be provided with a weatherproof door equipped with adequate locking devices. Windows shall also be provided with adequate locking devices.

The office shall be fully equipped and made available for use and occupancy by Agency personnel, as well as comparable personnel employed by a Consultant, prior to the start of any contract work. The Engineer shall notify the contractor, in writing, of the acceptability of the field office provided.

All buildings shall be maintained in good condition and appearance by the contractor for the designated period, after which all portable buildings or trailers, fencing, surfacing, and utilities shall be removed from the site, the areas cleaned and seeded, if required, and left in a neat and acceptable condition.

926-3.02 Basic Requirements.

(A) Lighting. Electric light, non-glare type luminaires to provide a minimum illumination level at desk height level.

(B) Heating and Cooling. Adequate equipment to maintain an ambient air temperature of 72° F ± 5 degrees (*22 °C ± 3 °C*).

(C) Telephone. A separate phone line and telephone for the exclusive use of Agency and/or Consultant personnel. Long distance phone calls made on this line shall be paid for by the Agency.

The contractor shall also furnish two cellular telephones. The cellular telephones shall have: rechargeable batteries of sufficient capacity to operate the telephones during the working shift; two battery chargers with transformers as necessary; two vehicle power adapters; and two cellular telephone cases.

The contractor shall furnish and maintain the cellular equipment in good working order. If additional chargers or batteries are needed to keep the telephones in service during the work day, they shall be provided at no cost to the Agency. The contractor shall also provide insurance or self insure all cellular equipment from damage or loss.

As a minimum, the cellular telephones shall be regulated so that all incoming calls will be charged to the calling party. Only those calls originating from the cellular telephones shall be charged to its respective number.

(D) Toilet. A separate, enclosed room, properly ventilated and complying with applicable sanitary codes. Said facilities may be portable and separate, but adjacent to the field office.

(E) Maintenance. The contractor shall maintain all facilities and furnish equipment in good working condition.

(F) Extinguisher. Nontoxic, dry chemical, fire extinguisher UL approved for Class A, Class B, and Class C fires with a minimum rating of 2A:10B:10C.

(G) Potable Water.

926-3.03 Specific Requirements. In addition to the basic requirements, the office shall have a minimum of 150 square feet (*14 square meters*) of floor space with one outside door and two windows. The furnishings shall be as follows:

1 - Suitable office desk with drawers and locks
2 - Office chairs (padded)
1 - Table, 3' x 6' (*900 millimeters x 1850 millimeters*)
1 - Stool
1 - Filing cabinet, legal size with two drawers and a lock.

926-4 METHOD OF MEASUREMENT

Payment will be by the lump sum for all services specified; however, incremental payments shall be made for each month of occupancy by the Agency and/or Consultant personnel during the period of the contract. Payment will begin the first month that the office is fully equipped, serviced as specified, and made available for occupancy.

The lump sum payment shall also include:

The minimum amount of cellular air time shall be established by the contractor and approved by the Engineer. The service period shall be from the contract start date to the date of the final acceptance of the project.

No payment will be made for occupancy and services during periods of contract extension of time where engineering charges are assessed, or for periods when the office is not available and/or fully equipped.

926-5 BASIS OF PAYMENT

The lump sum bid shall include the cost of all labor, material, equipment, ground rental, and utility charges, including monthly service charges, but excluding charges for long distance telephone charges incurred by the Engineer, necessary to complete the work.

The lump sum bid shall include the cost of all cellular equipment associated with obtaining, operating, insuring, and maintaining two cellular telephones for use by the Engineer, including the cost of the calls originating from the cellular telephones.

The adjustment provisions of Section 104 shall not apply to this item.

SECTION 929

BORING AND JACKING

929-1 DESCRIPTION

The work under this section shall consist of furnishing all materials, labor and equipment required for boring and jacking all casing pipe and direct jacked pipe at the locations and in accordance with the details shown on the project plans and conforming with the requirements of these specifications.

929-2 MATERIALS

929-2.01 General. The materials to be used shall be approved by the Engineer prior to construction. The pipe to be jacked shall conform to the requirements of Section 501, 508, 510, or 511 except as modified herein.

Additional reinforcement or strength of pipe required to withstand jacking pressure shall be determined and furnished by the contractor; however, in no case shall the D-load of the pipe be less than that specified on the project plans.

929-2.02 Reinforced Concrete Pipe. Only pipe using double-rubber gasket, fiberglass reinforced epoxy collar, or approved equal type joints may be jacked directly. When reinforced concrete pipe is to be jacked in place, the design of such pipe, as shown on the plans, is based solely on the superimposed loads and not upon the loads which may be placed on the pipe as a result of the jacking operations. Any increase in pipe strength required to withstand jacking loads shall be determined by, and be the responsibility of, the contractor.

929-2.03 Casing Pipe. The diameter of the casing pipe shall be sufficient to allow adjustments in the line and grade of the pipe to be installed within the casing so as to meet allowable tolerances and to allow sand and/or grout to be placed between it and the casing pipe. The minimum diameter of the casing pipe shall be 6 inches (*150 millimeters*) larger than the outside diameter of the joints of the pipe to be installed within it.

Steel casing pipe shall not be less than 3/8 inch (*10 millimeters*) thick unless otherwise specified on the project plans or in the Special Provisions. Steel casing pipe shall have a minimum yield strength of 35,000 pounds per square inch (*240 megapascals*). All joints in the carrier pipe shall be watertight. Any section of casing pipe showing signs of failure shall be replaced and any leaking joint shall be repaired at no additional cost to the Agency.

929-2.04 Small Diameter Pipelines for Wet Boring. Pipe material shall be polyvinyl chloride, cast iron or ductile iron with push-on joints.

(A) Polyvinyl Chloride Pipe (PVC). Unless otherwise specified in the special provisions, PVC Pressure Class 200 (DR-14) pipe, conforming to the requirements of AWWA C900, may be used in lieu

of cast iron or ductile iron pipe. All PVC pipe furnished shall be integral bell with elastomeric gaskets or plain ends with elastomeric gaskets and couplings. Elastomeric gaskets shall conform to the requirements of ASTM F 477.

(B)Cast Iron Pipe. Unless otherwise specified in the special provisions, cast iron pipe shall have a minimum 150 psi (*1.0 megapascal*) pressure rating, conform to and meeting the requirements of AWWA Standards C106 or C108, and have a cement mortar lining in conformance with AWWA Standards C104. Pipe shall be of 21/45 iron strength with thicknesses designed by methods as outlined in AWWA C101.

Joints for cast iron pipe shall be of the following types: bell and spigot single gasket type; mechanical joint type conforming to AWWA Standards C111; or flanged type conforming to ASA Standards B16.1, Class 125.

Flanges shall be of the thickness specified in the American Standard for Flanged Fittings for Steam, 125 psi (*860 kilopascals*) working pressure, as adopted by the American Society of Mechanical Engineers. Joint material shall be that provided by the manufacturer of the pipe.

(C)Ductile Iron Pipe. Unless otherwise specified in the special provisions, ductile iron pipe shall conform to ANSI A21.51 (AWWA C151) for a minimum working pressure of 150 psi (*1.0 megapascal*). Ductile iron castings shall conform to and be tested in accordance with ASTM A 536. Casting grade for pipe shall be 60-42-10. Laying length shall be the manufacturer's standard length, normally 18 feet (*5.5 meters*). Shorter lengths may be used when required for closures and proper location of special sections.

The interior surface of all ductile iron pipe shall be cement mortar lined and seal coated in conformance with AWWA C104, and the exterior surface shall have a bituminous coating of either coal tar or asphalt base, approximately 1 mil. thick.

Fittings shall be push-on, mechanical, or flanged-type ductile iron or cast iron, and shall conform to ANSI 21.10 (AWWA C110) or ANSI 21.11 (AWWA C111) designed for a working pressure of 250 or 350 psi (*1.7 or 2.4 megapascals*). Coating and lining requirements shall be the same as specified for pipe.

Joints shall be push-on or mechanical type, and shall conform to ANSI 21.11 (AWA C111) with rubber gaskets unless otherwise specified.

Ductile iron pipe for potable or reclaimed water systems shall be fitted with restrained joints in accordance with Subsection 510-3.04(F) and Standard Detail W-600.

929-3 CONSTRUCTION DETAILS

929-3.01 General. Prior to beginning the work, the contractor shall submit to the Engineer, for approval, a plan showing all jacking pit bracing and the contractor's proposed method of jacking pipe, including the jacking head, jacking support, jacks, pipe guides, method of handling the pipe, and method of grouting the voids around the pipe. Unless otherwise specified in the Special Provisions, the method and equipment used in jacking casing or pipe shall be optional with the contractor, provided that the proposed method is approved by the Engineer. The Engineer's approval of this submittal shall not relieve the contractor of his responsibility to perform the work without damage to existing construction or to obtain the specified results.

Construction plans, methods, work and necessary precautions related to jacking pipe under a railroad shall be submitted to meet the requirements of, and have the approval of the Chief Engineer of the railroad company. No work shall be commenced until such approval has been received from the railroad company.

The pipe shall be jacked from one end of the pipe. The pipe to be jacked shall be set on guides, braced together to properly support the section of the pipe being jacked and directed along the line and grade established by the Engineer.

Once jacking operations have begun, the jacking shall be continuous, without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

Heavy duty jacks suitable for forcing pipe through the embankment shall be provided by the contractor. Uniform pressure shall be applied from all jacks. Pressure shall be transmitted evenly around the ring of the pipe through an approved jacking head.

Material excavated ahead of the pipe shall be removed through the pipe. Jetting will not be permitted except as approved by the Engineer. Excavation shall not extend more than 2 feet (*600 millimeters*) beyond the forward end of the pipe and, if required to reduce caving of material, this distance shall be reduced. The diameter of the excavation shall conform as closely as practicable to the outside diameter and circumference of the pipe being jacked. Material shall not be excavated in excess of the outer dimensions of the pipe being jacked unless approved by the Engineer. Every effort shall be made to avoid the loss of earth outside the jacking head.

Excavated material shall be removed from the pipe as excavation progresses, and no accumulation of such material within the pipe will be permitted.

At the contractor's option, and with the Engineer's approval, a cutting edge may be fitted to the forward end of the pipe. The cutting edge shall extend a short distance beyond the pipe, with inside angles or lugs to prevent the cutting edge from slipping back into the pipe.

Upon completion of the jacking operations, all voids around the outside surface of the pipe shall be filled with an approved grout by methods approved by the Engineer.

929-3.02 Excavation of Jacking and Receiving Pits. Suitable pits or trenches for jacking and receiving pipe shall be excavated by the contractor. Excavation for the boring operation(s) shall be the minimum necessary to satisfactorily complete the work. Bracing and shoring shall be adequate to protect workmen and any adjacent structures or roadways.

Pits shall be protected to prevent the public from entering them. The Engineer may require that the excavations be fenced and protected from stormwater runoff.

Bore holes or pits shall be placed as far away from existing structures or the traveled way as possible. In no case shall pits be closer than 10 feet (*3 meters*) to the traveled way unless approved by the Engineer.

Bore holes or pits shall be backfilled and compacted to 95 percent maximum density.

929-3.03 Installation.

(A) Direct Jacking of Reinforced Concrete Pipe or Reinforced Concrete Sewer Pipe. Guide rails shall be accurately set to line and grade to insure installation within tolerances allowed. The diameter of the hole shall not be more than 0.1 foot (30 *millimeters*) greater than the outside diameter of the reinforced concrete pipe or reinforced concrete pipe sewer.

(B) Casing. The casing shall closely follow the boring operation. The bored hole shall not be more than 0.1 foot (30 *millimeters*) larger in diameter than the outside diameter of the casing. Guide rails shall be accurately set to line and grade to insure installation of the casing within allowable limits.

(C) Placing Pipe in Casing. Vitrified clay pipe, with joints larger in diameter than the barrel of the pipe, shall be strapped to 2 redwood skids, 24 to 30 inches (*600 to 750 millimeters*) in length, with steel straps. The redwood skids shall be near the center of each pipe section and shall be large enough to prevent any part of the joint from bearing on the casing.

Ductile iron pipe, cast iron pipe, PVC pipe or asbestos-cement pipe, with joints larger in diameter than the barrel of the pipe, shall be strapped to 2 pairs of redwood skids, 24 to 30 inches (*600 to 750 millimeters*) in length, centered at points approximately one-fifth the pipe length from each end.

Pipe with joints not larger than the pipe barrel shall be slid into place on 2 redwood skids or other approved metallic or non-metallic spacer. Skids or spacers shall be securely fastened to the invert of the casing or strapped to the barrel of the pipe, at locations hereinbefore specified.

Pipe sections shall be joined outside the casing and then slid into place. The space between the casing pipe and pipeline shall be completely filled with grout or clean, dry sand blown into place. The method of placing grout or sand shall be subject to the Engineer's approval. Necessary adjustments in grade shall be made by adjusting the height of the skids.

(D)Backfill of Voids. The contractor shall be held responsible for surface subsidence and damage or disturbance to adjacent property and facilities that may result from his construction methods. Whenever the nature of the soil indicates the likelihood of ground loss which would result in a greater space between the outer surface of the casing or direct jacked pipe than herein allowed, the contractor shall anticipate this condition and take immediate steps to prevent such occurrences by installing a jacking head extending at least 18 inches (*450 millimeters*) from the leading edge of the casing. The jacking head shall cover the upper two-thirds of the casing, and project not more than 1/2 inch (*13 millimeters*) beyond the outer surface of the casing. Excavation shall not be made in advance of this jacking head. In the case where cave-ins occur, all jacking will be discontinued, approved shoring shall be provided and all voids filled by either pressure grouting or other methods approved by the Engineer, prior to the continuation of jacking operations.

Voids greater than those allowed shall be filled with sand, soil cement, or grout, as directed by the Engineer. Where voids are suspected, the Engineer may direct the contractor to drill the casing, to pressure inject grout to refusal, and then to repair the drilled hole. Grouting pressure shall not exceed 50 psi (*345 kilopascals*) at the nozzle.

Grouting equipment and material shall be on the work site prior to jacking operations and the drilling of grout holes.

(E)Tolerances. Extreme care shall be exercised by the contractor to maintain line and grade during jacking operations. The maximum deviation for line and grade of casing pipe shall be such that the line and grade of the pipe installed within the casing can be adjusted a sufficient amount within the casing to achieve the line and grade shown on the plans. This adjustment shall be made to all pipe deviating from line and grade and not merely to the sections of pipe nearest the end of the casing.

Directly jacked reinforced concrete pipe will be allowed a maximum deviation of 0.1 foot (30 *millimeters*) per 100 feet (*30 meters*) from intended line and grade unless more stringent tolerances are shown on the plans or directed by the Engineer.

(F)Dry Boring Under Curb Gutter, and Sidewalk. Portions of sanitary sewers, service sewers, drainage lines, irrigation lines, and water mains and services, which pass beneath curbs and gutters, sidewalks, and other obstructions, may be placed by boring. If under the curb, gutter and sidewalk, the bore shall begin at the lip of the gutter and continue to slightly past the property line. The end of the pipe shall then be capped or plugged, and the pipe pushed into the hole. To determine final line and grade, and to install the cleanout or location post, the property end of the bore for a service sewer shall be exposed.

If the pipe material is vitrified clay the pipe shall be plain-end connected with compression type couplings. The bore shall be just large enough to pass the couplings and need not be backfilled. The maximum length of bore shall be 15 feet (*4.5 meters*) unless otherwise specified.

Borings shall not be used on sewer services when the required slope is such that probable deviation of the bore from the intended line would result in a final slope of less than 1/4 inch per foot (*20.8 millimeters per meter*).

(G)Wet Boring of Small Diameter Pipe. Wet boring may be permitted on 6 inch (*150 millimeters*) and smaller diameter pipe, if the soil conditions permit and approval is granted by the Engineer.

If the diameter of the bored hole is more than 0.1 foot (*30 millimeters*) greater than the outside diameter of the pipe to be installed, the void shall be backfilled with sand, soil cement, or grout as directed by the Engineer.

929-4 METHOD OF MEASUREMENT

Jacked in place reinforced concrete pipe will be measured by the linear foot (*meter*) measured in its final position.

Casing pipe will be measured by the linear foot (*meter*) measured in its final position.

No direct measurement will be made for either pipe dry bored under curb, gutter, and sidewalk or wet boring of small diameter pipe when this method of installation is at the option of the contractor.

929-5 BASIS OF PAYMENT

The accepted quantities of jacked in place concrete pipe and casing pipe, measured as provided above will be paid for at the contract unit price per linear foot (*meter*) inclusive of jacking; sheeting, bracing and flooring for jacking and receiving pits; excavation and backfill; removal and disposal of excavation; pressure grouting; construction plans; and all labor, materials and equipment, including dewatering if required, necessary to complete the work in accordance with the plans, specifications and

directions of the Engineer. No payment will be made under this item of work for pipe or fittings constructed within a casing pipe; or pipe dry bored under curb, gutter and sidewalk; or wet boring of small diameter pipe when this method of installation is at the contractor's option. Rather, these pipe and their fitting will be paid under their respective contract items.

SECTION 930

INCIDENTAL ITEMS

930-1 DESCRIPTION

The work under this section is intended to cover miscellaneous work added to the contract by the Engineer during the course of construction. Miscellaneous work shall be work that was not covered by other items included in the project.

930-2 MATERIALS (None Specified)

930-3 CONSTRUCTION DETAILS (None Specified)

930-4 METHOD OF MEASUREMENT

The work under this section shall be completed on a force account basis as specified in Subsection 109-5.

930-5 BASIS OF PAYMENT

Payment for incidental items of work will be made in accordance with the provisions of Subsection 109-5.

SECTION 931

DECORATIVE CONCRETE PAVEMENT

931-1 DESCRIPTION

The work under this item consists of furnishing all labor, equipment, tools and materials necessary to place special decorative concrete pavement in accordance with the locations and details shown on the project plans and the requirements of these specifications.

931-2 MATERIALS

931-2.01 Concrete for Decorative Pavement. Concrete for decorative pavement shall be Class S having a minimum 28-day compressive strength of 3000 psi (*20.7 megapascals*) Portland cement shall conform to ASTM C 150, Type II. Aggregate size shall be 3/4 inch (*19 millimeters*) minus conforming to ASTM C 33.

A normal set or retarded set water reducing admixture complying with ASTM C 494 may be used. Nothing containing calcium chloride shall be permitted in the concrete mix.

931-2.02 Concrete. Plain untextured concrete forming the band adjacent to the decorative paving, if detailed on the project plans, shall be Class S having a minimum compressive strength of 3000 psi (*20.7 megapascals*) at 28 days. Concrete shall conform to the requirements of Section 1006 of the Specifications.

931-2.03 Color Hardener. Color hardener shall be of a heavy duty variety and shall be specially formulated for the installation of decorative concrete pavement.

931-2.04 Welded Wire Fabric. Welded wire fabric and reinforcing bars shall conform to the requirements of Section 1003 of the specifications and shall be placed as detailed on the project plans.

931-2.05 Expansion Joint Filler. Expansion joint filler shall be 1/2 inch (*13 millimeters*) bituminous preformed strips conforming to the requirements of 1011.

931-3 CONSTRUCTION DETAILS

Decorative concrete pavement shall be a stamped concrete pattern as detailed on the project plans. The color and the pavement pattern shall be as detailed on the project plans or special provisions. All exposed edges of decorative concrete paving shall be the same color as the surface.

The workmen assigned to this work shall be tooled and trained to perform the stamped decorative concrete process. The contractor, at the preconstruction conference, shall provide a list of the locations of past projects demonstrating the quality of his work and shall provide a foreman capable of achieving work of the quality of the past projects.

Prior to commencing this work, the contractor shall construct a 4 foot by 4 foot (*1200 by 1200 millimeters*) sample panel of decorative pavement at a location designated by the Engineer. The sample panel shall be constructed using the same materials, methods, equipment and workmen as will be used for production work. This process shall be repeated until a sample panel is approved by the Engineer. The approved sample panel shall be maintained intact until the Engineer directs its removal.

Upon approval of the sample panel, the contractor shall construct decorative concrete pavement conforming with the approved sample panel.

The depth of the imprints in the decorative paving shall be a minimum of 1/8 inch (*3 millimeters*) but shall not exceed 3/8 inch (*10 millimeters*) with the normal being 1/4 inch (*6 millimeters*).

Expansion joints shall be constructed at a maximum of 40 foot (*12 meters*) intervals. Expansion joints shall be constructed at locations where the decorative concrete paving abuts existing concrete sidewalks and driveways, structures, poles, posts, boxes or other fixtures that protrude through the paving. Joint filler shall be placed vertically and extend the full depth of the concrete being placed. During placement and tamping of concrete, the joint filler shall be restrained in its proper position.

When a plain, untextured concrete border is placed adjacent to the decorative concrete, it shall be placed as a separate pour to avoid staining of the plain concrete border with the color hardener.

Curing shall be the sole responsibility of the contractor and shall be conducted in such a manner and using such materials so as to provide quality concrete and prevent the formation of cracks while not adversely effecting the pattern or color of the decorative concrete paving.

931-4 METHOD OF MEASUREMENT

Method of measurement will be by the square yard (*square meter*) of decorative pavement.

931-5 BASIS OF PAYMENT

Payment will be made at the contract price per square yard (*square meter*) for Decorative Pavement, inclusive of sample panels up to a maximum of 2 panels for a specific pattern or color. Should more than 2 sample panels be required prior to obtaining approval of the work, these additional panels shall be provided by the contractor at no additional cost to the Agency. The unit price shall be full compensation for the work, complete-in-place, as described herein and on the project plans.

SECTION 932

PAVERS

932-1 DESCRIPTION

The work under this section shall consist of the installation of brick pavers or interlocking concrete pavers in accordance with these specifications and in reasonably close conformity with the locations, lines and grades shown on the project plans or established by the Engineer.

932-2 MATERIALS

932-2.01 Brick Pavers. Brick pavers shall be manufactured from extruded fire clay or shale and shall be the shape, size, and color shown on the plans or specified in the special provisions. Samples of the brick pavers shall be submitted to the Engineer for approval prior to beginning the work.

The brick pavers shall be fired to produce a dense paver with the average water absorption being less than 8.0 percent after 24-hour submersion in cold water and the average compressive strength being in excess of 8000 psi (*55 megapascals*). Pavers shall be free of chinks, screeding scan, stress cracks or foreign substances. Brick pavers shall also conform to the requirements of ASTM C 216 and C 62, Grade SW.

932-2.02 Interlocking Concrete Pavers. Interlocking concrete pavers shall conform to the requirements of ASTM C 936. Colored concrete pavers shall also conform to the requirements of ASTM C 979. The interlocking concrete pavers shall be provided by a company with a minimum of 5 years experience in their manufacture.

932-2.03 Sand. Sand for a setting bed and joints shall consist of clean, hard, durable, uncoated particles, free from lumps of clay and all other deleterious substances. Sand for setting bed shall meet the gradation requirements of ASTM C 33 as noted below:

Sieve Size	Percent Passing by Weight
3/8 in. (*9.5 mm*)	100
No. 4 (*4.75 mm*)	95 to 100
No. 8 (*2.36 mm*)	85 to 100
No. 16 (*1.18 mm*)	50 to 85
No. 30 (*600 μm*)	25 to 60
No. 50 (*300 μm*)	10 to 30
No. 100 (*150 μm*)	2 to 10

Joint sand shall conform to the grading requirements of ASTM C 144 as noted below.

Sieve Size	Percent Passing
No. 4 (*4.75 mm*)	100
No. 8 (*2.36 mm*)	95 to 100
No. 16 (*1.18 mm*)	70 to 100
No. 30 (*600 µm*)	40 to 75
No. 50 (*300 µm*)	10 to 35
No. 100 (*150 µm*)	2 to 15
No. 200 (*75 µm*)	0

Sand containing more than 10 percent by volume of loam or silt will not be accepted. Loam and silt shall be as defined in ASTM D 653.

932-2.04 Concrete. Portland cement, water and admixtures shall conform to the requirements of Section 1006. Concrete shall be Class B.

932-3 CONSTRUCTION DETAILS

932-3.01 Subgrade Preparation. Subgrade preparation, compacted density, and elevations shall conform to the Plans and Special Provisions. Compaction of the subgrade shall be to a density of not less than 95 percent of the maximum density determined in accordance with the applicable test methods of the ADOT Materials Testing Manual as directed and approved by the Engineer. Stabilization of the subgrade and/or base material may be necessary when poor subgrade soils or conditions are encountered. The Engineer shall approve the subgrade preparation, elevations, and density prior to placement of bedding sand.

932-3.02 Brick Pavers. Brick pavers shall be laid in the pattern shown on the plans or as directed by the Engineer, to provide a uniformly even surface. Joints shall be hand tight unless otherwise specified.

Bedding for brick pavers shall be as follows:

Class A Bedding: 4 inches (*100 millimeters*) of portland cement concrete over which a 1 inch (*25 millimeters*) layer of sand-cement mixture consisting of 1 part portland cement and 15 parts sand is spread.

Class B Bedding: 4 inches (*100 millimeters*) of sand-cement mixture consisting of 1 part portland cement and 15 parts sand. The sand-cement bedding shall not be placed more than 4 hours prior to installing the brick pavers.

If a bedding class is not specified on the plans or special provisions, Class A bedding shall be used.

932-3.03 Interlocking Concrete Pavers. Bedding sand shall be spread evenly over the subgrade and screeded to a nominal 1-inch (*25 millimeters*) thickness, not exceeding 1-1/2 inches (*40 millimeters*) thickness. The screeded sand shall not be disturbed. Sufficient sand shall be placed ahead of the laid pavers. Bedding sand shall not be used to fill depressions in the surface of the subgrade. Depressions in the subgrade shall be filled with acceptable material from the site and recompacted in compliance with the requirements of Subsection 932-3.01.

The contractor shall ensure that pavers are free of foreign materials before installation.

Joints between the pavers shall range between 1/16 inch and 3/16 inch (*2 millimeters to 5 millimeters*) wide.

Gaps at the edges of the paved area shall be filled with appropriately cut pavers or edge units.

Pavers shall be cut only with a double blade paver splitter or masonry saw.

The contractor shall use a low-amplitude, high-frequency plate vibrator to vibrate the pavers into the bedding sand.

As the surface of the pavers is vibrated, dry joint sand shall be swept into the joints until they are full. The contractor shall make a sufficient number of passes with the plate vibrator to ensure that the joints are completely full of sand. The contractor shall avoid vibrating the area within 3 feet (*1 meter*) of the unrestrained edges of the paving units.

All work to within 3 feet (*1 meter*) of the laying face shall be left fully compacted with sand-filled joints at the completion of each day.

Excess sand shall be swept up and removed when the installation is complete.

The final surface elevations shall not deviate more than 3/8 inch (*10 millimeters*) under a 10-foot (*3 meter*) long straightedge.

Resanding, as necessary, of paver joints shall be accomplished by the contractor for a period of 90 days after completion of work.

932-4 METHOD OF MEASUREMENT

Brick pavers and interlocking concrete pavers shall be measured by the square foot (*square meter*) of area of pavers placed as shown on the plans or directed by the Engineer.

932-5 BASIS OF PAYMENT

The accepted quantities of brick pavers and interlocking concrete pavers, measured as provided above, will be paid for at the contract unit price per square foot (*square meter*), which price shall be full compensation for the item, complete-in-place, including furnishing and placing embankment material, excavation, removing unstable material, backfilling, placing Class A or Class B bedding, compacting, placing brick or interlocking concrete pavers and filling joints with sand.

SECTION 933

BARRICADE RAILING

933-1 DESCRIPTION

The work under this Section shall consist of furnishing all materials and constructing barricade railing, including railing, posts, fittings, and anchorages. Barricade railing shall be fabricated, installed, and painted at the locations and in accordance with the details shown on the project plans and the requirements of these specifications.

933-2 MATERIALS

933-2.01 General. Materials furnished for the barricade railing shall conform to the requirements specified on the plans or in the special provisions. Steel pipe shall conform to the requirements of ASTM A 53, Grade A or ASTM A 135, Grade A, with the exception that hydrostatic testing will not be required.

The minimum wall thickness for steel pipe shall be as follows:

Pipe I.D.	Minimum Wall Thickness
1 1/2 inch (*38 millimeters*)	Schedule 40
2 inch (*51 millimeters*)	Schedule 40
4 inch (*102 millimeters*)	Schedule 40

Mill reports shall be furnished for steel materials.

933-2.02 Concrete. Concrete for post foundations shall conform to the requirements of Section 922.

933-2.03 Paint. Paint shall conform to the applicable requirements of Section 1002.

933-3 CONSTRUCTION DETAILS

933-3.01 Fabrication. Fabrication of the barricade railing shall conform to the requirements and details shown on the project plans or specified in the special provisions.

Welding shall conform to the latest A.W.S. specification for the material being welded. Joints shall be as shown on the project plans. All joints shall be ground smooth to produce a straight, uniform rail or post.

933-3.02 Installation. The contractor shall be responsible for the layout of the barricade railing using the control points established by the Agency. The contractor's layout shall be approved by the Engineer prior to commencing installation.

Barricade railing shall present a smooth, uniform appearance in its final position.

Shims shall be installed at posts and rails, where necessary, to provide uniform bearing and appearance.

Materials shall be carefully handled such that no piece will be bent, broken or damaged. Fabrication, handling, or installation methods which will deform or distort members shall not be used.

Post holes shall be excavated in earth material or, in the case of concrete or soil cement, cored with a circular coring bit to the depth and dimensions indicated on the project plans, or specified in the special provisions.

Posts shall be placed in a vertical position. All posts shall be set in concrete foundations conforming to the details shown on the project plans and crowned at the top to shed water.

933-3.03 Painting. Painting of steel members shall be in accordance with the requirements of Section 610.

The prime coat for use on steel members shall be one coat of red iron oxide paint (Paint No. 1).

The prime coat shall be applied in the shop immediately after shop fabrication has been completed. When field erection has been completed, the same paint shall be applied in the field to touch up field connections and other areas where the prime coat has been abraded and to cover erection markings.

The finish coat shall consist of 2 coats of an industrial type paint of a color similar to Sherwin Williams, Industrial Maintenance Coatings, MC-37 Sienna. This paint shall be approved by the Engineer prior to use.

The reflective paint to be used on the ends of the railings shall be "Codit" or an approved equal.

The 2 finish coats shall be applied to the completed work after all erection and touch up work has been completed.

Painting in open yards or upon erected structures shall not be done when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

All metal coated with unauthorized paint shall be thoroughly cleaned and repainted, to the satisfaction of the Engineer, at the expense of the contractor.

The prime coats shall be at least 1.5 mils (*37.5 micrometers*) thick when dry, and each intermediate and finish coat shall be at least 1 mil (*25 micrometers*) thick when dry. No portion of the paint film shall be less than the thicknesses specified herein. The film thickness shall not be so great such that the appearance or service life of the paint is adversely affected.

When the touch up paint is thoroughly dry, the first and second finish coats may be applied. In no case shall a succeeding coat be applied until the previous coat has dried throughout the full thickness of the paint film. The first field coat shall be lightened with a white pigment to provide a contrast between the first and second coats.

Small cracks and cavities which have not become sealed in a watertight manner by the first finish coat shall be filled with a paste mixture of Paint No. 1 and linseed oil prior to the second finish coat being applied.

933-3.04 Fencing Fabric. Fencing fabric shall be added to the barricade railing at the locations noted on the plans or specified in the special provisions. Fencing fabric shall be 36 inches (*900 millimeters*) high and knuckled on both selvages. Fabric shall meet the requirements of Subsection 902-2.04.

Wire ties shall be zinc-coated or aluminum-coated steel of good commercial quality and shall be of the same gauge and breaking strength as the fencing fabric. Wire ties shall be 6-1/2 inches (*163 millimeters*) long and twisted around barricade posts such that twist is to the side opposite pedestrian traffic.

Tension bars and tension bands shall be fabricated from commercial quality steel and shall be zinc-coated in accordance with the requirements of AASHTO M111. Tension bars shall be 3/16 inch by 5/8 inch (5 *millimeters by 16 millimeters*) flat bars. Tension bands shall be 3/4 inch by 1-7/8 inch (*19 millimeters by 47 millimeters*) flat bars. Tension wire shall meet the requirements of Subsection 902-2.05.

933-3.05 Reflective Marking. Reflective markings shall be applied to the barricade railing at the locations specified by the Engineer. The reflective material shall be 3M Company No. 7211 Yellow Reflective Liquid.

933-4 METHOD OF MEASUREMENT

Barricade railing will be measured by the linear foot (*meter*), including joints.

Fencing Fabric will be measured by the linear foot (*meter*).

Access gates will be measured by unit installed, complete-in-place.

Pedestrian gates and horse gates will be measured by the unit installed, complete-in-place.

Reflective marking will be measured by the unit installed with a unit being a single 2 foot (*600 millimeters*) long stripe.

933-5 BASIS OF PAYMENT

The accepted quantity of barricade railing, measured as provided above, will be paid for at the contract unit price per linear foot (*meter*), complete-in-place. Fencing fabric, pedestrian gates, horse gates, and reflective markings will be paid for at the contract unit price, measured as provided above. No separate payment shall be made for excavation, concrete foundations, painting, or other items incidental to construction of the barricade railing.

SECTION 934

POST BARRICADES

934-1 DESCRIPTION

The work under this Section shall consist of furnishing all materials and constructing post barricades at the locations and in accordance with the details shown on the project plans, and the requirements of these specifications.

934-2 MATERIALS

934-2.01 Steel Pipe. Steel pipe for post barricades shall be either 3 inch (*75 millimeters*) or 5 inch (*125 millimeters*) in diameter standard weight steel pipe as shown on the plans or as specified in the special provisions and shall conform to the requirements of ASTM A 53, Grade A or ASTM A 135, Grade A, with the exception that hydrostatic testing will not be required.

934-2.02 Concrete. Concrete for post foundations shall conform to the requirements of Section 922.

934-2.03 Paint. Paint shall conform to the applicable requirements of Section 1002.

934-3 CONSTRUCTION DETAILS

Fabrication of post barricades shall conform to the requirements and details shown on the project plans or specified in the special provisions.

Welding shall conform to the latest A.W.S. specification.

Material shall be carefully handled such that it is not bent or otherwise damaged. Fabrication, handling or installation methods which will deform or distort the posts shall not be used.

Post holes shall be excavated in earth material to the depth and dimensions shown on the project plans, Standard Details, or as specified in the Special Provisions. In areas of asphalt concrete or portland cement concrete pavement, the post holes shall be formed in a neat manner in accordance with the Standard Details.

Posts shall be placed in a vertical position. All posts shall be set in a concrete foundation conforming to the details shown on the project plans and crowned at the top to shed water.

The prime coat for post barricades shall be one coat with red iron oxide paint (Paint No. 1).

The finish coat shall consist of one coat of dull black enamel conforming to the requirements of Subsection 1002-4.01.

Painting of steel posts shall be in accordance with the requirements of Section 610.

The prime coat shall be applied in the shop immediately after shop fabrication has been completed. When field erection has been completed, the same paint shall be applied in the field to touch up field connections and other areas where the prime coat has been abraded and to cover erection markings.

The finish coat may be applied prior to or after erection of the posts.

Before acceptance of the work, the finish coat shall be free of any defects and shall be of uniform appearance.

Painting in open yards or upon erected structures shall not be done when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

All metal coated with unauthorized paint shall be thoroughly cleaned and repainted, to the satisfaction of the Engineer, at the expense of the contractor.

The prime coat shall be at least 1.5 mils (*37.5 micrometers*) thick when dry, and the finish coat shall be at least 1 mil (*25 micrometers*) thick when dry. No portion of the paint film shall be less than the thickness specified herein. The film thickness shall not be so great such that the appearance or service life of the paint is adversely affected.

When the touch up paint is thoroughly dry, the finish coat may be applied.

The contractor shall take all steps necessary to ensure that the barricades remain centered in the foundations and plumb until such time as the concrete foundations have set sufficiently in the opinion of the Engineer.

934-4 METHOD OF MEASUREMENT

Post barricades will be measured by the unit installed.

934-5 BASIS OF PAYMENT

The accepted quantity of post barricades will be paid for at the Contract unit price, each, complete-in-place. No separate payment shall be made for excavation, concrete foundations, painting or other items incidental to construction of post barricades.

SECTION 940

REMOVAL OF ASBESTOS CONTAINING MATERIAL

940-1 DESCRIPTION

The work under this section consists of the removal of asbestos-containing materials (ACM), regulated asbestos-containing materials (RACM) and/or presumed asbestos-containing materials (PACM). The contractor shall comply with the latest revisions of all applicable local, state and federal codes and regulations, including but not limited to:

- Title 29, Code of Federal Regulations, Section 1926.1101, OSHA Construction Industry Standard
- Title 29, Code of Federal Regulations, Section 1910.1001, OSHA General Industry Standards
- Title 29, Code of Federal Regulations, Section 1910.34, OSHA Respirator Standards
- Title 40, Code of Federal Regulations, Part 61, Nationals Emission Standards for Hazardous Air Pollutants (NESHAP), Asbestos NESHAPS Revision, Final Rule
- Title 40, Code of Federal Regulations, Part 763, Asbestos-Containing Materials in Schools; Final Rule and Notice
- Title 17, Pima County Code, Air Quality

This specification is provided as an aid to the contractor and Engineer by condensing the above listed requirements. The contractor is expected to be familiar with these regulations and others and to perform his work in accordance with all applicable rules and regulations and to the current "state-of-the-art".

940-2 GENERAL

940-2.01 Definitions. Adequately Wet: The asbestos containing material is sufficiently mixed or penetrated with liquid to prevent the release of airborne particulates. If visible emissions are observed coming from the asbestos containing material (ACM), then the material is not adequately wet. Usually, adequately wet ACM does not produce a change in color due to water application. Amended water is often used to wet ACM during repair and removal.

Administrator: When used in these specifications or in 40 CFR Part 61 means the Control Officer except that the Control Officer shall not be authorized to approve alternate or equivalent test methods or alternate standards/work practices.

AHERA: The Asbestos Hazard Emergency Response Act, passed by Congress in 1986. The AHERA regulations mandate that schools must be inspected for asbestos and establish the concepts used by the industry for inspection, planning design and final clearance, accreditation, and lab certification.

Air Lock: An intermediate chamber that prevents air movement between the clean and contaminated areas. Usually, this chamber consists of two plastic curtained doorways with a minimum separation of 3 feet (*900 millimeters*).

Amended Water: Water modified by the addition of a surface active substance (surfactant, such as a detergent) in order to improve the wetting and penetrating properties of the water.

Asbestos Containing Material (ACM): Any material containing more than 1% asbestos as determined using Polarized Light Microscopy.

Asbestos Containing Roofing Material (ACRM): Any roofing material containing more than 1% asbestos.

Bulk Sample: A sizable sample of material that is suspected of containing asbestos fibers such as insulation, floor tile, building material, etc. The sample should contain all layers of the material being sampled. The sample gets analyzed for the presence and quantity of asbestos.

CA: Cement Asbestos.

CAA: The Clean Air Act (CAA) is the legislation which promulgated the asbestos regulations.

Category I Non-friable ACM: Asbestos-containing packings, gaskets and other pliable or resilient materials containing more than 1% asbestos.

(This definition has been modified for this specification to not include resilient floor covering or asphalt roofing products.)

Category II Non-friable ACM: Any material, excluding Category I non-friable ACM, resilient floor covering and asphalt roof products, containing more than 1% asbestos that when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.

Class I Asbestos Work: The removal of thermal systems insulation (TSI) asbestos containing material and the removal of asbestos containing surfacing material where the surfacing has been sprayed or troweled-on such as plaster or fireproofing.

Class II Asbestos Work: The removal of all other asbestos containing materials such as wallboard, floor tile, sheeting roofing, mastic, transite pipe, etc.

Class III Asbestos Work: The repair and maintenance operations where ACM, including thermal system insulation and surfacing ACM and PACM, may be disturbed. This work also includes encapsulation.

Competent Person: A person who is capable of identifying existing asbestos hazards in the work place and selecting the appropriate controls, who has the authority to take prompt corrective measures to eliminate the exposure, and who has received AHERA supervisor training.

Control Officer: The Director of Pima County Department of Environmental Quality who shall serve as the executive head of the Pima County Air Quality Control District, or one of his authorized agents.

Encapsulation: The application of a bonding or sealing agent to ACM to coat the ACM and prevent the release of airborne fibers.

EPA: The United States Environmental Protection Agency

EPA NESHAP Notification: A written notice of intent for asbestos renovation and/or demolition activities. The notification contains certain specific information that includes, but is not limited to: Scheduled start and completion dates, location of the site, names of operator/owner of the site, removal contractor, methods of removal and the amount of asbestos, and whether the operation is a demolition or renovation project.

Excursion Limit: The time weighted average limit an employee shall be exposed to an airborne concentration of asbestos. No employee shall be exposed to an airborne concentration in excess of one fiber per cubic centimeter (1.0 f/cc) of air in a thirty minute period computed by time weighted average.

Facility Demolition: A facility is demolished when any load-supporting structural member is removed, wrecked, or any related operation is performed. Also, a facility is demolished when it is burned.

Facility Renovation: A facility is renovated when any part of the facility is altered in a manner different from those described in "Facility Demolition". Renovation also includes stripping and removal of asbestos from the facility.

Friable Asbestos-Containing Material: Friable ACM is any material containing more than one percent (1%) asbestos as determined by Polarized Light Microscopy (PLM) that, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure.

Glove Bag: A polyethylene sealed compartment not more than 60 x 60 inch (*1.5 x 1.5 meters*) with attached inner gloves used for handling asbestos-containing materials.

HEPA Filter: A high efficiency particulate air (HEPA) filter capable of trapping and retaining 99.97% of all particulates larger than 0.30 microns.

HVAC System: Heating, ventilation and air conditioning (HVAC) system usually installed in large commercial and industrial facilities.

Intact: Means that the ACM has not crumbled, been pulverized, or otherwise deteriorated so that the asbestos is no longer likely to be bound with its matrix.

Multi-Employer Work Site: A work site where two or more employees work for two or more employers. This includes employers such as: Public agency, general contractor, subcontractor, supplier, utility company, consultants, etc., or a combination of the same.

Negative Exposure Assessment: Is a demonstration by the abatement contractor which complies with the criteria in 29 CFR 1926.1101 (f)(2)(ii) & (iii) and shows that the work practices being used will not expose the employees to airborne concentration above the permissible exposure limit.

Negative Pressure: An atmosphere in a work area enclosure where airborne fibers will tend to be drawn from outside areas by an exhaust filtration system. A HEPA filter is used on the exhaust system to eliminate the escape of asbestos fibers.

NESHAP: National Emissions Standards for Hazardous Air Pollutants (NESHAP) was established by the EPA. This is in accordance with the CAA that required the development and enforcement of regulations to protect the general public from exposure to airborne contaminants that are known to be a hazard to human health. EPA promulgated the Asbestos NESHAP in Title 40 of the Code of Federal Regulations (40 CFR), Part 61.

NESHAPS Facility: Means any industrial, commercial, public, industrial or residential structure, installation or building (including any structure, installation or building containing condominiums or individual dwelling units operated as a residential cooperative, but excluding residential buildings having four or fewer dwelling units); any ship; and any active or inactive waste disposal site.

Non-Friable Asbestos-Containing Material: Any material containing more than one percent (1%) asbestos as determined by Polarized Light Microscopy (PLM) that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure. Under the asbestos NESHAPS, non-friable ACM is divided into two categories, Category I and Category II. See definitions above.

Permissible Exposure Limit (PEL): The time weighted average limit an employee shall be exposed to an airborne concentration of asbestos. No employee shall be exposed to asbestos in an airborne concentration in excess of 0.1 fiber per cubic centimeter of air as determined by an 8 hour time weighted average using Phase Contrast Microscopy.

PDEQ: Pima County Department of Environmental Quality

Phase Contrast Microscopy (PCM): An optical microscopic method used on air samples to count fibers of five (5) microns or greater in size. The count is reported in fibers per cubic centimeter (f/cc). The PCM method is required for clearance on personal air samples and may be used to determine the successful completion of an abatement project. AHERA clearance is 0.01 f/cc. The PCM method cannot distinguish and identify the different fiber types, including asbestos fibers, or the samples.

Polarized Light Microscopy (PLM): An optical microscopic method used on bulk samples to distinguish and identify different types of asbestos fibers by their shape and unique optical properties. Non-asbestos fibers as well as other matrix materials are also distinguished and identified. The result is reported by a percent estimate based on a visual calibrated area.

Presumed Asbestos-Containing Material (PACM): Thermal system insulation and surfacing materials found in building constructed no later than 1980 and asphalt and vinyl flooring installed no later than 1980.

Regulated Area: An area established by the employer to demarcate areas where Class I, II, and III asbestos work is being performed and any adjoining area where debris and waste from such work accumulates; and a work area where the airborne concentrations of asbestos exceed or may exceed the PEL.

Regulated Asbestos-Containing Material (RACM): Means (a) Friable asbestos material, (b) Category I non-friable that has become friable, (c) Category I non-friable ACM that will be or has been subject to sanding, grinding, cutting, or abrading, (d) Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized or reduced to powder by the forces expected to act on the material on the course of demolition or renovation, (e) asbestos-containing resilient floor covering, or (f) asbestos-containing asphalt roofing materials. (This definition has been modified for the purposes of these specifications.)

Transmission Electron Microscopy (TEM): A microscopic analysis method that uses and focuses an electron beam onto a thin sample. As the electron beam transmits through the sample, an image is created on a fluorescent screen that reflects different densities of the sample constituents from which they can be identified and counted. The TEM Method produces a total number of asbestos fibers versus non-asbestos fibers and must be used for final clearance on schools.

940-2.02 Communications.

(A) General. All requests, reports, applications, submittals and other communications shall be submitted to the Control Officer with copies to the Engineer.

The Engineer shall notify the contractor of all ACM and all PACM and the results of tests done on presumed ACM, if any.

Within ten days of the completion of the asbestos removal, the abatement contractor shall notify the Engineer and employers of employees who will be working in the area of the current location and quantity of the remaining PACM and/or ACM and final monitoring results.

On multi-employer work sites the following shall occur:

(1) The Abatement Contractor performing the asbestos work shall inform all employees on the site of the nature of the Abatement Contractor's work with asbestos, of the existence of asbestos and requirements of a regulated area and the measures taken to ensure that the employees are not exposed to asbestos.

(2) Asbestos hazards shall be abated by the contractor who creates or controls the source of asbestos containment.

(3) All employers of employees exposed to asbestos hazards shall comply with the applicable protective provisions to protect their employees.

All employers of employees working adjacent to regulated areas established by another employer on a multi-employer work-site shall take steps on a daily basis to ascertain the integrity of the enclosure and/or the effectiveness of the control method.

All general contractors on a construction project which includes work covered by this standard shall be deemed to exercise general supervisory authority over the work of all employers on the work-site.

(4) Any employers who discover ACM or materials presumed to contain asbestos shall convey the information to the Engineer and all employees on the work-site within 24 hours on discovery.

(B) Warning Signs. Warning signs that demarcate the regulated areas shall be posted at such a distance and in such location to allow readers to avoid the area. These signs shall be posted by the abatement contractor that is performing the work involving the asbestos. The signs shall bear the following information:

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY

In addition, where the use of respirators and protective clothing are required, the warning signs shall include the following:

RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA

940-2.03 Training and Certification.

(A) Training. Prior to the start of work, copies of the training certificates for all personnel working on asbestos abatement or maintenance shall be provided to the Agency by the contractor and any asbestos Abatement Contractors working on the site.

(B) Certification. Medical records of the asbestos Abatement Contractors employees shall be available for review upon request

by the Engineer.

The contractor(s) shall provide the Engineer a signed statement to the fact that workers have been notified that (a) asbestos containing materials are present on the work site and (b) they are removing asbestos containing materials (as applicable to the employees).

940-2.04 Notification and Permit Requirements for NESHAP Facilities.

(A) General.

(1) Any asbestos abatement at a NESHAP facility shall be reported to the Control Officer prior to the start of demolition of the facility by the Abatement Contractor.

(2) Renovation of a NESHAP facility which involves the disturbance of RACM or activities that would make the RACM inaccessible, in amounts greater than or equal to EPA threshold amounts of: 260 linear feet (*80 meters*) on pipes, 160 square feet (*15 square meters*) on other facility components, or 35 cubic feet (*1 cubic meter*) of off facility components, or demolition of a NESHAP facility require the following:

(a) Ten working days notification to the Control Officer prior to the start of renovation or demolition activities. (See Section 940-2.04(B)).

(b) The results of any inspection of the facility including negative declarations must be submitted to the Control Officer on a form approved by the Control Officer at the time of application for an activity permit along with evidence regarding how the renovation or demolition will affect any ACM identified in the inspection.

(c) An activity permit.

(d) Payment of the activity permit fee pursuant to Table 17.12.540 of Pima County Code.

(e) Removal of the affected RACM prior to the start of renovation or demolition.

The Abatement Contractor shall fulfill the above requirements prior to the start of any work.

(3) The Agency shall obtain a Special Waste Identification Number from Arizona Department of Environmental Quality prior to the hauling or disposal of RACM.

(4) A copy of all correspondence with the Control Officer and a copy of any permits and/or notices regarding the removal of ACM from the project shall be submitted to the Agency.

(B) NESHAP Notification.

(1) In a facility being demolished, even if no asbestos is present, or in a facility being renovated, if the combined amount of RACM is at least 260 linear feet (*80 meters*) on pipes, or 160 square feet (*15 square meters*) on other facility components or 35 cubic feet (*1 cubic meter*) of off facility components where the length or area could not be measured previously, the Abatement Contractor shall provide notification as follows:

(a) Provide the Control Officer with written intention to demolish or renovate.

(b) Update notice, including when the amount of asbestos affected changes by at least 20 percent.

(c) Postmark or deliver the notice at least 10 working days before asbestos stripping or removal or any other activity begins which may disturb asbestos.

(d) Notify the Control Officer of a delayed start date by telephone and in writing as soon as possible before, but no later than the original start date; and of an earlier start date in writing at least 10 working days prior to start.

(e) Work must begin on the date provided either in the original or revised notice.

(f) A form is available for notification which includes:

1) An indication of whether the notice is original or revised notification.

2) Name, address, and telephone number of both the facility owner and operator and the asbestos removal contractor owner or operator.

3) Type of operation: Demolition or renovation.

4) Description of facility or affected part of the facility including the size (square meters and number of floors), age, and present or prior use of the facility.

5) Procedure, including analytical methods, employed to detect the presence of ACM.

6) Estimate of the approximate amount of RACM by type as well as the amount of Category I and II non-friable ACM.

7) Location and street address, city, county, and state of facility.

8) Scheduled start and completion dates of asbestos removal or any other activity which may disturb asbestos.

9) Scheduled start and completion dates of demolition or renovation.

10) Description of planned demolition or renovation work to be performed and methods to be employed.

11) Description of work practices and sound engineering controls to be used to comply with the requirements.

12) Name and location of the waste disposal site for the ACM.

13) Certification that at least one person trained will supervise the stripping or removal described.

14) For facilities which demolition is mandated by State or Local authorities: Provide the name, title, and authority, the date that the order was issued and the date the demolition was ordered to begin. A copy of the order shall be attached.

15) Description of procedures to be followed in the event that unexpected RACM is found or Category II non-friable ACM becomes crumbled, pulverized, or reduced to powder.

16) Name, address, and phone number of the waste transporter.

(2) If the facility is being demolished under order of a State or Local government agency, issued because the facility is structurally unsound and in danger of imminent collapse, the notification made by the Abatement Contractor shall include all of the items found in Section 940-2.04(B), except that the notice must only be filed as early as possible, but no later than the following work day. If more time is available, the 10 day notice shall be followed.

(3) In a facility being demolished where the combined amount of RACM is less than 260 linear feet (*80 linear meters*) on pipes and less than 160 square feet (*15 square meters*) on other facility components and less than 35 cubic feet (*1 cubic meter*) of facility components where the length or area could not be measured previously or there is no asbestos, the Abatement Contractor shall provide notification same as found in Section 940-2.04(B) with the exceptions of Paragraphs 1.f.8., 1.f.10 through 1.f.14 and 1.f.16.

940-2.05 Asbestos Renovation and Demolition Standards.

(1) Inspection viewing devices, at NESHAP facilities, are required at all asbestos renovation and abatement projects where RACM is being abated, except for roofing projects

involving ACRM exclusively. These viewing devices shall be so designed as to allow inspector viewing from the outside, either through ports or by video monitoring.

(2) Remove all affected RACM from the facility being demolished or renovated before any activity begins that would break up, dislodge, or similarly disturb the material or preclude access to the material for subsequent removal.

(3) The friable portion of ACM shall be kept adequately wet and contained in transparent, leak-tight wrapping or 6-mil (*150 micrometers*) polyethylene bags to prevent dust emissions during removal, transport, storage, and proper landfill disposal following local, county, state, and federal regulations. Each wrapping or bag shall be labeled with the name and address of the location that generated the asbestos-containing material.

(4) Any records obtained through the requirements of this section shall be retained for a minimum of two years after the date of renovation or demolition. The owner shall be provided a copy of all records.

(5) In addition to any other penalties, any person who knowingly submits any record or document that is not complete and accurate is tampering with a public record and subject to prosecution under the provisions of A.R.S. 13-2407, Tampering With a Public Record.

940-3 CONSTRUCTION

940-3.01 General.

(A) RACM Removal. Remove all affected RACM from a facility being demolished or renovated before any activity begins that would break up, dislodge or similarly disturb the material or preclude access to the material for subsequent removal. RACM need not be removed if:

(1) It is on a facility component that is encased in concrete or similarly hard material and is adequately wet whenever exposed during demolition.

(2) It was not accessible for testing and was, therefore, not discovered until after demolition began and, as a result of the demolition, the material cannot be safely removed. If not removed for safety reasons, the exposed RACM and any asbestos-contaminated debris must be treated as asbestos-containing waste material and adequately wet at all times until sealed up and disposed of.

(3) It is Category II non-friable ACM and the probability is low that the materials will be crumbled, pulverized, or reduced to powder during demolition.

(4) It is Category I non-friable ACM that is not in poor condition and is not friable.

(B) Minimum Engineering Controls. The abatement contractor shall use the following minimum engineering control and work practices in all abatement work:

Vacuum cleaners equipped with high efficiency particulate air (HEPA) filters to collect all dust and debris containing ACM.

Wet methods during all phases of the work unless it can be demonstrated that the method is infeasible.

Prompt clean-up and disposal of wastes and debris with asbestos in leak-tight containers or double wrapped. Wrappings shall consist of a double wrap of transparent 6-mil (*150 micrometers*) polyethylene sheeting or bags.

Encapsulate the ends of any broken pieces of asbestos containing pipe.

In addition, the abatement contractor shall use the following controls to achieve compliance with the permissible exposure limit (PEL):

Local exhaust ventilation with HEPA filter dust collection systems.

Enclosure or isolation of the process producing asbestos dust.

Ventilation of the regulated area to move contaminated air away from the workers and towards the collection system.

Respiratory protection as described in 40 CFR 1926.1101 (h).

In no case may the abatement contractor use the following practices:

High-speed abrasive disc saws that are not equipped with point of cut ventilator or enclosures with HEPA filtered exhaust.

Compressed air to remove ACM unless it is used in conjunction with an enclosed ventilation system designed to capture the dust.

Dry methods of clean-up of ACM.

Rotation of employees as a means of reducing employee exposure.

(C) Personnel Safety. Protective clothing shall be provided by the abatement contractor and used by the employees when performing Class I work or when the PEL or the excursion limit are exceeded or if a negative exposure assessment has not been produced.

(D)Regulated Areas. All Class I, Class II, and Class III asbestos work shall be conducted in a regulated area. A competent person shall supervise all work in the regulated area.

The regulated area shall be demarcated in any manner that minimizes the number of persons in the area and protects persons outside the area from exposure. Signs shall be provided and displayed as outlined in Section 940-2.02(B).

Access shall be limited to authorized personnel only. Respirators shall be worn in the regulated area as required by Sections 940-3.02(A) and 940-3.03(A).

Eating, drinking, smoking, chewing, or application of cosmetics is prohibited in the regulated area.

Air monitoring shall be performed in the regulated area as outlined in Section 940-3.05.

940-3.02 Class I Asbestos Work.

(A)Engineering Controls. All work shall be supervised by a competent person employed by the asbestos abatement contractor.

Respirators shall be used on all Class I work.

If a negative exposure assessment has not been produced and/or workers are working next to the regulated area, the construction of critical barriers or other isolation methods shall be installed to mitigate the migration of airborne asbestos from the regulated area.

Heating, ventilation, and air conditioning (HVAC) systems shall be isolated. Impermeable drop cloth shall be placed on all surfaces beneath the removal activity. All objects within the regulated area shall be covered with impermeable drop cloths or plastic sheeting.

On all jobs where the abatement contractor has not or cannot produce a negative exposure assessment or where exposure monitoring shows that the PEL is exceeded, the area shall be ventilated to move contamination away from the employees to the HEPA filtration collection system.

Additionally, all Class I work shall be done using one or more of the following control methods:

Negative Pressure Enclosures or Mini-Enclosures
Glove Bag System
Negative Pressure Glove Bag
Negative Pressure Glove Box

Variations of these methods may be submitted for approval by the owner's competent person. If approved, a copy must be sent to OSHA, Washington, D.C. (The limitations of these methods are described in 29 CFR 1926.1101 (g)(5) and (6).

(B) Decontamination. A minimum three chamber decontamination area shall be required for all Class I projects involving over 25 linear feet (*7.5 meters*) or 10 square feet (*1 square meter*) of thermal system insulation (TSI) or surfacing ACM. The area shall be adjacent and connected to the regulated area. The decontamination area shall consist of an equipment room, shower area and clean room in series. Entry and exit to the work area shall be through the decontamination area.

For Class I work under 25 linear feet (*7.5 meters*) or 10 square feet (*1 square meter*) of TSI or surfacing ACM and for Class II and Class III asbestos work where exposure exceeds the permissible exposure limit (PEL) or where no negative exposure assessment was produced, the abatement contractor shall establish an equipment room or area adjacent to the regulated area.

940-3.03 Class II Asbestos Work.

(A) Engineering Controls. All work shall be supervised by a competent person employed by the asbestos abatement contractor.

Appropriate respirators shall be used where ACM is not removed substantially intact; where work is performed not using wet methods; where the abatement contractor does not produce a negative exposure assessment; and during all work where the employees are exposed above the PEL or the excursion limit; or as otherwise outlined in the rules and regulations.

For all indoor jobs, where a negative exposure assessment has not been produced, or where the work may cause the PEL to be exceeded, or where the ACM does not come out essentially intact, the abatement contractor shall use critical barriers or another isolation method to ensure that the airborne asbestos does not migrate out of the regulated area.

Impermeable barriers shall be placed on all surfaces beneath the removal activity.

Class II work may be performed using the methods outlined for Class I work, except that glove bags and boxes are allowed only if they fully enclose the Class II material.

Additional Controls for Class II work by type are listed below. However, instead of the work practices listed below, the abatement contractor may use alternate methods provided that it can be demonstrated that the exposure to the employees remained under the PEL when other methods were used on similar projects. A competent person must certify that the different control methods are adequate to reduce the direct and indirect exposures to below the PEL.

(1) Vinyl and Asphalt Flooring Materials. Flooring and backing shall not be sanded.

Vacuums equipped with HEPA filter, disposable dust bags, and metal floor tool (no brush) shall be used to clean floor.

Resilient sheeting shall be removed by cutting with wetting of the snip point and wetting during delamination. The ripping-off of flooring material is prohibited.

All scraping of residual adhesive and/or backing shall be performed using wet methods.

Dry sweeping is prohibited.

Mechanical chipping is prohibited unless performed in a negative pressure enclosure.

Tiles shall be removed intact, unless the abatement contractor demonstrates that intact removal is not possible.

When tiles are heated and removed intact, wetting is not required.

(2) Roofing Material. Roofing material shall be removed intact to the extent possible.

Wet methods shall be used to remove roofing materials that are not intact, or that will be rendered not intact during removal, unless such wet methods are not feasible or will create a safety hazard.

Cutting machines shall be continuously misted during use, unless a competent person can demonstrate that misting substantially reduced workers safety.

When removing built-up roofs with asbestos-containing felts and an aggregate surface using a power roof cutter, all dust resulting from the cutting operation shall be collected by a HEPA dust collector, or shall be HEPA vacuumed by vacuuming along the cut line. When removing built-up roof with asbestos-containing roofing felts and a smooth surface using a power roof cutter, the dust resulting from the cutting operation shall be collected either by a HEPA dust collector or HEPA vacuuming along the cut line, or by gently sweeping and then carefully and completely wiping up the still-wet dust and debris left along the cut line. The dust and debris shall be immediately bagged or placed in covered containers.

Asbestos-containing material that has been removed from a roof shall not be dropped or thrown to the ground. Unless the material is carried or passed to the ground by hand, it shall be lowered to the ground via covered, dust-tight chute, crane or hoist. ACM that is not intact and is remaining on the roof shall either be kept wet, placed in an impermeable waste bag, or wrapped in plastic sheeting. All ACM shall be lowered to the ground as soon as practicable, but in no event no later than the end of the work shift.

Upon being lowered to the ground, unwrapped material shall be transferred to a closed receptacle in such a manner to preclude the dispersion of dust.

Roof level heating and ventilation air intake sources shall be isolated or the ventilation system shall be shut off.

Not withstanding any other provision of this section, removal or repair of sections of intact roofing less than 25 square feet (*2.3 square meters*) in area does not require use of wet methods or HEPA vacuuming as long as manual methods which do not render the material non-intact are used to remove the material and no visible dust is created by the removal method used. In determining whether a job involves 25 square feet (*2.3 square meters*), the employer shall include all removal and repair performed on the same roof on the same day.

(3) Cementatious Asbestos Siding and Shingles or Transite Panels. Cutting, abrading or breaking siding, shingles or transite panels, shall be prohibited unless the abatement contractor can demonstrate that the methods less likely to result in asbestos fiber release cannot be used.

Each panel or shingle shall be sprayed with amended water before removal.

Unwrapped or unbagged panels or shingles shall be immediately lowered to the ground via dust-tight chute, or placed in a transparent impervious waste bag or wrapped in transparent plastic sheeting and lowered to the ground no later than the end of the work shift.

Nails shall be cut with flat sharp instruments.

(4) Gaskets Containing ACM. If the gasket is visibly deteriorated and unlikely to come out intact, the removal shall be done in a glove bag.

The gasket shall be thoroughly wetted with amended water prior to its removal. The wet gasket shall be immediately placed in a disposal container. Any scraping to remove residue must be performed wet.

(5) Other Class II Removal of ACM (Transite Pipe). The material shall be thoroughly wetted with amended water prior to and during its removal. The material shall be removed intact unless the abatement contractor can demonstrate that intact removal is not possible.

Cutting, abrading or breaking the material shall be prohibited unless the abatement contractor can demonstrate that methods less likely to result in asbestos fiber release are not feasible.

The removed asbestos containing material that remains Category II non-friable ACM, such as intact transite pieces or pieces with only broken ends or minor chips, shall have a sealant placed over the exposed areas and shall be transferred to a closed receptacle no later than the end of the day.

Damaged pieces, chips, dust, etc. shall be treated as friable ACM. The material shall be kept thoroughly wetted with amended water prior to and during removal. It shall be double bagged or wrapped in 6 mil transparent polyethylene and transferred to a closed receptacle no later than the end of the shift work.

(B) Decontamination. For Class I work under 25 linear feet (*7.5 meters*) or 10 square feet (*1 square meter*) of TSI or surfacing ACM and for Class II and Class III asbestos work where exposure exceeds the PEL or where no negative exposure assessment was produced, the abatement contractor shall establish an equipment room or area adjacent to the regulated area.

940-3.04 Class III Asbestos Work.

(A) Engineering Controls. Class III asbestos work shall be done in accordance with the OSHA requirements of 29 CFR 1926.1101. Minimum requirements are:

(1) The work shall be performed using wet methods.

(2) Where feasible, the work shall be performed using local exhaust ventilation.

(3) Where the disturbance involves drilling, chipping, abrading, sanding, cutting, breaking or sawing of TSI or surfacing AC material, the employer shall use impermeable drop cloths and shall isolate the operation using mini-enclosures, glove bags, or other isolation methods.

(4) Where the employer does not produce a negative exposure assessment for a job, or where monitoring results show the PEL has been exceeded, the employer shall contain the area using impermeable drop cloths and plastic barriers or their equivalent or shall isolate the operation using a control system listed for Class I work.

(5) Employees performing Class III jobs, which involve the disturbance of TSI or surfacing ACM or for which a negative exposure assessment has not been produced or where monitoring results indicate that the PEL has been exceeded, shall wear appropriate respirators.

(B) Decontamination. For Class I work under 25 linear feet (*7.5 meters*) or 10 square feet (*1 square meter*) of TSI or surfacing ACM and for Class II and Class III asbestos work where exposure exceeds the PEL or where no negative exposure assessment was produced, the abatement contractor shall establish an equipment room or area adjacent to the regulated area.

940-3.05 Air Monitoring.

(A) General. Sampling shall be conducted for all work in a regulated area. The employer shall notify the employees of the monitoring results as soon as possible after receipt of the results.

Samples shall be measured using Phase Contrast Microscopy (PCM). Personal air monitoring samples shall be checked against the PEL of 0.1 fibers/cubic centimeter (f/cc) or 1.0 f/cc for the excursion limit.

Final clearance level within containment shall be 0.01 f/cc.

(B) Personal Sampling. The abatement contractor shall perform personal air monitoring on the employees within the regulated area on a daily basis.

Representative 8-hour and 30 minute short term sampling shall be done.

For the 8 hour Time Weighted Average (TWA): At a minimum, 2 employees shall be checked. Generally, 25% of the work force shall be monitored with the monitoring devices divided among the various types of work being done.

For the 30 minute short term exposure: Employee exposure shall be determined on the basis of 1 or more samples representing 30 minute exposure associate with operations likely to produce exposure above the excursion limit in each work area.

Samples shall be collected within the breathing zone of the employee. Records of the sampling results shall be provided to the owner daily after they become available.

(C) Area Sampling. Area sampling shall be performed daily by the abatement contractor. Sampling shall be performed inside containment and outside containment near the exhaust, bag out, entry/exit, and on the perimeter of the regulated area.

Samples shall be taken prior to the start of construction to establish the background levels of airborne contaminants. A minimum of four samples shall be taken.

(D) Clearance Sampling. Final clearance samples shall be taken inside the containment and outside as specified above under area samples. Samples inside containment shall be done using aggressive means and must pass a clearance level of 0.01 fibers per cubic (f/cc) centimeter using PCM prior to the removal of the containment.

Outside samples must be equal to or lower than 0.01 f/cc or the background levels, if the background levels were found to be higher than 0.01 f/cc.

TEM clearance may be required if requested by the Engineer. TEM

clearance will meet AHERA requirements of 70 structures per square millimeter (70 x/mm5).

940-3.06 Collection and Transport. All materials shall be kept adequately wet while being removed, collected, and prepared for transport. Seal all waste ACM in leak-tight containers while wet; or for materials which will not fit into containers without breaking, put materials into leak-tight wrapping. For Class II ACM not requiring wrapping under Section 940-3.03, the materials shall be placed in a leak-tight container such as a roll-off or lined truck with tight cover for transport.

Containers or wrapped materials shall be marked and labeled. The marking shall be printed in letters of sufficient size and contrast so as to be readily visible and legible. The labels shall be as pictured and the markings shall contain the following information

DANGER
CONTAINS ASBESTOS FIBERS (Label here)
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

RA Hazardous Substance
Asbestos
NA2212

Waste generator name and address
Location at which the waste was generated

For facilities demolished where the RACM is not removed prior to demolition (see 940-3.01A(1-3)), the asbestos-containing materials shall be kept adequately wet during demolition, handling and loading for transport to a disposal site. These materials need not be sealed in leak-tight containers or wrapped, but may be transported and disposed of in bulk.

Vehicles used to transport asbestos-containing waste materials shall be marked during the loading and unloading of waste. The markings must be displayed in such a manner and location that a person can easily read the legend. The sign shall conform to the requirements for 20 inch x 4 inch (*500 x 360 millimeters*) upright format signs specified in 29 CFR 1910.145 (d)(4) and display the following legend in the lower panel with letter sizes and styles of a visibility at least equal to those specified below.

DANGER	1 inch (*25 millimeters*) Sans Serif, Gothic or Block
ASBESTOS DUST HAZARD	1 inch (*25 millimeters*) Sans Serif, Gothic or Block
CANCER AND LUNG DISEASE HAZARD	3/4 inch (19 *millimeters*) Sans Serif, Gothic or Block
Authorized Personnel Only	14 Point Gothic

(Spacing between any two lines must be at least equal to the height of the upper of the two lines.)

When transporting friable asbestos in bulk packings, the transport vehicle shall be placarded. A placard shall be placed on each of the two sides and one on the front and one on the back. The contractor shall furnish the placards. The placards shall be as shown below except for the size.

Drivers of placarded vehicles must have HazMat commercial drivers licenses and the firm must be appropriately registered.

For all asbestos-containing waste material transported off the facility site:

(1) Maintain waste shipment records which include the following information:

(a) The name, address, and phone number of the waste generator.

(b) The name and address of the Control Officer.

(c) The approximate quantity in *cubic meters*.

(d) The name and phone number of the disposal site operator.

(e) The name and physical site location of the disposal site.

(f) The date transported.

(g) The name, address, and phone number of the transporter.

(h) A certification that the contents of this consignment are fully and accurately described by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by highway according to applicable international and government regulations.

(2) Provide a copy of the waste shipment record to the disposal site owner or operator at the same time as the waste ACM is delivered for disposal.

(3) For waste shipments where a copy of the waste shipment record, signed by the owner or operator of the designated disposal site, is not received by the waste generator within 35 days of the date the waste was accepted by the initial transporter, contact the transporter and/or the owner or operator of the designated disposal size to determine the status of the waste shipment.

(4) Report in writing to the Control Officer (with a copy to the Agency) if a copy of the waste shipment record, signed by the owner or operator of the designated waste disposal site, is not received by the waste generator within 45 days of the date the waste was accepted by the initial transporter. Include in the letter a copy of the waste shipment record for which a confirmation of delivery was not received and a cover letter signed by the waste generator explaining the efforts taken to locate the asbestos waste shipment and the results of those efforts.

(5) Retain a copy of all waste shipment records, including a copy of the waste shipment record signed by the owner or operator of the designated waste disposal site, for a minimum of two years.

940-3.07 Disposal. Disposal shall be made at an Agency approved facility. If using Tangerine Landfill, the contractor shall contact the landfill authority at Pima County Solid Waste at least 24 hours prior to the first date of disposal of asbestos-containing debris to insure that the landfill will be able to accept the shipment.

When disposing of water related CA material belonging to Tucson Water, the contractor shall provide Tucson Water with a signed, fully completed copy of the Asbestos Disposal Manifest demonstrating proper disposal at an approved asbestos disposal site.

940-4 METHOD OF MEASUREMENT

Removal of asbestos-containing materials will be measured by the unit as indicated on the bidding schedule for removal of regulated asbestos-containing material (RACM), Category I ACM and Category II ACM.

Cement-asbestos (CA) water pipe will be measured by the linear foot (*meter*) of CA pipe removed.

940-5 BASIS OF PAYMENT

Payment for the work will be at the contract unit bid price, including air monitoring, removal, hauling and disposal in accordance with these specifications and appropriate codes and regulations.

SECTION 1001

MATERIAL SOURCE

1001-1 DESCRIPTION

The work under this section shall consist of the procuring of borrow, subbase, base, materials, mineral aggregates for portland cement concrete, and mineral aggregates for surfacing materials specified for use, from commercial sources.

1001-2 DEFINITIONS

A commercial source shall be defined as a material source in which the owner or producer has been, for at least one year, regularly engaged during regular business hours and on a regular basis in the processing and selling of sand, rock, ready mixed portland cement concrete, asphaltic concrete and other similar products normally produced and sold to all parties. The company shall have an Arizona retail sales tax license.

1001-3 COMMERCIAL SOURCE

The contractor shall advise the Engineer promptly as to the source that he proposes to use.

The use of a commercial source will require written approval by the Engineer. No approval shall be assumed, nor will it be made, until the Agency has determined that the material not only meets the specified requirements, but is also compatible with the established project design criteria developed by the Agency and based on the soil support value of the embankment materials and the structural coefficients of the base and surfacing materials.

The contractor shall furnish equipment and personnel and shall obtain representative samples of the material under the supervision of the Engineer. At the option of the contractor, the material shall be tested by either the Agency or by a testing laboratory approved by the Agency.

If testing is performed by a testing laboratory, the contractor shall arrange for the samples to be delivered to the testing laboratory. Tests shall be performed using appropriate test procedures referred to in the sections of the specifications in which the specific material requirements are described.

The contractor shall make the arrangements necessary to see that the testing laboratory submits the results of the tests to the Agency. He shall submit to the Agency sufficient material from the samples taken so that the Agency may test the materials and verify the results.

The cost of all sampling and testing, including the cost of supervision by the Engineer, shall be borne by the contractor until the testing has been satisfactorily completed.

Every effort will be made by the Agency to advise the contractor, as soon as possible, that the source he proposes to use has been either approved or disapproved. The contract time will not be adjusted because of any time required by either the contractor or the Agency to sample and test the material and to determine the quality of the material.

1001-4 METHOD OF MEASUREMENT (None Specified)

1001-5 BASIS OF PAYMENT

Except as may be specifically provided for in other sections of these specifications, no measurement or direct payment will be made for any costs involved in the procuring of materials. Such costs shall be considered as included in the cost of contract items.

SECTION 1002

PAINT

1002-1 REQUIREMENTS

(A) General. All paints furnished shall be ready mixed at the manufacturer's plant, except for aluminum paint and zinc paint, which shall be mixed at the project site or by the fabricator just prior to application. All paints shall be standard paint products of the manufacturer with published product data sheets and shall comply in all details with the paint specifications contained herein.

Ready-mixed paint shall be homogeneous, free of contaminants and shall be of a consistency suitable for the use for which it is specified. The pigment shall be finely ground and properly dispersed in the vehicle, according to the requirements of the type of paint, and this dispersion shall be such that the pigment does not settle appreciably, does not cake or thicken in the paint container, and does not become granular, jelled or curdled. Any settlement of pigment in the paint shall be easily dispersed with a paddle so as to produce a smooth uniform paint of the proper consistency. The manufacturer shall include, in the paints, the necessary additives for control of sagging, leveling, drying, drier absorption and skinning.

Paint shall be furnished in new, unopened air-tight containers, clearly labeled with the exact title of the paint, Federal Specification number when applicable, name and address of manufacturer, product code, date of paint manufacture and the lot or batch number. The containers shall meet U.S. Department of Transportation Hazardous Material Shipping Regulations.

Precautions concerning the handling and the application of the paint shall be shown on the label of all paint containers.

When painting structural steel, the supplier or manufacturer of the primer, intermediate coat, and topcoat of paint shall be the same and the paint coats shall be compatible with each other, forming a complete paint system.

The contractor shall submit to the Engineer a Certificate of Compliance for each lot or batch of paint supplied, in accordance with Subsection 106-5, prior to the use. Product data sheets listing the paint constituents and their proportions, as well as Materials Safety Data Sheets (MSDS), are required for each paint material supplied prior to its use.

All applicable governmental regulations shall be adhered to during cleanup and the disposal of unused paint.

(B) Three-Paint Coating System. All three-paint coating systems, as specified in Subsection 1002-2.01, shall be ready-mixed at the manufacturer's plant.

Only approved paint systems will be allowed for use on structural steel. Paint systems approved in accordance with Subsection 1002-3(B) are shown on the Arizona Department of Transportation's Approved Products List (APL). Copies of the most current version of the Approved Products List are available on the internet at http://www.dot.state.az.us/ABOUT/atrc/apl.htm. Paint supplied by an approved manufacturer with a different product code from that which was previously evaluated and approved will require evaluation to determine if it is acceptable. It is the responsibility of the manufacturer to submit the necessary samples for paint system evaluation and approval.

(C) Aluminum and Zinc Paints. Aluminum and zinc paints shall be mixed at the project site or by the fabricator just prior to application.

For safety purposes, aluminum paint shall be mixed only as needed and any unused paint shall be safely discarded and shall not be stored.

(D) Acrylic Emulsion Paint. Paint approved in accordance with Subsection 1002-3(D) are shown on the Approved Products List (APL). For paints supplied which are not shown on the Approved Products List, a Certificate of Analysis showing conformance to Subsection 1002-2.04 for each lot or batch of paint supplied shall be submitted to the Engineer in accordance with Subsection 106-5, prior to its use.

1002-2 PAINTS

Lead, lead compounds, soluble barium compounds, or hexavalent chromium compounds shall not be used as raw materials in the paint formulas specified under this Section. Lead, lead compounds, soluble barium compounds, or hexavalent chromium compounds shall not be added to any paint formulas specified under this Section.

The use of halogenated solvents is not permitted.

Raw materials used in the paint formulas shall conform to the specifications designated by ASTM or by Federal or Military Specifications listed herein, except as otherwise specified herein. Subsequent amendments to the specifications quoted shall apply to all raw materials and finished products. No "or equal" substitutions for any specified material shall be made without the written consent of the Engineer.

A three-paint system shall be water-borne and each paint shall be ready-mixed by the manufacturer. The volatile organic content of the mixed paint shall not exceed 2.1 pounds per gallon (*0.25 kilograms per liter*).

Zinc paint shall be in accordance with Subsection 1002-2.02.

Aluminum paint shall be water-borne and shall be mixed in accordance with Subsection 1002-2.03.

All paints will be sampled and tested in accordance with Subsection 1002-3.

1002-2.01 Three-Paint Coating System.

(A) General. A three-paint coating system shall include a primer (Paint Number 1), intermediate coat (Paint Number 2), and topcoat (Paint Number 3) from the same system. A three-paint coating system will be tested as a complete system in accordance with Subsection 1002-3(B).

Each individual paint shall conform to all of the chemical and physical characteristics and properties as declared on the manufacturer's product data sheet. In addition, the paint color shall be as specified in the project plans, and the consistency shall be in accordance with the manufacturer's recommendations. The contractor shall use the checking and calibration procedures found in ASTM D 4212 and verify the paint consistency with the Engineer prior to each application.

Each coating is intended for spray application. Limited application can be made by brushing or rolling if approved by the Engineer.

(B) Paint Number 1 – Primer. Paint Number 1 shall be used on blast cleaned steel surfaces for the first coat of a three-paint coating which must include Paint Number 2 and Paint Number 3 from the same system.

(C) Paint Number 2 – Intermediate Coat. Paint Number 2 for intermediate coats shall be used on primed steel surfaces as the second coat of a three-paint coating system which must include Paint Number 1 and Paint Number 3 from the same system. The paint shall be appropriately tinted to contrast with the prime coat.

(D) Paint Number 3 – Topcoat. Paint for topcoats shall be used as the third coat of a three-paint coating system which must include Paint Number 1 and Paint Number 2 from the same system.

For topcoats, the gloss shall also be as specified on the project plans. The available colors for topcoats shall provide visual matches to the colors given in the Federal Standard No. 595. The colors shall be available in high-gloss enamels, if required.

When specified, a two-part aluminum paint conforming to Subsection 1002-2.03 shall be applied as the topcoat. The two parts shall be mixed in accordance with the manufacturer's label directions prior to use.

1002-2.02 Zinc Paint.

(A) General. Zinc paint shall be a zinc-dust, zinc-oxide primer conforming to the requirements of Federal Specification TT-P-641G, Type III, zinc dust, zinc oxide phenolic resin primer modified to conform to the requirements (1 through (8) below, and as otherwise specified herein.

The Volatile Organic Compound or solvent portion of the vehicle shall conform to the following requirements by volume:

(1) Solvents with an olefinic or cyclo-olefinic type of unsaturation shall not exceed five percent.

(2) The total of aromatic compounds with eight or more carbon atoms in the molecule, except ethylbenzene shall not exceed eight percent.

(3) The total of ethylbenzene, toluene, and branched-chain ketones shall not exceed 20 percent.

(4) A solvent which may be classified into more than one of the above groups shall be considered a member of the group having the lowest allowable concentration.

(5) The total of (1), (2), and (3) shall not exceed 20 percent.

(6) The volatile solvents shall contain no benzene or halogenated compounds.

(7) All paints shall be completely miscible with mineral spirits conforming to Grade II of Federal Specification TT-T-291.

(8) Mineral spirits, conforming to Grade II, of Federal Specification TT-T-291 shall be the preferred thinner for all paints specified in this Subsection. If necessary, other paint thinners conforming to the requirements of (1) through (6) above may be used.

If modified colors are required, pigments which do not contain lead, lead compounds, soluble barium compounds, or hexavalent chromium compounds shall be used in amounts not exceeding ten percent of the total pigment weight and replacing an equal weight of zinc oxide.

This specification covers a ready-to-mix or semi-prepared primer for use on, or repair of, galvanized metal surfaces. The primer ingredients shall be furnished in two separate containers, one consisting of a liquid (zinc oxide-vehicle) and the other of zinc dust which is to be added to the zinc oxide-vehicle just prior to use. When the entire amount of zinc dust from one container is mixed with all of the zinc oxide-vehicle from another container, a

primer, conforming to all the requirements of this specification, shall result. The mixed primer shall normally be a gray color characteristic of the composition, unless otherwise specified.

(B) Proportions. One gallon (*liter*) of zinc dust, zinc oxide primer meeting this specification will have the following characteristics, when the minimum figures are met, and the pigment is a mixture of 80 percent zinc dust and 20 percent zinc oxide:

Constituent	Composition by Volume (gallons)	Composition by Weight (pounds)
Zinc dust	0.1445 (*.547 liter*)	8.50 (*3.85 kilograms*)
Zinc Oxide	+ 0.0455 + (*0.1722 liter*)	+ 2.12 + (*0.96 kilograms*)
Total Pigment	0.1900 (*0.1238 liter*)	10.62 (*4.81 kilograms*)
Nonvolatile Vehicle	+ 0.3544 + (*1.3414 liters*)	+ 2.99 + (*1.35 kilograms*)
Total Solids	0.5444 (*2.0606 liters*)	13.61 (*6.165 kilograms*)
Volatile (thinner and drier)	+ 0.4556 + (*1.724 liter*)	+ 2.99 (*1.35 kilograms*)
Total primer (gallon)	1.0000 (*3.785 liters*)	16.60 (*7.52 kilograms*)

(C) Qualitative Requirements. The mixed primer shall meet the following qualitative requirements:

Characteristics	Min.	Max.	Test Method
Pigment, percent by weight of primer	64	67	ASTM D 723
Water, percent by weight of primer	---	0.1	ASTM D 3960
Coarse particles and skins, percent by weight of pigment	---	4	ASTM D 185
Consistency, Krebs-Stormer, shearing rate 200 r.p.m.	72	92	ASTM D 562
Time to set to touch, hours	0.5	4	ASTM D 1640
Time to dry, hours	---	18	ASTM D 1640
Weight per gallon, pounds (*kilograms/liter*)	16.4(2)	---	ASTM D 1475
VOC of mixed primer, lbs/gal. (*kg/l*)	---	3.5 (0.4)	ASTM D 3690

(D) Pigment. The pigment composition in the mixed primer (except when colors other than gray are specified) shall be in accordance with the following:

Ingredients	Percent by Weight	
	Min.	Max.
Zinc Dust (ASTM D 520, Type I)	79	89
Zinc Oxide (ASTM D 79, American Process, Lead Free)	19	21

Upon analysis, the zinc dust shall show not less than 94 percent metallic zinc by weight. The pigment, extracted from the zinc oxide-vehicle and ignited, shall show on analysis not less than 98 percent zinc oxide by weight.

The total pigment (zinc dust plus zinc oxide) in the mixed primer shall contain a minimum of 74 percent metallic zinc and a minimum of 18 percent zinc oxide by weight. The sum of the percentage by weight of metallic zinc and zinc oxide in the total pigment of the mixed primer shall be not less than 97.

(E) Vehicle. The vehicle shall consist of 100 percent phenolic resin spar varnish, suitable for grinding with zinc oxide, and shall have an oil-to-resin ratio of approximately 2 to 1 by weight.

The resin shall be 100 percent paraphenyl phenol-formaldehyde resin of the fortifying type, meeting the requirements of Federal Specification TT-R-271.

The vegetable oils shall consist of equal parts by volume of tung oil meeting the requirements of Federal Specification TT-T-775 and linseed oil conforming to Federal Specification TT-L-90.

The volatile solvent used shall be any solvent system complying with Subsection 1002-2.02(A) and applicable air pollution regulations by weight per gallon (*weight per liter*) Subsection 1002-2.02(C). Antiskinning agents may be present.

The vehicle shall contain not less than 50 percent solids by weight when tested according to Federal Standard No. 141, Method 4051.

1002-2.03 Aluminum Paint. This paint is a two-part waterborne leafing aluminum paint formulated for use on properly prepared metal surfaces exposed to the air. Aluminum paint shall conform to California D.O.T. Specification Formula PWB-160 or as otherwise specified herein. This paint may be utilized for the finish coat when the aluminum color is specified on the plans. Aluminum paint must be compatible with the underlying paint coats. The quantity of aluminum paint mixed during any one day shall be limited to the quantity to be used during that day. The paint shall be mixed in accordance with the manufacturer's label directions prior to use.

For safety purposes, aluminum paint shall be mixed only as needed and any unused paint shall be safely discarded and shall not be stored.

(A) Composition. This paint shall be supplied with 1.5 pounds of the specified aluminum paste to one gallon of vehicle (*0.2 kilograms per liter*).

(B) Pigment.

(1) Ingredients:

Water Dispersible Aluminum Paste (1)

(2) Characteristics:

Non-volatile content, percent, ASTM D 480	72 minimum

(C) Vehicle.

(1) Ingredients:

		% by Weight
Acrylic Latex (2)		89.31
2,2,4-Trimethylpentanediol-1,3-monoisobutyrate		4.44
Ammonium Hydroxide (28%)		0.47
Defoamer (3)		0.35
Preservative (4)		0.05
Thickener (5)	} Premix	approx. 0.12
2-(2-Methoxyethoxy)ethanol	} Premix	5.26

(2) Characteristics:

	Requirements
Density, grams per milliliter, ASTM D-1475	1.01 to 1.03
Nonvolatile content, percent, ASTM D2369, B	36.5 – 38.5
Viscosity, centipoises, ASTM D2196,	
Test Method A (50 RPM, #3 spindle)	900 – 1200
High-shear viscosity, ASTM D-4287,	
0 to 5-P cone, shear rate 12,000 s^{-1}	0.5 to 0.7
pH	9.0 – 9.5

(a) Hydro Paste® 830 (Silberline)

(b) Maincote® HG-54D (Rohm and Haas)

(c) Foamaster® AP (Henkel)

(d) Proxel® GXL (ICI Americas)

(e) Acrysol® RM·8W (Rohm and Haas)

(D) Mixed Paint.

a. Characteristics:

	Requirements
Nonvolatile Content, volume percent	
(calculated using maximum mix water)	33 – 35
Drying time, 100 µm wet film, ASTM D-1640	
Set to touch, hours	1/2 maximum
Dry through, hours	1 maximum

(E) Mixing Procedures. Add 0.5 gallons (*1.9 liters*) of potable water to the aluminum paste and mix to a smooth, lump-free consistency. Slowly stir in the vehicle. Mix well, but avoid incorporating air into the paint. Strain the mixed paint through

a double layer of cheesecloth prior to use. THE PAINT MUST BE MIXED FRESH EACH DAY. DO NOT STORE MIXED PAINT. DO NOT PLACE MIXED PAINT IN SEALED CONTAINERS.

(F) Application. The mixed paint shall be applied to a total dry film thickness of at least 2.0 mils (*50 micrometers*). This coating is intended for spray application, however, limited application can be made by brush. Paint should not be applied when the ambient or surface temperature is above 100 °F (*38° C*) or below 50 °F (*10° C*) or when the relative humidity exceeds 75 percent.

(G) Clean-Up. Use tap water for clean-up. Ten percent ammonia, acetone, or other suitable solvent may be used to remove dried paint from spray guns and other equipment. All applicable governmental pollution regulations shall be adhered to during cleanup and for the disposal of unused paint.

1002-2.04 Acrylic Emulsion Paint. Acrylic emulsion paint shall be waterborne and conform to the requirements of Federal Specification TT-P-19 Paint, Acrylic Emulsion Exterior. Acrylic emulsion paint will be tested in accordance with Subsection 1002-3(D).

This paint may be tinted by using "Universal" or "all purpose" concentrates.

The color of the final coat of paint shall be as indicated on the project plans. If no color is specified on the plans, the paint color shall approximate that of Paint Color Chip No. 30318, as specified by Federal Test Standard Number 595, when applied to either a concrete test specimen measuring 2-foot by 2-foot (*610 millimeters by 610 millimeters*) or to the surface of the concrete structure to be painted.

The Engineer will determine color acceptance by visual inspection.

1002-3 SAMPLING AND TESTING

(A) General. Any lot or batch of paint may, at any time, be sampled at random and tested for conformance to any of the chemical and physical characteristics and properties as declared by the manufacturer on the respective product data sheet. Also, complete three-paint coating system samples may be required at any time for follow-up evaluation using the performance test method employed in the original evaluation for approval of the system.

(B) Three-Paint Coating System. Paint coatings in Subsection 1002-2.01 will be tested as a complete three-paint coating system. Paint systems shall have an evaluation rating of 100 or greater, as described below, after being weathered in accordance with the requirements of ASTM D 4587 and ASTM G 53 in the Q-U-V Accelerated Weathering Tester (Fluorescent UV/Condensation Apparatus). Paint systems will be tested as follows:

(1) Paint coatings will be applied to cold rolled steel panels (ASTM D 609, Type 3, ASTM A 366). The paint will be thinned to 75± 2 Ku consistency using demineralized water. Three coats, each approximately 2 mils (*50 micrometers*) thickness are applied to each of four panels according to ASTM D 823. The fourth coated panel from each set will be inscribed with an "X" cut to the steel substrate and extending across the entire coated area.

(2) The exposure cycle used with the weathering tester shall be D = 8 h UV/60 degree C followed by 4 h CON/45 degree C. One panel from each set of four shall be removed at 500 hours and another at 750 hours. The last two panels shall be removed at 1000 hours.

(3) Paint systems will be evaluated on the basis of six measures of degradation which may be found to occur under the conditions of exposure. For each measure, a rating scale of from one to five points will be applied. A rating of one point indicates the poorest performance and five points indicate the best performance. The rating from each measure is multiplied by a weighting factor, which represents the relative importance of that measure. The product is a score for that measure. The sum of the scores for all measures is the overall score for the system. All paint systems shall have an overall score of 100 or higher.

(a) Cracking/Flaking: Three ASTM standard test methods are used to provide a measure of the degree of degradation in this area: ASTM D 660, ASTM D 661, and ASTM D 772. The definitions and illustrations contained in these methods are used in combination for the rating scale. A weighting factor of three will be applied to the results of these tests.

(b) Blistering/Flaking: Two ASTM methods are combined for this rating scale: ASTM D 714 and ASTM D 772. A weighting factor of three will be applied to the results of these tests.

(c) Corrosion: A rating scale is derived from ASTM D 610 for evaluating the degree of rusting. A weighting factor of three will be applied to the results of this test.

(d) Chalking/Erosion: Two ASTM methods are combined for this rating scale: ASTM D 4214 and ASTM D 662. A weighting factor of three will be applied to the results of these tests.

(e) Adhesion: The tape test is based on ASTM D 3359 and the rating scale is from the Classification of Adhesion Test Results under Test Method B. A weighting factor of five will be applied to the results of this test.

(f) Flexibility: This is a modified version of ASTM D 522 using a 1-1/4 inch (*30 millimeters*) mandrel. The degree of cracking observed after bending is used for the rating. A weighting factor of five will be applied to the results of this test.

Paint may also be tested in accordance with the requirements of Arizona Department of Transportation Testing procedures, ASTM, and Federal Test Method Standard Number 141.

(C) Aluminum and Zinc Paint. Aluminum and zinc paint vehicles may be tested in accordance with the requirements of ASTM D 2621, ASTM D 2805, ASTM E 1347, and Federal Test Method No. 141.

(D) Acrylic Emulsion Paint. Acrylic emulsion paints will be tested in accordance with the following procedure:

(1) Resistance to Accelerated Weathering. The paint will be applied to concrete mortar panels and weathered in a Q-U-V accelerated weathering tester, according to ASTM G 53, for 300 hours utilizing UVB-313 lamps and the exposure cycle as specified in Subsection 4.3.5.2 of Federal Specification TT-P-19. The paint weathered in this manner shall show no appreciable change in color or appearance due to fading, chalking, or material reaction.

(2) TT-P-19 Requirements. All performance requirements listed in Section 3 of Federal Specification TT-P-19 will be met as specified when tested according to the applicable test methods as specified in Section 4 of Federal Specification TT-P-19.

(3) Adhesion. The acrylic emulsion paint will be applied to a concrete test specimen or to the final concrete surface and subjected to one or both of the methods of adhesion testing described below, after a minimum period of 7 days of sunlight after application.

Adhesion will be measured in accordance with the requirements of ASTM D 3359. When Test Method A is used, a rating of 3A will be required. When Test Method B is used, a rating of 2B will be required.

(4) Testing. Random inspection testing of the completed paint finish will be performed by the Engineer according to the above performance requirements. Non-compliance with these test results will require remedial action, which may include substitution of the paint supplied, modification to the application plan, removal and repainting of the non-compliance section(s), or other action as deemed appropriate by the Engineer.

SECTION 1003

REINFORCING STEEL

1003-1 GENERAL REQUIREMENTS

Reinforcing steel shall be furnished in the sizes, shapes, and lengths shown on the plans and in conformance with the requirements of this Section. Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

When reinforcing steel is delivered to the site of the work, the contractor shall furnish the Engineer with three copies of all shipping documents. Each shipping document shall show the sizes, lengths and weights of the reinforcing steel separately for each structure.

The Engineer may waive the requirement for Certificates of Compliance and/or shipping documents for reinforcing steel used in minor structures or incidental construction for which shop drawings are not required.

1003-2 REINFORCING BARS

Except when used for wire ties or spirals, steel bars used as reinforcement in concrete shall be deformed and shall conform to the requirements of AASHTO M 31 (ASTM A 615) (or their metric equivalent).

Where shown on the plans, the bars shall be Grade 60 (*Grade 400*).

Where Grade 60 (*Grade 400*) is not specified on the plans, Grade 40 (*Grade 300*) shall be used if it is immediately available. If Grade 40 (*Grade 300*) is not immediately available, Grade 60 (*Grade 400*) may be used exclusively or in combination with Grade 40 (*Grade 300*) provided that the conditions under which the grades are used in combination are acceptable to the Engineer and further provided that there is no additional cost to the Agency.

1003-3 WIRE

Steel wire used as spirals or ties for reinforcement in concrete shall conform to the requirements of AASHTO M 32.

1003-4 WELDED WIRE FABRIC

Welded wire fabric used as reinforcement in concrete and mortar shall conform to the requirements of AASHTO M 55.

1003-5 EPOXY COATED REINFORCING BARS

1003-5.01 Steel. Steel reinforcing bars shall conform to the requirements of Subsection 1003-2.

1003-5.02 Epoxy for Coating. Powdered epoxy resins, which have passed prequalification tests of the Arizona Department of Transportation (ADOT), may be used if the material is applied and cured in the same manner as that used to coat test bars in the original powder prequalification test.

The powdered epoxy resin selected by the contractor and furnished by the manufacturer shall be of the same material and quality as the resins listed on the Arizona Department of Transportation's Approved Products List.

The approved powders are based on specific reinforcing steel preparation, powdered application and curing methods. These identical methods shall be followed during fabrication.

The coating manufacturer shall supply the purchaser with a certification which properly identifies the batch and/or lot number, material, quantity of batch, date of manufacture, name and address of manufacturer and a statement that the material is the same composition as the initial sample prequalified for use by ADOT. A statement shall also be submitted regarding the fact that production bars and prequalification bars have been identically prepared and applied with epoxy powders.

Patching or repair material, compatible with the coating and inert in concrete, shall be made available by the epoxy coating manufacturer. This material shall be suitable for repairs, made by the contractor, of areas of the coating damaged during fabrication and/or handling in the field.

1003-5.03 Application of Coating. The coating applicators facilities shall be subject to approval by the Agency. Applications for approval of facilities shall be made to the Agency by the coating applicator.

The surface to be coated shall be blast cleaned in accordance with the requirements of the Steel Structures Painting Council-Surface Preparation Specification No. 10 (SSPC-SP10), Near White Blast Cleaning.

The powdered epoxy resin coating shall be applied to the cleaned surface as soon as possible after cleaning and before visible oxidation occurs. In no case shall more than eight hours elapse between cleaning and coating.

The protective epoxy coatings shall be applied by the electrostatic spray method or the electrostatic fluidized bed method, in accordance with the recommendations of the coating manufacturer. The epoxy coating may be applied before or after fabrication of the reinforcing.

The epoxy coating shall be applied as a smooth uniform coat. After curing, the coating thickness shall be 7 $\pm$ 2 mils (*175 $\pm$ 50 micrometers*). Coating thickness shall be controlled by taking

measurements on a representative number of bars from each production lot. Coating thickness measurements shall be conducted by the method outlined in ASTM G 12.

The coating shall be checked visually for continuity. It shall be free from holes, voids, contamination, cracks and damaged areas.

The coating shall not have more than two holidays (pinholes not visible to the naked eye) in any linear foot (*300 millimeters*) of the coated item. A holiday detector shall be used, in accordance with the manufacturer's instructions, to check the coating for holidays.

The flexibility of the coating shall be evaluated on a representative number of bars selected from each production lot. The coated bar shall be bent 120 degrees (after rebound) around a six inch (*150 millimeters*) diameter mandrel. The bend shall be done at a uniform rate and may take up to one minute to complete. The test specimens shall be at thermal equilibrium between 68 and 85° F (*20 and 30 °C*) at the time of testing. No cracking of the coating shall be visible to the naked eye on the outside radius of the bent bar.

The contractor shall furnish a Certificate of Compliance from the coating applicator, in accordance with the requirements found in Section 106-5(B), with each shipment of coated steel. The Certificate of Compliance shall (1) verify that the coated items and coating material have been tested in accordance with the requirements of these specifications, (2) state the actual test results for each requirement, (3) state that the test results comply with the requirements, and (4) state that the entire lot is in a fully-cured condition.

The coating applicator shall be responsible for performing quality control and tests. This will include inspection and testing for compliance with the requirements of coating thickness, continuity of coating, coating cure and flexibility of coating, in accordance with the requirements of this subsection.

The Agency reserves the right to have its authorized representative observe the preparation, coating and testing of the reinforcement bars. The representative shall have free access to the plant. Any work done when access has been denied will be automatically rejected.

If the representative elects, lengths of coated bars may be taken from the production run on a random basis, for test, evaluation and check purposes by the Agency.

1003-5.04 Shop Repair. Epoxy coated reinforcement bars which do not meet the requirements for coating thickness, continuity of coating, coating cure or flexibility of coating shall not be repaired.

Reinforcement bars with these defects shall be replaced or alternately, stripped of epoxy coating, recleaned and recoated, in accordance with the requirements of this specification.

Coating breaks due to fabrication and handling shall be repaired with patching material if the defective area exceeds 2 percent of the surface area of the bar in a 12 inch (*300 millimeters*) length and the damaged spot is larger than 1/4 inch by 1/4 inch (*6 millimeters by 6 millimeters*). Defects which are smaller than the cross-sectional area need not be repaired.

The repair of coating breaks shall be limited to bars on which the total of the defective coating areas does not exceed five percent of the surface area of the reinforcement bar. Bars with greater than five percent damage shall be replaced or alternately, stripped of epoxy coating, recleaned and recoated in accordance with the requirements of this specification.

SECTION 1004

STRUCTURAL METAL

1004-1 GENERAL REQUIREMENTS

Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

1004-2 STRUCTURAL STEEL

Structural carbon steel shall conform to the requirements of AASHTO M 183 (ASTM A 36) (*or their metric equivalent*).

High strength, low-alloy structural manganese vanadium steel shall conform to the requirements of AASHTO M 188 (ASTM A 441) (*or their metric equivalent*).

High strength, low-alloy structural steel, up to four inches thick with 50,000 psi minimum-yield point, shall conform to the requirements of AASHTO M 222 (ASTM A 572) (*or their metric equivalent*).

1004-3 STEEL STRUCTURAL RIVETS

Steel structural rivets shall conform to the requirements of AASHTO M 228 (ASTM A 502).

1004-4 BOLTS, NUTS AND WASHERS

High strength structural steel, bolts and washers shall conform to the requirements of Subsection 604-2.03.

Bolts and nuts other than high strength steel bolts shall conform to the requirements of ASTM A 307, Grade A.

Non-headed anchor bolts, either straight or swaged, to be used for structural anchorage, shall conform to the requirements of AASHTO M 183 (ASTM A 36).

1004-5 STEEL FORGINGS

Carbon steel forgings shall conform to the requirements of AASHTO M 102 (ASTM A 668, Class C).

1004-6 CASTINGS

Carbon steel castings shall conform to the requirements of AASHTO M 103 (ASTM A 27, Grade 65-35) (*or their metric equivalent*).

Gray iron castings shall conform to the requirements of AASHTO M 105 (ASTM A 48, Class 30B).

Malleable iron castings shall conform to the requirements of ASTM A 47, Grade 35018.

Drainage structure castings shall conform to the requirements of AASHTO M 360. The weight of aluminum covers shall not be less than 150 pounds (*68 kilograms*).

1004-7 CAST BRONZE AND COPPER-ALLOY PLATES

Cast bronze bearing and expansion plates shall conform to the requirements of AASHTO M 107 (ASTM B 22, Copper Alloy UNS No. C 91100).

Rolled copper-alloy bearing and expansion plates shall conform to the requirements of AASHTO M 108 (ASTM B 100, Copper Alloy UNS No. C 51000 and No. C 51100).

1004-8 STEEL TUBES

Steel tubes, low-carbon, tapered for structural use shall conform to the requirements of ASTM A 595, Grade A.

1004-9 STEEL PIPE

Steel pipe shall conform to the requirements of ASTM A 53, Grade A or ASTM A135, Grade A, except hydrostatic testing will not be required.

SECTION 1005

BITUMINOUS MATERIALS FOR SURFACING

1005-1 GENERAL REQUIREMENTS

Bituminous materials shall conform to the following requirements, as applicable, for the types and grades designated and used. Testing shall be in accordance with the procedures hereinafter enumerated.

A Certificate of Compliance, conforming to the requirements of Subsection 106-5(B), shall be submitted for all grades and types of bituminous material used on the project.

1005-2 SAMPLING OF BITUMINOUS MATERIAL

Sampling of bituminous material shall conform to the requirements of AASHTO T 40. Samples shall be taken by the contractor and witnessed by the Engineer. The point of sampling and the number of samples will be specified by the Engineer.

The contractor shall provide convenient facilities for obtaining accurate samples of bituminous material.

1005-3 BITUMINOUS MATERIAL REQUIREMENTS

1005-3.01 Asphalt Cement. Asphalt cement shall be a performance grade (PG) asphalt binder conforming to the requirements of AASHTO Provisional Standard MP1. The pressure aging temperature shall be as specified in the Special Provisions.

A minimum of seven working days prior to the start of asphaltic concrete production, the contractor shall provide the Engineer a 1 gallon (*3.8 liter*) sample of the proposed asphalt binder and Certificate of Analysis showing complete AASHTO Provisional Standard MP1 asphalt binder testing. Laboratory-prepared samples will not be acceptable. Asphaltic concrete production shall not begin until the Engineer determines the acceptability of the proposed asphalt binder.

If, during asphaltic concrete production, it is determined by testing that asphalt cement fails to meet the requirements of AASHTO Provisional Standard MP1 for the specified grade, the asphaltic concrete represented by the corresponding test results shall be evaluated for acceptance. Should the asphaltic concrete be allowed to remain in place, the contract unit price will be adjusted in accordance with the provisions of Subsection 110-2.02. Should the asphalt cement be in reject status, the contractor may supply an engineering analysis in accordance with the provisions of Subsection 110.2.02.

1005-3.02 Liquid Asphalt. Liquid asphalt shall conform to the requirements of AASHTO M 82, Cut-Back Asphalt (Medium Curing Type).

1005-3.03 Emulsified Asphalt. Emulsified asphalt shall conform to the requirements of Table 1005-1 for Anionic Rapid Set (RS-1, RS-2), Anionic Slow Set (SS-1), Cationic Rapid Set (CRS-1, CRS-2) and Cationic Slow Set (CSS1).

Emulsified asphalts shall be homogeneous. If emulsified asphalt has separated, it shall be thoroughly mixed to insure homogeneity. If emulsified asphalt has separated due to freezing, it shall not be used. Emulsified asphalt shall not be used after 30 days from the date of delivery.

1005-3.04 Emulsified Asphalt (Special Type). Emulsified asphalt (special type) shall consist of Type SS-1 or CSS-1 diluted with water to provide an asphalt content not less than 26 percent. The material may be diluted in the field.

1005-3.05 Recycling Agents. Recycling agents shall conform to the requirements of Table 1005-2.

1005-3.06 Emulsified Recycling Agents. Emulsified recycling agents shall conform to the requirements of Table 1005-3.

1005-3.07 Other Requirements. Other requirements for bituminous materials shall conform to the requirements of Table 1005-4.

TABLE 1005-1

EMULSIFIED ASPHALTS

TEST ON EMULSIONS	TEST METHOD	REQUIREMENT					
		RS-1	CRS-1	RS-2	CRS-2	SS-1	CSS-1
Viscosity, Saybol Furol, seconds, range							
77° F (*25 °C*)	*T59	20-100				20-100	0-100
122° F (*50 °C*)	*T59		20-100	50-400	50-400		
Settlement, 5 days, percent, maximum	*T59	5	5	5	5	5	5
Sieve, Retained on No. 20 (*850 μm*), percent, max.	*T59 (1)	0.10	0.10	0.10		0.10	.10
Particle Charge	*T59		Pos.		Pos.	Pos.(2)	
Demulsibility, 35 ml., 0.02 N calcium chloride, percent, min.	*T59	60		60			
Classification, Uncoated, particles, percent, min.	Ariz.502				55		
Residue & Residue, percent, min.	(3) & (4)	55	60	63	65	57	57

* T 59 refers to AASHTO Test Method.

NOTES FOR TABLE 1005-1

Note (1) Distilled water will be used instead of the two percent sodium oleate solution.

Note (2) If the Particle Charge Test result is inconclusive, material having a maximum pH value of 6.7 will be acceptable.

Note (3) Residue will be obtained in accordance with the requirements of Arizona Test Method 504 and shall conform to all the requirements of Table 1005-1 for AC-20, except that for CRS-2, the viscosity at 140° F (*60 °C*) shall be between 1800 and 2400 poises (*180 and 240 pascal seconds*).

Note (4) Residue by evaporation may be determined in accordance with the requirements of Arizona Test Method 512; however, in case of dispute, AASHTO T 59 will be used.

TABLE 1005-2

RECYCLING AGENTS

TEST ON RECYCLING AGENT	TEST METHOD	REQUIREMENT RA-1 Min./Max.	RA-5 Min./Max.	RA-25 Min./Max.	RA-75 Min./Max.
Viscosity, 140° F (*60 ℃*), centistokes	* T 201	100 200	200 800	1000 4000	5000 10000
Flash Point, Pensky-Martens closed tester, degrees F (℃)	* T 73	340 (*170*)	375 (*190*)	425 (*220*)	450 (*230*)
Saturate, by wgt., percent	*D2007	30	30	30	30
Asphaltenes, percent (1)	*D2006-70	1.0	5.0	10.0	17.0
Chemical Composition:(2) $\frac{N+A1}{P+A2}$	*D2006-70	0.2 1.0	0.2 1.2	0.2 1.4	0.2 1.6
Compatibility:(2) $\frac{N}{P}$	*D2006-70	0.5	0.5	0.5	0.5
Test on Residue Weight change, percent (3)		6.5	4	3	2
Viscosity Ratio(4)		3	3	3	3

* "T" designations are AASHTO Test Methods
* "D" Designations are ASTM Test Methods

NOTES FOR TABLE 1005-2

Note (1) Asphaltenes for RA-1 may be determined in accordance with the requirements of Arizona Test Method 505; however, in case of dispute, ASTM D2006-70 shall be used.

Note (2) N = nitrogen bases; P = paraffins; A1 = acidaffins; A2 = second acidaffins.

Note (3) Residue will be obtained in accordance with the requirements of AASHTO T 240.

Note (4) Viscosity Ratio:

$$\frac{\text{Viscosity of resident at 140° F (60 °C), centistokes (millimeters squared per second)}}{\text{Viscosity of recycling agent at 140° F (60 °C), centistokes (millimeters squared per second)}}$$

TABLE 1005-3

EMULSIFIED RECYCLING AGENTS

TEST ON EMULSIFIED RECYCLING AGENT	AASHTO TEST METHOD, EXCEPT AS SHOWN	REQUIREMENT			
		ERA-1	ERA-5	ERA-25	ERA-75
Viscosity, Saybolt Furol, 77° F (*25 °C*), seconds, range	T59	15 to 40	15 to 100	15 to 100	15 to 100
Miscibility	T59	Passes	Passes	Passes	Passes
Sieve Test, percent, maximum	T59(1)	0.10	0.10	0.10	0.10
Particle Charge	T59	Positive	Positive	Positive	Positive
Residue(2) Residue, percent minimum(3)		60	60	60	60

Note (1) Distilled water will be used instead of the two percent sodium oleate solution.

Note (2) Residue will be obtained in accordance with the requirements of Arizona Test Method 504 and shall conform to all the requirements specified in Table 1005-3.

Note (3) Residue by evaporation may be determined in accordance with the requirements of Arizona Test Method 512; however, in case of dispute, AASHTO T 59 will be used.

TABLE 1005-4

OTHER REQUIREMENTS

GRADE OF ASPHALT SPECIFICATION DESIGNATION	RANGE OF TEMPERATURES FOR APPLICATION BY SPRAYING, DEGREES F (*C*)	RANGE OF AND MAXIMUM TEMPERATURE OF AGGREGATE FOR PLANT MIXING, DEGREES F (*C*)	BASIS OF CONVERSION AVERAGE NUMBER OF GALLONS PER TON (*Liters Per Metric Ton*) AT 60 DEGREES F (*C*)
Paving Asphalt:	275-400 (*135-205*)	-----	235 (*981*)
Liquid Asphalt:			
MC-70	105-175 (*40-80*)	90-155 (*30-70*)	253 (*1053*)
MC-250	140-225 (*60-110*)	125-200 (*50-90*)	249 (*1039*)
MC-800	175-255 (*80-125*)	160-225 (*70-110*)	245 (*1022*)
MC-3000	215-290 (*100-140*)	200-260 (*90-125*)	241 (*1006*)
Emulsified Asphalt:			
RS-1	70-140 (*20-60*)	-----	240 (*1000*)
CRS-1	125-185 (*50-85*)	-----	240 (*1000*)
RS-2	125-185 (*50-85*)	-----	240 (*1000*)
CRS-2	125-185 (*50-85*)	-----	240 (*1000*)
SS-1	70-160 (*20-70*)	-----	240 (*1000*)
CSS-1	70-160 (*20-70*)	-----	240 (*1000*)
Emulsified Asphalt: (Special Type)	70-160 (*20-70*)	-----	240 (*1000*)
Recycling Agent:			
RA-1	-----	-----	240 (*1000*)
RA-5	-----	-----	240 (*1000*)
RA-25	-----	-----	240 (*1000*)
RA-75	-----	-----	240 (*1000*)
Emulsified Recycling Agent:			
ERA-1	70-160 (*20-70*)	-----	240 (*1000*)
ERA-5	70-160 (*20-70*)	-----	240 (*1000*)
ERA-25	70-160 (*20-70*)	-----	240 (*1000*)
ERA-75	70-160 (*20-70*)	-----	240 (*1000*)

SECTION 1006

PORTLAND CEMENT CONCRETE

1006-1 GENERAL REQUIREMENTS

Portland cement concrete shall consist of a mixture of hydraulic cement, fine aggregate, coarse aggregate, water and admixtures.

The contractor shall determine the mix proportions and shall furnish concrete which conforms to the requirements of these specifications. All concrete shall be sufficiently workable, at the slump proposed by the contractor and within the specified range, to allow proper placement of the concrete without harmful segregation, bleeding, or incomplete consolidation. It shall be the responsibility of the contractor to proportion, mix, place, finish, and cure the concrete properly in accordance with the requirements of these specifications.

1006-2 MATERIALS

1006-2.01 Hydraulic Cement. Hydraulic cement shall consist of either portland cement or portland-pozzolan cement.

Portland cement shall conform to the requirements of ASTM C 150 for Type II or Type III.

Portland-pozzolan cement shall conform to the requirements of ASTM C 595 for Type IP (MS).

Hydraulic cement shall not contain more than 0.60 percent total alkali. The word alkali as used in these specifications shall be taken as the sum of sodium oxide and potassium oxide calculated as sodium oxide.

Certificates of Analysis conforming to the requirements of Subsection 106-5(C) shall be submitted.

Cement of different types or brands shall not be intermingled or used in the same batch. The contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which for any reason has become partially set or which contains caked lumps shall not be used.

The use of either sacked cement or bulk cement is permissible. The use of fractional bags of sacked cement will not be permitted unless the contractor elects to weigh the cement into each batch.

1006-2.02 Water. The water used shall be free from injurious amounts of oil, acid, alkali, clay, vegetable matter, silt or other harmful matter. Water shall contain not more than 1,000 parts per million of chlorides as Cl or of sulfates as SO_4.

Water shall be sampled and tested in accordance with the requirements of AASHTO T 26. Potable water obtained from public utility distribution lines will be acceptable.

1006-2.03 Aggregates.

(A) General Requirements. When concrete is to be placed at elevations above 4,500 feet (*1370 meters*), the fine and coarse aggregate shall be subject to five cycles of the sodium sulfate soundness test in accordance with the requirements of AASHTO T 104. The total loss shall not exceed ten percent by weight of the aggregate. Tests for soundness may be waived when aggregates from the source have been previously approved and the approved test results apply to the current production from that source.

Concrete aggregate shall be washed.

Mill tailings or material from mine dumps which have been in contact with processing chemicals shall not be used in the production of fine or coarse aggregate.

The handling and storage of concrete aggregate shall be such as to minimize segregation or the intermixing and contamination with foreign materials. Aggregates shall be stored separately. Different sizes of aggregate shall be separated by bulkheads or stored in separate stockpiles sufficiently removed from each other to prevent the material from becoming intermixed.

When aggregates are stored on the ground, the sites for the stockpiles shall be clear of all vegetation and level. The bottom 1 foot (*300 millimeters*) layer of aggregate shall not be disturbed or used.

The handling and storage of concrete aggregate [redacted] at the stockpile site shall be such as to minimize segregation. Stockpiles shall be neat and regular in form and shall occupy as small an area as possible. Stockpiles shall be constructed by first distributing the aggregate over the entire base and then building upward in successive layers not more than 5 feet (*1.5 meters*) in depth. Aggregate shall not be dumped or spilled over the side of the pile. When a conveyor is used to stockpile aggregate in its final position, it shall be equipped with an adequate rock tremie or rock ladder to reduce segregation and it shall be moved continuously across the stockpile. The distance the material drops from the tremie shall not exceed 10 feet (*3 meters*). Aggregate shall be distributed over the stockpile so that the formation of conical piles higher than 10 feet (*3 meters*) is prevented.

Contamination of concrete aggregate [redacted] by contact with the ground at the job site shall be positively prevented. The contractor shall take the necessary measures to prevent such contamination. Such preventive measures shall include, but not necessarily be limited to, placing aggregate on hardened surfaces consisting of portland cement concrete, asphaltic concrete, or cement treated material.

(B) Fine Aggregate. Fine aggregate shall be natural sand or other approved inert material with similar characteristics composed of clean, hard, strong, durable, uncoated particles. Fine aggregate shall be free from deleterious amounts of soft or flaky particles, loam, caliche, ice, frost, organic matter or clay lumps.

The grading shall meet the following requirements when tested in accordance with the requirements of Arizona Test Method 201.

Sieve Size	Percent Passing All Classes
3/8 inch (*9.5 millimeter*)	100
No. 4 (4.75 *millimeter*)	95-100
No. 16 (1.18 *millimeter*)	45- 80
No. 50 (*300 μm*)	0- 30
No. 100 (150 *μm*)	0- 10
No. 200 (75 *μm*)	0- 4.0

Fine aggregate shall have an average sand equivalent value of not less than 75 when tested in accordance with the requirements of AASHTO T 176.

Fine aggregate shall be of such quality that, when made into mortar and subjected to the test for mortar-making properties, in accordance with the requirements of AASHTO T 71, the mortar shall develop a compressive strength at seven and 28 days of not less than 90 percent of that developed by a mortar prepared in the same manner with the same Type II cement and graded Ottawa sand having a fineness modulus of 2.40 plus or minus 0.10.

(C) Coarse Aggregate. Coarse aggregate shall consist of crushed stone, gravel, or other approved inert material of similar characteristics, including cinders when specified, having hard, strong and durable pieces free of clay and other deleterious substances. The aggregate shall be washed.

The coarse aggregate gradation shall conform to the appropriate size designation of AASHTO M 43, as modified herein, when tested in accordance with the requirements of Arizona Test Method 201, Section 12(3), except the amount of material passing the No. 200 sieve shall not exceed 1.0 percent.

The percent of wear of coarse aggregate at 500 revolutions, when tested in accordance with the requirements of AASHTO T 96, shall not exceed 40.

1006-2.04 Admixtures.

(A) General Requirements. The contractor shall furnish Certificates of Compliance conforming to the requirements of Subsection 106-5(B) for each type of admixture furnished. Admixtures containing chlorides will not be acceptable for concrete containing uncoated reinforcing steel or embedded metal items.

All concrete admixtures shall be stored in suitable containers in accordance with the manufacturer's recommendations. All liquid admixtures shall be protected from freezing. Liquid admixtures that have frozen shall not be used.

(B) Air-Entraining Admixtures. Air-entraining admixtures shall conform to the requirements of AASHTO M 154.

(C) Chemical Admixtures. Chemical admixtures shall conform to the requirements of AASHTO M 194. Water reducing agents shall only be used in accordance with the manufacturers' recommendation.

(D) Fly Ash. Fly ash shall conform to the requirements of ASTM C 618 for Class C or F mineral admixture, except that the loss on ignition shall not exceed 3.0 percent.

Fly ash, when used as a replacement for portland cement, shall have an R factor less than 2.5. The R factor is defined as (C-5%)/F, where C is the calcium oxide content expressed as a percentage and F is the ferric oxide content expressed as a percentage. Fly ash shall not contain more than 1.5 percent available alkali as defined in ASTM C 311.

1006-2.05 Concrete Curing Materials. Liquid membrane curing compounds shall conform to the requirements of AASHTO M 148. Type 2 compound, with either a Class A or Class B vehicle, shall be used for concrete pavement, bridge decks and approach slabs. Type 1-D compound, with either a Class A or Class B vehicle, shall be used for other concrete items.

Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

1006-3 DESIGN OF MIXTURES

1006-3.01 Design Criteria. Portland cement concrete shall conform to the requirements specified in Table 1006-1 for each of the classes listed therein.

Unless otherwise shown in Table 1006-1, the proposed slump shall be chosen by the contractor. Concrete at the proposed slump shall be sufficiently workable to allow proper placement, without harmful segregation, bleeding, or incomplete consolidation.

Air-entraining admixtures may be required when noted in the special provisions for all classes of concrete placed above an elevation of 3,000 feet (*915 meters*), except for precast, prestressed structural members. The amount of entrained air in the concrete mixture shall not be less than four percent nor more than seven percent by volume.

For elevations below 3,000 feet (*915 meters*), air-entraining admixtures may be used at the option of the contractor and the amount of entrained air in the concrete shall not exceed 7 percent by volume.

Concrete that fails to conform to the entrained air content requirements listed above for the respective elevation as determined by the Engineer, shall be rejected prior to placement.

Unless specifically required, water reducing admixtures may be used at the option of the contractor.

TABLE 1006-1

CLASS OF CONCRETE	HYDRAULIC CEMENT: LBS/CU YD (*kg/m³*) (MINIMUM-MAXIMUM)	28-DAY COMPRESSIVE STRENGTH REQUIRED, (PSI) (*MPa*)
S	564–752 (*335–446*)	3,000 (*20.7*) (minimum)
B	517–658 (*307–390*)	2,500 (*17.2*)

The minimum and maximum weights of hydraulic cement required are shown on Table 1006-1 for each class of concrete. A fly ash admixture may be used at the option of the contractor only when portland cement is used. A maximum of 20 percent of the required weight of portland cement may be replaced with a fly ash admixture. A minimum of 1.2 pounds (*0.5 kilograms*) of fly ash shall replace each 1.0 pound (*0.5 kilograms*) of portland cement removed with the exception of IP cements, where a replacement ratio of 1 to 1 is acceptable. Mix design calculation for concrete mixes utilizing fly ash shall specify either the base cement content used or the fly ash replacement value.

Class S concrete shall have a 28-day compressive strength (f'c) not less than that shown on the project plans. The absolute minimum 28-day compressive strength for Class S concrete shall be 3000 psi (*20.7 megapascals*). Class B concrete shall have a minimum strength of, not less than that shown in Table 1006-1 at 28 days. Testing for compressive strength of cylinders shall be in accordance with the requirements of Arizona Test Method 314.

The coarse aggregate size designation for Class S and Class B concrete shall be chosen by the contractor and approved by the Engineer and shall conform to the size designation and grading requirements of AASHTO M 43. In choosing the size designation, the maximum size of coarse aggregate shall not be larger than 1/5 of the narrowest dimension between sides of adjacent forms, or 2/3 of the minimum clear spacing between reinforcing bars, or 1/3 the depth of the slab, whichever is least. However, coarse aggregate used in Class S concrete for caissons shall meet the requirements for size designation Number 67 when tested in accordance with AASHTO T 27.

If two or more stockpiles are utilized to manufacture an AASHTO M 43 size designation, at the time of proportioning for mixing, the aggregate from each stockpile shall be measured by weight and proportioned so that the resulting mixture of coarse aggregate meets the requirements for the chosen size designation.

Concrete to be placed under water (tremie concrete) shall conform to the requirements for the class required except that the hydraulic cement content of the base mix shall be increased by 47 pounds per cubic yard (*28 kilograms per cubic meter*) of concrete.

1006-3.02 Design Procedures. At least two weeks prior to the appropriate concreting operation, the contractor shall furnish a mix design for each class of concrete and each strength of Class S concrete for review and approval. More than one mix design for each class of concrete and each strength of Class S concrete may be submitted for approval provided specific items and locations of intended uses accompany the mix design. The contractor shall substantiate each mix design by furnishing test data and providing all details of the mixtures proposed for use.

The complete, solid volume mix designs, submitted for approval, shall include all weights and volumes of all ingredients. The brand, type, and source of hydraulic cement and admixtures, the coarse aggregate size number designation, source of aggregates, the specific gravities of all ingredients, the proposed slump, a code number to identify the mix design, and the intended use of each mix design shall be an integral part of each mix design. The mix design to be used for caisson construction shall also include the results of set-time and slump-loss-rate tests when the casing is to be removed in accordance with Subsection 609-2.01.

No changes in the approved mix designs or code numbers shall be made by the contractor except with the approval of the Engineer. A new mix design shall be submitted for approval any time the contractor requests a change in each approved mix design. In no case shall the approval of a mix design relieve the contractor of the responsibility for the results obtained by the use of such approved mix design.

Mix designs from previous or concurrent projects may be submitted for approval.

New mix designs shall be prepared in accordance with Chapter 4 - Concrete Quality of Part 3 of the Manual of Concrete Practice of the American Concrete Institute.

A new mix design shall be submitted for approval any time the test results of an approved mix design indicate that the concrete will not meet the required 28-day compressive strength.

1006-4 CONCRETE PRODUCTION

1006-4.01 General Requirements. For each class of concrete and each strength of Class S concrete, the contractor shall furnish an invoice for each batch of concrete. The minimum information to be shown on each invoice shall be the batch weights or mix design code number, date, time batched, truck identification or number, name or identification of batch plant, name of contractor, name and location of project, and the volume of concrete. An authorized representative of the contractor shall be responsible for each invoice and shall sign each invoice accepting the contractor's responsibility for the concrete as the concrete is being placed. After signing, the representative shall immediately furnish the invoice to the Engineer.

1006-4.02 Proportioning.

(A) Cement. Separate scales, positioned so as to be easily visible to the Engineer and accurate to ± 0.2 percent of scale capacity, shall be provided to weigh all hydraulic cement. The batching accuracy shall be within ± 1.0 percent of the required weight. Dial scales or a load cell providing a digital printed readout will be required to weigh all hydraulic cement.

The cement shall be conveyed by means of an enclosed conveying system and the weighing hopper shall be equipped with one or more vibrators as required to insure the complete discharge of all cement from the hopper after each batch is weighed.

(B) Water. Water shall be measured by volume or by weight. Measurement by volume may be by metering.

Scales shall be accurate within ± 0.2 percent of scale capacity. Volumetric measuring devices shall have an accuracy of ± 1.5 percent. The batching devices shall be capable of routinely batching water within ± 1.5 percent.

(C) Aggregates. All aggregates shall be proportioned by weight.

Suitable dial scales shall be provided by the contractor to weigh each size of aggregate. The scales shall be positioned so as to be easily visible to the Engineer and accurate to ± 0.2 percent of scale capacity. The weighing equipment shall have a batching accuracy of ± 2 percent of the required weight. The weighing equipment shall be arranged so as to permit the convenient removal of excess material from the weighing hopper and the equipment shall be arranged to enable the operator to have convenient access to all controls. The scales shall be so equipped and the dials so graduated that the weights of materials being weighed can be accurately determined.

Every expedient shall be used to obtain and preserve uniform moisture content in the coarse and fine aggregates. The moisture content shall not vary more than three percent during any day's

production. The estimated percent of free moisture in each of the coarse and fine aggregates shall be determined by the contractor using acceptable test methods.

The moisture content of the aggregate shall be such that no free drainage of water from the aggregate will be visible during transportation from the stockpile to the point of mixing. Aggregate containing excess mosture shall be stockpiled prior to use until it is sufficiently dry to meet the above requirement.

In the event that either the coarse or fine aggregate has a moisture absorption rate of more than 1.5 percent, the materials shall be thoroughly prewetted and allowed to drain in advance of use until the moisture content is stable.

(D)Admixtures. The equipment and the procedures used to measure admixtures and dispense them into the concrete batch shall be approved by the Engineer prior to use.

Dry admixtures shall be measured by weight, with a separate dial scale positioned so as to be easily visible to the Engineer and accurate to within ± 1.0 percent of the amount being weighed. Paste or liquid admixtures shall be measured either by weight or by volume. Only mechanical dispensing equipment shall be used for adding admixtures. Dosage rates shall conform to the manufacturer's recommendations or approved rates, or as determined from field trial batches.

Dispensers for admixtures shall have sufficient capacity to measure at one time the full quantity required for each batch. Unless liquid admixtures are added to premeasured water for the batch, their discharge into the batch shall be arranged to flow into the stream of water or on the fine aggregate. The amount of liquid admixtures shall not vary from the required amount by more than ± 5.0 percent.

Equipment for measurement shall be designed for convenient confirmation of measurement accuracy. If more than one liquid admixture is used, each admixture shall be dispensed by separate equipment unless otherwise permitted, in writing, by the Engineer.

Separate dial scales, positioned so as to be easily visible to the Engineer and accurate to ± 0.2 percent of scale capacity, shall be provided to weigh all fly ash admixtures. The batching accuracy shall be within ± 1.0 percent of the required weight.

Weighing of a fly ash admixture may be accomplished by the use of the hydraulic cement scales if proposed by the contractor and approved, in writing, by the Engineer.

The fly ash admixture shall be conveyed by means of an enclosed conveying system and the weighing hopper shall be equipped with one or more vibrators as required to insure the complete discharge of all fly ash from the hopper after each batch is weighed.

1006-4.03 Mixing.

(A) General Requirements. The concrete may be mixed in a stationary mixer, either at a central mixing plant or at the site or it may be mixed in a truck mixer, either at a central mixing plant or at the site. Concrete may be mixed in a mobile mixer at the site for Class S and Class B concrete, provided written permission of the Engineer is granted.

Each mixer shall meet the specified requirements for type and size and shall have attached in a prominent place, a manufacturer's plate showing the gross volume of the mixer and the recommended speeds of the mixer for mixing and for agitating.

The mixer shall be equipped to measure accurately mixing water, and to control the time when the water enters the mixer during the mixing cycle. If the measurement of the water cannot be visually verified, such as by a sight glass on the water storage tank, the equipment shall have a manually operated outlet valve allowing external measurement to verify indicated quantities.

Mixer blades may be periodically checked for wear. All blades over 3/4 inch (*19 millimeters*) below the original dimension shall be relined or replaced.

Truck mixer or truck agitators used for mixing or transporting mixed concrete shall be capable of discharging concrete at a consistent rate without manual or mechanical assistance.

Each batch plant shall be equipped to control the time when the water enters the mixer during the mixing cycle. Batch and mixing time shall be from the time hydraulic cement is combined with water.

Mixers shall be cleaned at suitable intervals. Water used for cleaning the mixer shall be discharged prior to further batching.

Equipment having components made of aluminum or magnesium alloys, which would have contact with plastic concrete during mixing and transporting, shall not be used.

All concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of undispersed cement.

All concrete produced shall meet the uniformity requirements in Table 1006-2, Concrete Uniformity. Tests shall be conducted when required by the special provisions or as directed by the Engineer. It will not be necessary to verify that mixing equipment meets the uniformity requirements unless evidence of non-uniform concrete is observed or the contractor requests a reduced mixing time for stationary mixers.

TABLE 1006-2

CONCRETE UNIFORMITY

TEST	PERMISSIBLE VARIATION Concrete Samples Taken at Two Locations in the Batch
1. Weight calculated to an Air-Free Basis.	2.0 pounds per cubic foot (*32 kilograms per cubic meter*)
2. Air Content, % by volume of concrete.	1.0 percent
3. Slump:	
Average slump 4 inches (*100 millimeters*) or less	1.0 inch (*25 millimeters*)
Average slump greater than 4 inches (*100 millimeters*)	1.5 inches (*38 millimeters*)
4. Coarse aggregate content, portion by weight of each sample retained on a No. 4 sieve.	6.0 percent
5. Unit weight of air-free mortars based on average for all comparative samples tested.	1.6 percent
6. Average compressive strength of 7 days for each sample based on average strength of all comparative test specimens.	10.0 percent

NOTE: Samples shall be taken at the point of discharge of the concrete mixer.

(B)Mixing in a Stationary Mixer. After measurement is made of the materials in the required proportions and amounts, the batch of concrete materials shall be placed in the mixer. The flow of water into the mixer shall be uniform with a portion of the water entering in advance of the cement and aggregates and all of the water entering within the first 15 seconds of the mixing time.

The volume of concrete mixed per batch shall not exceed the capacity of the mixer as shown on the manufacturer's plate. No spillage of concrete will be allowed during the process of mixing. While mixing, the mixer shall be operated at the speed shown on the manufacturer's plate as the mixing speed.

The mixing time shall be not less than 60 seconds for one cubic yard (*0.75 cubic meter*) and shall be increased 15 seconds for each additional cubic yard (*0.75 cubic meter*) or fraction thereof for Class S and Class B concrete.

The mixers shall have an automatic timing device which locks the discharge equipment until the required mixing time has been completed. The mixer shall be operating at mixing speed at the time that all ingredients enter the mixer to insure the immediate beginning of the mixing cycle. Mixing time shall end when the discharge chute opens. The contents of the mixer shall be completely discharged before the succeeding batch is placed in the mixer.

Any concrete discharged before the mixing time is completed shall be disposed of by the contractor at his expense.

Mixed concrete shall be transported in truck mixers, truck agitators or in non-agitating trucks having special bodies.

When truck mixers or truck agitators are used, the concrete shall be continuously agitated from the time of loading until the time of discharge. Agitation shall be by rotation of the drum at the speed shown on the manufacturer's plate as agitating speed.

The truck mixer or truck agitator shall be loaded and operated within a capacity not to exceed 80 percent of the gross volume of the drum. The rate of discharge shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully opened.

Discharge from the truck mixer or truck agitator shall be completed within 90 minutes from the time batched unless the concrete has received an approved hydration stabilizer. The addition of the hydration stabilizer shall be noted on the delivery ticket and shall be in accordance with the manufacture’s recommendations.

Bodies of non-agitating trucks shall be smooth, mortar-tight, metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation. If discharge of concrete is accomplished by tilting the body, the surface of the load shall be retarded by a suitable baffle. Covers shall be provided when needed for protection.

The haul road used by non-agitating trucks shall be free of holes, washboarding or any other features that would cause segregation in the mix.

Discharge from non-agitating trucks shall be completed within 45 minutes from the time concrete is batched. Concrete hauled in open-top vehicles shall be protected against the access of rain, or exposure to the sun for more than 30 minutes when the ambient temperature exceeds 85° F (*30 °C*).

(C)Mixing in Truck Mixers. Truck-mixed concrete shall be mixed entirely in the truck mixer and shall be mixed at the batch plant or at the site.

Truck mixers shall be operated within a capacity not to exceed 63 percent of the gross volume of the drum and at speeds shown on the manufacturer's plate as mixing and agitating speeds.

Each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum at mixing speed after all materials have been loaded into the drum, except that when approved by the Engineer, the maximum of 100 revolutions may be increased. Any revolving of the drum beyond the maximum number of revolutions shall be at the agitating speed. Mixing shall begin within 10 minutes after the cement has been combined with either the aggregate or water.

The truck mixer shall be equipped with an electrically or mechanically activated revolution counter by which the number of drum revolutions may be verified. The counter shall be of the "continuous registering" type, which accurately registers the number of revolutions. It shall be mounted on the truck mixer or just inside the truck cab, so that it may be safely and conveniently read from beside the truck. The revolution counter shall be reset to zero after all materials have been loaded into the drum.

Discharge from the truck mixer shall be completed within 90 minutes from the time batched unless the concrete has received an approved hydration stabilizer. The addition of the hydration stabilizer shall be noted on the delivery ticket and shall be in accordance with the manufacture’s recommendation.

If additional mixing water is required to maintain the specified slump, the concrete shall be mixed by a minimum of 20 revolutions of the drum at mixing speed after the water has been added, prior to discharge of any concrete for placement. Any additional mixing water and required mixing revolutions shall be recorded on the invoice specified in Section 1006-4.01. This additional mixing may be in excess of the maximum revolutions previously specified.

(D)Mixing in Mobile Mixers. Concrete mixing in mobile mixers for Class S and Class B concrete shall be performed in accordance with the requirements of AASHTO M 241.

1006-4.04 Consistency. The contractor shall furnish Class S and Class B concrete having the slump shown on the approved mix designs with a permissible variation of ± 1 inch (*± 25 millimeters*); however, the permissible variation will be ± 2 inches (*± 50 millimeters*) when an approved high range reducer conforming to Type F or G requirements of AASHTO M 194 is used.

Concrete that fails to conform to the consistency requirements will be rejected.

When concrete is pumped, samples for consistency will be taken both as the concrete leaves the mixer and at the pump hose discharge. If the Engineer determines that there is a good correlation between the results of consistency tests on samples obtained from the mixer and from the pump hose, the Engineer may discontinue sampling from the pump hose; however, the Engineer may take periodic samples from both sources to verify the correlation of test results.

1006-5 WEATHER LIMITATION

1006-5.01 General Requirements. The temperature of the concrete mixture immediately before placement shall not exceed 90° F (*32 °C*) or 86° F (*30 °C*) when used for drilled shafts. Under rainy conditions, placing of concrete shall be stopped before the quantity of surface water is sufficient to cause a flow or wash of the concrete surface or have a detrimental effect on the finished concrete and acceptance parameters.

Placing of concrete shall immediately cease if the hauling vehicles or any equipment or pedestrian traffic tracks mud on the prepared base or changes the allowable subgrade dimensional tolerances for slabs placed on subgrade for Class S and Class B concrete.

The contractor shall provide adequate insulation or heat, or both, to protect the concrete after placement. This protection shall be to the extent required to maintain a concrete surface temperature above 50° F (*10 °C*) for a period of three days.

1006-5.02 Concrete Placement in Hot Weather. Concrete that fails to conform to the maximum temperature requirement in hot weather when the air temperature is above 90° F (32 °C) and rising, shall be rejected prior to placement.

Forms, subgrade and reinforcing steel, shall be sprinkled with cool water just prior to placement of concrete.

Mix water may be cooled by refrigeration, liquid nitrogen, or well-crushed ice of the size that will melt completely during the mixing operation,. Crushed ice may be substituted for part of the mix water on a pound for pound (*kilogram for kilogram*) basis.

1006-5.03 Cold Weather Concrete Placement. The temperature of the mixed concrete immediately before placing shall not be less than 50° F (*10 °C*).

Concrete shall not be placed on or against ice-coated forms, reinforcing steel, structural steel, conduits or construction joints, nor on or against snow, ice, or frozen earth materials.

Concrete operations shall be discontinued when a descending air temperature in the shade and away from artificial heat falls below 40° F (*4 °C*) nor shall concrete operations be resumed until an

ascending air temperature in the shade and away from artificial heat reaches 35° F (2 °C) unless otherwise approved by the Engineer.

Mixing and placing concrete shall continue no later in any day than that time which will allow sufficient time to place and protect the concrete already poured before the air temperature drops to 35° F (2 °C).

Concrete operations may be allowed although the air temperature at any time during the cure period in the shade and away from artificial heat is below the limit permitted above. Where concrete operations are thus allowed, the contractor shall use equipment to heat the aggregates or water, or both, prior to mixing. If aggregates are heated, the minimum temperature shall be 60° F (16 °C) and the aggregates shall have no chunks of ice or frozen aggregate present. Equipment used to heat the aggregates shall be such that consistent temperatures are obtained throughout the aggregate within each batch and from one batch to another. Water shall not be heated in excess of 150° F (66 °C) unless the water is mixed with the aggregate prior to the addition of cement to the batch.

When concreting operations are allowed when the air temperature falls below the limits permitted in the shade and away from artificial heat, the contractor shall provide adequate insulation or heat, or both, to protect the concrete after placement. This protection shall be to the extent required to maintain a concrete surface temperature of not less than 50° F (*10 °C*) for a period of 72 hours after placement and at not less than 40° F (*4 °C*) for an additional 96 hours. When artificial heating is required, the heating units shall not locally heat or dry the surface of the concrete. A written outline of the proposed protection method shall be submitted to the Engineer for approval.

The placing of concrete will not be permitted until the Engineer is satisfied that all the necessary protection equipment and materials are on hand at the site and in satisfactory working condition.

Concrete requiring cold weather protection shall have such protection removed at the end of the required period in a manner that will permit a gradual drop in the concrete temperature.

1006-6 CURING CONCRETE

1006-6.01 Curing Cast-In-Place Concrete.

(A) General Requirements. All cast-in-place concrete shall be cured by one or by a combination of more than one of the methods specified herein and curing shall begin immediately after completion of machine or hand finishing of the fresh concrete.

Curing shall be continued for a period of at least seven days after placing of either Type II portland cement or portland pozzolan cement has been used, or for at least three days if Type III portland cement has been used.

Surfaces requiring a Class II finish shall not be cured by the Liquid-Membrane Forming Compound Method until after the finishing operations are completed.

No traffic, hauling, storing of material or other work shall be allowed on any concrete surface during the required curing periods.

(B)Water Curing Method. All surfaces not covered by reasonably waterproof forms shall be kept damp by applying water with a nozzle that so atomizes the flow of the water that a fog mist and not a spray is formed until the surface of the concrete is either covered with a curing medium or sprinkling of the surface is permitted for the curing period. The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.

Burlap, rugs, carpets, or earth or sand blankets may be used as a curing medium to retain the moisture during the curing period. The curing medium shall be kept continuously wet by sprinkling with water for the entire curing period. Application of the curing medium shall not begin until such time that placement can be made without marring the surfaces of the concrete.

If a curing medium is not used, the entire surface of the concrete shall be kept damp by the application of water with an atomizing nozzle as specified above until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for the entire curing period.

In no case shall curing be interrupted by more than one hour during the curing period.

(C)Liquid-Membrane Forming Compound Method. All surfaces not covered by reasonably water proof forms shall be cured by the liquid-membrane forming compound method. The curing compound shall be applied to the concrete immediately following the surface finishing operation in one or more applications totaling a rate of not less than 1 gallon per 100 square feet (*0.4 liter per square meter*) unless otherwise specified.

The curing compound shall form a continuous unbroken surface.

If the membrane film is broken during the curing period, the broken area shall be given a new application of compound at the rate of 1 gallon per 200 square feet (*0.2 liter per square meter*).

In no case shall curing be interrupted by more than one hour during the curing period.

(D) Forms in Place Method. Formed surfaces of concrete may be cured by retaining the forms in place. The forms shall remain in place for the entire curing period.

All joints in the forms and the joints between the end of forms and concrete shall be kept moisture-tight during the curing period.

Cracks in the forms and cracks between the forms and the concrete shall be resealed by methods approved by the Engineer.

(E) Curing Bridge Deck. The top surface of bridge decks shall be cured by the liquid-membrane forming compound method and by the water curing method. The curing compound shall be applied progressively immediately following the surface finishing operation. Liquid-membrane forming compound shall be applied at a rate of 1 gallon per 100 square feet (*0.4 liter per square meter*). The curing compound shall form a continuous unbroken surface.

Water curing shall be applied not later than four hours after the completion of the deck finishing operations and shall be applied as specified herein.

The top surface of bridge decks that will be covered with a special riding surface or water proofing membrane shall be cured by the water curing method only. Water curing shall be applied progressively immediately following the surface finishing operation as specified herein.

1006-6.02 Curing Precast Concrete.

(A) General Requirements. The contractor may cure precast concrete in accordance with the requirements specified above for curing cast-in-place concrete or, if it elects, the curing of precast concrete may be performed by external heating. This may be accomplished by the use of low-pressure steam or radiant heat with moisture.

If curing of the concrete is accomplished by low-pressure steam or radiant heat with moisture, curing will be considered completed after termination of steam or radiant heat curing. Rapid temperature changes in the concrete shall be avoided during the cooling period.

If curing of the concrete is accomplished by the water curing method, the liquid-membrane forming compound method, or the forms-in-place method, such curing shall be continued for a period of at least seven days after placement of the concrete. The curing time may be reduced to a minimum of three days when a Type III portland cement has been used.

(B) Low-Pressure Steam Curing. After placement of the concrete, precast items shall be held for a minimum two-hour presteaming period. If the ambient air temperature is below 50° F (10

°C),steam shall be applied during the presteaming period to hold the air surrounding the precast item at a temperature between 50° and 90° F (*10 and 32 °C*).

To prevent moisture loss on exposed surfaces during the presteaming period, precast items shall be covered as soon as possible after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

Steam at the jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders or forms. During application of the steam, the ambient air temperature rise within the enclosure shall not exceed 40° F (*4 °C*) per hour. The average curing temperature throughout the enclosure shall not exceed 160° F (71 *°C*) and shall be maintained at a constant level for a sufficient length of time so as to ensure the development of the required compressive strength by the age of 28 days in concrete items which are not to be prestressed. For items which are to be prestressed, the constant temperature shall be maintained for sufficient time necessary to develop the concrete compressive strength required for prestressing. The ambient curing temperature shall not exceed 175° F (79 *°C*) at any point. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

Temperature recording devices that will provide an accurate continuous permanent record of the ambient curing temperature shall be provided. A minimum of two temperature recording devices or one for every 200 feet (*60 meters*) of continuous bed length will be required for checking temperature.

In the event, the side forms are removed before the precast unit has obtained the required release compressive strength. The curing method shall be continuous in maintaining the temperature and moisture level as described above, within the enclosure, as nearly as practical. There shall not be a delay in re-covering the girder or prestress member.

(C)Radiant Heat With Moisture. Radiant heat shall be applied by means of pipes circulating steam, hot oil or hot water, or by heating elements or electric blankets on the forms. Pipes, blankets or elements shall not be in contact with the concrete surfaces.

Moisture shall be applied in such a manner as to keep the top surface of the precast unit continuously moist during the curing period by fogging or spraying. Moisture shall be maintained by a cover of burlap or cotton matting and further covered by a waterproof tarpaulin with an insulating cover.

Temperature limits and the use of recording thermometers shall be the same as curing with low-pressure steam. Application of the heat cycle may be accelerated to meet climatic conditions upon the approval of the Engineer. A temperature sensing device shall be placed two inches, ± 1/2 inch (*50 millimeters ± 13 millimeters*), from the heated form.

1006-7 ACCEPTANCE SAMPLING AND TESTING

1006-7.01 General. Rejection of concrete will occur due to improper temperature, slump, and/or air content for the concrete mixture delivered to the site. The Engineer at his discretion may allow the failed concrete mixture, already placed, to remain in place subject to acceptance by compressive strength or may require its removal.

Rejection of concrete will also occur due to insufficient compressive strength. Concrete compressive strength requirements consist of the specified strength which the concrete shall attain before various loads or stresses are applied and a minimum strength at 28 days.

Acceptance and penalties for placed concrete which meets the above mixture requirements or is allowed to remain in place shall be determined by the results of the 28 day compressive strength. Sampling and testing for compressive strength will be performed on all classes of concrete furnished, including each strength specified on the project plans for Class S concrete.

1006-7.02 Sampling and Testing of Concrete:

A sample of concrete for determination of temperature, slump, and air content as well as for fabrication of test cylinders for compressive strength determination at 28 days will be taken at random at the sampling frequency specified herein for each type of concrete.

Samples of concrete shall be of sufficient size to perform all the required tests and fabricate the necessary test cylinders. The samples shall be taken in accordance with the requirements of AASHTO T 141, except that concrete for Class S or B shall be sampled only once during discharge in the middle portion of the batch. At the discretion of the Engineer, a sample may be obtained at the beginning of the discharge if, in his opinion, the properties of the concrete do not appear to be within the specification limits for slump or temperature.

If concrete is pumped to facilitate placement, at the discretion of the Engineer, samples may be taken from the truck and pump hose discharge to determine that the compressive strength

specifications are met in the structure, and to correlate temperature, slump and air content results. If the correlation is satisfactory and meets with the approval of the Engineer, sampling may continue from the most convenient location with occasional re-testing for correlation. Rejection of concrete due to improper temperature or slump may occur at either the truck or pump hose discharge; however, rejection of concrete due to improper air content will only occur due to a failing test for a sample obtained at the final point of discharge.

Temperature of the concrete mixture will be determined in accordance with ASTM C 1064. Slump of the concrete mixture will be determined in accordance with AASHTO T 119. Air content of the concrete mixture will be determined in accordance with AASHTO T 152. All compressive strength test cylinders will be fabricated in accordance with the requirements of AASHTO T 23. Testing for compressive strength of cylinders shall be in accordance with the requirements of Arizona Test Method 314.

A strength test will consist of the average strength of two cylinders or 95 percent of the high strength cylinder, whichever is greater.

1006-7.03 Sampling Frequency for Cast-in-Place Concrete:

A sample of concrete for the required tests, as specified in Subsection 1006-7.02, will be taken for each 100 cubic yards (*75 cubic meters*), or fraction thereof, of continuously placed concrete, on a daily basis, for Class B concrete and for each strength classification of Class S concrete, from each batch plant or source. A concrete sample will be taken for each 50 cubic yards (*40 cubic meters*) placed, for air content testing, at elevations above 3,000 feet (*915 meters*). A sample for the required tests on daily placements of 20 cubic yards (*15 cubic meters*) or less may be taken at the discretion of the Engineer. An additional sample or samples for any of the required tests may be taken, at an interval of less than 100 cubic yards (*75 cubic meters*), at the discretion of the Engineer on any batch or load of concrete. The Engineer will determine the quality of concrete represented by each sample of concrete for any test performed.

1006-7.04 Sampling and Testing for Precast Concrete. A sample for a strength test will be taken at random for either each precast concrete member or for each day's production at the discretion of the Engineer, when the method of measurement is by the unit.

When a sample for a strength test is taken to represent a single day's production and not for each precast member, the degree of acceptance for all precast concrete members in that day's production will be established by the results of such test.

Samples of concrete for test specimens will be taken in accordance with requirements of AASHTO T 141. All test cylinders will be fabricated in accordance with the requirements of AASHTO T 23. Testing for compressive strength will be in accordance with the requirements of AASHTO T 22.

A strength test will consist of the average strength of two cylinders or 95 percent of the higher strength cylinder, whichever is greater.

1006-7.05 Sampling and Testing for Precast Minor Concrete Structures. Sampling and testing will be performed in accordance with the requirements of Subsection 1006-7.03 or the following:

A strength test on each precast unit produced will consist of the average rebound number as determined from readings taken on the precast unit with a rebound hammer. The average rebound number will be determined in accordance with the requirements of ASTM C 805.

The compressive strength of the concrete will be determined from the average rebound number and the calibration chart established for the specific rebound hammer being used. The calibration chart will be established from rebound readings taken on concrete test cylinders fabricated at the precast plant and the actual compressive strength of the cylinders. The test cylinders will be fabricated in accordance with the requirements of AASHTO T 23. The compressive strength of the test cylinders will be determined in accordance with the requirements of Arizona Test Method 314.

1006-7.06 Acceptance for Compressive Strength.

Class S and Class B concrete represented by a strength test of at least 95 percent of the required 28-day compressive strength will be acceptable for cast-in-place and precast concrete subject to the unit price adjustment factors in Table 110-9. All concrete failing to meet this requirement will be rejected in accordance with the provisions found in Subsection 106-11 unless the contractor, at his own expense, can submit evidence that will indicate to the Engineer that the strength and quality of the concrete is such that the concrete should be considered acceptable.

If such evidence consists of concrete cores, the contractor shall obtain three cores from the concrete represented by the failing strength test and deliver them to the Engineer in time to allow complete testing of such cores within 42 days after the placement of the concrete. All cores shall be obtained and tested in accordance with the requirements of AASHTO T 24. All cores will be tested in the wet condition. The concrete represented by the cores will be considered acceptable to remain in place if the numerical average of the compressive strength of the three cores

is at least 95 percent of the required 28-day compressive strength. Concrete cores achieving at least an average of 95 percent of the 28 days compressive strength shall be subject to a unit price adjustment as specified in Table 110.9.

If the average compressive strength does not achieve 95 percent of the average 28 day compressive strength, all concrete so represented shall be removed at no additional cost to the Agency.

If the concrete is permitted to remain in place when the average compressive strength of the three cores tested at 42 days fails to meet 95 percent of the required 28 day compressive strength, it shall be paid for at 55 percent of the contract unit price.

1006-8 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The method of measurement and basis of payment will be made under the provisions specified in the various sections of the specifications covering construction requiring the use of concrete.

SECTION 1007

RETROREFLECTIVE SHEETING

1007-1 GENERAL REQUIREMENTS

Retroreflective sheeting shall consist of a retroreflective system having a smooth outer surface. The sheeting shall have a pre-coated adhesive on the back side protected by an easily removable liner.

Retroreflective sheeting is specified as standard reflectivity enclosed-lens sheeting and high reflectivity encapsulated-lens sheeting. The level of reflectivity and color shall be as specified herein or on the project plans.

Manufacturer's identification marks shall be fabricated in, or on, the face of the various types of sheeting utilized. The markings shall be visible from a distance not greater than 3 feet (*1 meter*); and the identification codes shall be furnished to the Engineer.

A Certificate of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

1007-2 COLOR REQUIREMENTS

The colors specified for Retroreflective Sheeting shall conform to all criteria established in AASHTO M 268 with the following exceptions:

(1) Silver is an acceptable color designation for white.

(2) Minimum reflectance limit for the color orange in Table 2 shall be 12.

The Engineer may, at his discretion, accept colors by certification or require the contractor to furnish laboratory test results.

If testing is required, the test instrument must be one of the following or an approved equal:

(1) Gardner Multipurpose Reflectometer or Model XL20 Color Difference Meter.

(2) Gardner Model AC-2a Color Difference Meter or Model XL30 Color Difference Meter.

(3) Meeco Model V Colormaster.

(4) Hunterlab D25 Color Difference Meter.

Test panels shall be mounted according to the manufacturer's recommendations.

1007-3 SPECIFIC INTENSITY PER UNIT AREA (SIA)

The Specific Intensity Per Unit Area (SIA) of the sheeting shall meet the minimum requirements of AASHTO M 268 for the type of sheeting called for in the Arizona Department of Transportation Manual of Approved Signs or the project plans.

1007-4 COLOR PROCESSING

Color processing shall meet all requirements specified in AASHTO M 268. Opaque or transparent colors, inks, and paints used in sign fabrication shall be of the type and quality as recommended by the manufacturer of the reflective sheeting. Application will be by a screen process which results in uniform color and tone, possessing sharply defined edges of legend and border.

1007-5 ADHESIVE

The reflective sheeting shall include either Class 1 or Class 2 adhesive backing as specified in AASHTO M 268.

SECTION 1008

PRISMATIC REFLECTORS

1008-1 GENERAL REQUIREMENTS

The contractor shall furnish a Certificate of Compliance in accordance with the requirements found in subsection 106-5(B). The certificate shall state that the reflectors comply, in all respects, with the following requirements:

The retroreflectors shall consist of a plastic face (herein referred to as the lens) and an opaque back fused to the lens (under heat and pressure) around the entire perimeter to form a homogeneous unit permanently sealed against dust, water, and water vapor. The retroreflector shall be clear (crystal) in color. The lens shall consist of a smooth front surface free from projections or indentations other than for identification and a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the face of the lens.

1008-2 DELINEATOR AND OBJECT MARKER RETROREFLECTORS

The specific intensity of each acrylic retroreflector shall be equal to or exceed the minimum values in Table 1008-1 with measurements made with retroreflectors spinning.

The retroreflectors shall be either white, yellow, green, or red as specified and shall be ready for mounting.

The lens shall have a retroreflective area of not less than 6.5 square inches (*4195 square millimeters*). Retroreflection shall be provided by the lens prismatic optical elements.

The following test shall be used to determine if a retroreflector is adequately sealed against dust, water, or air.

Submerge 50 samples in water bath at room temperature. Subject the submerged samples to a vacuum of 5 inches (*127 millimeters*) gauge for 5 minutes. Restore atmospheric pressure and leave samples submerged for 5 minutes, then remove and examine the samples for water intake. Failure of three or more units shall be cause for rejection of the entire lot.

The delineator or object marker device shall consist of an acrylic plastic retroreflector unit mounted in a housing fabricated of 0.063 inch (*1.60 millimeter*) 3003-H-14 or similar aluminum, or of cold rolled, hot dip, galvanized steel, having a thickness of 0.064 inch (*1.62 millimeter*). Housing dimensions, including assembly and post mounting hardware will be as shown on the plans or as specified in the contract. Attachment hardware shall permit easy removal with the proper tools, but removal shall not be possible without the use of such tools.

The housing shall be protected against corrosion as recommended by the manufacturer.

1008-3 CUT-OUT LETTERS, SYMBOLS, AND ACCESSORY RETROREFLECTORS

The retroreflectors shall be clear and transparent mounted as an integral part of the character. Five retroreflectors shall be submitted for test. Failure of one or more units shall constitute failure of the lot.

The sealed prismatic retroreflector units shall be tested for dust and water intrusion as follows:

- Submerge five retroreflectors in a water bath at room temperature. Subject the submerged units to a vacuum of 5 inches gauge (*127 millimeters*) (water) for 5 minutes, then examine them for water intake. Failure of one or more units shall constitute failure of the lot.

- Three reflectors shall be tested for 4 hours in a circulating air oven at 175° F ± 5 degrees (*80 °C ± 3 degrees*). The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the retroreflectors shall be removed from the oven and permitted to cool in air to room temperature. The units, after exposure to heat and air cooling, shall show no significant change in shape and general appearance when compared with unexposed control standards. Failure of one or more units shall constitute failure of the lot.

- The assembled cut-out letter, symbol, or accessory shall withstand the combined corrosion test set forth in ASTM B 117. No failures permitted.

Table 1008-1

Minimum Specific Intensity per Unit Area (SIA)

(Candelas per Footcandle per Square Inch)
(*Candelas per Lux per Square Meter*)

Reflector Units

Observation Angle (Degrees)	Entrance Angle (Degrees)	Delineators & Objects *White	Yellow	Green	Red	Markers Colorless	Cut-Out Letters Symbols & Access.
0.1	0	17.7 (*2550*)	6.5 (*935*)	4.6 (*660*)	4.6 (*660*)	14.0 (*2015*)	
0.1	20	6.9 (*995*)	3.8 (*545*)	1.8 (*260*)	1.8 (*260*)	5.6 (*805*)	
0.33	0	-	-	-	-	10.0 (*1440*)	
0.33	20	-	-	-	-	4.0 (*575*)	
0.17	0	-	-	-	-	7.0 (*1010*)	
0.17	20	-	-	-	-	2.8 (*405*)	

*Crystal, Clear, or Colorless

SECTION 1009

ASPHALT-RUBBER MATERIAL

1009-1 DESCRIPTION

The work under this section shall consist of furnishing, proportioning and mixing all the ingredients necessary to produce an asphalt-rubber material.

1009-2 MATERIALS

1009-2.01 Asphalt-Rubber.

(A) Asphalt Cement: Asphalt cement shall be a performance grade (PG) asphalt binder conforming to the requirements of Section 1005.

(B) Rubber: Rubber shall meet the following gradation requirements when tested in accordance with Arizona Test Method 714.

Sieve Size	Percent Passing	
	TYPE A	TYPE B
No. 8 (*2.36 mm*)	100	
No. 10 (*2.00 mm*)	95-100	100
No. 16 (*1.18 mm*)		65-100
No. 30 (*600 μm*)	0-10	20-100
No. 50 (*300 μm*)		0-45
No. 200 (75 *μm*)		0-5

The rubber shall have a specific gravity of 1.15 ± 0.05 and shall be free of wire or other contaminating materials, except that Type A rubber shall contain not more than 0.1 percent fabric and Type B shall contain not more than 0.5 percent fabric. Calcium carbonate, up to four percent by weight of the granulated rubber, may be added to prevent the particles from sticking together.

1009-2.02 Certification Requirements. Certificates of Compliance, conforming to the requirements of Subsection 106-5(B), shall be submitted. In addition, the Certificates shall confirm that the rubber is a crumb rubber, derived from processing whole scrap tires or shredded tire materials; and the tires from which the crumb rubber is produced are taken from automobiles, trucks, or other equipment owned and operated in the United States. The Certificates shall also verify that the processing does not produce, as a waste product, casings or other round tire materials that can hold water when stored or disposed of above ground.

1009-2.03 Asphalt-Rubber Proportions. The asphalt-rubber shall contain a minimum of 20 percent ground rubber by the weight of the asphalt cement.

1009-2.04 Asphalt-Rubber Properties. Asphalt-rubber shall conform to the following:

Property	Requirement	
	Type 1	Type 2
Grade of base asphalt cement	PG 64-16	PG 58-22
Rotational Viscosity*; 350° F (*177 °C*); Pascal seconds	1.5-4.0	1.5-4.0
Penetration; 40° F, (*4 °C*), 1/2 pound (*200 g*), 60 sec. (ASTM D 5); min.	10	15
Softening Point; (ASTM D 36); °F (°C), min.	135 (57)	130 (54)
Resilience; 77° F (*25 °C*) (ASTM D 3407); %, min.	30	25
* The viscometer used must be correlated to a Haake Viscometer, Model VT-04, Rotor No. 1		

1009-2.05 Asphalt-Rubber Design. At least two weeks prior to the use of asphalt-rubber, the contractor shall submit an asphalt-rubber design prepared by an approved laboratory. Such design shall meet the requirements specified herein. The design shall show the values obtained from the required tests, along with the following information: percent, grade and source of the asphalt cement used; and percent, gradation and source(s) of rubber used.

1009-3 CONSTRUCTION REQUIREMENTS

During production of asphalt-rubber, the contractor shall combine materials in conformance with the asphalt-rubber design unless otherwise approved by the Engineer.

1009-3.01 Mixing of Asphalt-Rubber. The temperature of the asphalt-cement shall be between 350 and 400° F (*177 and 204 °C*) at the time of addition of the ground rubber. No agglomerations of rubber particles in excess of 2 inches (*50 millimeters*) in the least dimension shall be allowed in the mixing chamber. The ground rubber and asphalt-cement shall be accurately proportioned in accordance with the design and thoroughly mixed prior to the beginning of the one-hour reaction period. The contractor shall document that the proportions are accurate and that the rubber has been uniformly incorporated into the mixture. Additionally, the contractor shall demonstrate that the rubber particles have been thoroughly mixed such that they have been "wetted". The occurrence of rubber floating on the surface of agglomerations of rubber particles shall be evidence of insufficient mixing. The temperature of the asphalt-rubber immediately after mixing shall be between 325 and 375° F (*163 and 191 °C*). The asphalt-rubber shall be maintained at such temperature for one hour before being used.

Prior to use, the viscosity of the asphalt-rubber shall be tested by the use of a rotational viscometer, which is to be furnished by the contractor or supplier.

1009-3.02 Handling of Asphalt-Rubber. Once the asphalt-rubber has been mixed, it shall be kept thoroughly agitated during periods of use to prevent settling of the rubber particles. During the

production of asphaltic concrete the temperature of the asphalt-rubber shall be maintained between 325 and 375° F (*163 and 191 °C*). However, in no case shall the asphalt-rubber be held at a temperature of 325° F (*163 °C*) or above for more than 10 hours. Asphalt rubber held for more than 10 hours shall be allowed to cool and gradually be reheated to a temperature between 325 and 375° F (*163 and 191 °C*) before use. The cooling and reheating shall not be allowed more than one time. Asphalt-rubber shall not be held at temperatures above 250° F (*121 °C*) for more than four days.

For each load or batch of asphalt-rubber, the contractor shall provide the Engineer with the following documentation:

(A) The source, grade, amount and temperature of the asphalt cement prior to the addition of rubber.

(B) The source and amount of rubber and the rubber content expressed as percent by the weight of the asphalt cement.

(C) Times and dates of the rubber additions and resultant viscosity test.

(D) A record of the temperature, with time and date reference for each load or batch. The record shall begin at the time of the addition of rubber and continue until the load or batch is completely used. Readings and recordings shall be made at every temperature change in excess of 6° F (*11 °C*), and as needed to document other events which are significant to batch use and quality.

1009-4 METHOD OF MEASUREMENT

Asphalt-rubber material will be measured by the ton (*metric ton*), in accordance with the requirements of Subsection 109-1 for bituminous materials, except that any conversion from volume to weight will be calculated on the basis of 7.5 pounds per hot gallon (*0.90 kilogram per liter*) of asphalt-rubber material.

For asphalt-rubber asphaltic concrete, the weight of the asphalt-rubber shall either be weighed directly enroute from the reaction vessel to the point of delivery or determined from the weight of the asphalt cement and the weight of the rubber minus wastage.

The results of a nuclear asphalt content gauge shall not be used to determine the weight of asphalt-rubber material as the basis for payment.

SECTION 1010

PIPE MATERIALS

1010-1 GENERAL REQUIREMENTS

Certificates of Compliance for all pipe materials covered by this Section shall be furnished in accordance with the requirements of Subsection 106-5(B).

1010-2 DRAINAGE PIPE

1010-2.01 Corrugated Metal Pipe. Metallic coated (zinc or aluminum) corrugated iron or steel culverts, underdrains, and spiral rib corrugated steel pipe shall conform to the requirements of AASHTO M 36/M 36M except as otherwise noted herein.

Type 1A pipe may be used if the shell thickness meets or exceeds the thickness specified on the plans for Type 1 pipe.

Polymer precoated, metallic coated (zinc or aluminum) corrugated steel culverts and underdrains shall conform to the requirements of AASHTO M 245, except as otherwise noted herein.

All helically-wound corrugated metal pipe shall have annular rerolled ends, and shall have a marking system which shall provide a quick, external visual check of diameter variations during and after the manufacturing process.

Bituminous coated corrugated metal (metallic coated steel or aluminum) culverts and underdrains shall conform to the requirements of AASHTO M 190.

Aluminum alloy corrugated metal pipe shall conform to the requirements of AASHTO M 196.

The types of bituminous coating and the type of precoated sheets to be used will be specified on the project plans. In lieu of the Type A bituminous coating, the pipe shall be coated either in the field or at the plant, on the outside surface only, in accordance with the requirements of AASHTO M 243. Either asphalt mastic or tar base material shall be used.

Coupling bands shall conform to the requirements of AASHTO M 36/M 36M, M 245/M 245M, and M 196/M 196M, except that the use of bands with projections (dimples) will be limited to end sections, to pipe laid on grades under ten percent, and to pipe requiring water resistant joints.

Bands of special design that engage factory reformed ends of corrugated metal pipe may be used.

Bolts and nuts for all types of coupling bands shall conform to the requirements of ASTM F 568.

Coupling band connection hardware consisting of nuts, bolts, rods, bars, and rivets shall be either galvanized after fabrication by the hot-dip process, in accordance with the requirements of ASTM A 153, or coated by the electroplating process, in accordance with

the requirements of ASTM B 633, Type RS or ASTM B 766, Type TS. Components of bolted assemblies shall be coated separately before assembly.

Special sections, such as elbows and prefabricated end sections, shall conform to the applicable requirements of AASHTO M 36/M 36M, M 190/M 190M, M 196/M 196M, and M 245/M 245M.

Gaskets for all water-resistant joints shall be a continuous band or strip, at least 7 inches (*180 millimeters*) wide and 1/2 inch (*13 millimeters*) thick. Rubber for the gaskets shall conform to the requirements of ASTM D 1056 for the "2A" closed cell expanded grades.

Watertight joints, when specified on the project plans, shall use "O"-ring gaskets, with appropriate diameters as specified under AASHTO M 36/M 36M, and conforming to the technical requirements of AASHTO M 198. Watertight joints may substitute or be used when water-resistant joints are required.

1010-2.02 Spiral Rib Steel Pipe. Spiral rib steel shall conform to the requirements specified under Subsection 1010-2.01(A) for corrugated metal pipe, except as identified herein:

(A) Fabrication: Ribbed steel pipe shall be fabricated with a continuous helical lock seam in accordance with AASHTO M 36/M 36M, Type 1R or corrugation in accordance with AASHTO M 196/M 196M, Type 1R. Aluminum rib pipe shall be manufactured in accordance with AASHTO M 196/M 196M, Type 1R.

Each pipe end shall be fabricated with a minimum of two annular rerolled corrugations for the purposes of joining pipes together with band couplers.

(B) Coatings: The types of coatings and the type of precoated sheets to be used shall be as specified on the project plans.

(C) Coupling Bands: Coupling bands for spiral ribbed steel pipe shall be rerolled bands manufactured from 0.064 inch (*1.62 millimeters*) thick metallic coated steel conforming to the requirements specified under Subsection 1010-1.02(A) and shall be two-piece for pipe greater than 48 inches (*1200 millimeters*) of nominal diameter.

Coupling bands shall be a minimum of 10-1/2 inches (*263 millimeters*) wide, formed with two corrugations that are spaced to provide nesting in the second corrugation of each pipe end and shall be drawn together by a minimum of two 1/2 inch (*metric M12*) diameter galvanized bolts through the use of a bar and strap suitably welded to the band. Bands may be drawn together by other means, such as angles, as approved by the Engineer.

(D) Fittings: Fittings for ribbed steel pipe shall conform to the requirements for corrugated steel pipe fittings specified in Subsection 1010-2.01, except the material shall be ribbed steel.

(E)Miscellaneous: All spiral rib manhole risers 24 inch (*600 millimeters*) in diameter or greater shall be reinforced with a rolled 3 inch x 3 inch x 1/4 inch (*75 x 75 x 6 millimeters*) angle or as approved by the Engineer.

Pipe thickness for spiral rib pipe shall be specified in the pipe summary, but shall not be less than that listed in the following tables.

Table 1010-1

SPIRAL RIB METALLIC COATED STEEL PIPE		
Pipe Diameter	**Minimum Thickness**	**Corrugation Rib Size**
18 – 60 inch (*460 – 1520 mm*)	1/16 inch (*1.63 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)
66 – 78 inch (*1680 – 1980 mm*)	5/64 inch (*2.01 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)
84 – 102 inch (*2130 – 2590 mm*)	7/64 inch (*2.77 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)

SPIRAL RIB ALUMINUM PIPE		
Pipe Diameter	**Minimum Thickness**	**Corrugation Rib Size**
18 – 42 inch (*460 – 1070 mm*)	16 gage (*1.52 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)
48 – 54 inch (*1220 – 1370 mm*)	14 gage (*1.91 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)
60 – 72 inch (*1520 – 1830 mm*)	12 gage (*2.67 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)
78 – 84 inch (*1980 – 2130 mm*)	10 gage (*3.43 mm*)	3/4 x 3/4 x 7-1/2 inch (*19 x 19 x 190 mm*) or 3/4 x 1 x 11-1/2 inch (*19 x 25 x 292 mm*)

1010-2.03 Concrete-lined Corrugated Metal Pipe

(A)Corrugated Metal Pipe. Corrugated metal pipe, coupling bands and fittings for concrete-lined pipe shall conform to the requirements of AASHTO M 36/M 36M for the specified sectional dimensions and metallic coatings. Aluminized coating shall conform to AASHTO M 274.

Pipe shall be full circle and shall be fabricated with helical corrugations.

Pipe thickness shall be as specified in the pipe summary, but shall not be less than that listed in the following table.

Table 1010-2

Pipe Diameter inches (*millimeter*)	**Minimum Thickness Inch/Gage (*millimeter*)**	**Corrugation Rib Size inches (*millimeter*)**
12-48 (*300-1220*)	0.064/16 (*1.63*)	2-2/3 x 1/2 (*68x13*)
54-72 (*1370-1830*)	0.064/16 (*1.63*)	2-2/3 x 1/2 (*63x13*) 3 x 1 (*75x25*) 5 x 1 (*125x25*)
78-84 (*1980-2130*)	0.138/10 (*3.50*)	2-2/3 x 1/2 (*68x13*) 3 x 1 (*75x25*) 5 x 1 (*125x25*)
90-102 (*2290-2590*)	0.109/12 (*2.77*)	2-2/3 x 1/2 (*68x13*) 3 x 1 (*75x25*) 5 x 1 (*125x25*)
108-120 (*2740-3050*)	0.138/10 (*3.50*)	3 x 1 (*75x25*) 5 x 1 (*125x25*)

Each pipe end shall be fabricated with a minimum of two annular rerolled corrugations for purpose of joining pipes together with band couplers.

Pipe shall be joined with rerolled bands made from the same material as the pipe. The bands shall be a minimum of 16 gage/.064 inch (*1.63 millimeters*). Bands shall be two piece for pipe greater than 48 inches (*1200 millimeters*) in diameter.

Coupling bands shall be a minimum of 10-1/2 inches (*263 millimeters*) wide, formed with two corrugations that are spaced to provide nesting in the second corrugation of each pipe end and shall be drawn together by a minimum of two 1/2 inch (*metric M 12*) diameter galvanized bolts through the use of a bar and strap suitably welded to the band. Bands may be drawn together by other means, such as angles, as approved by the Engineer.

When watertight joints are specified, "O" ring gaskets will be required. "O" ring gaskets shall be per ASTM C 361 Section 5.9 and shall be placed in the first corrugation of each pipe end and shall be compressed by tightening the coupling band, in accordance with the manufacturers installation instructions.

(B) Concrete Lining:

(1) Composition. Concrete for the lining shall be composed of cement, fine aggregate and water that are well mixed and of such consistency as to produce a dense, homogeneous, non-segregating lining.

(2) Cement. Portland Cement shall be in accordance with Subsection 1006-2.01.

(3) Aggregate. Aggregates shall conform to AASHTO M 6, except that the requirements for gradation and uniformity of gradation shall not apply.

(4) Mixture. The aggregates shall be sized, graded, proportioned and thoroughly mixed with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the design requirements of this specification. In no case, however, shall the proportions of Portland Cement plus pozzolanic admixture be less than 470 pounds per cubic yard (*280 kilograms per cubic meter*) of concrete.

(5) Lining. The lining shall have a minimum thickness of 3/8 inch (*10 millimeters*) above the rest of the corrugations and shall be applied by a machine traveling through a stationary pipe. The rate of travel of the machine and the rate of concrete placement shall be mechanically regulated so as to produce a homogeneous non-segregated lining throughout. The lining shall be applied in a two course application, and shall be mechanically troweled by the lining machine as the unit moves through the pipe. The trowel attachment shall be such that the pressure applied to the lining will be uniform and shall produce a lining that has a uniform thickness and a consistent troweled finish. The vertical diameter anywhere inside the pipe must be 95% of the nominal diameter less acceptable tolerances as started in AASHTO M 36. Pipe not meeting these tolerances will be rejected.

(C) Experience. The manufacturer shall certify in writing that he has successfully manufactured and furnished corrugated steel pipe with a concrete lining per these specifications on a minimum of fifteen (15) previous projects of a storm sewer nature.

1010-2.04 Slotted Pipe. Slotted pipe shall conform to the applicable requirements of AASHTO M 36/M 36M. It shall be the grate slot or angle slot type. Pipe shall be helically or annular corrugated.

Grate assemblies shall be fabricated from steel conforming to the requirements of either ASTM A 36 or ASTM A 576 and shall be galvanized in accordance with the requirements of ASTM A 123. The method of manufacture shall relieve all strain and prevent distortion of the pipe.

When a lockseam joint is used, slotted drain pipe shall be placed in a clamping device and cut the entire length prior to placement of grate. The grate must be continuous and full depth. The grate shall be welded continuously to the pipe with a 3/16 inch (*5 millimeter*) fillet weld from end to end on both sides.

Bolts and nuts shall be steel, conforming to the requirements of ASTM F 568, and shall be galvanized in accordance with the requirements of ASTM A 123.

The butyl rubber joint sealant shall be an extruded strip or bead, compounded from a nondrying, nontoxic, synthetic resin base with butyl rubber and inorganic extenders, and shall be 100 percent solid material with no shrinkage. The sealant material shall have sufficient adhesion so that the strip or bead will adhere to galvanized steel and be soft enough to allow cold flow when compressed during connection of the pipe sections. The sealant material shall not flow or sag at temperatures up to 180° F (*82 °C*) nor become brittle, crack or lose adhesion at temperatures as low as -30° F (*-34 °C*) and shall contain no migrating components that could leach out or produce any chemical reaction with galvanized steel. The sealant material shall be furnished in 5/8 x 1 inch (*16 x 25 millimeter*) strips or in 1 inch (*25 millimeter*) diameter beads on 1 inch (*25 millimeter*) wide release paper and wound into rolls.

An alternative joint sealant or sealing method that will provide a watertight joint may be used if approved by the Engineer.

Materials used for grout shall conform to the requirements of Section 1006. The grout shall be composed, by volume, of one part portland cement, three parts fine aggregate and one-fifth part hydrated lime. Hydrated lime shall conform to the requirements of ASTM C 207, Type N. To these mixed materials sufficient water shall be added to provide a mixture that will flow readily. Grout that has been mixed more than one hour shall not be used. Retempering of grout will not be permitted.

1010-2.05 Structural Plate Pipe. Structural plate (steel) for pipe, pipe-arches and arches and the accessories for connecting the plates shall conform to the requirements of AASHTO M 167/M 167M.

Structural plate (aluminum alloy) for pipe, pipe arches and arches and the accessories for connecting the plates shall conform to the requirements of AASHTO M 219.

When specified on the project plans or in the Special Provisions, structural plates (steel) and structural plates (aluminum alloy) shall be bituminous coated in accordance with the requirements of AASHTO M 243. Unless otherwise specified, the coating shall be applied to the outside only.

Concrete for footings, bottom slabs on paved inverts, and rings on struts shall conform to the requirements of Section 1006 for the strength and class specified on the project plans.

Steel bars, wire, wire fabric, anchor bolts, and structural steel shall conform to the requirements of Section 1003 or Section 1004, as applicable.

1010-2.06 Nestable Steel Pipe. Nestable corrugated steel pipe shall conform to the requirements of AASHTO M 36/M 36M, except that the pipe shall be fabricated in two separate semi-circular sections. The two sections shall be firmly joined together in accordance with the requirements of Military Specification MIL-P-236. At the option of the contractor, the longitudinal joint of the nestable pipe sections shall be either Type I, flanged, or Type II, notched, as specified in MIL-P-236.

1010-2.07 Reinforced Concrete Pipe. Reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 242/M 242M for the D-load specified.

Reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 170/M 170M for the class of pipe specified.

Reinforced concrete pipe (elliptical) shall conform to the requirements of AASHTO M 207/M 207M for the class of pipe specified.

Reinforced concrete pipe (arch) shall conform to the requirements of AASHTO M 206/M 206M for the class of pipe specified.

The contractor shall furnish the Engineer a copy of the pipe design when the standard AASHTO tables are exceeded.

Precast, reinforced concrete flared end sections shall conform to the requirements of the previously cited specifications to the extent to which they apply. The area of steel reinforcement, per linear foot (*meter*) of the flared end section, shall be at least equal to the minimum steel requirement for reinforcement in that portion of the flared end section which abuts the pipe.

Gaskets for reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 198.

Mortar used to join reinforced concrete pipe shall be composed by volume of one part portland cement, two parts fine aggregate, one-fifth part hydrated lime and sufficient water to provide a plastic mixture. Cement and water shall conform to the requirements of Section 1006. Fine aggregate shall conform to the grading requirements of ASTM C 144. Hydrated lime shall conform to the requirements of ASTM C 207, Type N. The lime shall be considered as an addition to and not as replacing any cement.

1010-2.08 Nonreinforced Concrete Pipe. Nonreinforced concrete pipe shall conform to the requirements of AASHTO M 86/M 86M for the class of pipe specified.

Gaskets and mortar used to join nonreinforced concrete pipe shall conform to the requirements hereinbefore specified under Subsection 1010-2.07.

1010-2.09 Corrugated High Density Polyethylene Pipe. Corrugated high density polyethylene pipe, fittings, couplings, and ends, where specified, shall conform to the requirements of AASHTO M 252 for pipe sizes less than 12 inches (*300 millimeters*) in diameter and AASHTO M 294 for pipe sizes 12 to inches (*300 millimeters*) in diameter and larger.

Corrugated high density polyethylene pipe shall be watertight unless otherwise specified in the Special Provisions, indicated on the plans, and/or approved by the Engineer. When watertight pipe is used, the use of a water stop designed for corrugated high density polyethylene shall be used at all connections to concrete structures.

Water stop shall meet the physical properties of ASTM C923, and the performance requirements of Subsection 501-3.06. Expanding sealants or ASTM F477 gasket supplied with the pipe to make the bell spigot connection on pipe and fittings does not meet these requirements for corrugated high density polyethylene. Installation of water stops shall be per manufacturer recommendations.

Watertight pipe shall conform to the controlled pressure test of 10.8 psi (*74.5 KiloPascals*) of air or 25 feet (*7.6 meters*) of water as stipulated in ASTM D3212 (Lab Test). For the purpose of this specification, field testing is defined as the pressures of 3.5 psi (*24.1 KiloPascals*) of air or 4 feet (*100 millimeters*) of water as specified in Subsection 501-3.06.

Water resistant pipe shall be watertight according to the requirements of ASTM D 3212, except that the internal water pressure test shall be conducted at 2 psi (*14 kPa*). Water resistant pipe cannot be field tested.

Non-perforated pipe shall have either water resistant or watertight joints, as specified on the project plans. Watertight joints may substitute or be used when water resistant joints are required.

Watertight joints shall be watertight according to the requirements of ASTM D 3212.

Pipe and resin producers that manufacture AASHTO M294, and AASHTO MP7 Pipe, shall be certified according to the Plastics Pipe Institute (PPI) Third Party Certification Program. All certified corrugated high density polyethylene pipe shall contain the appropriate program mark, either an official label or permanent affixation prior to shipment.

For the latest certification listing refer to www.cppa-info.org/certification/pipe.html

Magnetic tape, which is to be placed in the trench with the polyethylene pipe as an aid in location after burial, shall have a minimum overall thickness of 5.5 mils (*140 micrometers*) and a minimum tensile strength of 5000 pounds per square inch (*34.5 mega Pascals*).

1010-3 SANITARY SEWER PIPE AND APPURTENANCES

1010-3.01 General Requirements. A Certificate of Compliance from the manufacturer shall be furnished attesting that the pipe and appurtenances (excluding linings and coatings if applied by an independent applicator) meet the requirements set forth in these Subsections. The Certificate of compliance shall conform to the requirements of Subsection 106-5(B). All pipe and appurtenances shall be clearly marked with the name or trademark of the manufacturer, the batch number, and the location of the plant.

1010-3.02 Vitrified Clay Pipe (VCP) Except as modified herein, all materials, manufacture and testing for VCP shall be in accordance with ASTM C 700.

VCP shall be new and extra strength in accordance with the requirements set forth in ASTM C 700, and meet the requirements set forth herein.

The dimensions and permissible tolerances for the laying length, squareness of ends, and variation of inside diameter of VCP shall conform to Table 2 of ASTM C 700.

VCP shall meet the crushing strength and acid resistance tests, and either the absorption or hydrostatic pressure tests using the criteria set forth in ASTM C 700 and the testing procedures set forth in ASTM C 301.

Repairs of any type at the spigot or socket shall be limited to one for each 60 degrees of circumference and a maximum of four at either end. No repairs will be permitted on pipe to be used for fabrication of fittings unless the repaired pipe is tested. However, fittings may be repaired within the scope of these specifications.

All surfaces to be repaired shall be clean and dry. All unsound material at lumps or blisters shall be ground smooth and flush with adjacent surfaces. Cracks shall be saw cut, ground or otherwise grooved 3/16 to 1/4 inch wide (*5 to 6 millimeters*) and 1/8 to 1/4 inch (*3 to 6 millimeters*) deep for the full length of the crack and then cleaned of all loose material. All unsound material such as chips, flakes, pits, and spalls shall be removed. Edges shall be chipped or ground 1/16 inch (*2 millimeters*) minimum below adjacent surfaces. There shall be no feather edges.

Materials used for repair shall be approved by the Engineer. Repair material shall be mixed, applied, and cured as recommended by the manufacturer and approved by the Engineer, and shall have a color contrasting with the color of the pipe to be repaired. If necessary to produce a contrast in color, carbon black in a small quantity may be added to the repair material.

Repair material shall be compounded to provide properties most desirable for sewerage service. Repair material shall resist bacterial attack and attack by chemicals or combinations of chemicals normally present in domestic and industrial sewerage.

The repair material shall be subject to the following tests:

(1) Vitrified clay bars 1 inch (*25 millimeters*) square in cross section and approximately 8 inches (*200 millimeters*) in length, compounded of the same materials as the vitrified clay pipe and fired to clay pipe manufacturing temperature, shall be used in preparing the test specimens. The Bars shall have a modulus of rupture of not less than 1,600 psi (*11 megapascals*) when tested in flexure with three-point loading. The bars shall be cut through at the midpoint and then bonded with the repair material. Following a seven-day maximum cure period at ambient room temperature, the bonded bars shall be tested in flexure with three-point loading. The average modulus of rupture of five test bars bonded with the repair material shall be not less than 1,600 psi (*11 megapascals*).

(2) Five additional test bars bonded with repair material and immersed for 60 days in water at ambient room temperature shall have an average modulus of rupture not less than 1,500 psi (*10 megapascals*).

Each specimen of repair material shall lose not more than 2.0 percent of its weight when immersed in the solutions listed below for a period of 30 days. Specimens shall be conditioned for seven days at 110° F (*43 °C*) and cooled in a desiccator for three hours prior to weighing.

Chemical	Percent Concentration
Sulfuric Acid	20 *
Sodium Hydroxide	5
Ammonia Hydroxide	5 *
Nitric Acid	1 *
Ferric Chloride	1

* Volumetric percentages of concentrated C.P. grade reagents.

All pipe permitted to be repaired shall be inspected after preparation and prior to repair (to determine what repairs are to be made) and after repairs have been completed.

Pipe having unauthorized repairs will be rejected. The Engineer may require retesting of any repaired pipe to demonstrate its soundness. The Engineer will supervise all repairs and inspections required by this section. The Agency shall be reimbursed for all costs incurred for inspection and testing of the repaired pipe.

1010-3.03 Ductile Iron Pipe (DIP). Except as modified herein, all materials, manufacture, and testing for DIP shall be in accordance with ASTM A 746.

Ductile Iron Pipe shall be manufactured with the material, have the dimensions, be within the tolerances, and meet the testing requirements set forth in ASTM A 746. DIP shall be manufactured in nominal 18-foot (*5.5 meter*) or 20-foot (*6.1 meter*) laying lengths and shall be lined as specified herein.

(A) Polyethylene or Polyethylene/Fusion Bonded Epoxy Lining (for 8 inch (*200 millimeter*) and Greater DIP and Fittings). Polyethylene lining material shall be virgin polyethylene complying with ANSI/ASTM D 1248, compounded with or without an inert filler and with sufficient carbon black or other additives to resist ultraviolet rays during aboveground storage of the pipe and fittings. The polyethylene (PE) or polyethylene combined with a fusion-bonded epoxy (PE/FBE) shall be bonded to the interior of the pipe and fittings by heat.

The polyethylene (PE) or polyethylene (PE) or polyethylene lining in combination with a fusion bonded epoxy (PE/FBE) shall cover, as a minimum, the inner surfaces of the pipe and fittings from the plain or beveled spigot end to the bottom of the gasket socket. However, the lining extending into the gasket socket area and onto the exterior of the spigot end of the pipe can be either PE, PE/FBE or a hybrid novolac epoxy.

All PE or PE/FBE lining shall be applied by the pipe manufacturer at the location of pipe manufacture or by an approved lining applicator at the lining applicator's facility. The minimum thickness of the PE or PE/FBE lining shall be 35 mils (875 *micrometers*) and a nominal thickness of 40 mils (*1000 micrometers*).

Hybrid novolac epoxy used in conjunction with the polyethylene lining shall conform to the requirements of Subsection 1010-3.02(B).

(B) Hybrid Novolac Epoxy Lining (for 4 inch (*100 millimeter*) and Greater DIP and Fittings). Hybrid novolac epoxy lining compound must be a two-component epoxy compound capable of at least a 40 mil (*1000 micrometer*) nominal (35 mil minimum (*875 micrometers*)) dry film thickness in an application process whereby delamination will not occur. The material must also meet the following minimum performance requirements:

- A direct impact resistance as measured in accordance with ASTM D 2794 at 35 mil (*875 micrometer*) dry film thickness on ductile iron panels. The material shall pass 100 inch-pounds (*1.13 kilonewton*) of impact.
- A maximum coating weight loss of 300 milligrams as measured in accordance with ASTM D 4060 using CS-17 wheels with a 1,000 gram load for 1,000 cycles.
- A minimum adhesion value of 2000 psi as measured in accordance with ASTM D 4541.

- A maximum weight change of 1% when a sample of the lining is completely immersed in a 50% by weight solution of sulfuric acid having a temperature of 75° F (*24 °C*) and being tested for 30 days. The test specimens are to be cast to a 1/8 inch (*3 millimeter*) thickness and allowed to cure for 7 days at 75° F (*24 °C*). The specimen weight is to be determined after 8 hours, 24 hours, 72 hours, 7 days and 30 days of continual exposure to the sulfuric acid. Prior to each weight measurement, the specimen is to be rinsed off and allowed to dry for one hour.

The Engineer may require additional testing to be run on a proposed lining or coating to determine its suitability on a given project. Unless a special waiver is granted by the Agency, all tests are to be performed by an independent testing laboratory approved by the Agency.

Epoxy linings shall be applied by the pipe manufacturer at the location of the manufacture of the pipe, or by a qualified applicator who would apply the lining at the applicator's place of business. The applicator shall demonstrate, to the satisfaction of the Agency, that they are capable of successfully applying the specified lining on ductile iron or steel pipe.

(C) Application and Testing of Lining. The pipe manufacturer shall be responsible for the quality of the pipe. The lining applicator shall be responsible for the quality of the lining.

All surface areas which will be exposed to sewer liquids and gases shall be cleaned so as to remove all deleterious materials. After cleaning, the lining compound shall be applied to all surface areas which will be exposed to the sewer liquids and gases. The lining compound shall be applied so as to obtain a continuous and relatively uniform and smooth integral lining.

The lining in the barrel area shall have a nominal thickness of 40 mils (*1000 micrometers*) and a minimum thickness of 35 mils (*875 micrometers*). However, the lining in the bell area may transition from a 35 mil (*875 micrometers*) minimum thickness at the edge of the barrel area to a 10 mil (*250 micrometer*) minimum thickness at the bottom of the gasket socket. The 10 mil (*250 micrometer*) lining shall extend into the gasket socket area to a point where the gasket would overlap the lining when it is compressed due to pipe assembly during construction. The 10 mil (*250 micrometer*) lining shall also continue from inside the barrel area, around the spigot end of the pipe and along the outside of the pipe to a point where the center of the gasket of the next pipe section would contact the edge of the lining on the spigot end of the previous pipe section. This is a minimum requirement. The thickness of linings shall be determined by using a dry film thickness magnetic gauge. The maximum dry film thickness in the gasket seat area and on the exterior of the spigot end is 15 mils (*375 micrometers*).

Each piece of pipe shall be tested and shall have an absence of holidays (small areas of pipe devoid of lining) when tested by a suitable holiday detector. In all cases, the barrel area of the

pipe shall be tested using both a voltage of 7500 volts and a dry conductive probe. The bell area and the exterior of the spigot end, shall be tested using both a voltage of 67.5 volts and a wet sponge.

Fittings and stoppers shall meet the requirements of ANSI A 21.10. Joints shall be push on type and meet the requirements of ANSI A 21.11. EPDM gaskets shall be used for all DIP, unless the plans or Special Provisions state otherwise.

1010-3.04 Reinforced Concrete Pipe (RCP). Reinforced concrete pipe shall meet the requirements of ASTM C 76 except as modified by these specifications. The absorption test as stated in Section 11.4.2 of ASTM C 76 shall be amended to read, "The absorption of a sample from the wall of the pipe, as determined in accordance with Method C 497, shall not exceed 7% of the dry mass for Method A or 6.5% for Method B". Portland cement shall be Type II unless otherwise specified by the Engineer and conform to the requirements of ASTM C 150.

Reinforced concrete pipe used for sanitary sewer applications shall have all of its interior surfaces protected by the installation of polyvinyl chloride (PVC) liner unless an alternate method of protection is approved by the Agency.

Lined pipe shall have joints utilizing EPDM "O"-ring rubber gaskets meeting the requirements of ASTM C 443, except as modified by these specifications. The lined pipe shall also have an interior lining of plastic-liner plate meeting the requirements of ASTM C 76 except when otherwise permitted by the Engineer. No materials shall be used in the manufacture of the pipe other than water, Type II Portland cement as specified in ASTM C 150, mineral aggregate and steel conforming to ASTM C 76 and approved admixtures.

The interior area of RCP shall be sealed with a protective lining installed by the pipe manufacturer or a lining applicator approved by the Engineer. The material used in the liner plate shall be a combination of inert, synthetic resins, pigments, and plasticizers, compounded to make permanently flexible sheets.

Liner plate shall be white in color and shall be resistant to oxidizing agents; sulfuric, phosphoric, nitric, chromic, oleic, and stearic acids; sodium and calcium hydroxides; ammonia; sodium, calcium, magnesium and ferric chlorides, ferric sulfate; petroleum oils and greases; vegetable and animal oils; fats; greases; and soaps. The liner plate shall be impermeable to sewage gases and liquids, and shall be non-conducive to bacterial and fungus growth. All liner plates shall be factory checked electrically with a high-voltage Holiday detector set at 20,000 volts to insure freedom from any porosity. The lining shall have good impact resistance, shall be flexible, and shall have an elongation sufficient to bridge a 1/8 inch (*3 millimeter*) settling crack without damage. Once cast into the pipe, the lining shall be permanently and physically (not adhesively) attached by a T-lock

mechanism. The lining shall withstand a 15 psi (*103 kilopascal*) back hydrostatic pressure applied to the under surface of the lining without losing anchorage or without rupture or leakage.

Liner plate shall be supplied as pipe-size sheets fabricated by shop welding together the basic-size sheets. Joint strips shall be 4.0 inches (*100 millimeters*) ± 0.25 inches (*6 millimeters*) in width and shall have each edge beveled prior to application.

The liner plate shall not be less than 0.065 inches (*1.65 millimeters*) in thickness. Locking extensions shall be of the same material as the liner and shall be integrally extended with the sheets. If steel bands are used to secure the liner plate to the forms transversely, strap channels shall be integrally molded into the sheet.

The pipe manufacturer shall certify that no calcium chloride has been used in the manufacture of the pipe. Other admixtures may be used if approved by the Agency.

The reinforcement shall be fabricated as a rigid cage of bars or wire. Transverse reinforcement shall be fabricated either as complete hoops, welded or lapped, or as a continual helix. If the transverse reinforcement is formed as a cylindrical or elliptical helix, both ends of the cage shall be finished off as a complete hoop.

Splices shall be either welded or lapped and tightly wired. Either lap or butt welds may be used, but the weld must develop the full strength of the bar. The lap of un-welded splices shall extend 30 diameters when bars or rods are used for reinforcement, and 40 diameters when wire is used.

The placement of reinforcement steel shall not vary from the position in the pipe wall shown on the drawings by more than 1/4 inch (*6 millimeters*). In no case shall the cover over reinforcement be less than 3/4 inch (*19 millimeters*).

Suitable devices shall be used to hold the cage of reinforcement in its elliptical or circular shape and to maintain the cage in place within the forms during the placing and consolidation of the concrete. Supports between the reinforcement and the forms that are to be exposed in the finished pipe shall be made of plastic or plastic coated steel.

When two reinforcement cages are used, the longitudinal reinforcement shall be divided approximately equally between the two cages, and only the longitudinal reinforcement on the outer cage need extend into the bell. The end hoops of the transverse reinforcement will be nominally 1 inch (*25 millimeters*) from the extreme and concrete faces of the pipe. For pipe with a wall thickness of 2-1/2 inches (*64 millimeters*) or less, the transverse reinforcement shall be located in accordance with ASTM C 76. The cover over longitudinal reinforcement shall be not less than 3/8 inch (*10 millimeters*).

Reinforced concrete pipe shall have a nominal laying length of 8 to 20 feet (*2.4 to 6.1 meters*) unless otherwise specified. The internal diameter of 27 inch (*685 millimeters*) and larger pipe shall not vary more than one percent, but in no case shall the variance exceed 3/8 inch (*10 millimeters*) from the nominal diameter. The pipe wall may be thicker than the design thickness, but cannot be less than the design by more than five percent or 3/16 inch (*5 millimeters*) whichever is less. Variation in laying lengths of two opposite sides of pipe shall not be more than either 1/8 inch per foot (*10.5 millimeters per meter*) of diameter or 5/8 inch (*16 millimeter*) total whichever is less. The underrun in length of a section of pipe shall not be more than 1/8 inch per foot (*10.5 millimeters per meter*) with a maximum of 1/2 inch (*13 millimeters*) in any length of pipe.

Each day's run shall be marked and stored in the manufacturer's yard so that the pipe made on any particular day may be easily identified. The date of manufacture, size and D-load, lot number, manufacturer's identification mark, and, where elliptical reinforcement is used, a four-inch high "T" marking the location of the minor axis of the reinforcements, shall be legibly painted or stamped on the inside of each pipe.

Reinforced concrete pipe shall meet the physical requirements set forth in Section 11 of ASTM C 76.

All liner shall be shop tested for holes, using an approved spark detector set at a minimum of 20,000 volts. Sheets having holes shall be satisfactorily repaired in the shop and retested prior to shipping to the project.

All D-load bearing strength tests shall conform to ASTM C 497, latest edition, except as modified by these specifications.

Pipe to be D-load tested shall be randomly selected at the point of manufacture by the Engineer. One pipe will be selected for each lot, or fraction thereof, of the pipe to be furnished to the project.

For the purpose of these specifications, a lot is defined as 600 feet (*180 meters*), but no more than 50 sections of pipe (or a fraction thereof), of one size and class manufactured on consecutive working days. If the 600 feet (*180 meters*), but no more than 50 sections, of pipe are not made on consecutive working days, then only those made on consecutive working days shall be considered a lot. If an interruption in the manufacture of a lot occurs, the Engineer may permit the pipe made after the interruption to be included in the lot, provided the interruption does not last more than seven calendar days. A new lot number will be assigned if any change occurs in the size or spacing of reinforcing steel, in the concrete mix, or in the curing method.

The contractor or pipe manufacturer shall furnish the test pipe without charge and shall provide adequate equipment and facilities for conducting tests and shall bear all expense in connection therewith. Testing shall be under the supervision of the Engineer. Test equipment shall accommodate a length of pipe of

the same length as furnished for the project. All testing equipment shall be calibrated at intervals not to exceed six months by an agency approved by the Engineer.

Test pipe shall conform in all other respects to the applicable requirements specified herein. Pipe shall be tested by the three-edge bearing method as described in ASTM C 497 as modified by these specifications. Test pipe that meet the 0.01 inch (*0.25 millimeter*) crack load requirements shall be accepted for use.

The required strength of the pipe specimens undergoing the bearing tests will be designated in terms of D-load. Such designation indicates the actual load in pounds per linear foot (*kilograms per meter*) of pipe divided by the inside diameter of the pipe in feet (*meters*). The pipe shall withstand the required test load before a crack having a width of 0.01 inch (*0.25 millimeter*) measured at close intervals occurs throughout a length of 1 foot (*300 millimeters*) or more. The crack shall be considered 0.01 inch (*0.25 millimeter*) in width when the point of the measuring gauge will, without forcing, penetrate it 1/16 inch (*2 millimeters*) at close intervals throughout the specified distance of 1 foot (*300 millimeters*).

The load shall be applied at a uniform rate not to exceed 2,000 pounds per minute per foot (*907 kilograms per minute per 300 millimeters*) of length of pipe for the first 80 percent of the required load, and then at a uniform rate not to exceed 500 pounds per minute per foot (*225 kilograms per minute per 300 millimeters*) of length of pipe for the remainder of the test.

The length on which the test load is computed shall be determined by measuring the inside length of the barrel of the pipe from the bottom of the socket to the end of the spigot. The length of a beveled pipe shall be the average length of the inside of the barrel of the pipe measured from the bottom of the socket to the end of the spigot.

If the tested specimen of a designated lot passes the test, all of the pipe of that lot shall be considered as complying with these requirements.

If the tested specimen of a designated lot fails to pass the test, then two additional specimens from the same lot shall be selected for test.

If the two additional specimens pass the requirements of the test, the total number of that lot to be furnished shall be considered as complying with the requirements except that the one previous test specimen failing to meet the test requirements shall be rejected.

If any of the two additional specimens fail to meet the test requirements, the entire lot shall be rejected, or may be down-graded, except the test specimen which met the test requirements.

The contractor may test specimens of a rejected lot individually to determine whether they may comply with the requirements for acceptance.

In addition to D-load bearing strength tests described above, it is required that one short length joint for each internal diameter having a different design D-load requirement shall be bearing loaded to ultimate strength in accordance with ASTM C 497. The test specimen shall be manufactured without a lining and shall be surface-dry when tested.

1010-3.05 Polyvinyl Chloride Pipe (Gravity System Installations). Except as modified herein, all materials, manufacture and testing for PVC gravity sewer pipe shall be in accordance with ASTM D 3034 and ASTM F 679.

Gravity PVC pipe, nominal diameter size 4 inch (*100 millimeters*) through 15 inch (*375 millimeters*), shall meet the minimum wall thickness requirements of SDR-35, ASTM D 3034, and be of clean, virgin PVC having a cell classification of 12454-B, or 13364-B and meeting the requirements of ASTM D 3034 as defined in ASTM D 1784. Gravity PVC pipe, nominal sizes 18 inch (*450 millimeters*) and larger, shall meet the minimum wall thickness requirements of T-1, ASTM F 679 and be of clean, virgin PVC having a cell classification of 12354C meeting the requirement of ASTM F 679 as defined in ASTM D 1784.

Rubber gaskets shall conform with the low-head requirements of ASTM F 477 and shall also be made of EPDM.

PVC gravity pipe shall be tested in accordance with ASTM D 3034 for nominal pipe diameters of 4 inch (*100 millimeters*) through 15 inch (*375 millimeters*) and ASTM F 679 for nominal pipe diameter of 18 inch (*450 millimeters*) and larger. The minimum pipe stiffness at 5 percent deflection shall be 46 psi (*317 kilopascals*) for all sizes when tested in accordance with ASTM D 2412.

1010-3.06 High Density Polyethylene (HDPE) Pipe (Force Main System Installations). High density polyethylene (HDPE) pipe shall conform to the requirements of ASTM D 1248, ASTM D 2122, ASTM D 3035, and ASTM C 3350, except as otherwise noted herein.

HDPE pipe, nominal diameter size 3 inch (*75 millimeters*) through 63 inch (*1.6 meters*), shall meet the minimum wall thickness requirements of SDR-PR, ASTM F 714.

The pipe manufacturer shall have a minimum of 5 years experience in producing HDPE pipe meeting the requirements specified herein. HDPE pipe and fittings shall be manufactured from the product of a single approved manufacturer.

The pipe manufacturer shall maintain a continuous quality control program.

HDPE pipe shall be manufactured from extra high molecular weight polyethylene material meeting the requirements of Type III, Class C, Category 5, Grade P34 as defined in ASTM D 1248. The pipe

material shall meet the requirements of cell classification PE345464C or PE345464E of Standard PE Code Designation PE3408 as defined by ASTM D 3350. The manufacturer shall certify that the pipe material has been tested, in accordance with the provisions of ASTM F 1473, for >100 hours, without failure. The manufacturer shall also certify that the pipe has a hydrostatic design basis of 1,600 psi (*11.0 MPa)* at 73° F (*23 °C*) and 800 psi (*5.5 MPa*) at 140° F (*60 °C*) when tested in accordance with the provisions of ASTM D 2837.

The design pressure of the pipe shall be in accordance with ASTM D 3035 and ASTM F 714.

1010-4 POTABLE AND RECLAIMED WATER SYSTEM PIPE AND APPURTENANCES

All pipe and appurtenances for potable and reclaimed water systems shall conform to those products and materials included in the water utility's list of approved materials or to the requirements specified in the Special Provisions.

A Certificates of Compliance from the manufacturer or supplier shall be furnished attesting that the pipe and appurtenances comply with those materials or products included in the water utility's list of approved materials or conform to the requirements specified in the Special Provisions. The Certificate of Compliance shall conform to the requirements of Subsection 106-5(B). All pipe and appurtenances shall be clearly marked with the name or trademark of the manufacturer, the batch number, and the location of the plant.

SECTION 1011

JOINT MATERIALS

1011-1 RUBBER WATERSTOPS

Rubber waterstops shall be either molded or extruded from plain rubber or synthetic rubber, at the option of the contractor.

The waterstops shall be formed with an integral cross section which shall be uniform within ±1/8 inch (*±3 millimeters*) in width and the web thickness or bulb diameter within +1/16 (*+1.6 millimeter*) and -1/32 inch (*-0.8 millimeter*). No splices will be permitted in straight strips and special connection pieces shall be well cured in a manner such that any cross section shall be dense, homogeneous and free from porosity or other defects. All junctions in the special connection pieces shall be full-molded. During the vulcanizing period the joints shall be securely held by suitable clamps. The material at the spices shall be dense and homogeneous throughout the cross section.

Field splices shall be vulcanized; mechanical, using stainless steel parts; or made with a splicing union of the same stock as the waterstop, all at the option of the contractor. Finished splices shall have a tensile strength of not less than 50 percent of the unspliced material.

A Certificate of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

1011-1.01 Plain Rubber Waterstops. Plain rubber waterstops shall be formed from stock composed of a high grade compound made exclusively from new plantation rubber, reinforcing carbon black, zinc oxide, accelerators, anti-oxidants and softeners and shall conform to the following requirements:

New Plantation Rubber Content, by volume, percent	Minimum	72
Tensile Strength (ASTM D 412), pounds per square inch (*megapascals*)	Minimum	3500 (*24*)
Elongation at Breaking (ASTM D 412), percent	Minimum	550
Unit Stresses:		
At 300 percent Elongation, pounds per square inch (*megapascals*)	Minimum	1100 (*7.6*)
At 500 percent Elongation, pounds per square inch (*megapascals*)	Minimum	2800 (*19.3*)
Shore Durometer (Hardness) (ASTM D 2240)	55 to 65	
Tensile Strength and Elongation at Breaking (ASTM D 572), after seven days in air at 158 degrees (± 2 degrees) F (*70 °C ± 1 °C*), or after 48 hours in oxygen at 158 degrees (± 2 degrees) F (*70 °C ± 1 °C*), and 300 pounds per square inch (*2 megapascals*) = percent of original	Minimum	65

1011-1.02 Synthetic Rubber Waterstops. Synthetic rubber waterstops shall be formed from a compound made exclusively from neoprene or SBR (styrene butadiene rubber), reinforcing carbon black, zinc oxide, polymerization agents and softeners and shall conform to the following requirements:

Neoprene or SBR Content, by volume, percent	Minimum	70
Tensile Strength (ASTM D 412), pounds per square inch (*megapascals*)	Minimum	2500 (*17.2*)
Elongation at Breaking (ASTM D 412), percent	Minimum	425
Shore Durometer (Hardness) (ASTM D 2240)	50 to 70	
Tensile Strength at Breaking (ASTM D 572), after seven days in air at 158 degrees (± 2 degrees) F (*70 °C ± 1 °C*), or after 48 hours in oxygen at 158 degrees (± 2 degrees) F (*70 °C ± 1 °C*), and 300 pounds per square inch (*2 megapascals*) percent of original	Minimum	65

1011-2 POLYVINYLCHLORIDE (PVC) WATERSTOPS

Polyvinylchloride waterstops shall be manufactured from virgin polyvinylchloride conforming to the requirements of the Corps of Engineers Specification Number CRD-C572.

A Certificate of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted stating that the requirements specified under paragraph 6 of CRD-C572 have been complied with.

Field splices shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. The heat shall be sufficient to melt but not char the plastic.

1011-3 JOINT SEALANT (HOT-POURED)

Joint sealant material shall be a one component, hot poured type, conforming to the requirements of either ASTM D 3406 or ASTM D 3569. Joint sealant shall not contain any coal-tar materials.

The following requirement shall be added to paragraphs 7.1 of ASTM D 3406 and 7.1 of ASTM D 3569:

> The minimum ambient temperature during application and ambient temperatures under various storage conditions shall be clearly marked on the container.

1011-4 JOINT SEALANT (COLD-APPLICATION)

Joint sealant shall be cold-application, mastic, single or multiple component type.

Certificates of Compliance conforming to the requirements of Subsection 106-5 shall be submitted.

1011-5 BRIDGE DECK JOINT SEALS

The elastomer for joint seal elements shall be polychloroprene rubber (Neoprene) and shall be compatible with concrete and shall be resistant to abrasion, oxidation, aging, and sunlight, and to oils, gasoline, salt, and other materials that may be spilled on or applied to the surface.

Joint seals shall be of the cellular compression type or strip type.

One piece of the material supplied shall be at least 18 inches (*450 millimeters*) longer than required by the plans and the additional length may be removed by the Engineer and used for testing by the Agency. A Certificate of Compliance conforming to the requirements of Subsection 106-5(5).

1011-5.01 Compression Seals. Compression seals shall consist of a prefabricated preformed elastomer joint seal material and shall conform to the requirements of ASTM D 3542.

The seal shall consist of a multi-channel nonporous, homogeneous material furnished in a finished extruded form.

The minimum depth of the seal, measured at the contact surface, shall be at least 95 percent of the minimum uncompressed width of the seal as designated by the manufacturer.

The joint seal shall provide a Movement Rating (MR) of not less than that shown on the plans. The seal shall be so formed that it can be compressed to 40 percent of its original width without damage while simultaneously maintaining the top center of the exposed surface below the top surface of the installed joint.

The top and bottom edges of the joint seal shall maintain continuous contact with the side of the armor over the entire range of joint movement.

The Compression seal shall be furnished full length except as otherwise specified on the project plans and as indicated on ADOT Standard Drawing B-24.20.

At all open ends of the seal that would admit water or debris, each cell shall be filled to a depth of 3 inches (*75 millimeters*) with commercial quality open cell polyurethane foam or closed by other means subject to the approval of the Engineer.

The seal element shall be installed in strict accordance with the manufacturer's recommendations, subject to these specifications and the approval of the Engineer, using equipment manufactured specifically for the installation of said element. The equipment shall not cause structural damage to either the seal element or the joint armor and shall not twist, distort, or cause other malformations in the installed seal element. Contact surfaces of the seal element shall be cleaned with normal butylacetate, using clean rags or mops, immediately prior to application of lubricant

adhesive and sealant. The lubricant adhesive and sealant shall be applied to the seal element and joint armor contact surfaces at the rate recommended by the manufacturer.

If the required joint opening at the time of installation is inadequate to allow for easy installation of the seal element, the compression seal shall be shop installed into deck joint assemblies to be shipped fully assembled and installed as a unit. Fully assembled units shall have the lubricant adhesive applied to the seal and armor contact surfaces and shall be equipped with shipping and temperature adjustment devices approved by the Engineer.

The lubricant adhesive and sealant shall conform to the provisions of ASTM D 4070.

The lubricant adhesive and sealant shall have a viscosity such that it will perform suitably with installation equipment, remaining fluid from 5 to 120° F (*-15 to 49 °C*).

Each lot of lubricant adhesive and sealant shall be delivered in sealed containers plainly marked with the manufacturer's name or trademark and the date of manufacture. The shipping containers shall also indicate any special precautions or instruction required because of product toxicity, flammability, or other such information pertinent to the proper storage and use of the product.

1011-5.02 Strip Seals. Strip seals shall be performed non-reinforced, polychloroprene strip seal glands that mechanically lock into steel retainers. The steel retainers shall be anchored into the structure in accordance with the contract requirements.

The adhesive lubricant used to install the strip seal gland into the locking steel retainer shall be a one part moisture curing polyurethane compound, meeting the requirements of ASTM D 4070.

The strip seal gland shall be delivered to the jobsite in lengths suitable for continuous one piece installation for each individual expansion joint. Field splicing is not permitted.

All steel surfaces that come in contact with the strip seal gland shall be cleaned to meet the requirements of SSPC-SP6.

Special conditions such as mitres, tees, and crosses shall be shop fabricated in a mold under heat and pressure.

Strip seal gland installation at joint openings of less than 1-1/2 inches (*38 millimeters*) will not be permitted.

The elastomer for strip seal elements shall conform to the requirements of ASTM D 3542 modified as follows:

(1) Recover testing is excluded

(2) TABLE 1 of ASTM C 3542 is revised as follows:

TABLE NO. 1

PHYSICAL PROPERTIES FOR PREFORMED ELASTOMER STRIP SEALS

Property	Requirement	ASTM Test Method
Tensile strength, min. Mpa	13.8	D 412
Elongation at break, min. %	250	D412
Hardness, Type A durometer, points	60 ± 5	D 2240 (Modified) (1.3)
Oven aging, 70 h at 100 °C		D 573
Tensile strength, loss, max. %	20	
Elongation, loss, max. %	20	
Hardness, Type A durometer, points change	0 to +10	D 2240 (Modified) (1.3)
Oil swell, ASTM Oil No. 3 70 h at 100 °C Weight change, max. %	45	D 471
Ozone resistance 20% strain, 300 pphm in air, 70 h at 40 °C	No Cracks	D1149 (Modified) (2)
Low temperature stiffening 7 days at -10 °C, Hardness, Type A durometer, points Change	0 to +15	D 2240 D 2240 (Modified) (1.3)
Compression set, 70 h at 100 °C max. %	40	D 395 Method B (Modified) (1)

Notes:
(1) The term "modified" in the table relates to the specimen preparation. The use of the strip seal as the specimen source requires that more plies than specified in either of the modified test procedures be used. Such specimen modification shall be agreed upon by the purchaser and producer or supplier prior to testing.
(2) Test in accordance with procedure A of ASTM D 518 and ozone concentration is expressed in pphm.
(3) The hardness test shall be made with the durometer in a durometer stand as recommended in ASTM D 2240.

1011-6 PREFORMED EXPANSION JOINT FILLER

Preformed expansion joint filler for concrete structures, pavements and incidental items shall conform to the requirements on the plans. When not specified, one of the following joint fillers may be used.

1011-6.01 Bituminous Joint Filler. Bituminous joint filler shall conform to the requirements of AASHTO M 213.

1011-6.02 Nonbituminous Joint Filler. Nonbituminous joint filler shall conform to the requirements of AASHTO M 153, Type II, with the following modifications. The joint filler may be formed as a premolded strip from suitable fibers. The compression test specimen of the premolded fiber joint filler shall recover to at least 65 percent of its thickness before testing.

1011-7 CELLULAR PLASTIC JOINT FILLER

Cellular plastic joint filler shall conform to the requirements of ASTM D 3204. The lubricant-adhesive shall be furnished by the manufacturer and used according to his recommendations. A Certificate of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

1011-8 SILICONE JOINT SEALANT

1011-8.01 Testing. Silicone joint sealant shall be a low modulus silicone that is specifically formulated to seal portland cement concrete pavement joints. Silicone sealant shall be furnished in a one part formulation which is non-acid curing and shall meet the following physical requirements:

TEST METHOD	MATERIAL TEST	REQUIREMENTS
ASTM D 412 (Method A, Die C)	Tensile Stress at 150% Elongation (1)	45 psi maximum
ASTM D 412 (Method A, Die C)	Elongation (1)	700% minimum
ASTM C 603	Extrusion Rate (ASTM C 920, Type S, Grade NS)	25 seconds maximum
ASTM D 792 (Method A)	Specific Gravity	1.15-1.515
ASTM C 679	Tack Free Time	120 minutes maximum
ASTM D 2240 (Shore A)	Durometer Hardness	25 maximum
ASTM C 719 (4) (Mortar Block)	Movement (2) (3)	+50% and -50% of the joint width

NOTE 1: Sample cured 7 days at 77° F ±2° F (*25 °C ±1 °C*) and 50% ±5% relative humidity.

NOTE 2: Curing of specimens shall be in accordance with Article 8.2; any option or alternate conditions will not be permitted.

NOTE 3: Section 9, Procedure, shall be strictly adhered to through and including Article 9.5. The test procedure will then be considered concluded.

NOTE 4: Adhesive Loss Maximum 15% of surface area and no cohesive failure after 10 cycles at standard conditions.

1011-8.02 Packaging and Marking. The sealant shall be delivered in the manufacturer's original sealed container. Each container shall have attached, intact, the original manufacturer's label. The label shall be tamper-proof, non-removable and shall be legibly marked with the manufacturer's name, the trade name of the sealer, the manufacturer's batch or production lot number, and the expiration date of the manufacturer's shelf life warranty. Sealant that has exceeded the shelf life warranty expiration date shall not be used unless it has been retested and recertified for adhesion in conformance with ASTM C 719. The sealant may be recertified for a period not exceeding 6 months from the date of retesting. Retesting or replacement of the sealant will be at the contractor's option. Retesting will be at the contractor's expense. Failure to meet specification requirements shall not be cause for claim or extension of the contract. The contractor shall be held liable for all costs incurred in procuring and testing of materials that are found to be outside specification requirements.

1011-8.03 Field Performance. The manufacturer of the joint sealant shall demonstrate satisfactory field performance in Arizona of less than 1% total failure (either within the material or the adhesive bond to the joint face) after one year of service, before the material shall be used.

1011-8.04 Sampling. All sealant to be used on the project shall be stockpiled at the site at least forty-five (45) working days prior to use, or at least sixty (60) working days prior to use if stockpiled at the vendor's place of business. This will allow thirty-five (35) days for laboratory testing to determine compliance. Subsequent deliveries shall be placed in separate stockpiles. The Engineer shall be notified when each stockpile has been established and is ready to be sampled. Not less than one random sample of each lot or batch number (minimum of 10 lbs (*4.5 kilograms*) per sample) shall be taken. No material shall be placed until the Engineer has approved the material for placement.

1011-8.05 Certification. The contractor, shall at his expense, have the previously obtained sample tested by an independent laboratory. The testing laboratory shall be approved by the Engineer, shall be independent of the sealant manufacturer, and shall be under the supervision of a registered professional engineer. The contractor shall furnish to the Engineer certification by the approved testing laboratory that the production lot tested meets the specified requirements. A Certificate of Compliance and Certificate of Analysis conforming to the requirements of Subsection 106-5(B) shall be submitted.

SECTION 1012

GUARD RAIL MATERIALS

1012-1 GENERAL REQUIREMENTS

Certificates of Compliance conforming to the requirements of Subsection 106-5(B) shall be submitted.

References to ARTBA in this section shall mean the latest edition and supplements to the publication "A Guide to Standardized Highway Barrier Rail Hardware", ARTBA Technical Bulletin No. 268-B.

1012-2 FASTENERS, ELEMENTS, AND POSTS

Guard rail fasteners shall conform to the requirements of Table 1012-1. Guard rail elements shall conform to the requirements of Table 1012-2. Metal guard rail posts and blocks shall conform to the requirements of Table 1012-3. Timber guard rail posts and blocks shall conform to the requirements of Subsection 1012-4.

All surfaces of guard rail elements which are exposed to traffic shall present a uniform, pleasing appearance and shall be free of scars, stains or corrosion.

1012-3 MISCELLANEOUS MATERIALS

Nails shall be 16 penny common, galvanized. Nails for retainer straps shall be 10 penny common, galvanized.

Welded wire fabric for the guard rail anchor assembly shall be 6x6-W2.9xW2.9 (*152.4 mm x 152.4 mm – MW 18.7 mm x 18.7 mm*) and shall conform to the requirements of AASHTO M 55.

Concrete for the guard rail anchor assemblies shall conform to the requirements of Section 1006 for Class S concrete of the strength shown on the plans.

Polystyrene filler for the guard rail anchor assembly shall be 1/2 inch (*13 millimeters*) thick insulation sheets.

The metal used to manufacture reflector tabs shall be either 3003-H14 aluminum strip 0.063 inch ± 0.004 inch (*1.6 ± 0.1 millimeter*) thick or steel strip 0.078 inch ± 0.008 inch (*2.0 ± 0.2 millimeter*) thick galvanized in accordance with ASTM A 653, coating designation G 90. The reflector material shall be high-reflectivity sheeting, either silver-white or yellow and shall conform to the requirements of Section 1007. The reflective sheeting shall adhere to the metal tabs.

Nuts, bolts, and washers to be used in installations for which details are not shown on the plans nor in the ARTBA publication shall conform to the requirements of ASTM F 568 or A 307 and be galvanized in accordance with the requirements of ASTM A 153, Class C, and conform to the dimensional requirements of the American National Standards Institute.

SECTION 1012

Structural steel shapes, plates, bars and strips used in fabrication of hardware and all miscellaneous steel shall conform to the requirements of ASTM A 36 and shall be galvanized in conformance with the appropriate requirements of AASHTO M 111 and AASHTO M 232. They shall meet the dimensional requirements of the American Institute of Steel Construction.

Round and square structural steel tubing shall conform to the material requirements of either ASTM A 500 or ASTM A 501 and shall be galvanized in accordance with the requirements of AASHTO M 180, Type 1.

The tubular thrie beam shall be fabricated from thrie beam elements conforming to the requirements of ARTBA, RE-63, Class A, Type 1.

Concrete anchors shall be of the type indicated on the project plans. The self-drilling type shall be internally threaded and the study type shall be externally threaded. Both types shall have an external slit expansion element and a single cone expander. Galvanizing shall be in accordance with the requirements of AASHTO M 232.

Where galvanizing has been damaged, the coating shall be repaired by painting with two coats of Paint No. 4.

TABLE 1012-1

GUARD RAIL FASTENERS

PART NAME	ARTBA DRAWING NO.	SPECIFICATION
Button Head Bolt (5/8" or M16), and Recess Nut	F- 3	AASHTO M 180
Hex Bolt		ASTM A 307
Heavy Hex Structural Bolt		ASTM A 325, Type 1
Hex Nut and Hex Thick Nut		ASTM A 563, Grade A
Heavy Hex Nut		ASTM A 563, Grade DH
Heavy Hex Screw		ASTM A 449
Plain Washer (Type A) and Plain Washer (Wide) (Type A)		ASTM F 436
Rectangular Plate Washer	F-12	AASHTO M 180, Class A, Type 1
Cable Assembly	F-37	AASHTO M 30, Class C
Cable End Plate	F-38	
Tapered Washer	F-40	ASTM F 436
Bearing Plate	F-41	
Flat Plate Washer	F-43	ASTM F 436
High Strength Anchor Bolt (3/4” or m20)	F-44	
Hex Nut		ASTM A 563
Round Head Square Neck Bolt		ASTM F 568

TABLE 1012-2

GUARD RAIL ELEMENTS

PART NAME	ARTBA DRAWING NO.	SPECIFICATION (AASHTO M 180)
W Beam	RE- 3	Class A, Type 1
W Beam Back-Up Plate	RE- 4	Class A, Type 1
W Beam Terminal Connector	RE- 8	Class A, Type 1
Rub Rail and Splice Plate	RE- 9	
Thrie Beam	RE-63	Class A, Type 1
Thrie Beam Back-Up Plate	RE-64	Class A, Type 1
Anchor Plate	RE-71	

TABLE 1012-3

GUARD RAIL POSTS

PART NAME	ARTBA DRAWING NO.	SPECIFICATION
G4 and MB4 Structural Shape Post and Block	P-10	
G4 and MB4 Bent Plate Post and Block (Steel)	P-52	ASTM A 570, Grade 40
G9 and MB9 Structural Shape Post and Block	P-54	
G9 and MB9 Bent Plate Post and Block (Steel)	P-56	ASTM A 570, Grade 40
Terminal Post (Steel)	P-60	ASTM A 500, Grade B
Terminal Post Foundation Plates (Steel)	P-61	

Timber for posts and blocks shall be rough sawn (unplanned) or S4S with the nominal dimensions indicated. Any species or group of woods graded in accordance with the requirements for Timber and Posts of the Western Wood Products Association may be used.

Timber shall be No. 1 and the stress grade shall be as follows:

6" x 8" (*150 x 200 mm*) Post and Block	1200 psi (*8.3 MPa*)
8" x 8" (*200 x 200 mm*) Post and Block	900 psi (*6.2 MPa*)
10" x 10" (*250 x 250 mm*) Post	900 psi (*6.2 MPa*)

When the plans show guard rail systems using 8 inch x 8 inch (*200 x 200 millimeters*) timber posts and blocks, the Contractor may use 8 1/4 inch x 8 1/4 inch (*210 x 210 millimeters*) nominal size posts and blocks with a stress grade of 825 psi (*5.7 megapascals*).

At the time of installation, the dimensions of timber posts and blocks shall vary no more than ± 1/2 inch (*± 13 millimeters*) from the nominal dimensions as hereinbefore specified.

The size tolerance of rough sawn blocks in the direction of the bolt holes shall vary no more than ± 3/8 inch (*± 10 millimeters*). Only one type of post and block shall be used for any one continuous length of guard rail.

All timber shall have a preservative treatment in accordance with the requirements of AASHTO M 133.

SECTION 1013

BEARING PADS

1013-1 PREFORMED FABRIC PADS

Preformed fabric pads shall be composed of multiple layers of 8 ounce (*227 grams*) cotton duck impregnated and bound with high quality natural rubber or of equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be such as to produce the specified thickness, after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 pounds per square inch (*69 megapascals*) without detrimental reduction in thickness or extrusion.

The manufacturer certification and sampling shall conform to the requirements of Subsection 1013-3.

1013-2 ELASTOMERIC BEARING PADS

1013-2.01 General. The work shall consist of furnishing and installing elastomeric bearing pads. Bearings shall be constructed in accordance with the details shown on the plans and as specified in these specifications.

Prior to shipment from the point of manufacture, bearings shall be packaged in such manner to ensure that during shipment and storage the bearings will be protected against damage from handling, weather, or any normal hazard. All bearings shall be stored at the work site in an area that provides protection from environmental and physical damage. When installed, bearings shall be clean and free of all foreign substances.

Bearings shall be installed to the positions and orientations shown on the plans. Bearings shall be set level, in exact positions, and must have full and even bearing on all bearing planes. Bearings surfaces located at improper elevations or set not level and true to plane shall be corrected prior to placement of bearings. Elastomeric bearing pads shall be set directly on properly prepared concrete surfaces without bedding material.

Elastomeric bearing pads shall include unreinforced pads (consisting of elastomer only) and reinforced bearings with steel or fabric laminates.

Bearings shall be furnished with the dimensions, material properties and elastomer grade required by the plans. Unless otherwise specified on the plans, bearings which have thicknesses greater than 1/2 inch (*13 millimeters*) shall be reinforced with steel or fabric laminates. The design method (A or B) and the design load shall also be shown on the plans and testing shall be performed accordingly. In the absence of more specific information, bearings shall be Grade 3, an elastomer with 130 psi (*895 kilopascals*) shear modulus (55 durometer hardness), and shall be subjected to the load testing requirements corresponding to Method A design.

1013-2.02 Material Properties. The sole polymer in the elastomeric compound shall be neoprene and shall not be less than 60 percent, by volume, of the total compound. The elastomer compound shall be classified as being of low temperature Grade 0, 2 or 3. The grades are defined by the testing requirements in Table 1013-1. A higher grade of elastomer may be substituted for a lower one.

The elastomer compound shall meet the minimum requirements of Table A except as otherwise specified by the Engineer. Test requirements may be interpolated for intermediate hardness. The material will be specified by its shear modulus whose measured value shall lie within 15 percent of the specified value. A consistent value of hardness shall also be supplied for the purpose of defining limits for the tests in Table A. Laminated bearings shall not have a shear modulus greater than 1.4 megapascals. When test specimens are cut from the finished product, the physical properties shall be permitted to vary from those specified in Table A by 10 percent. All material tests shall be carried out at 75° ± 3° F (*23 ± 2 °C*), unless otherwise noted. Shear modulus tests shall be carried out using the apparatus and procedure described in Annex A of ASTM D 4014.

TABLE 1013-1

NEOPRENE QUALITY CONTROL TESTS Note in the table that ASTM D 1043 refers to "modulus of rigidity" while ASTM D 4014 refers to "shear modulus." The work "stiffness" is used here to cover both terms.				
Physical Properties				
D 2240	Hardness (Shore A Durometer)	45 to 75		
		50 ± 5	60 ± 5	70 ± 5
D 412	Tensile Strength, Minimum PSI (*Mpa*)	2250 (*15.5*)	2250 (*15.5*)	2250 (*15.5*)
	Ultimate Elongation, Minimum	400	350	300
Heat Resistance				
D 573 70 hrs at 100 °C	Change in Durometer Hardness Maximum Points	15	15	15
	Change in Tensile Strength, Maximum %	-15	-15	-15
	Change in Ultimate Elongation, Maximum %	-40	-40	-40
Compression Set				
D 395 Method B	22 hours at 100 °C Maximum %	35	35	35
Ozone				
D 1149	100 PPHM Ozone in Air by Volume 20% Strain 100 ±2° F (*38 ± 1 °C*) 100 Hours Mounting Procedure ASTM D 518, Procedure A	No Cracks		

TABLE A: NEOPRENE QUALITY CONTROL TESTS. Note in the table that ASTM D 1043 refers to "modulus of rigidity" while ASTM D 4014 refers to "shear modulus." The word "stiffness" is used here to cover both terms.		
Instantaneous Low Temperature Brittleness		
D 746 Procedure B	Grade 1 No Test Required Grade 2 No Test Required Grade 3 Brittleness at -40 °C	No Failure
Instantaneous Thermal Stiffening		
D 1043	Grade 0 -Tested at -32 °C Grade 2 - Tested at -32 °C Grade 3 - Tested at -40 °C	(1) (1) (1)
Low Temperature Crystallization		
Quad Shear Test as Described	Grade 0 - No Test Required Grade 2 - 7 Days at -18°C Grade 3 - 14 Days at -26 °C	(2) (2) (2)
(1) Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C. (2) Stiffness at test time and temperature shall not exceed four times the stiffness measured at 23 °C with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ±24 % strain cycle shall be used, and a complete cycle of strain shall be applied with a period of 100 seconds. The first 3/4 cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next 1/2 cycle of loading.		

Certification, sampling and testing shall conform to the requirements of Subsection 1013-3.

1013-2.03 Plain and Fabric Reinforced Elastomeric Bearing Pads: Pads less than or equal to 1/2 inch (*13 millimeters*) in thickness shall be all elastomer. Pads greater than 1/2 inch (*13 millimeters*) will not be permitted; however, cold bonding of individual laminated pads will be permitted providing the bond between the pads has a minimum peel strength of 20 pounds per square inch (*3.5 newtons per millimeter*).

Laminated pads shall consist of alternate layers of elastomer and fabric reinforcement bonded together. The top and bottom layers of reinforcement shall be uniformly covered with a layer of elastomer. The thickness of elastomer cover shall not vary.

Laminated pads shall have reinforcement every 1/2 inch (*13*

millimeters) through the entire thickness. Fabric reinforcement shall be single ply at top and bottom surfaces of the pad and double ply within the pad. Fabric shall be free of folds and ripples and shall be parallel to the top and bottom surfaces. Variations in the location of the reinforcement from its theoretical location in excess of the specified Fabrication Tolerances will be cause for rejections.

Pads of all-elastomer, or with fabric reinforcement, may be cut from large sheets. Cutting shall be performed in such a manner as to avoid heating of the material, to produce a smooth edge with no tears or other jagged area, and to cause as little damage to the material as possible. The cutting method shall not cause any separation of the fabric from the elastomer of laminated bearings.

Flash tolerance, finish, and appearance shall meet the requirements of the latest edition of the Rubber Handbook, published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings.

The bond between elastomer and fabric shall be such that when a sample is tested for separations, it shall have a minimum peel strength of 30 pounds per square inch (*5.3 newtons per millimeter*) of width.

Fabric reinforcement shall be woven from 100 percent glass fibers of "E" type yarn with continuous fibers. The minimum thread count in either direction shall be one thread per millimeter. The fabric shall have either a crowfoot or an 8 harness Satin weave. Each ply of fabric shall have a breaking strength of not less than 140 newtons per millimeter of width in each thread direction when 3 inch (*75 millimeter*) by 3 foot (*900 millimeter*) samples are tested on split drum grips. The bond between double plies shall have a minimum peel strength of 20 pounds per square inch (*3.5 newtons per millimeter*) of width. Holes in the fabric will not be permitted.

1013-2.04 Steel Reinforced Elastomeric Bearing Pads: At the contractor's option, steel reinforced elastomeric bearing pads may be furnished in lieu of fabric reinforced elastomeric bearing pads that are 1/2 inch (*13 millimeters*) in thickness and over.

Steel reinforced elastomeric bearing pads shall conform to the requirements for steel-laminated elastomeric bearings as specified in ASTM Designation D 4014 and the following:

The thickness of each bearing pad shall be as shown on the project plans. The bearings shall consist of N-1 internal elastomer laminates and N steel laminates, where N is equal to the bearing pad thickness shown on the project plans divided by 1/2 inch (*13 millimeters*). The steel laminates shall be 3/64 inch (*1.90 millimeters*) thick and shall be spaced every 1/2 inch (*13 millimeters*) center-to-center. The top and bottom steel laminates shall have 1/4 inch (*6 millimeters*) of elastomer cover as measured from the center of the steel laminate to the pad surface.

The elastomer clear cover thickness from the surface to the steel laminates at the sides of the bearings shall be 1/8 inch (*3 millimeters*). If guide pins or other devices are used to control the side cover over the steel laminates, any exposed portions of the steel laminates shall be sealed by vulcanized patching.

Steel laminates used for reinforcement shall be made from rolled mild steel conforming to ASTM A 36/A 36M, A 570/A 570M, or A 611, Grade D, unless otherwise specified by the Engineer. Holes in plats for manufacturing purposes will not be permitted unless they have been accounted for in the design, as shown on the plans.

Bearings with steel laminates shall be cast as a unit in a mold and shall be bonded and vulcanized under heat and pressure. The mold finish shall conform to standard shop practice. The internal steel laminates shall be sandblasted and cleaned of all surface coatings, rust, mill scale, and dirt before bonding, and shall be free of sharp edges and burrs. External load plats (sole plates) shall be protected from rusting by the manufacture, and preferably shall be hot bonded to the bearing during vulcanization. Bearings that are designed to act as a single unit with a given shape factor must be manufactured as a single unit.

Steel laminated bearings shall develop a minimum peel strength of 40 pounds per square inch (*7.0 newtons per millimeter*) of width. Peel strength tests shall be performed by ASTM D 429 Method B.

1013-2.05 Fabrication Tolerances: Plain pads and laminated bearings shall be built to the specified dimension within the tolerances listed in Table 1013-2:

TABLE 1013-2

FABRICATION TOLERANCES

Parameters	Tolerance
1. Overall Height	
Design Thickness 1-1/4 inches (*32 millimeters*) or less	- 0, + 1/8 inch (*+3.2 millimeters*)
Design Thickness over 1-1/4 inches (*32 millimeters*)	- 0, + 1/4 inch (*+ 6.4 millimeters*)
2. Overall Horizontal Dimensions	
36 inches (*900 millimeters*) or Less	- 0, +1/4 inch (*+ 6.4 millimeters*)
Over 36 inches (*900 millimeters*)	- 0, 1/2 inch (*+ 12.7 millimeters*)
3. Thickness of Individual Layers of Elastomer at any Point Within the Bearing	± 20% of Design Value but no more than ± 1/8 inch (*± 3.2 millimeters*)
4. Parallelism with Opposite Face	
Top and Bottom	0.005 Radians
Sides	0.02 Radians
5. Position of Exposed Connection Member, Holes, slots or Inserts	± 1/8 inch (*± 3.2 millimeters*)
6. Edge Cover Embedded Laminates or Connection Members	- 0, ± 1/3 inch (*+ 3.2 millimeters*)
7. Thickness	
Top and Bottom Cover Layer (if required)	- 0, the smaller of 1/16 inch (*+1.6 millimeters*) and + 20% if the nominal cover layer thickness
8. Size	
Holes, Slots, or Inserts	± 1/8 inch (*± 3.2 millimeters*)

1013-3 CERTIFICATION AND TESTING

1013-3.01 General Requirements: The contractor shall furnish the Engineer with certification from the manufacturer that the bearings to be furnished conform to all specified requirements. The certifications shall be supported by Certificates of Analysis conforming to the requirements of Subsection 106-5 each reinforced bearing shall be marked in indelible ink or flexible paint. The marking shall consist of the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified in the contract document, the marking shall be on the face that is visible after erection of the bridge.

A minimum of two sample pads from every 100 pads furnished, or portion thereof, will be selected at random by the Engineer at the project site for testing. A minimum of one sample pad will be selected from each lot. A lot shall consist of a single type of bearing of the same design, material, plan dimensions and thickness, delivered to the project site at the same time. Samples shall consist of complete pads as detailed on the project plans and as specified herein. The contractor shall furnish additional complete pads to replace those taken for testing. Pads shall be available for testing at least three weeks in advance of intended use.

The contractor shall, at no additional cost to the Agency, have the sample elastomeric bearing pads tested by a testing laboratory. The testing laboratory shall be as approved by the Engineer, shall be independent of the bearing pad manufacturer, and shall be under the supervision of a registered professional engineer. The contractor shall furnish the Engineer with certification by the approved testing laboratory that the bearings tested conform to the specified requirements for dimensional tolerances.

The contractor shall furnish to the Engineer certification by the approved testing laboratory that the bearings tested conform to all of the above requirements. The certification shall be support by Certificates of Analysis conforming to the requirements of Subsection 106-5.

The ambient temperature tests on the elastomer described in Subsection 1013-3.02(A) shall be conducted for the materials used in each lot of bearings. In lieu of performing a shear modulus test for each batch of material, the manufacturer may elect to provide certificates from tests performed on identical formulations within the preceding year, unless otherwise specified by the Engineer. Test certificates from the supplier shall be provided for each lot of reinforcement.

The three low temperature tests on the elastomer described in Subsection 1013-3.02(B) shall be conducted on the material used in each lot of bearings for Grade 3 material, and the instantaneous thermal stiffening test shall be conducted on material of Grades 0 and 2. For Grade 3 material, in lieu of the low temperature crystallization test, the manufacturer may choose to provide certificates from low-temperature crystallization tests performed on identical material within the latest year, unless otherwise specified by the engineer. Low temperature brittleness and crystallization tests are not required for Grades 0 and 2 materials, unless especially requested by the Engineer.

Every finished bearing shall be visually inspected in accordance with Subsection 1013-3.02(C).

Every steel reinforced bearing shall be subjected to the short-term load test described in Subsection 1013-3.02(D).

From each lot of bearings designed by Method B of Article 14.4, Division 1 of the AASHTO Specification, a random sample shall be subjected to the long-term load test described in Subsection 1013-3.02(E). The sample shall consist of at least one bearing chosen randomly form each size and material batch and shall comprise at least 10 percent of the lot. If one bearing of the sample fails, all the bearings of that lot shall be rejected, unless that manufacturer elects to test each bearing of the lost at not additional cost to the Department. In lieu of this procedure, the Engineer may require every bearing of the lot to be tested.

The Engineer may require shear stiffness tests on material from a random sample of the finished bearings in accordance with Subsection 1013-3.02(F).

1013-3.02 Testing Requirements

(A) Ambient Temperature Test on the Elastomer: The elastomer used shall at least satisfy the limits prescribed in Table A for durometer hardness, tensile strength, ultimate elongation, heat resistance, compression set, and ozone resistance. The bond to the reinforcement, if any, shall also satisfy the bond requirements in Subsection 1013-2.03 or 1013-2.04. The shear modulus of the material shall be tested at 75° F (*23 °C*) using the apparatus and procedure described in Annex A of ASTM D 4014. If shall fall within 15 percent of the specified value.

(B) Low Temperature Tests on the Elastomer: Grade 3 elastomer shall be subjected to low temperature brittleness tests (ASTM C 746), instantaneous low temperature stiffness tests (ASTM D 1043), and low temperature crystallization tests (ASTM D 4014). Grades 0 and 2 elastomers shall be subjected to instantaneous low temperature stiffness tests (ASTM D 1043). The tests shall be performed in accordance with the requirements of Table A and the compound shall satisfy all limits for its grade.

(C) Visual Inspection of the Finished Bearing: Every finished bearing shall be inspected for compliance with dimensional tolerances and for overall quality of manufacture. In steel reinforced bearings, the edges of the steel shall be protected everywhere from corrosion.

(D) Short-Duration Compression Tests on Bearings: The bearing shall be loaded in compression to 1.5 times its maximum design load. The load shall be held constant for 5 minutes, removed, and reapplied for another 5 minutes. The bearing shall be examined visually while under the second loading. If the bulging pattern suggests laminate parallelism or a layer thickness that is outside the specified tolerances, or poor laminate bond, the bearing shall be rejected. If there are three or more separate surface cracks that are greater than two millimeters wide and two millimeters deep, the bearing shall be rejected.

(E) Long-Duration Compression Tests on Bearings: The bearing shall be loaded in compression to 1.5 times its maximum design load for a minimum period of 15 hours. If, during the test, the load falls below 1.3 times the maximum design load, the test duration shall be increased by the period of time for which the load is below this limit. The bearing shall be examined visually at the end of the test while it is still under load. If the bulging pattern suggests laminate parallelism or a layer thickness that is outside the specified tolerances, or poor laminate bond, the bearing shall be rejected. If there are three or more separate surface cracks that are greater than 5/64 inch (*2 millimeters*) wide and 5/64 inch (*2 millimeters*) deep, the bearing shall be rejected.

(F) Shear Modulus Tests on Material From Bearings: The shear modulus of the material in the finished bearing shall be evaluated by testing a specimen cut from it using the apparatus and procedure described in Annex A of ASTM D 4014, or, at the discretion of the Engineer, a comparable nondestructive stiffness

test may be conducted on a pair of finished bearings. The shear modulus shall fall within 15 percent of the specified value. If the test is conducted on finished bearings, the material shear modulus shall be computed from the measured shear stiffness of the bearings, taking due account of the influence on shear stiffness of bearing geometry and compressive load.

1013-4 INSTALLATION:

Bearings shall be placed on surfaces that are plane to within 1/16 inch (*1.6 millimeters*) and horizontal to within 0.01 radians. Exterior plates of the bearing shall not be welded unless at least 1-1/2 inch (*38 millimeters*) of steel exists between the weld and the elastomer. In no case shall the elastomer or the bond be subjected to temperatures higher than 400 °F (*204° C*).

SECTION 1014

GEOSYNTHETICS

1014-1 GENERAL REQUIREMENTS

Certificates of compliance, conforming to the requirements of Subsection 106-5(B), shall be submitted to the Engineer by the contractor upon delivery of geosynthetic materials for use on a specific project. If the delivered materials have not been evaluated and preapproved as noted below, it will be necessary for a Certificate of Analysis to be submitted to the Engineer along with the supporting documentation before the material may be considered for use on the project. Each geosynthetic material lot or shipment must be approved by the Engineer before the materials may be incorporated in the work.

Certificates of Analysis, conforming to the requirements of Subsection 106-5(C), may be submitted, along with a representative sample of appropriate size for testing, by the supplier or manufacturer of any geosynthetic material to the Agency's Materials Section for evaluation and preapproval. Testing methods and results shown in the Certificate of Analysis shall conform to the listed specifications for the proposed geosynthetic use. Supporting documentation including, but not limited to, product information use, and project references shall also be submitted by the supplier on manufacturer as part of product evaluation and preapproval.

Geosynthetic materials shall be furnished in protective covers capable of protecting the materials from harmful environmental conditions such as ultraviolet rays, abrasion, extreme heat, and water. Storage of the geosynthetic materials will be in a manner to prevent damage, contamination, or deterioration of the materials.

1014-2 PAVEMENT FABRIC

Pavement fabric shall be a geotextile fabric material, constructed of non-woven synthetic fibers of polyester or polypropylene. The pavement fabric shall be resistant to chemical attack, rot, and mildew, and shall have no tears or defects which will adversely alter its physical properties. The fabric shall be specifically designed for the designated pavement application, as a stress relieving membrane between two successive asphalt layers. The fabric material shall additionally conform to the following physical requirements:

Property	Requirements	Test Methods
Weight	3.5 to 5.0 oz./sq. yd. (*120 to 170 g/m^2*)	ASTM D 3776
Grab tensile strength,	80 lbs. minimum * (*355 N, minimum*)	ASTM D 4632
Elongation at break, percent	50 minimum *	ASTM D 4632
Fabric thickness	25 to 100 mils (*0.65 to 2.55 mm*)	ASTM D 461
Melting point	300° F or greater (*149 °C*)	ASTM D 276
Asphalt Retention,	0.2 gal./sq.yd. minimum (*0.9 L/M^2*)	Task Force 25, Method 8

* Minimum - Average value in weaker principal direction. All numerical values represent minimum average roll values, i.e., the average test result in the weak direction for a lot shall meet or exceed the minimum values listed when sampled according to ASTM D 4354 and tested according to the test method specified above.

The width of the fabric shall be appropriate for the proposed construction. Longitudinal fabric joints shall meet the same location requirements shown in Subsection 406-3.07 for pavement joints.

1014-3 GEOGRID

Geogrid reinforcement material for roadway base applications shall be a biaxial polymer grid structure, specifically fabricated for use as a base reinforcement. The geogrid shall be one of the following structure types:

(1) A structure comprised of punched and drawn polypropylene or high density polyethylene sheet to form a grid.

(2) A structure comprised of high density polyethylene or polypropylene extruded to form a grid.

The geogrid shall have high tensile strength and modulus in both principal directions, perpendicular to each other. The geogrid polymer materials shall contain stabilizers or inhibitors or shall be coated or encapsulated to prevent degradation of properties due to ultraviolet light exposure. The polymer shall also be inert to all naturally occurring alkaline and acidic soil conditions. The geogrid material shall additionally conform to the following physical requirements:

Property	Requirements	Test Methods
Average Aperture Size		I.D. CALIPERED, (1)
MD, (2)	0.8-2.0 inch (*20-50 mm*)	
XD, (3)	0.8-2.0 inch (*20-50 mm*)	
Open Area, (%)	70 min., (4)	COE Method, (5)
Weight, oz./yd.	5.5 oz./sq. yd. (*185 g/m^2*) min.	ASTM D 3776
Thickness, mils		ASTM D 1777
At Rib	30 mils min. (*0.75 mm*)	
At Junction	60 mils min. (*1.50 mm*)	
Wide Width Strip Tensile Strength		ASTM D 4595
At 2% Strain	275 lb./ft. min. (*4000 N/m*)	
At 5% Strain	550 lb./ft. min. (*800 N/m*)	
At 15% Strain or Ultimate	800 lb./ft. min. (*11500 N/m*)	
Flexural Rigidity, mg-cm	250,000 min.	ASTM D 1388
Junction Strength, %	80 min.	ASTM D 638 Mod., (6)

Note (1) Maximum inside dimension in each principal direction measured by calipers.

Note (2) MD-Machine direction which is along roll length.

Note (3) XD-Cross machine direction which is across the roll width.

Note (4) Minimum-Average value in weaker principal direction. All numerical values represent minimum average roll values, i.e., the average test result in the weaker principal direction shall meet or exceed the minimum values listed when sampled according to ASTM D 4354 and tested according to the test method specified above.

Note (5) Percent open area measured without magnification by the Corps of Engineers Method as specified in CW 02215 Civil Works Construction Guide, November 1977.

Note (6) Junction strength is measured as a percent of ultimate single rib strength by tensile loading test ASTM D 638 modified to clamp the horizontal and vertical ribs of the "T" shaped specimen, with the grid junction forming the cross of the "T", and with a constant rate of extension of the specimen applied across the junction at a rate of 2 inches (*50 millimeters*) per minute at a temperature of 68° F (*20 °C*).

The width of the geogrid shall normally be approximately 13 feet (*4 meters*) or as appropriate for the proposed construction. Longitudinal geogrid joints shall meet the same location requirements shown in Subsection 406-3.07 for pavement joints.

1014-4 SEPARATION GEOTEXTILE FABRIC

Separation geotextile fabric shall be a non-woven fabric consisting only of long chain polymeric filaments such as polypropylene, polyethylene, or polyester formed into a stable network such that the filaments retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals, resistant to rot, and mildew, and shall have no tears or defects which adversely affect or alter its physical properties. The physical requirements for the separation fabric will be determined by the survivability rating called out for the fabric in the special provisions or as shown on the project plans. Physical requirements for each survivability rating are listed in Subsections 1014-4.01, 1014-4.02, 1014-4.03, and 1014-4.04.

1014-4.01 Low Survivability Fabric.

(A) Non-Woven: Low survivability non-woven separation fabric shall meet the following minimum average roll values:

Property	Requirements	Test Methods
Grab Tensile Strength	90 lbs. (*400N*)	ASTM D 4632
Grab Elongation at Break, %	45 min., 115 max	ASTM D 4632
Puncture Strength	30 lbs. (*135 N*)	ASTM D 4833
Burst Strength	145(*1.0 MPa*)	ASTM D 3786
Trapezoidal Tear	30 lbs. (*135 N*)	ASTM D 4533
Permittivity, sec -1	0.07	ARIZ 730
Apparent Opening Size, U.S. Standard Sieve Size	30-100 (*600-150 μm*)	ASTM D 4751
Ultraviolet Stability, %	70	ASTM D4355-84

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater than 115 percent at break, the elongation will be acceptable if the grab/tensile strength requirement is met prior to or at 115 percent elongation.

(B) Woven: Low survivability, woven separation fabric shall meet the physical requirements listed in Subsection 1014-4.02(A) for moderate survivability non-woven fabric except that the grab elongation at break, percent, shall be 13 minimum, 115 maximum.

1014-4.02 Moderate Survivability Fabric.

(A) Non-Woven: Moderate survivability non-woven separation fabric shall meet the following minimum average roll values:

Property	Requirements	Test Methods
Grab Tensile Strength	140 lbs. (*625 N*)	ASTM D 4632
Grab Elongation at Break, %	45 min., 115 max	ASTM D 4632
Puncture Strength	50 lbs. (*220 N*)	ASTM D 4833
Burst Strength	220 psi (*1.50 MPa*)	ASTM D 3786
Trapezoidal Tear	40 lbs. (*180 N*)	ASTM D 4533
Permittivity, sec -1	0.07	ARIZ 730
Apparent Opening Size, U.S. Standard Sieve Size	30-100 (*600-150 µm*)	ASTM D 4751
Ultraviolet Stability, %	70	ASTM D4355-84

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater than 115 percent at break, the elongation will be acceptable if the grab tensile strength requirement is met prior to or at 115 percent elongation.

(B) Woven: Moderate survivability, woven separation fabric shall meet the physical requirements listed in Subsection 1014-4.03(A) for high survivability nonwoven fabric except that the grab elongation at break, percent, shall be 13 minimum, 115 maximum.

1014-4.03 High Survivability Fabric. High survivability geotextile fabrics shall meet the following minimum average roll values:

Property	Requirements	Test Methods
Grab Tensile Strength	200 lbs. (*1.2 kN*)	ASTM D 4632
Grab Elongation at Break, %	45 min., 115 max	ASTM D 4632
Puncture Strength	80 lbs. (*360 N*)	ASTM D 4833
Burst Strength	320 psi (*2.20 MPa*)	ASTM D 3786
Trapezoidal Tear	50 lbs. (*220 N*)	ASTM D 4533
Permittivity, sec -1	0.07	ARIZ 730
Apparent Opening Size, U.S. Standard Sieve Size	30-100 (*600-150 µm*)	ASTM D 4751
Ultraviolet Stability, %	70	ASTM D4355-84

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater than 115 percent at break, the elongation will be acceptable if the grab tensile strength requirement is met prior to or at 115 percent elongation.

(A) Woven: High survivability, woven separation fabric shall meet the physical requirements listed in Subsection 1014-4.04(A) for very high survivability nonwoven fabric except that the grab elongation at break, percent, shall be 13 minimum,. 115 maximum.

1014-4.04 Very High Survivability Fabric.

(A) Non-woven: Very high survivability non-woven separation fabric shall meet the following minimum average roll values:

Property	Requirements	Test Methods
Grab Tensile Strength	270 lbs. (*1.2 kN*)	ASTM D 4632
Grab Elongation at Break, %	45 min., 115 max	ASTM D 4632
Puncture Strength	110 lbs. (*490 N*)	ASTM D 3787
Burst Strength	430 psi (*2.96 MPa*)	ASTM D 3786
Trapezoidal Tear	75 lbs. (*335 N*)	ASTM D 4533
Permittivity, sec -1	0.07	ARIZ 730
Apparent Opening Size, U.S. Standard Sieve Size	30-100 (*600-150 μm*)	ASTM D 4751
Ultraviolet Stability, %	70	ASTM D4355-84

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater than 115 percent at break, the elongation will be acceptable if the grab tensile strength requirement is met prior to or at 115 percent elongation.

(B) Woven: Very high survivability, woven separation fabric shall meet the following minimum average roll values:

Property	Requirements	Test Methods
Grab Tensile Strength, kN	1.51	ASTM D 4632
Grab Elongation at Break, %	13 minimum, 115 maximum	ASTM D 4632
Puncture Strength, N	580	ASTM D 4833
Burst Strength, MPa	3.45	ASTM D 3786
Trapezoidal Tear, N	400	ASTM D 4533
Permittivity, sec -1	0.07	ARIZ 730
Apparent Opening Size, Sieve Size, µm	106-600	ASTM D 4751
Ultraviolet Stability, %	70	ASTM D4355-84

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater than 115 percent at break, the elongation will be acceptable if the grab tensile strength requirement is met prior to or at 115 percent elongation.

1014-5 BANK PROTECTION FABRIC

Geotextile fabric to be used behind bank protection such as rip rap, rail bank, or gabions as called out on the project plans shall be a woven monofilament fabric or non-woven fabric consisting only of long chain polymeric filaments such as polypropylene or polyester formed into a stable network such that the filaments retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties. The requirements for the bank protection fabric shall be as specified in Subsection 1014-4.03(A) except that the grab elongation at break shall be 15 percent minimum, 115 percent maximum, and the permittivity shall be 0.50 minimum.

1014-6 GEOCOMPOSITE WALL DRAIN SYSTEM

The Geocomposite Wall System shall be of composite construction, consisting of a supporting structure of drainage core material and a geotextile filter fabric permanently bonded to the core material on one side only. The geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure.

1014-6.01 Geocomposite Wall Drain Core. The wall drain core material shall consist of a preformed, stable, polymer plastic material with a cuspated, nippled, or geonet structure. The wall drain core shall provide support for and shall be bonded to the geotextile filter fabric at intervals not exceeding 1-1/8 inches (*30 millimeters*) in any direction. Its preformed structure shall

be perforated to allow water to flow freely to the weephole drainage outlets. If not perforated during manufacture, the core shall be perforated in the field at the weephole drainage outlet locations. The core shall have at least 14 square inches (*9 030 square millimeters*) of flat area in contact with the geotextile fabric to support the fabric. The core material shall additionally conform to the following physical requirements:

Property	Requirements	Test Methods
Thickness with Fabric	0.23 inch (*5.8 mm*)*	ASTM D 1777
Compressive Strength	6000 psf min. (*290 KPa*)	ASTM D 1621
Transmissivity (minimum) Gradient=1.0, Normal Stress= 3000 psf,	4.0 gal/min/foot (*50L/min/m*)	ASTM D 4716

*Minimum average roll value, i.e., the average test results for a lot shall meet or exceed the minimum valve listed when sampled and tested according to the specific test method.

The geocomposite core shall be furnished with an approved method for connecting with outlet pipes or weepholes as shown on the plans. These fittings shall allow entry of water from the core, but shall not allow intrusion of backfill material into the core.

1014-6.02 Geocomposite Wall Drain Fabric. The geotextile wall drain fabric shall be laminated onto or adhere to the side of the drainage core which will face the backfill. The geotextile fabric shall be a non-woven polyester or polypropylene fabric meeting the following minimum average roll values:

Property	Requirements	Test Methods
Weight	3.5 oz./sq.yd. (*120 g/m^2*)	ASTM D 3776
Grab Tensile Strength	90 lbs. (*400 N*)	ASTM D 4632
Grab Elongation at Break, %	35 min., 115 max	ASTM D 4632
Mullen Burst Strength	140 psi (*965 KPa*)	ASTM D 3786
Trapezoidal Tear Strength	30 lbs. (*130 N*)	ASTM D 4533
Puncture Strength	30 lbs. (*130 N*)	ASTM D 3787
Apparent Opening Size, U.S. Standard Sieve Size	30-140 (*600-150 μm*)	ASTM D 4751
Permittivity, sec -1	0.50	ARIZ 730
Ultraviolet Stability, %	70	ASTM D 4355

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater than 115

percent at break, the elongation will be acceptable if the grab tensile strength requirement is met prior to or at 115 percent elongation.

A minimum 3 inch (*75 millimeter*) wide flap of geotextile fabric shall extend beyond both longitudinal edges of the geocomposite core. The geotextile fabric shall cover the full length of the core.

1014-7 GEOCOMPOSITE EDGE DRAIN SYSTEM

The geocomposite edge drain system shall be of composite construction, consisting of a supporting rectangular structure of drainage core material wrapped with a geotextile filter fabric. The fabric shall surround and be attached to the core material in a manner that does not restrict the flow capacity of the core material. The geocomposite shall be resistant to commonly encountered chemicals and hydrocarbons, and resistant to ultraviolet exposure.

1014-7.01 Geocomposite Edge Drain Core. The edge drain core material shall consist of a preformed, stable, polymer plastic material with a cuspated, nippled, ridged, slotted, and/or perforated structure. The drainage core shall provide support for and may be bonded to the geotextile filter fabric. Its preformed structure shall be perforated to allow water to flow freely to the weephole drainage outlets. If not perforated during manufacture, the core shall be perforated in the field at the weephole drainage outlet locations unless otherwise approved by the Engineer. The core shall have at least 14 square inches (*9 030 square millimeters*) of flat area in contact with the geotextile fabric to support the fabric per square foot (*300 square millimeters*). The core material shall additionally conform to the following physical requirements:

Property	Requirements	Test Methods
Thickness Wrapped with Fabric	0.75 in (*19 mm*) min [1]	ASTM D 1777
Compressive Strength	4000 psf (*190 KPa*) min.	ASTM D 1621
Transmissivity, Fabric Wrapped Core Gradient=0.1, Normal Stress= 1500 psf	4.0 gal/min/ft min. (*50L/min/m*)	ASTM D 4716 [2]
Width	1.0 t (*300 mm*) min [3]	Measured

(1) Minimum average roll value, i.e., the average test results for a lot shall meet or exceed the minimum valve listed when sampled and tested according to the specific test method.

(2) Use a full width panel, if possible, testing flow on the side which may be placed against the soil to be drained.

(3) Minimum width normally required, but shall be the minimum width specified on the plans, if that is greater.

1014-7.02 Geocomposite Edge Drain Fabric. The geotextile edge drain fabric shall completely wrap around the drainage core material in a snug manner and may be permanently bonded to the core. The geotextile fabric shall be a non-woven polyester or polypropylene fabric meeting the following minimum average roll values:

Property	Requirements	Test Methods
Weight	3.5 oz./sq.yd. (*120 g/m²*)	ASTM D 3776
Grab Tensile Strength	90 lbs. (*400 N*)	ASTM D 4632
Grab Elongation at Break, %	35 min., 115 max	ASTM D 4632
Mullen Burst Strength	140 psi (*965 KPa*)	ASTM D 3786
Trapezoidal Tear Strength	30 lbs. (*130 N*)	ASTM D 4533
Puncture Strength	30 lbs. (*130 N*)	ASTM D 4833
Apparent Opening Size, U.S. Standard Sieve Size	30-100 (*600-150 μm*)	ASTM D 4751
Permittivity, sec -1	0.50	ARIZ 730
Ultraviolet Stability, %	70	ASTM D 4355

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above.

1014-7.03 Outlet Pipes. The pipe for the edge drain outlet lateral shall be rigid, 4 inch (*100 millimeter*) diameter, Schedule 40 PVC pipe conforming to the requirements of ASTM D 1785, Schedule 40 polyethylene pipe conforming to the requirements of ASTM D 2104, or Schedule 40 ABS pipe conforming to the requirements of ASTM D 1527 or AASHTO M265.

The open end of the outlet pipe conduit shall be connected into either a drainage structure or a concrete pad drain in accordance with the details shown on the plans.

1014-8 SILT FENCE FABRIC

The geotextile silt fence fabric shall be non-woven or woven fabric consisting only of long chain polymeric filaments such as polypropylene or polyester formed or woven into a stable network such that the filaments retain their relative position to each other.

The fabric shall contain a stabilizer and/or inhibitors to make the filaments resistant to deterioration resulting from exposure to sunlight or heat.

The edges of the fabric shall be finished to prevent the outer yarn from pulling away from the fabric. The fabric shall be free of defects or flaws which significantly affect its physical or filtering properties. The fabric shall have a minimum width of 3 feet (*900 millimeters*). Sheets of fabric may be sewn or bonded together. No deviation from any physical requirements will be permitted due to the presence of the seam.

The fabric may be manufactured with pockets for posts, hems with cord or with posts preattached using staples or button head nails.

During all periods of shipment and storage, the fabric shall be wrapped in a heavy duty protected covering which will protect the cloth from sunlight, mud, dust, and debris. The fabric shall not be exposed to temperatures greater than 140° F (*60 °C*).

The fabric shall meet the following average roll values:

Property	**Requirements**	**Test Methods**
Grab Tensile Strength	120 lbs. min (*534 N*)	ASTM D 4632
Elongation at 50% of the minimum tensile strength (60 lbs. (*270 N*)), percent	50 maximum	ASTM D 4632
Permittivity, second $^{-1}$	0.05 minimum	ARIZ 730
Apparent Opening size, Sieve Size	30 (*600 µm*) max	ASTM D 4751
Ultraviolet Stability, percent	70 minimum	ASTM D 4355

Minimum average roll values represent the average test results for a lot in the weaker direction when sampled according to ASTM D 4354 and tested according to the test method specified above. If the average grab elongation of the fabric is greater that 115 percent at break, the elongation will be acceptable if the grab tensile strength requirement is met prior to or at 115 percent elongation.

1014-9 DRAINAGE FABRIC

Drainage geotextile fabric shall be used in the following applications: pavement edge drains, interceptor drains, underdrains, wall drains, recharge basins, and relief wells.

Drainage geotextile fabric shall be a non-woven fabric consisting only of long chain polymeric filaments such as polypropylene, polyethylene, or polyester formed into a stable network such that the filaments retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals, resistant to rot and mildew, and shall have no tears or defects which adversely affect or alter its physical properties.

The physical requirements for the drainage fabric shall be as specified in Subsection 1014-4.02(A) for moderate survivability non-woven separation fabric except that the permittivity requirement for drainage fabric shall be 0.50 section $^{-1}$.

SECTION 1015

EPOXY MATERIALS

1015-1 GENERAL REQUIREMENTS

Certificates of Compliance, conforming to the requirements of Subsection 106.05(B), shall be submitted to the Engineer by the contractor for any epoxy materials used on a specific project. The epoxy material must be on the current Approved Product List compiled by the Arizona Department of Transportation prior to submittal for use on an Agency project. The epoxy material must be approved for the use or application for which it is intended.

The contractor shall submit product literature and Material Safety Data Sheets (MSDS). The literature shall identify the recommended product use or applications for which it is intended, and the directions for use.

1015-1.01 Packaging, Labeling, and Storing. Each component of epoxy material shall be packaged in containers of size proportional to the amount of that component in the mix so that one container of each component is used in mixing one batch of epoxy material.

The containers shall be of such design that all of the contents may be readily removed, and shall be well sealed to prevent leakage. The containers and labeling shall meet U.S. Department of Transportation Hazardous Material Shipping Regulations, and the containers shall be of a material, or lined with a material, of such character as to resist any action or breakdown by the components.

Each container shall be clearly labeled with the product type and identification code, component designation (A or B), manufacturer's name, date of manufacture, batch or lot number, all directions for use, and such warnings or precautions concerning the contents as may be required by State or Federal Laws and Regulations.

Epoxy materials shall be stored in accordance with the manufacturer's recommendations at all times. Attention is directed to the characteristic of some epoxy components to crystallize or thicken excessively prior to use when stored at temperatures below 35 °F (*2 °C*). Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments, which cannot be readily dispersed with a paddle, shall not be used.

1015-1.02 Direction For Use. Use of epoxy materials shall be in accordance with the manufacturer's recommendations unless otherwise specified by the Engineer. Use of epoxy materials shall be allowed for only those uses as shown on the Approved Product List compiled by the Arizona Department of Transportation.

At the time of mixing, the two components of the epoxy material shall be at a temperature between 60 °F (*16 °C*) and 85 °F (*29 °C*), unless otherwise specified or approved by the Engineer. Any heating of the epoxy components shall be done by application of indirect heat.

Immediately prior to mixing, each component shall be thoroughly mixed with a paddle. Separate paddles shall be used to stir each component.

Immediately prior to use, the components of the epoxy materials shall be mixed together in the specified ratios according to the manufacturer's recommendations. When mixed, all epoxy materials shall have a uniform color without streaks. No solvent shall be added to any epoxy.

Surfaces on which the epoxy is to be placed shall be free of rust, paint, grease, asphalt and loose or otherwise deleterious materials. The surface shall be dry unless otherwise allowed according to the manufacturer's recommendations for use. Any overlay or inserted material which is to be bonded to the underlying surface shall be placed before thickening of the epoxy has begun.

When epoxy is used as a binder to make epoxy mortar, the components of the epoxy shall be thoroughly mixed together before the sand or fine aggregate is added. The type, gradation, and proportion of sand or fine aggregate added and mixed with the epoxy adhesive to make epoxy mortar shall be as specified or recommended by the manufacturer. The sand or fine aggregate moisture content shall not be more than 0.5 percent as determined in accordance with AASHTO T 265. All surfaces against which epoxy mortar is to be placed shall be primed with a coat of the epoxy adhesive just prior to placing the epoxy mortar.

1015-2 EPOXY RESIN BASE ANCHORING ADHESIVE

Epoxy resin base anchoring adhesive shall be used in anchoring dowels or tie bars into concrete. For horizontal applications where flow out of the anchoring hole is a problem, high viscosity or non-sag epoxies in the form of a gel are to be used. Low and medium viscosity epoxies may be used in vertical holes which open upward. The product shall specifically be designed for this application according to the manufacturer's product literature.

Epoxy resin base anchoring material shall provide a minimum pullout resistance of 5200 inch pounds (*58.7 kilonewtons*) when tested in accordance with Arizona Test Method 725. The pot life of the material shall be determined in accordance with AASHTO T 237, Part I. The pot life shall be within 25 percent or 10 minutes of the pot life specified by the manufacturer, whichever is greater.

1015-3 EPOXY RESIN BASE ADHESIVES

(A) General. The grade of the epoxy adhesive system shall match the proposed use as identified in the product literature provided by the manufacturer. The product shall specifically be designed for this application according to the manufacturer's product literature. The pot life of the material shall be determined in accordance with AASHTO T 237, Part I. The pot life shall be within 25 percent or 10 minutes of the pot life specified by the manufacturer, whichever is greater. Epoxies with high early strength development, as stated by the manufacturer, will be tested for conformance to the manufacturer's claims.

(B) Hardened Concrete to Hardened Concrete. Epoxy resin base adhesive to be used for adhering or bonding hardened concrete to hardened concrete and other materials shall conform to the requirements of ASTM C881, Type I for non-load bearing applications and Type IV for load bearing applications. Epoxy resin base adhesive shall be tested in accordance with the requirements of ASTM C882 and shall provide a slant shear compressive strength of 1000 psi (*7 MPa*) at 2 days and 1500 psi (*10 MPa*) at 14 days. The compressive strength shall be determined in accordance with ASTM C 109 for 2 inch (*50 millimeter*) cube specimens except that the epoxy materials shall be tested without the addition of sand, and for low viscosity materials which readily flow, no tamping is necessary. The compressive strength determined at 7 days shall be 8000 psi (*55 MPa*) for Type I epoxy and 10,000 psi (*70 MPa*) for Type IV epoxy.

(C) Hardened Concrete to Fresh Concrete. Epoxy resin base materials to be utilized for adhering or bonding freshly mixed concrete materials to hardened concrete, shall conform to the requirements of ASTM C 881, Type II for non-load bearing applications and Type V for load bearing applications. Epoxy resin base adhesive shall be tested in accordance with the requirements of ASTM C 882 and shall provide a slant shear compressive strength of 1500 psi (*10 MPa*) at 14 days. The compressive strength shall be determined in accordance with ASTM C 109 for 2 inch (*50 millimeter*) cube specimens except that the epoxy materials shall be tested without the addition of sand, and for low viscosity materials which readily flow, no tamping is necessary. The compressive strength determined at 7 days shall be 5000 psi (*35 MPa*) for Type II epoxy and 8000 psi (*55 MPa*) for Type V epoxy.

1015-4 EPOXY RESIN BASE BINDER FOR EPOXY MORTAR

Epoxy resin base materials to be used for binder in epoxy mortar, shall conform to the requirements of ASTM C 881, Type I for non-load bearing applications and Type IV for load bearing applications. The grade of the epoxy adhesive system shall match the proposed use as identified in the product literature provided by the manufacturer. The product shall specifically be designed for this application according to the manufacturer's product literature.

Epoxy resin base adhesive for use as binder in epoxy mortar shall be tested in accordance with the requirements of ASTM C 882. In this test, the upper half of the slant shear test shall be molded epoxy mortar with the epoxy adhesive and sand or aggregate material mixed together as specified and in the proportions as recommended by the manufacturer. Prior to placing the epoxy mortar, the same epoxy adhesive shall be applied to the underlying concrete slant shear surface. The epoxy adhesive and mortar tested in this manner shall provide a slant shear compressive strength of 1000 psi (*7 MPa*) at 2 days and 1500 psi (*10 MPa*) at 14 days. The pot life of the mixed epoxy mortar shall be determined in accordance with AASHTO T 237, Part I. The pot life shall be within 25 percent or 10 minutes of the pot life specified by the manufacturer, whichever is greater. The compressive strength of the epoxy mortar shall be determined in accordance with ASTM C 109 for 2 inch (*50 millimeter*) cube specimens. The epoxy material shall be tested with the addition of sand, mixed together as specified and in the proportions as recommended by the manufacturer. The compressive strength determined in this test at 7 days shall be 8000 psi (*55 MPa*) for Type I epoxy and 10,000 psi (*70 MPa*) for Type IV epoxy. Epoxies with high early strength development, as stated by the manufacturer, will be tested for conformance to the manufacturer's claims.

1015-5 EPOXY RESIN BASE ADHESIVE FOR CRACK REPAIR

Epoxy resin base materials to be used for crack repair in concrete, shall be furnished as two components which shall be mixed together at or just before the point of injection.

The epoxy resin base adhesive shall conform to the requirements of ASTM C 881, Type I for use in non-load bearing applications and Type IV for use in load bearing applications. The grade of the epoxy adhesive system shall normally be Grade 1, low viscosity. Grade 2, medium viscosity epoxy adhesive systems may be used in larger width cracks. The product shall specifically be designed for this application according to the manufacturer's product literature.

The epoxy resin base adhesive for crack repair shall be tested in accordance with the requirements specified in Subsection 1015-3(B).

Immediately prior to injection, usually at or near the injection tip, the two components shall be brought together as part of the injection process. The injection equipment and process utilized shall be in accordance with the manufacturer's recommendations. No solvents shall be used to thin the material.

SECTION 1016

PACKAGED DRY CONCRETE AND MORTAR MATERIALS

1016-1 GENERAL REQUIREMENTS

Certificates of Compliance, conforming to the requirements of Subsection 106.05(B), shall be submitted to the Engineer by the contractor for any packaged dry concrete or mortar materials used on a specific project. The packaged dry concrete or mortar material must be on the current Approved Product List compiled by the Arizona Department of Transportation prior to submittal for use on the project, and must be approved for the application for which it is intended.

Packaged dry concrete and mortar materials shall be furnished premixed in a dry state including hydraulic cement, fine aggregate, coarse aggregate, and other ingredients as required for product performance. Only the addition of mix water shall be required at the site of the work.

The contractor shall submit product literature and Material Safety Data Sheets (MSDS). The literature shall identify the recommended product use or application for which it is intended, and the direction for use.

1016-1.01 Packaging, Labeling, and Storing. The dry concrete or mortar material shall be packaged in suitable containers of such design that all of the contents may be readily removed, and shall be moisture resistant to prevent premature hydration of the hydraulic cement in the mixture. The containers and labeling shall meet the applicable U.S. Department of Transportation Material Shipping Regulations, and the containers shall be of a material, or lined with a material, of such character as to resist any action or breakdown by the components.

Each package or container shall be clearly labeled with the product name, type and identification code, manufacturer's name, date of manufacture, batch or lot number, and such warnings or precautions concerning the contents as may be required by State or Federal Laws and Regulations. Additional information shall be either marked on the package or attached to it. The additional information may include surface preparation requirements; mixing, placing and curing instructions; maximum amount of water to be used or maximum recommended consistency; recommended maximum usable working time "pot-life" and approximate consistency at the end of that time; and the allowable temperature range for preparation and placement of the material.

Packaged dry concrete or mortar materials shall be stored in accordance with the manufacturer's recommendations at all times. Attention is directed to the characteristic of hydraulic cement materials to hydrate in the presence of moisture. Any material which shows evidence of hydration or does not appear suitable shall not be used.

1016-1.02 Directions For Use. Use of packaged dry concrete or mortar materials shall be in accordance with the manufacturer's recommendations unless otherwise specified or limited by the Engineer. Use of packaged dry concrete or mortar materials shall be allowed for only those uses as shown on the Approved Product List compiled by the Arizona Department of Transportation.

At the time of mixing, the packaged dry concrete or mortar materials shall be at a temperature within the range allowed according to the manufacturer's recommendations unless otherwise specified or approved by the Engineer. Any heating of the dry materials shall be done by application of indirect heat. The manufacturer may permit, in the package instructions, adjusting the mixing water temperature to achieve temperature limitations imposed for use of the dry concrete or mortar materials.

Immediately prior to use, the mixing apparatus shall be clean, prewetted, and drained, and essentially free of hardened concrete, mortar, and other foreign material that can be removed with a trowel or with a hammer, using reasonable force. Water shall be added to the dry concrete or mortar mix materials and the materials shall be thoroughly mixed to the desired consistency according to the manufacturer's recommendations. When thoroughly mixed, the concrete or mortar mixture shall have a uniform color. The amount of mixing water may be varied to achieve the desired consistency for the proposed use; however, the maximum recommended amount of mixing water shall not be exceeded.

Surfaces on which the concrete or mortar material is to be placed shall be free of rust, paint, oil, grease, asphalt and loose or otherwise deleterious materials. The surface of existing concrete shall be roughened to ensure a good bond and shall be cleaned thoroughly with water, leaving existing concrete saturated, but free of standing water. Any epoxy resin base adhesive may be required to bond the concrete or mortar material to the old concrete. Any overlay or inserted material which is to be bonded to the underlying surface shall be placed before the concrete patching material has begun to set.

The concrete or mortar materials may be drypacked, troweled, flowed, pumped or vibrated into place unless otherwise recommended by the manufacturer or specified herein. Use of an epoxy adhesive for bonding requires a dry surface unless otherwise recommended by the adhesive manufacturer. The method of placement depends on the application, but shall be in accordance with the manufacturer's recommendations.

1016-2 PACKAGED DRY HIGH-EARLY STRENGTH CONCRETE

Packaged dry high-early strength concrete materials for use in building and repair jobs requiring a more rapid strength development, such as required for the earlier removal of forms, shall conform to the requirements of ASTM C 387.

The compressive strength of packaged high-early strength concrete material at 3 days shall be a minimum of 3000 psi (*20.7 MPa*). The compressive strength at 7 days shall be a minimum of 3500 psi (*24 MPa*).

When placing the mixed high-early strength concrete against existing concrete for repair or patching applications, an epoxy resin base adhesive meeting the requirements of Subsection 1015-3 shall be applied to the surface of the existing concrete prior to placing the new concrete.

1016-3 PACKAGED DRY NORMAL STRENGTH CONCRETE

Packaged dry normal strength concrete materials for use in building and repair jobs where thicknesses exceed 9 inches (*50 millimeters*), shall conform to the requirements of ASTM C 387, normal weight concrete. Typical uses include building or repairing sidewalks, steps, footings, and for setting posts.

The compressive strength of packaged normal strength concrete material at 7 days shall be a minimum of 3000 psi (*20.7 MPa*). The compressive strength at 28 days shall be a minimum of 3500 psi (*24 MPa*).

When placing the mixed normal strength concrete against existing concrete for repair or patching applications, an epoxy resin base adhesive meeting the requirements of Subsection 1015-3 shall be applied to the surface of the existing concrete prior to placing the new concrete.

1016-4 PACKAGED DRY HIGH STRENGTH MORTAR

Packaged dry high strength mortar materials for use in work requiring thicknesses less than 2 inches (*50 millimeters*) shall conform to the requirements of ASTM C 387. Typical uses include topping and patching. High strength mortar is often referred to as "sand mix."

The compressive strength (mortar cubes) of packaged high strength mortar material at 7 days shall be a minimum of 3000 psi (*20.7 MPa*). The compressive strength at 28 days shall be a minimum of 5000 psi (*34.5 MPa*).

When placing the mixed high strength mortar against existing concrete for repair or patching applications, an epoxy resin base adhesive meeting the requirements of Subsection 1015-3 shall be applied to the surface of the existing concrete prior to placing the new mortar.

1016-5 PACKAGED DRY RAPID-HARDENING CONCRETE

Packaged dry rapid-hardening concrete materials for use in rapid repairs to hardened concrete shall conform to the requirements of ASTM C 928.

Aqueous solutions, emulsions or dispersions may be included as components of the packaged materials. The manufacturer may specify that these liquids are to replace some or all of the mixing water.

If the material contains soluble chlorides or other ingredients in sufficient quantity to cause corrosion to steel reinforcement, the material will not be acceptable.

The compressive strength of packaged rapid-hardening concrete material at 3 hours shall be a minimum of 500 psi (*3.5 MPa*). The compressive strength at 1 day shall be a minimum of 2000 psi (*13.8 MPa*) and at 7 days the compressive strength shall not be less than 4000 psi (*27.6 MPa*). The strength at 28 days shall not be less than the strength at 7 days.

Rapid-hardening concrete materials shall be tested in accordance with the slant shear requirements of ASTM C 882 by placing the test sample against a dummy section of hardened portland cement mortar. The slant shear test samples prepared in this manner shall provide a slant shear compressive strength of 1000 psi (*7 MPa*) at 1 day and 1500 psi (*10 MPa*) at 7 days.

The allowable length change of the rapid-hardening concrete material shall be determined in accordance with the requirements of ASTM C 157, except as modified in ASTM C 928, Sections 8.3 and 7.3. Based on the lengths of 3 inch (*75 millimeter*) prisms at 3 hours, the allowable length increase after 28 days in water shall be less than + 0.15 percent. The allowable length decrease in air after 28 days shall be less than - 0.15 percent.

The rapid-hardening concrete shall have a slump of 3 inches (*75 millimeters*) at 15 minutes after addition of the mixing liquid. When placing the mixed rapid-hardening concrete against existing concrete for repair or patching applications, no adhesive or other bonding system will be necessary unless required by the manufacturer.

1016-6 PACKAGED DRY VERY RAPID-HARDENING CONCRETE

Packaged dry very rapid-hardening concrete materials for use in rapid repairs to hardened concrete shall conform to the requirements of ASTM C 928.

Aqueous solutions, emulsions or dispersions may be included as components of the package materials. The manufacturer may specify that these liquids are to replace some or all of the mixing water.

If the material contains soluble chlorides or other ingredients in sufficient quantity to cause corrosion to steel reinforcement, the material will not be acceptable.

The compressive strength of packaged very rapid-hardening concrete material at 3 hours shall be a minimum of 1000 psi (*7 MPa*). The compressive strength at 1 day shall be a minimum of 3000 psi (*20.7*

MPa) and at 7 days the compressive strength shall not be less than 4000 (*27.6 MPa*). The strength at 28 days shall not be less than the strength at 7 days.

Very rapid-hardening concrete materials shall be tested in accordance with the slant shear requirements of ASTM C 882 by placing the test sample against a dummy section of hardened portland cement mortar. The slant shear test samples prepared in this manner shall provide a slant shear compressive strength of 1000 psi (7 *MPa*) at 1 day and 1500 psi (*10 MPa*) at 7 days.

The allowable length change of the very rapid-hardening concrete material shall be determined in accordance with the requirements of ASTM C 157, except as modified in ASTM C 928, Sections 8.3 and 7.3. Based on the lengths of 3 inch (*75 millimeter*) prisms at 3 hours, the allowable length increase after 28 days in water shall be less than + 0.15 percent. The allowable length decrease in air after 28 days shall be less than – 0.15 percent.

The very rapid-hardening concrete shall have a slump of 3 inches (*75 millimeter*) at 5 minutes after addition of the mixing liquid. When placing the mixed very rapid-hardening concrete against existing concrete for repair or patching applications, no adhesive or other bonding system will be necessary unless required by the manufacturer.

1016-7 PACKAGED DRY RAPID-HARDENING MORTAR

Packaged dry rapid-hardening mortar materials for use in rapid repairs to hardened concrete shall conform to the requirements of ASTM C 928.

The packaged dry rapid hardening mortar material shall conform to the same requirements for rapid hardening concrete listed in Subsection 1016-5, except that the compressive strength shall be determined on mortar cubes, the length changes will be determined using 1 inch (*25 millimeter*) prisms, and the consistency of 15 minutes after mixing will be a mortar flow of 100 percent, minimum.

1016-8 PACKAGED DRY VERY RAPID-HARDENING MORTAR

Packaged dry very rapid-hardening mortar materials, for use in rapid repairs to hardened concrete, shall conform to the requirements of ASTM C 928.

The packaged dry very rapid hardening mortar material shall conform to the same requirements for very rapid hardening concrete listed in Subsection 1016-6, except that the compressive strength shall be determined on mortar cubes, the length changes will be determined using 1 inch (*25 millimeter*) prisms, and the consistency at 5 minutes after mixing will be a mortar flow of 100 percent, minimum.

SECTION 1017

NONSHRINK GROUT MATERIALS

1017-1 GENERAL REQUIREMENTS

Certificates of Compliance, conforming to the requirements of Subsection 106.05(B), shall be submitted to the Engineer by the contractor for any nonshrink grout materials used on a specific project. The nonshrink grout material must be on the current Approved Product List compiled by the Arizona Department of Transportation prior to submittal for use on an Agency project. The nonshrink grout material must be approved for the use of application for which it is intended and shall meet the requirements of CRD-C621-83 Corps of Engineers Specification For Nonshrink Grout unless otherwise specified herein.

The contractor shall submit product literature and Material Safety Data Sheets (MSDS). The literature shall identify the recommended product use or application for which it is intended, and the direction for use.

Nonshrink grout materials shall be furnished premixed in a dry state including hydraulic cement, fine aggregate, and other ingredients as required for grout performance. Only the addition of mix water shall be required at the site of the work.

1017-2 PACKAGING, LABELING, AND STORING

The nonshrink grout materials shall be packaged in suitable containers of such design that all of the contents may be readily removed, and shall be moisture resistant to prevent premature hydration of the hydraulic cement in the grout mixture. The containers and labeling shall meet the applicable U.S. Department of Transportation Material Shipping Regulations, and the containers shall be of a material, or lined with a material, of such character as to resist any action or breakdown by the components.

Each package or container shall be clearly labeled with the product name, type and identification code, manufacturer's name, date of manufacture, batch or lot number, and such warnings or precautions concerning the contents as may be required by State or Federal Laws and Regulations. Additional information shall be either marked on the package or attached to it. The additional information may include surface preparation requirements; mixing, placing and curing instructions; maximum amount of water to be used or maximum recommended consistency; unit weight and yield at maximum recommended water content or maximum consistency; recommended maximum usable working time "pot-life" and approximate consistency at the end of that time; and the allowable temperature range for preparation and placement of the material.

Nonshrink grout materials shall be stored in accordance with the manufacturer's recommendations at all times. Attention is directed to the characteristic of hydraulic cement materials to

hydrate in the presence of moisture. Any material which shows evidence of hydration or does not appear suitable shall not be used.

1017-3 DIRECTIONS FOR USE

Use of nonshrink grout materials shall be in accordance with the manufacturer's recommendations unless otherwise specified or limited by the Engineer. Use of nonshrink grout materials shall be allowed for only those uses as shown on the Approved Product List compiled by the Arizona Department of Transportation.

At the time of mixing, the nonshrink grout materials shall be at a temperature within the range allowed according to the manufacturer's recommendations unless otherwise specified or approved by the Engineer. Any heating of the dry materials shall be done by application of indirect heat. The manufacturer may permit, in the package instructions, adjusting the mixing water temperature to achieve temperature limitations imposed for use of the grout materials.

Immediately prior to use, the grout mixing apparatus shall be clean, prewetted, and drained, and essentially free of hardened grout and other foreign material that can be removed with a trowel or with a hammer, using reasonable effort. Water shall be added to the grout materials and the grout shall be thoroughly mixed to the desired consistency according to the manufacturer's recommendations. When thoroughly mixed, the nonshrink grout mixture shall have a uniform color. The amount of mixing water may be varied to achieve the desired consistency for the proposed use; however, the maximum recommended amount of mixing water shall not be exceeded.

Surfaces on which the nonshrink grout material is to be placed shall be free of rust, paint, oil, grease, asphalt and loose or otherwise deleterious materials. The surface of existing concrete shall be roughened to ensure a good bond and shall be cleaned thoroughly with water, leaving existing concrete saturated, but free of standing water. Any overlay or inserted material which is to be bonded to the underlying surface shall be placed before the nonshrink grout material has begun to set.

The nonshrink grout materials may be drypacked, troweled, flowed, pumped or vibrated into place unless otherwise recommended by the manufacturer. The method of placement depends on the application, but shall be in accordance with the manufacturer's recommendations.

1017-4 NONSHRINK GROUT MATERIAL REQUIREMENTS

Nonshrink grout materials placed against existing concrete shall be tested in accordance with the slant shear requirements of ASTM C 882 by placing nonshrink grout against a dummy section of hardened portland cement mortar. The slant shear test samples

prepared in this manner shall provide a slant shear compressive strength of 1000 psi (*7 MPa*) at 7 days and 1500 psi (*10 MPa*) at 28 days.

The Vicat time of set for the material shall be determined in accordance with AASHTO T 131. The time of set shall be within 25 percent or 10 minutes of the time of set specified by the manufacturer, whichever is greater. The time of final setting shall be a maximum of 8 hours.

The compressive strength shall be determined in accordance with the requirements of CRD-C621-83, Corps of Engineers Specification For Nonshrink Grouts. The minimum compressive strength at 7 days shall be 3000 psi (*20.7 MPa*) and the minimum compressive strength at 28 days shall be 5000 psi (*34.5 MPa*). Nonshrink grouts with high early strength development as stated by the manufacturer will be tested for comformance to the manufacturer's claims. The compressive strength of nonshrink grout material at 28 days shall be equal to or greater than the 28 day compressive strength requirement of the concrete to be patched.

The expansion percent for the nonshrink grout material shall be determined in accordance with the requirements of CRD-C621-83. The maximum expansion shall be 0.4 percent when measured at 3, 14, and 28 days. The percent shrinkage at 28 days shall be none.

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