PROJECT SPECIFICATIONS

FOR

ARIZONA PROJECT

202 MA 054 H8827 01C

202-D-(200)S

Registered Professional Engineer (Civil)
CERTIFICATE NO.
49430
GREGORY
PATRICK
FLY
Date Signed 11-11-20
ARIZONA U.S.A.

SOUTH MOUNTAIN FREEWAY (SR 202)

I-10 (MARICOPA) – I-10 (PAPAGO)

CONSTRUCT ROADWAY

PROJECT SPECIFICATIONS (NON-ADOT MAINTAINED AREAS) – VOLUME 2

VERSION	***DESCRIPTION***	***DATE***
A	*INITIAL REVIEW SUBMITTAL*	*6/22/16*
B	*FINAL REVIEW SUBMITTAL*	*10/3/16*
0	*RELEASED FOR CONSTRUCTION*	*12/22/16*
1	*NDC 0011*	*03/07/17*
2	*NDC 0037*	*05/22/17*
3	*NDC 0061*	*05/22/17*
4	*NDC 0159*	*09/04/17*
5	*NDC 0133*	*08/02/17*
6	*NDC 0160*	*09/18/17*
7	*NDC 0226*	*11/17/17*
8	*NDC 0490*	*09/28/18*
9	*NDC 0594*	*05/17/19*
10	*NDC 0641*	*07/31/19*
11	*NDC 0673*	*11/15/19*
12	*NDC 0706*	*04/10/20*
13	*NDC 0732*	*11/02/20*

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	3	05/22/17	NDC 0061
	4	09/04/17	NDC 0159
	5	08/02/17	NDC 0133
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	7	11/17/17	NDC 0226
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DIVISION 1000	0	12/08/16	RFC
	1	09/28/18	NDC 0490
	2	07/31/19	NDC 0641

SECTION 100 GENERAL:

The Design-Build-Maintain Agreement (DBMA) shall be used as the underlying agreement with regards to the development of the proposed improvements. These Specifications are intended to address the construction activities, the design and maintenance activities are to be delivered based on other contract documents.

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

Elements of work that are outside of the control of access of the Project are to be constructed per the appropriate jurisdictional specifications. Note that select City of Phoenix specifications have been incorporated to these project specifications pertaining to the following:

1. Traffic signals at:
    a. NB 59th Ave/Roosevelt,
    b. SB 59th Ave/Roosevelt,
    c. 59th Ave/Lower Buckeye
2. Crossroad lighting (except for the lighting on ADOT signals)
3. Striping from the 300' full width improvements transitioning to existing stripes
4. Water Distribution Components

Specifications for ADOT and City of Phoenix for their respective maintenance areas will be covered in a separate document.

SECTION 101 DEFINITIONS AND TERMS:

101.01 Abbreviations:

Wherever the following abbreviations are used in these specifications or in other contract documents, they are to be construed the same as the respective expressions represented:

ADOT Arizona Department of Transportation

ASTM American Society for Testing and Materials

AWG American Wire Gauge

C202P Connect 202 Partners (Developer)

FHWAFederal Highway Administration

MAG Maricopa Association of Governments

MUTCD Manual on Uniform Traffic Control Devices

OSHA Occupational Safety and Health Administration/Act

101.02 Definitions:

Wherever in the contract the following are used, the intent and meaning shall be interpreted as follows:

Aggregate:

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

Average Value (AVE):

The arithmetic mean of a set of values, which is defined as the sum of all of the values divided by the number of values.

Backfill:

Material placed in an excavated space to fill such space.

Bridge:

A structure, including supports, erected over a depression or an obstruction, as water, highway or railway and having a track or passageway for carrying traffic or other moving loads and having an opening measured along the center of the roadway of more than 20 feet between under copings 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 bridge floor.

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

Substructure: All that part of a structure below the bearings of simple and continuous spans, skewbacks of arches and top of footings of rigid frames; including backwalls, wingwalls and wing protection railings.

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

Channel:

A natural or artificial watercourse.

Characteristic:

A measurable property of a material, product, or item of construction.

Conduit:

A pipe used for receiving and protecting wires or cable.

Construction Easement:

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

Contract (or Contract Documents):

The term "Contract Documents" shall mean the documents listed in this Section 1.2. Each of the Contract Documents is an essential part of the agreement between the Parties, and a requirement occurring in one is as binding as though occurring in all. The Contract Documents are intended to be complementary and to describe and provide for a complete agreement. Subject to Sections 1.2.2 through 1.2.6, in the event of any conflict among the Contract Documents, the order of precedence, from highest to lowest, shall be as set forth below:

(a) Supplemental Agreements and Agreement amendments (excluding amendments to the Technical Provisions which are separately addressed in subparagraphs (d) and (e), below), and all exhibits and attachments thereto;
(b) This Agreement (including all exhibits and the executed originals of exhibits that are contracts, except Exhibit 2);
(c) Developer's Proposal Commitments, and ATCs and alternative design concepts as set forth in Exhibit 2-1;
(d) Technical Provisions amendments, and all exhibits and attachments to such amendments;
(e) Technical Provisions, and all exhibits and attachments to the Technical Provisions;
(f) Special provisions in publications and manuals to the extent incorporated by reference into the Technical Provisions;
(g) Publications and manuals to the extent incorporated by reference into the Technical Provisions; and
(h) RFC Submittals to be developed in accordance with the Contract Documents, provided that: (i) specifications contained therein shall have precedence over plans; (ii) no conflict shall be deemed to exist between the RFC Submittals and the other Contract Documents with respect to requirements of the RFC Submittals that ADOT determines are more beneficial than the requirements of the other Contract Documents; and (iii) any other Deviations contained in the RFC Submittals shall have priority over conflicting requirements of other Contract Documents only to the extent that the conflicts are specifically identified to ADOT by Developer and ADOT approves such Deviations in writing in its sole discretion.

Contractor:

The individual, partnership, firm, corporation, or any acceptable combination thereof, or joint venture, contracting with the Developer for performance of the Project. Term also refers to the Developer if the scope of work is being self-performed by the Developer.

Culvert:

Any structure, not classified as a bridge, which provides an opening under the roadway and/or grade.

Day:

A calendar day.

Deficiency:

Departure from, or noncompliance with, specified criteria.

Department:

Means the Arizona Department of Transportation, a public agency as constituted under the laws of the State of Arizona.

Developer (C202P):

Means Connect 202 Partners, LLC, a Delaware limited liability company, together with its permitted successors and assigns.

Engineer:

The Design Engineer, acting by and under the authority of the laws of the State of Arizona in matters relating to design activities.

Equipment:

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

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.

Independent Quality Firm:

means the independent firm identified in the Proposal (or such other firm approved by ADOT in ADOT's sole discretion) responsible for performing independent quality assurance material testing, inspection, audits of the Construction Quality Management Plan, and audits of the Maintenance Quality Management Plan as it relates to Capital Asset Replacement Work. The initial ADOT approved IQF is Raba Kistner, Inc., a Texas corporation.

Inspector:

The Independent Quality Firm's authorized representative assigned to make detailed inspections of construction installations and contract performance.

Laboratory:

The testing laboratory of the Developer or any other testing laboratory which is certified or approved by the Developer.

Lot:

A designated or measured amount of construction or quantity of material assumed to be produced by the same process.

Materials:

Substances used in the construction of the project.

Median:

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

Pavement Structure:

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

Subbase Course:

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 specified materials 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."

Producer:

Refers to entity that utilizes raw materials to generate a finished product for the project. This entity may either have a direct contract with C202P or be subcontracted by the contractor placing the finished on the project.

Professional Engineer:

Means a person who has been granted registration in one or more branches of engineering by the Arizona State Board of Technical Registration, 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 intersecting the top surface of the proposed wearing surface, usually along the longitudinal center line of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.

Range:

Specified limits of acceptability for a measured characteristic.

Reasonably Close Conformity:

Where working tolerances are specified, reasonably close conformity means compliance with such working tolerances. Where working tolerances are not specified, reasonably close conformity means compliance with reasonable and customary manufacturing and construction tolerances as determined by the Independent Quality Firm subject to concurrence with the Department.

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.

RFC Plans:

The project plans, Plans, working drawings and supplemental drawings, or reproductions thereof, which show the location, character, dimensions and details of the work to be performed.

All Plans marked RFC (RELEASE FOR CONSTRUCTION) plus subsequent revisions and additions are listed on the project plans along with the latest (current) revision dates.

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:

Items 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; and such planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

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.

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 and not otherwise classified.

Subgrade:

The roadbed materials beneath the pavement structure. The top prepared surface of the subgrade is called finished subgrade elevation.

Superintendent:

The Developer's authorized representative in responsible charge of the work.

Supplier:

The entity that is providing a single source of materials (e.g. asphalt binder) that may be further incorporated into a finished product (e.g. asphaltic concrete).

Traveled Way:

The portion of the roadway for the movement of vehicles, exclusive of shoulders.

SECTION 104 SCOPE OF WORK:

Refer to Design Build Maintain Agreement (DBMA) Article 1 through 25

104.15 Providing Magnetic Detection for Underground Facilities

(A) General:

All new underground utility, drainage facilities, and ITS empty conduits, including service connections, placed within ADOT Right-of Way by the contractor must be magnetically detectable with standard locating instruments, such as a Metrotech Model 810 or approved equal. The contractor shall place continuous detectable tracer wire with all those underground utility facilities that lack a continuous and integral metallic component capable of detection by standard locating instruments.

Developer shall prepare a Tracer Wire Report that includes all conductivity test results of tracer wires installed outside of the Maintenance Services Limits. No later than 10 Business Days after testing, Developer shall submit a Tracer Wire Report to ADOT for review and comment.

Tracer wire will not be required for power cables and wires, telephonic or electronic communications, or for landscape irrigation lines smaller than two inches in diameter. For Salt River Project Water Users Association (S.R.V.W.U.A.) irrigation facilities, no tracer wire will be required if Salt River Project provides their own tracer system.

Tracer wire will be required for non-metallic pipe such as High Density Polyethylene (HDPE) and Vitrified Clay Pipe (VCP); and for Polyvinyl Chloride pipe (PVC) two inches in diameter and larger. Tracer wire will be required where the metallic component is encased within the pipe, such as reinforced concrete pipe (RCP) and (RGRCP), and Steel Cylinder Concrete Pipe.

Tracer wire will also be required for non-metallic cable, service connections, and other utility lines; fiber optic lines; empty duct banks and duct banks containing a utility that is not magnetically detectable, either before or after backfilling; and other facilities as determined by the Engineer.

Cast iron and ductile iron pipes may be non-conductive because of site specific soil conditions or construction configuration; as a consequence all new installations of cast iron and ductile iron pipes shall also be made detectable with tracer wire.

For all other underground facilities, should the magnetic characteristics be unknown, the contractor shall perform sufficient tests with standard locating instruments to determine whether tracer wire will be necessary, and provide the results to the Engineer. Such tests shall be performed prior to construction.

The contractor shall also provide access points, as specified below, for all facilities that will receive tracer wire.

(B) Materials:

Tracer wire shall be a minimum 12 American Wire Gauge (AWG) solid copper. Tracer wire shall be coated with a minimum 30 mil polyethylene jacket designed specifically for buried use. Tracer wire shall conform to the specifications of the NEC, UL, and other applicable industry standards. Splices as required to promote continuity shall utilize sealed water tight connections.

New access boxes shall be concrete pull boxes in accordance with Subsection 732-2.03 (Number 5 Pull Box, Traffic Standard T.S. 1-1), except that the cover shall be marked with the name of the utility or type of facility.

(C) Construction Requirements:

The contractor shall install tracer wire along the top of the entire length of the underground facilities. The tracer wire shall be attached to the facility at minimum intervals of not more than 20 feet, and shall be secured in such a manner that the wire remains firmly attached throughout the construction period.

Tracer wire shall be made accessible along the facility through appropriate pull boxes or other means as approved by the Engineer. New or existing junction boxes or pull boxes included in the construction of conduit or other transmission facilities shall be utilized as access structures wherever possible. For sanitary and storm sewer pipe, tracer wire shall be constructed into the manhole at the pipe entry point, secured to the inside wall along the full length, and be accessible from above upon removal of the manhole cover. For water lines requiring tracer wire, the contractor shall provide access to the wire within the valve boxes. The contractor shall provide and install new access boxes for all tracer wire which cannot be terminated in a new or existing junction or pull box, or new manhole or valve box.

Pull boxes shall be installed flush with the finished grade.

Tracer wire shall be securely attached to the facility at each access point and extended vertically to the access box. The tracer wire shall be terminated with a minimum of 12 inches of slack above the bottom of the pull box.

Tracer wire installed for each segment of underground utility shall be terminated at each access point within the pull box, junction box, manhole, or valve box. The contractor shall make no connections or splices of tracer wire across access points.

New pull boxes installed exclusively for tracer wire shall be placed directly above the utility line in easily reachable areas.

For facilities that cross ADOT right-of-way, tracer wire shall be made accessible at the right-of-way line at approved access points.

For facilities placed longitudinally in ADOT right-of-way, access points shall be located between the right-of-way line and the outside edge of the shoulder or grader ditch, or back of sidewalk or curb and gutter as applicable. Access boxes installed exclusively for tracer wire shall be provided at intervals no greater than 2,000 feet or, as a minimum, at the point each line crosses ADOT right of way. If the utility line is placed outside the preferred location of the access box as described above, the box shall be located in the preferred location and tracer wire shall be installed in a suitable conduit and brought up to the pull box.

For jacking and boring, tracer wire shall be placed inside the jacked sleeve and attached to the utility facility

Empty conduits and duct banks shall have a tracer wire attached to the outside of the facility.

When sanitary sewer force mains are installed in ADOT right-of-way, tracer wire access shall be accomplished by attaching the wire to the outside of wet wells and terminating the wire in pull boxes (Number 5, Traffic Standard T.S. 1-1) placed adjacent to the wet well.

(D) Testing:

The contractor shall test all installed tracer wire, and all those facilities determined to be magnetically detectable without tracer wire, with standard locating instruments to verify conductivity, both before and after backfilling, and provide the results to the Engineer. The contractor shall install new tracer wire for those newly installed utilities that fail to be detectable, at no additional cost to the Department. Tracer wires that fail to test properly shall also be replaced at no additional cost to the Department.

104.16 Project Environmental Commitments

Developer shall comply with environmental commitments and requirements included in the Record of Decision. The table provided in TP Attachment 420-1 includes the Project-specific environmental commitments associated with the Record of Decision. Environmental mitigation measures have been reviewed and approved by FHWA for the construction of the Project. These mitigation measures are not subject to change without prior written approval from FHWA. Developer shall be responsible for all environmental commitment requirements in TP Attachment 420-1, except those requirements that are specifically identified as an ADOT action

SECTION 105 CONTROL OF WORK:

Refer to DBMA Articles 1 through 25

105.06 Coordination of Plans, Specifications, and Special Provisions:

Refer to DBMA Article 1 (summarized below)

"In the event of any conflict among the Contract Documents, the order of precedence, from highest to lowest, shall be as set forth below:

1. Supplemental Agreements and Agreement amendments
2. DBMA
3. Developer's Proposal Commitments, and ATCs and ADC's
4. Technical Provisions amendments
5. Technical Provisions, and all exhibits and attachments
*6. **Project Specifications***
7. Publications and manuals to the extent incorporated by reference into the Technical Provisions;
8. RFC Submittals to be developed in accordance with the Contract Documents, provided that:
(i) specifications contained therein shall have precedence over plans;
(ii) no conflict shall be deemed to exist between the RFC Submittals and the other Contract Documents
(iii) any other Deviations contained in the RFC Submittals shall have priority over conflicting requirements of other Contract Documents"

SECTION 106 CONTROL OF MATERIAL:

Refer to DBMA Articles 1 through 25, and Connect 202 Partners Quality Management Plan

106.05 Certificates:

(A) General:

The contractor shall submit to the Engineer an original or copy 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 the specifications require that such a certificate be furnished.

Certificates shall be specifically identified as either a "Certificate of Compliance" or a "Certificate of Analysis".

The Engineer may permit the use of certain materials or manufactured assemblies prior to, or without, sampling and testing if accompanied by a Certificate of Compliance or 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 not in conformity with the requirements of the plans and the specifications, will be subject to rejection, whether in place or not.

Certificates of Compliance and Certificates of Analysis shall comply with the requirements specified herein, the ADOT Materials Testing Manual, and applicable ADOT Materials Policy and Procedure Directives.

(B) Certificate of Compliance:

A Certificate of Compliance shall be submitted on the manufacturer's or supplier's official letterhead, and shall contain the following information:

(1) The current name, address, and phone number of the manufacturer or supplier of the material.

(2) A description of the material supplied.

(3) Quantity of material represented by the certificate.

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

(5) A statement that the material complies in all respects with the requirements of the cited specifications. Certificates shall state compliance with the cited specification, such as AASHTO M 320, ASTM C 494; or specific table or subsection of the Arizona Department of Transportation Standard Specifications or Special Provisions. Certificates may cite both, if applicable.

(6) A statement that the individual identified in item seven below has the legal authority to bind the manufacturer or the supplier of the material.

(7) The name, title, and signature of the responsible individual. The date of the signature shall also be given.

Each of the first six items specified above shall be completed prior to the signing of the certificate as defined in item seven. No certificate will be accepted that has been altered, added to, or changed in any way after the authorized signature has been affixed to the original certificate. However, notations of a clarifying nature, such as project number, contractor, or quantity shipped are acceptable, provided the basic requirements of the certificate are not affected.

A copy or facsimile reproduction of the original certificate will be acceptable; however, the original certificate shall be made available upon request.

(C) Certificate of Analysis:

A Certificate of Analysis shall include all the information required for a Certificate of Compliance and, in addition, shall include the results of all tests required by the specifications.

SECTION 107 LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC:

Refer to DBMA Articles 1 through 25

107.05 Archaeological Features:

Refer to DBMA Article 4 and TP Attachment 420-1. In addition, refer to the Connect 202 Partners project Environmental Management Plan including the Unanticipated Archaeological Discovery Plan.

107.06 Historic Preservation:

Refer to DBMA Article 4 and TP Attachment 420-1. In addition, refer to the Connect 202 Partners project Environmental Management Plan including the Unanticipated Archaeological Discovery Plan.

SECTION 109 MEASUREMENT AND PAYMENT:

109.11 Statistical Acceptance:

(A) General:

When referenced in individual specifications, this subsection will be used to determine the "Total Percentage of Lot Within UL and LL (PT)" or the "Percent of Lot Within Limits (PWL)" for statistical acceptance.

Subsection 109.11(B) is used for asphaltic concrete. Subsection 109.11(C) is used for thickness of Portland cement concrete pavement, and Subsection 109.11(D) for compressive strength of Portland cement concrete pavement.

(B) Definitions, Abbreviations, and Formulas for Determining the "Total Percentage of Lot Within UL and LL (PT)" for Asphaltic Concrete:

Target Value (TV):

Target values for gradation, asphalt cement content or asphalt-rubber content, and effective voids shall be as given in the contractor's mix design.

Average (AVE):

The sum of the lot's test results for a measured characteristic divided by the number of test results; the arithmetic mean. The average will be determined to one decimal place, except for asphalt cement content or asphalt-rubber content, which will be determined to two decimal places.

Standard Deviation (s):

The square root of the value formed by summing the squared difference between each individual test result for a measured characteristic and AVE, divided by the number of test results minus one, as shown in the equation below. The standard deviation will be determined to two decimal places.

$$s = \sqrt{\frac{\Sigma\left[\left(\text{Each Individual Test Result - AVE}\right)^2\right]}{\text{Number of Test Results - 1}}}$$

If the standard deviation calculated above is zero and the average of the individual test results meets the specified limits for “UL” and “LL”, the determination of “QU”, “QL”, “PU”, “PL”, and “PT” as shown below will not be made; rather, the value for “PT” (Total Percent of Lot Within UL and LL) shall be “100”. If the standard deviation calculated above is zero and the average of the individual test results does not meet the specified limits for “UL” and “LL”, the value for “PT” shall be “0”.

Upper Limit (UL):

The value above the TV of each measured characteristic which defines the upper limit of acceptable production.

Lower Limit (LL):

The value below the TV of each measured characteristic which defines the lower limit of acceptable production.

Upper Limit (UL):

The value above the TV of each measured characteristic which defines the upper limit of acceptable production.

Lower Limit (LL):

The value below the TV of each measured characteristic which defines the lower limit of acceptable production.

Upper Quality Index (QU):

$$QU = \frac{\text{UL - AVE}}{s}$$

The QU will be calculated to three decimal places.

Lower Quality Index (QL):

$$QL = \frac{AVE - LL}{s}$$

The QL will be calculated to three decimal places.

Percentage of Lot Within UL (PU):

Determined by entering the appropriate "N" value table with QU.

Percentage of Lot Within LL (PL):

Determined by entering the appropriate "N" value table with QL.

Total Percentage of Lot Within UL and LL (PT):

PT = (PU+PL)-100

(C) Definitions, Abbreviations, and Formulas for Determining the "Percent of Lot Within Limits (PWL)" for Thickness of Portland Cement Concrete Pavement and Asphaltic Concrete Pavement:

Average (AVE):

The average of the thickness measurements of the cores obtained in accordance with Subsection 401-4.04. The average will be determined to the nearest hundredth of an inch.

Standard Deviation (s):

The square root of the value formed by summing the squared difference between the thickness measurement for each core and AVE, divided by the number of cores minus one, as shown in the equation below. The standard deviation will be determined to two decimal places.

$$s = \sqrt{\frac{\Sigma\left[(\text{Thickness Measurement for each Core} - \text{AVE})^2\right]}{\text{Number of Cores} - 1}}$$

If the standard deviation calculated above is zero and the average of the individual test results meets the specified “LL” (Lower Limit), the determination of “QL” and “PWL” as shown below will not be made; rather, the value for “PWL” (Percent of Lot Within Limits) shall be “100”. If the standard deviation calculated above is zero and the average of the individual test results does not meet the specified Lower Limit, the value for “PWL” shall be “0”.

Lower Limit (LL): The required thickness less 0.2 inches.

Lower Quality Index (QL):

$$QL = \frac{AVE - LL}{s}$$

QL will be determined to three decimal places.

Percent of Lot Within Limits (PWL):

Determined by entering the appropriate "N" value table with QL.

(D) Definitions, Abbreviations, and Formulas for Determining the "Percent of Lot Within Limits (PWL)" for Compressive Strength of Portland Cement Concrete Pavement:

Average (AVE):

The average of the compressive strengths of the samples. The average will be determined to the nearest whole number.

Standard Deviation (s):

The square root of the value formed by summing the squared difference between the compressive strength result for each sample and AVE, divided by the number of samples minus one, as shown in the equation below. The standard deviation will be determined to the nearest whole number.

$$s = \sqrt{\frac{\Sigma\left[\left(\text{Compressive Strength Result for each Sample - AVE}\right)^2\right]}{\text{Number of Samples - 1}}}$$

If the standard deviation calculated above is zero and the average of the individual test results meets the specified minimum strength “LL”, the determination of “QL” and “PWL” as shown below will not be made; rather, the value for “PWL” (Percent of Lot Within Limits) shall be “100”. If the standard deviation calculated above is zero and the average of the individual test results does not meet the specified minimum strength, the value for “PWL” shall be “0”.

Lower Limit (LL): The specified minimum strength.

Lower Quality Index (QL):

$$QL = \frac{AVE - LL}{s}$$

QL will be determined to three decimal places.

Percent of Lot Within Limits (PWL):

Determined by entering the appropriate "N" value table with QL.

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 3							
QU or QL			**PU, PL, or PWL**	**QU or QL**			**PU, PL, or PWL**
1.155 or More			100	0.000	to	-0.017	50
1.153	to	1.154	99	-0.018	to	-0.054	49
1.151	to	1.152	98	-0.055	to	-0.090	48
1.148	to	1.150	97	-0.091	to	-0.126	47
1.143	to	1.147	96	-0.127	to	-0.162	46
1.137	to	1.142	95	-0.163	to	-0.198	45
1.131	to	1.136	94	-0.199	to	-0.233	44
1.123	to	1.130	93	-0.234	to	-0.269	43
1.114	to	1.122	92	-0.270	to	-0.304	42
1.104	to	1.113	91	-0.305	to	-0.339	41
1.092	to	1.103	90	-0.340	to	-0.373	40
1.080	to	1.091	89	-0.374	to	-0.407	39
1.067	to	1.079	88	-0.408	to	-0.441	38
1.053	to	1.066	87	-0.442	to	-0.475	37
1.037	to	1.052	86	-0.476	to	-0.507	36
1.021	to	1.036	85	-0.508	to	-0.539	35
1.003	to	1.020	84	-0.540	to	-0.571	34
0.985	to	1.002	83	-0.572	to	-0.603	33
0.965	to	0.984	82	-0.604	to	-0.633	32
0.945	to	0.964	81	-0.634	to	-0.663	31
0.923	to	0.944	80	-0.664	to	-0.693	30
0.901	to	0.922	79	-0.694	to	-0.721	29
0.878	to	0.900	78	-0.722	to	-0.749	28
0.854	to	0.877	77	-0.750	to	-0.776	27
0.829	to	0.853	76	-0.777	to	-0.802	26
0.803	to	0.828	75	-0.803	to	-0.828	25
0.777	to	0.802	74	-0.829	to	-0.853	24
0.750	to	0.776	73	-0.854	to	-0.877	23
0.722	to	0.749	72	-0.878	to	-0.900	22
0.694	to	0.721	71	-0.901	to	-0.922	21
0.664	to	0.693	70	-0.923	to	-0.944	20
0.634	to	0.663	69	-0.945	to	-0.964	19

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 3							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
0.604	to	0.633	68	-0.965	to	-0.984	18
0.572	to	0.603	67	-0.985	to	-1.002	17
0.540	to	0.571	66	-1.003	to	-1.020	16
0.508	to	0.539	65	-1.021	to	-1.036	15
0.476	to	0.507	64	-1.037	to	-1.052	14
0.442	to	0.475	63	-1.053	to	-1.066	13
0.408	to	0.441	62	-1.067	to	-1.079	12
0.374	to	0.407	61	-1.080	to	-1.091	11
0.340	to	0.373	60	-1.092	to	-1.103	10
0.305	to	0.339	59	-1.104	to	-1.113	9
0.270	to	0.304	58	-1.114	to	-1.122	8
0.234	to	0.269	57	-1.123	to	-1.130	7
0.199	to	0.233	56	-1.131	to	-1.136	6
0.163	to	0.198	55	-1.137	to	-1.142	5
0.127	to	0.162	54	-1.143	to	-1.147	4
0.091	to	0.126	53	-1.148	to	-1.150	3
0.055	to	0.090	52	-1.151	to	-1.152	2
0.018	to	0.054	51	-1.153	to	-1.154	1
0.000	to	0.017	50	-1.155 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 4							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
1.485 or More			100	0.000	to	-0.014	50
1.455	to	1.484	99	-0.015	to	-0.044	49
1.425	to	1.454	98	-0.045	to	-0.074	48
1.395	to	1.424	97	0.075	to	-0.104	47
1.365	to	1.394	96	-0.105	to	-0.134	46
1.335	to	1.364	95	-0.135	to	-0.164	45
1.305	to	1.334	94	-0.165	to	-0.194	44
1.275	to	1.304	93	-0.195	to	-0.224	43
1.245	to	1.274	92	-0.225	to	-0.254	42
1.215	to	1.244	91	-0.255	to	-0.284	41
1.185	to	1.214	90	-0.285	to	-0.314	40
1.155	to	1.184	89	-0.315	to	-0.344	39
1.125	to	1.154	88	-0.345	to	-0.374	38
1.095	to	1.124	87	-0.375	to	-0.404	37
1.065	to	1.094	86	-0.405	to	-0.434	36
1.035	to	1.064	85	-0.435	to	-0.464	35
1.005	to	1.034	84	-0.465	to	-0.494	34
0.975	to	1.004	83	-0.495	to	-0.524	33
0.945	to	0.974	82	-0.525	to	-0.554	32

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 4							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
0.915	to	0.944	81	-0.555	to	-0.584	31
0.885	to	0.914	80	-0.585	to	-0.614	30
0.855	to	0.884	79	-0.615	to	-0.644	29
0.825	to	0.854	78	-0.645	to	-0.674	28
0.795	to	0.824	77	-0.675	to	-0.704	27
0.765	to	0.794	76	-0.705	to	-0.734	26
0.735	to	0.764	75	-0.735	to	-0.764	25
0.705	to	0.734	74	-0.765	to	-0.794	24
0.675	to	0.704	73	-0.795	to	-0.824	23
0.645	to	0.674	72	-0.825	to	-0.854	22
0.615	to	0.644	71	-0.855	to	-0.884	21
0.585	to	0.614	70	-0.885	to	-0.914	20
0.555	to	0.584	69	-0.915	to	-0.944	19
0.525	to	0.554	68	-0.945	to	-0.974	18
0.495	to	0.524	67	-0.975	to	-1.004	17
0.465	to	0.494	66	-1.005	to	-1.034	16
0.435	to	0.464	65	-1.035	to	-1.064	15
0.405	to	0.434	64	-1.065	to	-1.094	14
0.375	to	0.404	63	-1.095	to	-1.124	13
0.345	to	0.374	62	-1.125	to	-1.154	12
0.315	to	0.344	61	-1.155	to	-1.184	11
0.285	to	0.314	60	-1.185	to	-1.214	10
0.255	to	0.284	59	-1.215	to	-1.244	9
0.225	to	0.254	58	-1.245	to	-1.274	8
0.195	to	0.224	57	-1.275	to	-1.304	7
0.165	to	0.194	56	-1.305	to	-1.334	6
0.135	to	0.164	55	-1.335	to	-1.364	5
0.105	to	0.134	54	-1.365	to	-1.394	4
0.075	to	0.104	53	-1.395	to	-1.424	3
0.045	to	0.074	52	-1.425	to	-1.454	2
0.015	to	0.044	51	-1.455	to	-1.484	1
0.000	to	0.014	50	-1.485 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 5							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
1.716 or More			100	0.000	to	-0.013	50
1.637	to	1.715	99	-0.014	to	-0.041	49
1.573	to	1.636	98	-0.042	to	-0.069	48
1.517	to	1.572	97	-0.070	to	-0.097	47
1.466	to	1.516	96	-0.098	to	-0.126	46
1.418	to	1.465	95	-0.127	to	-0.154	45

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 5							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
1.373	to	1.417	94	-0.155	to	-0.182	44
1.330	to	1.372	93	-0.183	to	-0.210	43
1.289	to	1.329	92	-0.211	to	-0.239	42
1.249	to	1.288	91	-0.240	to	-0.267	41
1.210	to	1.248	90	-0.268	to	-0.296	40
1.173	to	1.209	89	-0.297	to	-0.324	39
1.136	to	1.172	88	-0.325	to	-0.353	38
1.100	to	1.135	87	-0.354	to	-0.382	37
1.065	to	1.099	86	-0.383	to	-0.411	36
1.030	to	1.064	85	-0.412	to	-0.440	35
0.996	to	1.029	84	-0.441	to	-0.469	34
0.962	to	0.995	83	-0.470	to	-0.498	33
0.929	to	0.961	82	-0.499	to	-0.527	32
0.896	to	0.928	81	-0.528	to	-0.556	31
0.864	to	0.895	80	-0.557	to	-0.586	30
0.832	to	0.863	79	-0.587	to	-0.616	29
0.801	to	0.831	78	-0.617	to	-0.646	28
0.769	to	0.800	77	-0.647	to	-0.676	27
0.738	to	0.768	76	-0.677	to	-0.707	26
0.708	to	0.737	75	-0.708	to	-0.737	25
0.677	to	0.707	74	-0.738	to	-0.768	24
0.647	to	0.676	73	-0.769	to	-0.800	23
0.617	to	0.646	72	-0.801	to	-0.831	22
0.587	to	0.616	71	-0.832	to	-0.863	21
0.557	to	0.586	70	-0.864	to	-0.895	20
0.528	to	0.556	69	-0.896	to	-0.928	19
0.499	to	0.527	68	-0.929	to	-0.961	18
0.470	to	0.498	67	-0.962	to	-0.995	17
0.441	to	0.469	66	-0.996	to	-1.029	16
0.412	to	0.440	65	-1.030	to	-1.064	15
0.383	to	0.411	64	-1.065	to	-1.099	14
0.354	to	0.382	63	-1.100	to	-1.135	13
0.325	to	0.353	62	-1.136	to	-1.172	12
0.297	to	0.324	61	-1.173	to	-1.209	11
0.268	to	0.296	60	-1.210	to	-1.248	10
0.240	to	0.267	59	-1.249	to	-1.288	9
0.211	to	0.239	58	-1.289	to	-1.329	8
0.183	to	0.210	57	-1.330	to	-1.372	7
0.155	to	0.182	56	-1.373	to	-1.417	6
0.127	to	0.154	55	-1.418	to	-1.465	5
0.098	to	0.126	54	-1.466	to	-1.516	4
0.070	to	0.097	53	-1.517	to	-1.572	3

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 5			
QU or QL	**PU, PL, or PWL**	**QU or QL**	**PU, PL, or PWL**
0.042 to 0.069	52	-1.573 to -1.636	2
0.014 to 0.041	51	-1.637 to -1.715	1
0.000 to 0.013	50	-1.716 or Less	0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 6			
QU or QL	**PU, PL, or PWL**	**QU or QL**	**PU, PL, or PWL**
1.876 or More	100	0.000 to -0.013	50
1.750 to 1.875	99	-0.014 to -0.040	49
1.658 to 1.749	98	-0.041 to -0.067	48
1.584 to 1.657	97	-0.068 to -0.095	47
1.520 to 1.583	96	-0.096 to -0.122	46
1.461 to 1.519	95	-0.123 to -0.149	45
1.407 to 1.460	94	-0.150 to -0.177	44
1.357 to 1.406	93	-0.178 to -0.204	43
1.309 to 1.356	92	-0.205 to -0.232	42
1.264 to 1.308	91	-0.233 to -0.259	41
1.221 to 1.263	90	-0.260 to -0.287	40
1.179 to 1.220	89	-0.288 to -0.315	39
1.139 to 1.178	88	-0.316 to -0.342	38
1.100 to 1.138	87	-0.343 to -0.371	37
1.062 to 1.099	86	-0.372 to -0.399	36
1.025 to 1.061	85	-0.400 to -0.427	35
0.990 to 1.024	84	-0.428 to -0.456	34
0.955 to 0.989	83	-0.457 to -0.485	33
0.920 to 0.954	82	-0.486 to -0.514	32
0.886 to 0.919	81	-0.515 to -0.543	31
0.853 to 0.885	80	-0.544 to -0.572	30
0.820 to 0.852	79	-0.573 to -0.602	29
0.788 to 0.819	78	-0.603 to -0.632	28
0.756 to 0.787	77	-0.633 to -0.662	27
0.725 to 0.755	76	-0.663 to -0.693	26
0.694 to 0.724	75	-0.694 to -0.724	25
0.663 to 0.693	74	-0.725 to -0.755	24
0.633 to 0.662	73	-0.756 to -0.787	23
0.603 to 0.632	72	-0.788 to -0.819	22
0.573 to 0.602	71	-0.820 to -0.852	21
0.544 to 0.572	70	-0.853 to -0.885	20
0.515 to 0.543	69	-0.886 to -0.919	19
0.486 to 0.514	68	-0.920 to -0.954	18
0.457 to 0.485	67	-0.955 to -0.989	17
0.428 to 0.456	66	-0.990 to -1.024	16

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 6								
QU or QL			**PU, PL, or PWL**	**QU or QL**			**PU, PL, or PWL**
0.400	to	0.427	65	-1.025	to	-1.061	15
0.372	to	0.399	64	-1.062	to	-1.099	14
0.343	to	0.371	63	-1.100	to	-1.138	13
0.316	to	0.342	62	-1.139	to	-1.178	12
0.288	to	0.315	61	-1.179	to	-1.220	11
0.260	to	0.287	60	-1.221	to	-1.263	10
0.233	to	0.259	59	-1.264	to	-1.308	9
0.205	to	0.232	58	-1.309	to	-1.356	8
0.178	to	0.204	57	-1.357	to	-1.406	7
0.150	to	0.177	56	-1.407	to	-1.460	6
0.123	to	0.149	55	-1.461	to	-1.519	5
0.096	to	0.122	54	-1.520	to	-1.583	4
0.068	to	0.095	53	-1.584	to	-1.657	3
0.041	to	0.067	52	-1.658	to	-1.749	2
0.014	to	0.040	51	-1.750	to	-1.875	1
0.000	to	0.013	50	-1.876 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 7							
QU or QL			**PU, PL, or PWL**	**QU or QL**			**PU, PL, or PWL**
1.983 or More			100	0.000	to	-0.013	50
1.825	to	1.982	99	-0.014	to	-0.039	49
1.714	to	1.824	98	-0.040	to	-0.066	48
1.627	to	1.713	97	-0.067	to	-0.093	47
1.553	to	1.626	96	-0.094	to	-0.120	46
1.487	to	1.552	95	-0.121	to	-0.147	45
1.428	to	1.486	94	-0.148	to	-0.174	44
1.373	to	1.427	93	-0.175	to	-0.201	43
1.321	to	1.372	92	-0.202	to	-0.228	42
1.273	to	1.320	91	-0.229	to	-0.255	41
1.227	to	1.272	90	-0.256	to	-0.282	40
1.183	to	1.226	89	-0.283	to	-0.309	39
1.141	to	1.182	88	-0.310	to	-0.337	38
1.100	to	1.140	87	-0.338	to	-0.365	37
1.061	to	1.099	86	-0.366	to	-0.392	36
1.023	to	1.060	85	-0.393	to	-0.420	35
0.986	to	1.022	84	-0.421	to	-0.449	34
0.949	to	0.985	83	-0.450	to	-0.477	33
0.914	to	0.948	82	-0.478	to	-0.506	32
0.880	to	0.913	81	-0.507	to	-0.535	31
0.846	to	0.879	80	-0.536	to	-0.564	30
0.813	to	0.845	79	-0.565	to	-0.594	29

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 7							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
0.780	to	0.812	78	-0.595	to	-0.624	28
0.748	to	0.779	77	-0.625	to	-0.654	27
0.717	to	0.747	76	-0.655	to	-0.685	26
0.686	to	0.716	75	-0.686	to	-0.716	25
0.655	to	0.685	74	-0.717	to	-0.747	24
0.625	to	0.654	73	-0.748	to	-0.779	23
0.595	to	0.624	72	-0.780	to	-0.812	22
0.565	to	0.594	71	-0.813	to	-0.845	21
0.536	to	0.564	70	-0.846	to	-0.879	20
0.507	to	0.535	69	-0.880	to	-0.913	19
0.478	to	0.506	68	-0.914	to	-0.948	18
0.450	to	0.477	67	-0.949	to	-0.985	17
0.421	to	0.449	66	-0.986	to	-1.022	16
0.393	to	0.420	65	-1.023	to	-1.060	15
0.366	to	0.392	64	-1.061	to	-1.099	14
0.338	to	0.365	63	-1.100	to	-1.140	13
0.310	to	0.337	62	-1.141	to	-1.182	12
0.283	to	0.309	61	-1.183	to	-1.226	11
0.256	to	0.282	60	-1.227	to	-1.272	10
0.229	to	0.255	59	-1.273	to	-1.320	9
0.202	to	0.228	58	-1.321	to	-1.372	8
0.175	to	0.201	57	-1.373	to	-1.427	7
0.148	to	0.174	56	-1.428	to	-1.486	6
0.121	to	0.147	55	-1.487	to	-1.552	5
0.094	to	0.120	54	-1.553	to	-1.626	4
0.067	to	0.093	53	-1.627	to	-1.713	3
0.040	to	0.066	52	-1.714	to	-1.824	2
0.014	to	0.039	51	-1.825	to	-1.982	1
0.000	to	0.013	50	-1.983 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 8							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
2.064 or More			100	0.000	to	-0.012	50
1.879	to	2.063	99	-0.013	to	-0.039	49
1.752	to	1.878	98	-0.040	to	-0.065	48
1.656	to	1.751	97	-0.066	to	-0.092	47
1.576	to	1.655	96	-0.093	to	-0.118	46
1.505	to	1.575	95	-0.119	to	-0.145	45
1.442	to	1.504	94	-0.146	to	-0.171	44
1.383	to	1.441	93	-0.172	to	-0.198	43
1.329	to	1.382	92	-0.199	to	-0.225	42

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 8							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
1.279	to	1.328	91	-0.226	to	-0.252	41
1.231	to	1.278	90	-0.253	to	-0.279	40
1.185	to	1.230	89	-0.280	to	-0.306	39
1.142	to	1.184	88	-0.307	to	-0.333	38
1.100	to	1.141	87	-0.334	to	-0.361	37
1.060	to	1.099	86	-0.362	to	-0.388	36
1.021	to	1.059	85	-0.389	to	-0.416	35
0.983	to	1.020	84	-0.417	to	-0.444	34
0.946	to	0.982	83	-0.445	to	-0.473	33
0.911	to	0.945	82	-0.474	to	-0.501	32
0.876	to	0.910	81	-0.502	to	-0.530	31
0.842	to	0.875	80	-0.531	to	-0.559	30
0.808	to	0.841	79	-0.560	to	-0.589	29
0.775	to	0.807	78	-0.590	to	-0.618	28
0.743	to	0.774	77	-0.619	to	-0.649	27
0.712	to	0.742	76	-0.650	to	-0.680	26
0.681	to	0.711	75	-0.681	to	-0.711	25
0.650	to	0.680	74	-0.712	to	-0.742	24
0.619	to	0.649	73	-0.743	to	-0.774	23
0.590	to	0.618	72	-0.775	to	-0.807	22
0.560	to	0.589	71	-0.808	to	-0.841	21
0.531	to	0.559	70	-0.842	to	-0.875	20
0.502	to	0.530	69	-0.876	to	-0.910	19
0.474	to	0.501	68	-0.911	to	-0.945	18
0.445	to	0.473	67	-0.946	to	-0.982	17
0.417	to	0.444	66	-0.983	to	-1.020	16
0.389	to	0.416	65	-1.021	to	-1.059	15
0.362	to	0.388	64	-1.060	to	-1.099	14
0.334	to	0.361	63	-1.100	to	-1.141	13
0.307	to	0.333	62	-1.142	to	-1.184	12
0.280	to	0.306	61	-1.185	to	-1.230	11
0.253	to	0.279	60	-1.231	to	-1.278	10
0.226	to	0.252	59	-1.279	to	-1.328	9
0.199	to	0.225	58	-1.329	to	-1.382	8
0.172	to	0.198	57	-1.383	to	-1.441	7
0.146	to	0.171	56	-1.442	to	-1.504	6
0.119	to	0.145	55	-1.505	to	-1.575	5
0.093	to	0.118	54	-1.576	to	-1.655	4
0.066	to	0.092	53	-1.656	to	-1.751	3
0.040	to	0.065	52	-1.752	to	-1.878	2
0.013	to	0.039	51	-1.879	to	-2.063	1
0.000	to	0.012	50	-2.064 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 9			
QU or QL	**PU, PL, or PWL**	**QU or QL**	**PU, PL, or PWL**
2.127 or More	100	0.000 to -0.012	50
1.919 to 2.126	99	-0.013 to -0.038	49
1.781 to 1.918	98	-0.039 to -0.065	48
1.678 to 1.780	97	-0.066 to -0.091	47
1.592 to 1.677	96	-0.092 to -0.117	46
1.518 to 1.591	95	-0.118 to -0.144	45
1.452 to 1.517	94	-0.145 to -0.170	44
1.391 to 1.451	93	-0.171 to -0.196	43
1.335 to 1.390	92	-0.197 to -0.223	42
1.283 to 1.334	91	-0.224 to -0.250	41
1.234 to 1.282	90	-0.251 to -0.277	40
1.187 to 1.233	89	-0.278 to -0.304	39
1.143 to 1.186	88	-0.305 to -0.331	38
1.100 to 1.142	87	-0.332 to -0.358	37
1.059 to 1.099	86	-0.359 to -0.386	36
1.020 to 1.058	85	-0.387 to -0.413	35
0.981 to 1.019	84	-0.414 to -0.441	34
0.944 to 0.980	83	-0.442 to -0.469	33
0.908 to 0.943	82	-0.470 to -0.498	32
0.873 to 0.907	81	-0.499 to -0.527	31
0.838 to 0.872	80	-0.528 to -0.556	30
0.805 to 0.837	79	-0.557 to -0.585	29
0.772 to 0.804	78	-0.586 to -0.615	28
0.740 to 0.771	77	-0.616 to -0.645	27
0.708 to 0.739	76	-0.646 to -0.676	26
0.677 to 0.707	75	-0.677 to -0.707	25
0.646 to 0.676	74	-0.708 to -0.739	24
0.616 to 0.645	73	-0.740 to -0.771	23
0.586 to 0.615	72	-0.772 to -0.804	22
0.557 to 0.585	71	-0.805 to -0.837	21
0.528 to 0.556	70	-0.838 to -0.872	20
0.499 to 0.527	69	-0.873 to -0.907	19
0.470 to 0.498	68	-0.908 to -0.943	18
0.442 to 0.469	67	-0.944 to -0.980	17
0.414 to 0.441	66	-0.981 to -1.019	16
0.387 to 0.413	65	-1.020 to -1.058	15
0.359 to 0.386	64	-1.059 to -1.099	14
0.332 to 0.358	63	-1.100 to -1.142	13
0.305 to 0.331	62	-1.143 to -1.186	12
0.278 to 0.304	61	-1.187 to -1.233	11
0.251 to 0.277	60	-1.234 to -1.282	10

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 9								
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
0.224	to	0.250	59	-1.283	to	-1.334	9
0.197	to	0.223	58	-1.335	to	-1.390	8
0.171	to	0.196	57	-1.391	to	-1.451	7
0.145	to	0.170	56	-1.452	to	-1.517	6
0.118	to	0.144	55	-1.518	to	-1.591	5
0.092	to	0.117	54	-1.592	to	-1.677	4
0.066	to	0.091	53	-1.678	to	-1.780	3
0.039	to	0.065	52	-1.781	to	-1.918	2
0.013	to	0.038	51	-1.919	to	-2.126	1
0.000	to	0.012	50	-2.127 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 10							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
2.176 or More			100	0.000	to	-0.012	50
1.950	to	2.175	99	-0.013	to	-0.038	49
1.803	to	1.949	98	-0.039	to	-0.064	48
1.694	to	1.802	97	-0.065	to	-0.090	47
1.605	to	1.693	96	-0.091	to	-0.116	46
1.528	to	1.604	95	-0.117	to	-0.143	45
1.459	to	1.527	94	-0.144	to	-0.169	44
1.397	to	1.458	93	-0.170	to	-0.195	43
1.340	to	1.396	92	-0.196	to	-0.222	42
1.286	to	1.339	91	-0.223	to	-0.248	41
1.236	to	1.285	90	-0.249	to	-0.275	40
1.188	to	1.235	89	-0.276	to	-0.302	39
1.143	to	1.187	88	-0.303	to	-0.329	38
1.100	to	1.142	87	-0.330	to	-0.356	37
1.059	to	1.099	86	-0.357	to	-0.383	36
1.019	to	1.058	85	-0.384	to	-0.411	35
0.980	to	1.018	84	-0.412	to	-0.439	34
0.943	to	0.979	83	-0.440	to	-0.467	33
0.906	to	0.942	82	-0.468	to	-0.495	32
0.871	to	0.905	81	-0.496	to	-0.524	31
0.836	to	0.870	80	-0.525	to	-0.553	30
0.803	to	0.835	79	-0.554	to	-0.583	29
0.770	to	0.802	78	-0.584	to	-0.612	28
0.737	to	0.769	77	-0.613	to	-0.643	27
0.706	to	0.736	76	-0.644	to	-0.674	26
0.675	to	0.705	75	-0.675	to	-0.705	25
0.644	to	0.674	74	-0.706	to	-0.736	24
0.613	to	0.643	73	-0.737	to	-0.769	23

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 10								
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
0.584	to	0.612	72	-0.770	to	-0.802	22
0.554	to	0.583	71	-0.803	to	-0.835	21
0.525	to	0.553	70	-0.836	to	-0.870	20
0.496	to	0.524	69	-0.871	to	-0.905	19
0.468	to	0.495	68	-0.906	to	-0.942	18
0.440	to	0.467	67	-0.943	to	-0.979	17
0.412	to	0.439	66	-0.980	to	-1.018	16
0.384	to	0.411	65	-1.019	to	-1.058	15
0.357	to	0.383	64	-1.059	to	-1.099	14
0.330	to	0.356	63	-1.100	to	-1.142	13
0.303	to	0.329	62	-1.143	to	-1.187	12
0.276	to	0.302	61	-1.188	to	-1.235	11
0.249	to	0.275	60	-1.236	to	-1.285	10
0.223	to	0.248	59	-1.286	to	-1.339	9
0.196	to	0.222	58	-1.340	to	-1.396	8
0.170	to	0.195	57	-1.397	to	-1.458	7
0.144	to	0.169	56	-1.459	to	-1.527	6
0.117	to	0.143	55	-1.528	to	-1.604	5
0.091	to	0.116	54	-1.605	to	-1.693	4
0.065	to	0.090	53	-1.694	to	-1.802	3
0.039	to	0.064	52	-1.803	to	-1.949	2
0.013	to	0.038	51	-1.950	to	-2.175	1
0.000	to	0.012	50	-2.176 or Less			0

DETERMINATION OF PU, PL, or PWL Number of Tests "N" = 10							
QU or QL			PU, PL, or PWL	QU or QL			PU, PL, or PWL
0.737	to	0.769	77	-0.613	to	-0.643	27
0.706	to	0.736	76	-0.644	to	-0.674	26
0.675	to	0.705	75	-0.675	to	-0.705	25
0.644	to	0.674	74	-0.706	to	-0.736	24
0.613	to	0.643	73	-0.737	to	-0.769	23
0.584	to	0.612	72	-0.770	to	-0.802	22
0.554	to	0.583	71	-0.803	to	-0.835	21
0.525	to	0.553	70	-0.836	to	-0.870	20
0.496	to	0.524	69	-0.871	to	-0.905	19
0.468	to	0.495	68	-0.906	to	-0.942	18
0.440	to	0.467	67	-0.943	to	-0.979	17
0.412	to	0.439	66	-0.980	to	-1.018	16
0.384	to	0.411	65	-1.019	to	-1.058	15
0.357	to	0.383	64	-1.059	to	-1.099	14
0.330	to	0.356	63	-1.100	to	-1.142	13
0.303	to	0.329	62	-1.143	to	-1.187	12
0.276	to	0.302	61	-1.188	to	-1.235	11
0.249	to	0.275	60	-1.236	to	-1.285	10
0.223	to	0.248	59	-1.286	to	-1.339	9
0.196	to	0.222	58	-1.340	to	-1.396	8
0.170	to	0.195	57	-1.397	to	-1.458	7
0.144	to	0.169	56	-1.459	to	-1.527	6
0.117	to	0.143	55	-1.528	to	-1.604	5
0.091	to	0.116	54	-1.605	to	-1.693	4
0.065	to	0.090	53	-1.694	to	-1.802	3
0.039	to	0.064	52	-1.803	to	-1.949	2
0.013	to	0.038	51	-1.950	to	-2.175	1
0.000	to	0.012	50	-2.176 or Less			0

Burning of trash, debris, plant material, wood, or any other waste materials will not be allowed.

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 Project Limits. .

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 Developer.

202-2 Blank

202-3 Construction Requirements:

202-3.01 General:

Blasting, per the blasting plan, 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.

202-3.02 Removal of Pipe:

Removal of existing pipe shall be removed by excavation or crushed in place. Existing pipe within five vertical feet of subgrade shall be removed by excavation. Abandonment of existing pipe shall be filled with cement slurry. Existing manholes shall be removed completely or abandoned by removal of top three feet, below subgrade, and cement slurry filled, as determined by the Developer in accordance with the plans.

202-3.03 Removal of Pavement:

(A) Portland Cement Concrete Pavement:

Concrete pavement removed within the project limits or from other sources within project scope can be buried in embankment areas. The concrete shall be broken into pieces and placed in the embankment in pieces less than two feet in the largest dimension without any exposed rebar in excess of two inches.

Where new construction is to join the existing concrete pavement, the pavement shall be saw cut to a line perpendicular to the centerline of the pavement with straight vertical edges free from irregularities.

(B) Bituminous Pavement:

Bituminous pavement removed within the project limits can be buried in embankment areas. The pavement shall be broken into pieces and placed in the embankment in pieces less than two feet in the largest dimension. Where new construction is to join existing bituminous pavement, the existing pavement shall be cut or milled in a straight line perpendicular to the centerline of the pavement with straight vertical edges free from irregularities.

(C) Bituminous Pavement Removal By Milling:

Existing asphaltic concrete shall be removed in accordance with the details shown on the project plans to a controlled line and grade within 0.10 feet of the specified removal depth.

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.

On projects with existing curb and gutter, any existing or new asphaltic concrete buildup in the gutter shall be removed without 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, curbs, gutters, sidewalks, driveways, aprons, slope paving, island paving, retaining walls, spillways, drainage structures, concrete box culverts, foundations, footings and all other Portland cement concrete or masonry construction, except bridges and pavement. All existing concrete shall be removed to a depth of at least two feet below finished subgrade or broken into pieces less than two foot in largest dimension in areas of embankment greater than five feet in vertical depth.

202-3.05 Removal of Bridges:

The removal of existing bridges, either wholly or in part, shall be as shown on the project plans.

202-3.06 Removal of Signs and Delineators:

Existing warning, regulatory, guide, route marker signs and delineators that are to be removed will be removed as shown on the plans. 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

202-3.08 Removal of Fence:

All fence to be removed, shall become the property of the Developer. Salvaged fence materials may be used for temporary fence.

In areas where new fence or relocated fence is to be installed, the Developer shall perform the removals in such a manner as to prevent the escape of any livestock.

202-3.09 Removal of Guardrail:

All guardrail to be removed, shall become the property of the Developer.

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 for structures, culverts, and other facilities; to furnish and place borrow material for use as specified; to construct embankments; to place backfills 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 as designated on the project plans,

203-2 General:

Operations shall be conducted such that existing highway facilities, utilities, railroad tracks and other non-highway facilities which are to remain in place will not be damaged. The Developer, shall furnish and install sheet piling, cribbing, bulkheads, shoring, or provide whatever means necessary to adequately support the facilities which are to remain, and 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 by the Developer.

When hauling is done over highways 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.

203-3 Roadway Excavation:

203-3.01 Description:

Roadway excavation shall consist of excavating, grading, and hauling all types of materials encountered in constructing the roadway, driveway entrances, ditches within the roadway, and other road-related areas as designated on the plans.

203-3.03 Construction Requirements:

(A) General:

All roadway excavation shall be finished to a reasonably smooth, uniform surface finished subgrade shall not vary by more than 0.04 feet, except in areas comprised of “Rock” as defined in 203-10.03 (D) in which case the surface shall not vary by more than 0.2’, above or below the grade established and shall be in reasonably close conformance to the lines, dimensions and cross-sections shown on the project plans. The top nine inches of the subgrade shall be compacted to a density of not less than 95 percent of the maximum density.

When Portland Concrete Pavement or Asphaltic Concrete Pavement are to be placed directly on the subgrade, the finished surface shall not vary by more than 0.04 feet above or 0.04 feet below the established grade.

In areas where excavation of material is accomplished by blasting, the tolerance of the finished slopes will be determined in the blasting plan. Wasted material shall be disposed of by the Developer. During construction, the roadway shall be maintained in a well-drained condition at all times.

(B) Slopes:

Earth slopes shall be finished to reasonably smooth surfaces and shall be free of all debris and loose material. Slopes may be track walked for temporary slope finishing prior to seeding. When earth slopes are to be seeded, the surface shall be finished to a loose, evenly roughened condition, in accordance with the requirements of Subsection 805-3.02(B).

All shattered or loosened material shall be removed from rock cut slopes.

Adjustments in slopes shall be made 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.
Except in rock, the intersection of roadway cut slopes with the ground surfaces shall be rounded as shown on the plans.

Topsoil removal and replacement will be determined in the Developer’s Plating Plan.

(C) Blasting:

(1) General:

Overshooting or any method of blasting that might cause damage to the roadway section or highway structures, or that might be dangerous or destructive to adjacent property or landscape, will not be permitted. The Developer shall provide and install suitable protection for all trees, shrubbery, pole lines and other existing facilities within the adjacent area. All blasting specification are covered in the Developer's Blasting Plan.

203-5 Structure Excavation and Structure Backfill:

203-5.01 Description:

Structure excavation shall consist of the excavation and removal of all materials necessary for the construction of bridges, concrete box culverts, inlet and outlet wings, retaining walls or other specific items designated on the project plans.

Structure backfill shall consist of furnishing, placing and compacting backfill material around structures as designated on the plan.

The work under this section includes the furnishing and installing of a geocomposite drainage system as an abutment or retaining wall drainage when specified in the plans.

203-5.02 Materials:

(A) Geocomposite Drain:
The geocomposite wall drain materials shall conform to the requirements of Subsections 1014-1 and 1014-6.

(B) Geocomposite Packaging, Handling, and Storage:
The identification, packaging, handling, and storage of the geocomposite wall drain material shall be in accordance with ASTM D 4873. 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. At no time shall the geocomposite wall drain materials be exposed to direct sunlight for a period exceeding 14 days.

203-5.03 Construction Requirements:

(A) Excavation:

In lieu of providing shoring, the sides of excavations may be sloped as required by soil conditions to stabilize the sides for safe working conditions. Side slopes shall conform to the requirements specified in current OSHA regulations.

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, the foundation shall be restored. Developer's Geotechnical Engineer and IQF Segment Manager will review the suitability of bearing surfaces prior to structure work.

When structures are to rest on rock, the surface shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled or cut to steps, and the surface roughened. Any seams in the rock shall be inspected by Developer's Geotechnical Engineer to determine if any remediation work is necessary. Developer's Geotechnical Engineer will recommend remediation work to take place prior to structure work, if necessary.

Where rock or other unyielding material is encountered at the planned grade of a structure and a yielding material is encountered in an adjacent area for the same structure, the unyielding material shall be removed and replaced with cement slurry or concrete that has a minimum 7 day compressive strength equal to or greater than that of the concrete footing.

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 Developer shall 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 suitable for and not used as structure backfill shall be used either for the construction of embankment or in fill area on the plans where material is acceptable.

(B) Backfill:

(1) Structure Backfill:

Structure backfill material shall be selected from excavation or from a source selected by the Developer. It shall not contain frozen lumps, chunks of clay, or other objectionable material. Backfill material shall have a value of resistivity not less than 2,000 ohm-centimeters. Backfill material to be used for metal piles or similar items of metal shall have a value of resistivity not less than 2,000 ohm-centimeters or the value shown on the plans. Backfill material shall have a pH value between 6.0 and 10.0, inclusive, when placed against metal installations, except aluminum. Backfill material shall have a pH value between 6.0 and 9.0, inclusive, when placed against aluminum installations. Backfill material shall have a pH value between 6.0 and 12.0, inclusive, when placed against installations other than metal. 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 (Arizona Test Method 201):

Sieve Size	Percent Passing
3 inch	100
3/4 inch	60 - 100
No. 8	35 - 80
No. 200	0 - 12

** Projectwide, including 51st Ave to 17th Ave*

Sieve Size	Percent Passing
1-1/2 inch	100
No. 8	25 - 45
No. 200	0 - 12

** Alternative South Mountain backfill between 51st Ave and 17th Ave*
*** Alternative Gradation acceptable within the Pecos Segment*

The plasticity index shall not exceed 5 when tested in accordance with the requirements of AASHTO T 90.

Structure backfill may be comprised in part of salvaged Portland cement concrete material in all locations. Structure backfill may contain salvaged asphaltic concrete materials at Sound Wall backfill locations only. All metal reinforcement materials shall be removed from salvaged Portland cement concrete prior to its use in structure backfill. A maximum of 50 percent salvaged pavement, by weight or volume, will be allowed. Changes in proportions that result in more than 50 percent salvaged pavement will not be allowed. Structure backfill material containing salvaged materials shall be thoroughly mixed by means of a mechanical mixing device prior to placement.

Structure backfill composed of soil and aggregate materials and salvaged concrete shall conform to the gradation requirements specified for structure backfill. When soil and aggregate materials are blended with salvaged concrete, the soil and aggregate portion shall conform to the pH, resistivity, and plasticity index requirements specified for structure backfill.

Pipe bedding material conforming to Section 500 of these specifications, shall be placed six inches below the pipe structures as shown on the plans. The depth of AB to be placed beneath precast box culverts is 4 inches, unless otherwise dictated by the geotechnical engineer, shall be placed six inches below the pipe and pre-cast manhole structures as shown on the plans.

(2) Use of Slurry:

As an alternate to the material requirements of Structure Backfill, a slurry mixture may be used.

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	90 - 100
No. 8	35 - 80
No. 200	0 - 8.0

The plasticity index shall not exceed 8 when tested in accordance with the requirements of AASHTO T 90.

MAG #57 0.5 sk CLSM SEC 728 at 8” slump can be used for box culverts, storm drainage, and abandonment of facilities and utilities.

(3) 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 72 hours of cure or 80% of full design strength, whichever occurs first. Backfill material shall not be placed against concrete structures not designed to retain earth loads until the concrete has attained a minimum compressive strength of 2,000 pounds per square inch and 72 hours after casting. Backfill shall be placed uniformly on each side of the structure, and at all times during placement shall be not more than four feet above any other side. When a structure is located within a paved area, all backfill material above finished subgrade elevation shall conform to the requirements of the typical pavement section of the same elevations.

Backfill shall be placed in layers not more than 12 inches in depth before compaction.

Backfill material placed as a slurry shall be placed in uniform layers not exceeding five feet in depth. The maximum water content of the slurry mixture shall be 40 gallons of water per ton of backfill material.

(4) Compaction of Backfill:

Each layer of structure backfill material shall be compacted to at least 95 percent of the maximum density as determined by the Inspector.

Compaction equipment or methods which may cause excessive displacement shall not be used.

(C) Geocomposite Wall Drain:

Geocomposite wall drains shall be constructed, repaired and installed in accordance with manufacturer's requirements. If shown on the plans, geocomposite wall drains shall be installed on the soil side of abutment walls, retaining walls, culvert wing walls, and culvert sidewalls.

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 continuous contact between the concrete surface and the drain material. The geocomposite drain shall be installed with the single fabric surface in contact with the backfill material.

When the core of the geocomposite wall drain is not perforated during manufacture, perforations shall be made in the core where the wall drain will lay against a weep hole or other drainage outlet.

Structure backfill operations shall be started as soon as possible after placing the geocomposite material, but in no case shall the geocomposite material be exposed to sunlight for more than 14 continuous days after installation. Care shall be taken during the backfill operation not to damage the geotextile surface of the drain and to avoid excessive settlement of the backfill material.

203-9 Borrow:

203-9.01 Description:

The work under this section shall consist of furnishing and placing suitable and satisfactory 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.

203-9.02 Materials:

Borrow material shall be of a quality suitable for the purpose intended, free of vegetation or other unsatisfactory material.

203-9.03 Construction Requirements:

Borrow material shall be placed in accordance with the requirements of Subsection 203-10.

203-10 Embankment Requirements:

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.

The following generalized Pavement Support conditions are used for purposes of pavement design for the project. Refer to the Project Plans for determination of Pavement Support Group classification for various pavement areas.

PAVEMENT SUPPORT GROUP (PSG)	RMEAN**	DESIGN RESILIENT MODULUS (MR)
Pavement Support A	42.2	26,000 psi
Pavement Support B	40.0	24,425 psi
Pavement Support C	35.0	21,050 psi
Pavement Support D	30.0	17,875 psi
Pavement Support E	25.0	14,900 psi
Pavement Support F	20.0	12,125 psi
Pavement Support G*	20.0	17,875 psi
Pavement Support H	15.0	9,550 psi

*Represents PSG F with the addition of geogrid
**R_{mean} Represents the target R-value to meet the Design M_r. A separate construction control R-value is provided in the Materials Design Report.

Borrow placed within three (3) feet of finished subgrade shall meet the following requirements, based on the selected Pavement Support Group (PSG):

The Plasticity Index (PI) (AASHTO T90) and the percent passing the No. 200 Sieve (Minus 200) (Ariz. Test Method 201) when used in the equation below, shall give a value of X that does not exceed the X values outlined in the table below.

$$X = (\text{Minus } 200) + [2.83\ (PI)]$$

PAVEMENT SUPPORT GROUP (PSG)	RMEAN	X*
Pavement Support A	42.2	62
Pavement Support B	40.0	66
Pavement Support C	35.0	76
Pavement Support D	30.0	87
Pavement Support E	25.0	100
Pavement Support F	20.0	116
Pavement Support G**	20.0	116
Pavement Support H	15.0	137

*Does not exceed
**Represents PSG F with the addition of geogrid

203-10.02 Embankment Materials:

(A) Drilled Shaft Locations:

Embankment material containing broken concrete, rock, or other solid material which is larger than 12 inches in its greatest dimension shall not be placed horizontally within 10 feet of any proposed drilled shaft.

(C) Abutment, Wingwall and Anchor Slab Locations:

Embankment material placed adjacent to bridge abutments and wingwalls shall be structural backfill if shown on the plans.

203-10.03 Embankment Construction Requirements:

(A) Placement:

All embankments shall be constructed to a reasonably smooth and uniform surface and shall not vary by more than 0.10 feet, except in areas comprised of “Rock” as defined in 203-10.03 (D) in which case the surface shall not vary by more than 0.2’, above or below the grade established and in reasonably close conformity to the lines, dimensions and cross sections shown on the project plans. All embankment material, whether from sources within the site or from borrow, to be placed within three feet of the finished subgrade elevation shall have a resilient modulus value equal to or greater than the design resilient modulus value for the pavement structure.

When embankment material is to be placed over existing bituminous surfacing, the surfacing shall be scarified prior to placing embankment material. Surplus material or unsuitable material, shall be either used for the construction of embankment or in fill area on the plans where material is acceptable.

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 four feet 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 re-compacted along with the new embankment material.

Embankment of earth material shall be placed in uniform horizontal layers not exceeding 12 inches 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, of rock or concrete consisting predominately of fragments of such size that the material cannot be placed in a twelve-inch 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 equal to two feet.

The placing of individual rocks and boulders greater than 24 inches in diameter will be permitted provided they do not exceed 36 inches in maximum dimension, are carefully distributed to prevent nesting and the interstices are filled with finer material and compacted to form a dense and compact mass. Each layer shall be leveled and smoothed by evenly distributing spalls and finer fragments of rock and earthen material.

Embankment material containing broken concrete, rock, or other solid materials which are larger than six inches in greatest dimension shall be placed so that no surface of said material is within one foot horizontally of any planned piling, structure, pole or sign foundations, and underground conduit.

Embankment material placed at bridge abutments shall have a Plasticity Index of not more than 15 when tested in accordance with AASHTO T 90. Material placed within these limits shall contain no rocks or other solid material greater than 12 inches in its largest dimension between the subgrade elevation and a depth of five feet. Embankments deeper than five feet within these limits shall contain no rocks or other solid material greater than 36 inches in its largest dimension.

Concrete with any dimension greater than two feet shall be removed and wasted or reduced to a maximum of 24 inches before placing in embankment.

(B) Compaction:

Each layer of the embankment material shall be compacted by rolling, tamping, or other suitable means 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 shall be required to assure uniform density. The moisture content of the material shall be adjusted, if necessary, to obtain the required density. As far as practicable, construction equipment shall be continuously routed uniformly over the entire surface of each layer.

Where embankments are to be constructed, the top nine inches of the existing ground on which the embankment material is to be placed shall be compacted to a density of not less than 95 percent of the maximum density.

When embankments are to be constructed at bridge abutments, each layer of embankment material placed beneath the approach slab and an additional 50 feet beyond the limits of this slabs, shall be compacted to a density of not less than 100 percent of the maximum density, including the material specified in Subsection 203-10.02(C). The compaction requirements for Reinforced Backfill and Retained Backfill at bridge abutments shall be as specified in Section 929. Density requirements will not apply to rocky material placed within these limits.

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 six inches of the embankment shall be compacted to a density of not less than 100 percent of the maximum density.

All density determinations will be made in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual.

If soils contain more than 50% gravel, acceptable compaction will be based on visual observation during proof rolling. Compaction shall be achieved with sufficient haul truck and water trailer passes over the entire width of the embankment to create a uniformly compacted surface as approved by the Engineer. Prior to compaction, the moisture content shall be adjusted to a level suitable for compaction and fill the interstices around rock with earth or other fine material as practical.

Where embankments for retaining walls are to be constructed, the exposed surface shall be proof-rolled to determine if any pumping, soft of loose zones exist that should be further removed. Proof rolling of exposed bedrock will not be required. Proof rolling of other areas of the project where over-excavation is not required may be waived by the geotechnical engineer.

(C) Proof Rolling:

The contractor shall perform proof rolling to evaluate the stability and uniformity of the subgrades on which roadway embankment or retaining walls will be constructed. Proof rolling shall be performed on the entire bottom of required over-excavation for embankment and retaining wall locations.

Proof rolling shall be performed with pneumatic-tired tandem axle equipment, with a gross minimum weight of 24 tons, a minimum tire pressure of 75 pounds per square inch. Approved alternative equipment for proof rolling includes fully loaded 10-wheel 4,000 gallon water trucks and 4-wheel 8,000 gallon water pulls, or equivalent equipment determined by gross weight, as approved by Geotechnical Engineer. Proof rolling equipment shall be operated at a speed of between 1.5 and 3 miles per hour, or slower as required to permit measurements of the deformations, ruts and/or pumping.

Proof rolling shall be carried out longitudinally with roadway, or both directions as required by the geotechnical engineer at right angles to each other with no more than 24 inches between tire tracks of adjacent passes (or as modified by the geotechnical engineer). Proof rolling shall occur in a pattern that readily allows for the recording of deformation data and complete coverage of the subgrade.

Acceptability requirements of subgrade suitability is based on the results of the proof rolling, as follows:

1. Rutting less than ½-inch – The subgrade is acceptable. The subgrade shall be scarified 9 inches deep and re-compacted.

2. Rutting greater than ½-inch and less than 1½ inches – The subgrade shall be scarified 9 inches deep and re-compacted.

3. Rutting greater than 1½ inches – The Subgrade is rejected. The effective area shall be removed 2 feet deep (or as modified by the geotechnical engineer) and recompacted. Pumping deformations that rebound, or materials that are squeezed out of a wheel's path, greater than 1 inch shall be remediated as directed by the geotechnical engineer. Once the geotechnical engineer and IQF agree that sufficient material has been removed, the exposed surface upon which embankment fills are to be placed shall be scarified to a depth of at least 9 inches and compacted in accordance to a density of not less than 95 percent of the maximum density. Retaining wall construction in areas of pumping (rutting greater than 1½") should not commence until the foundation has been approved by the geotechnical engineer.

(D) Rock:

Minimum relative compaction requirements shall not apply to embankment constructed of materials which contain at least 50 percent gravel and which cannot be tested for compacted density by approved test methods. Rock embankment shall be compacted on a minimum rolling basis using specified compaction equipment and minimum number of passes as described in this section.

Rock embankment material shall be placed, spread and leveled in maximum 36-inch thick layers, over the full width of the embankment, with sufficient earth or other fine material deposited so as to fill the interstices between rock particles to produce a dense compact embankment. The average dimension of the largest rock particle placed in the rock embankment shall not exceed 24 inches.

Rock embankment material shall be continually watered during placement and compaction operations. The moisture content of the minus No. 4 fraction of the material shall be adjusted to be a minimum of 2 percent below optimum moisture content when tested in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual. Compaction of each lift of rock embankment material shall be achieved by a minimum of five (5) passes of either a fully-loaded 8,000 gallon water pull, or a minimum 15-ton (static weight) padfoot compactor such as a Caterpillar CP68B or equivalent. The wheel path of the compaction equipment shall be adjusted to ensure complete coverage of the entire width of each lift of material by each pass. Each lift of compacted rock embankment material shall then be proof-rolled in accordance with Section 203-10.03(C).

Acceptance of each lift of compacted rock embankment shall be based on conformance with all requirements of the above paragraph.

Additional compaction of rock embankments may be required at the discretion of the Independent Quality Firm.

SECTION 204 RESHAPING AND GRADING EXISTING IMPROVEMENTS

204-1 Description:

The work under this section shall consist of reconstructing or restoring existing dikes, berms and median slopes, including furnishing, placing and compacting embankment material, as required, at the locations and in accordance with the details shown on the project plans

204-2 Blank

204-3 Construction Requirements:

Reconstructing or restoring shall be the rebuilding of existing improvements, to either new lines, grades and cross sections or to their original lines, grades and cross sections as shown on the project plans.

The reconstruction or restoring of dikes, berms and median slopes shall be accomplished in accordance with the same requirements as for new work.

compacted rock embankment material shall then be proof-rolled in accordance with Section 203-10.03(C).

Acceptance of each lift of compacted rock embankment shall be based on conformance with all requirements of the above paragraph.

Additional compaction of rock embankments may be required at the discretion of the Independent Quality Firm.

SECTION 204 RESHAPING AND GRADING EXISTING IMPROVEMENTS

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204-2 Blank

204-3 Construction Requirements:

Reconstructing or restoring shall be the rebuilding of existing improvements, to either new lines, grades and cross sections or to their original lines, grades and cross sections as shown on the project plans.

The reconstruction or restoring of dikes, berms and median slopes shall be accomplished in accordance with the same requirements as for new work.

Lime from more than one source may be used on the same project, but the different limes shall not be mixed. The lime shall be protected from exposure to moisture until used and shall be sufficiently dry to flow freely when handled.

A mix design shall be performed for each soil type to verify proper mixing ratio and performance.

301-2.02 Water:

When hydrated lime is used, the required amount of lime may be applied in the form of a slurry.

Water used for mixing shall conform to the requirements of Subsection 1006-2.02.

301-2.03 Bituminous Material for Curing Seal:

Bituminous material for curing seal shall be Emulsified Asphalt, Grade SS-1 conforming to the requirements of Section 1005.

301-3 Construction Requirements:

301-3.01 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 contain no rocks larger than 2-1/2 inches in any dimension. The depth to be scarified shall be such that when the lime, water and in-place material is mixed and compacted, the treated subgrade will be in close conformity to the specified thickness.

If the mixing machine to be used requires that the material be windrowed, the windrows shall be of uniform cross section and limited to such size that all the material can be passed through the mixer at each operation. Otherwise the material shall be shaped to the required line, grade and cross section before application of lime and mixing.

301-3.02 Application of Lime:

Lime shall be added to the material to be treated at a rate not varying more than 10 percent from the rate specified in the Mix Design. The equipment used to distribute the lime shall be capable of uniformly distributing the required amount of lime for the full width of the pass.

Lime or lime treated material shall not be spread or mixed when the soil is frozen, when the air temperature is less than 40 degrees F in the shade, or when conditions indicate that the temperature may fall below 40 degrees F within 24 hours.

The area upon which lime may be spread ahead of the mixing operation shall be limited to that which the Developer 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.

301-3.03 Mixing:

Mixing shall be accomplished by a traveling pugmill or a single or multiple transverse shaft mixer. It 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 within two percentage points 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.

Mixing or re-mixing operations shall continue until the material is uniformly mixed, free of streaks or pockets of lime. The final mixture shall not contain more than five percent of untreated dirt clods larger than one inch in diameter.

After the initial mixing operation and before the lime treated material is compacted, a curing period of a minimum of 24 hours will be required.

301-3.04 Compaction and Finishing:

The treated mixture shall be spread and compacted to the required width, grade and cross section.

The thickness of a compacted layer shall not exceed eight inches. Where the required thickness is more than eight inches, 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, 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 methods of the ADOT Materials Testing Manual.

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. The surface of the treated subgrade shall not vary by more than 0.04 feet above or below the grade established on the project plans.

301-3.05 Curing:

The surface of each compacted layer of lime treated material shall be kept moist until covered by a subsequent layer of lime treated material, or until a bituminous curing seal is applied. The bituminous curing seal shall be applied uniformly at an approximate rate of 0.15 gallons per square yard of surface, or as approved by the Developer. The curing seal shall be applied as soon as possible after the completion of final compaction and before the temperature falls below 35 degrees F.

No equipment or traffic (other than equipment used for LTSG operations) will be permitted on lime treated subgrade for three days after curing seal is applied. Subsequent subbase, base or pavement course shall be placed between three to four days after the curing seal is applied.

SECTION 303 AGGREGATE SUBBASES AND AGGREGATE BASES:

303-1 Description:

The work under this section shall consist of furnishing, placing and compacting aggregate subbases and aggregate bases in accordance with the details shown on the project plans and the requirements of these specifications.

Aggregate subbases and aggregate bases are designated as Class 1 through Class 6. The class of aggregate subbase and aggregate base will be shown on the project plans.

303-2 Materials:

Aggregate for the various classes of aggregate subbases and aggregate bases shall consist of stone, gravel or other approved inert material of similar characteristics, and shall be clean and free from vegetable matter and other deleterious substances.

Aggregate subbases and aggregate bases shall conform to the requirements shown in the following table for the class specified:

TABLE 303-1

Class of Aggregate	Percent Passing Sieve (Inch or No.)							PI, Max.
	3	1-1/2	1	3/4	1/4	8	200	
1			100	90 - 100		35 - 55	0 - 8.0	3
2		100	90 - 100			35 - 55	0 - 8.0	3
3		100	85 - 100			25 - 45	0 – 12.0	3
4	100				35 - 70		0 - 10.0	5
5	100				30 - 75		0 - 10.0	5
6								

Notes:

(1) The percentage, by weight, passing each sieve will be determined in accordance with the requirements of Arizona Test Method 201.

(2) The PI (Plasticity Index) will be determined in accordance with the requirements

of AASHTO T 90.

(3) Classes 1, 2 and 3 are bases; Classes 4, 5 and 6 are subbases.

(4) For Classes of Aggregate 1 or 2, if the percent passing the #200 sieve exceeds 8 percent but is less than 13 percent and/or the PI exceeds 3 percent but is less than 9 percent, a laboratory resilient modulus test, per AASHTO T307, (Sequence 11, 100% compaction (standard), and optimum moisture) shall be completed before acceptance. Testing must demonstrate a minimum resilient modulus of 34,000 psi.

(5) For Class 1 through Class 4 aggregate, the amount of fractured coarse aggregate particles shall be at least 30 percent, when tested in accordance with the requirements of Arizona Test Method 212.

(6) Resistance to abrasion for Class 1 through Class 4 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

(7) Class 3 is an alternative material for South Mountain between Sta 2040+00 and 51st Ave.

When production of Class 1 through Class 4 aggregate requires composite mixing of materials from more than one source to meet the gradation requirements of Table 303-1, the material from each source shall meet the abrasion requirements specified in herein.

Aggregate subbase and aggregate base material may be comprised of salvaged asphaltic concrete, salvaged existing aggregate base or Portland cement concrete materials.

Salvaged asphaltic concrete, salvaged existing aggregate base and Portland cement concrete materials shall not contain hazardous materials. All metal reinforcement materials shall be removed from salvaged Portland cement concrete prior to its use in aggregate subbase and aggregate base material.

Aggregate subbase and aggregate base material containing salvaged materials shall be thoroughly mixed using an approved mixing method, as provided by the Developer.

Virgin aggregate shall conform to the gradation, plasticity index, fractured coarse aggregate particles, and abrasion requirements for the class of aggregate specified.

Aggregate subbase and aggregate base material composed of virgin aggregate and/or salvaged materials shall conform to the gradation requirements for the class of aggregate specified. In addition, aggregate subbase and aggregate base material composed of virgin aggregate and/or salvaged Portland cement concrete shall conform to the plasticity index requirements for the class of aggregate specified.

If salvaged asphaltic concrete material contains underlying base material, the plasticity index of the salvaged material (including the underlying base material) shall conform to the requirements for the class of aggregate specified.

When determining gradation of aggregate subbase or aggregate base material composed of virgin aggregate and/or salvaged asphaltic concrete materials, drying to a constant weight shall be performed at a temperature of 140 ± five degrees F.

303-3 Construction Requirements:

303-3.01 Placement:

Aggregate subbases and aggregate bases shall be processed to a uniform blend and placed and spread on the prepared subgrade, subbase or base in a uniform layer or layers not exceeding eight inches in compacted depth. The spread material shall be free of segregation.

303-3.02 Compaction:

Each layer of aggregate subbase and aggregate base material consisting of virgin aggregate, salvaged asphaltic concrete and/or Portland cement concrete material shall be compacted to at least 100 percent of the maximum density determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual.

When determining maximum density and optimum moisture content for aggregate subbase and aggregate base material composed of virgin aggregate and/or salvaged asphaltic concrete materials, drying to a constant weight shall be performed at a temperature of 140 ± five degrees F.

303-3.03 Finishing:

The final layer of subbase or base shall be finished with equipment capable of shaping and grading the finish surface within the tolerances specified herein.

The finished surface of aggregate subbase or aggregate base shall not vary from the grades established on the plans by more than ± 0.04 feet.

The compacted layers of aggregate subbase and aggregate base shall be maintained in a condition satisfactory to receive any subsequent subbase, base or surfacing material or traffic, when so required.

Areas not within the allowable tolerance shall be corrected by scarifying, placing additional material, re-mixing, reshaping and re-compacting to the specified density and surface tolerance.

SECTION 306 GEOGRID BASE REINFORCEMENT:

306-1 Description:

The work under this section shall consist of furnishing and placing a geogrid material within and/or below the aggregate base as shown on the project plans or in area of unsuitable material that is moving under the weight of construction equipment in locations outside of the pavement prism in the opinion of the Developer.

306-2.01 Geogrid Materials:

The geogrid material shall be supplied in accordance with and conform to the material requirements of Subsections 1014-1 and 1014-3 unless otherwise specified in the project plans.

306-2.02 Geogrid Packaging, Handling, and Storage:

The identification, packaging, handling, and storage of the geogrid material shall be in accordance with ASTM D 4873. 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 zero degrees F or in extreme heat. Torn, damaged, or defective geogrid will be rejected.

306-3 Construction Requirements:

306-3.01 Weather Limitations:

The geogrid shall not be placed when weather or surface conditions are not suitable for placement per the manufacturer's recommendations. This will normally be at times of wet and snowy conditions, heavy rainfall, extreme cold or frost conditions, or extreme heat.

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 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 303-3.03 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. All material will be placed in accordance with manufacturer's recommendations.

A 12-inch minimum overlap with securing pins is required at all joints (both transverse and longitudinal). At transverse joints, the preceding roll shall overlap the following roll in the direction that the aggregate base will be placed. The use of securing pins may be reduced or eliminated from the installation process as recommended (in writing) by the manufacturer.

The center of a longitudinal overlapped joint in a geogrid layer shall be staggered a minimum of one foot with relation to the center of a longitudinal overlapped joint in any immediate underlying geogrid layer.

The center of a longitudinal overlapped joint in a geogrid layer below an asphaltic concrete pavement shall be located within one foot of the center of a lane or within one foot of the centerline between two adjacent lanes.

At transverse joints, the top layer of the geogrid shall overlap the lower layer of geogrid in the direction that the aggregate base will be placed.

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 dumped and spread in a uniform lift maintaining the design aggregate thickness at all times. The aggregate material shall be placed onto the geogrid in such a manner that the aggregate rolls onto the grid ahead.

If the underlying material is capable of supporting rubber tire trucks, they may drive over the grid at very low speeds, less than five miles per hour, and dump aggregate as they go. Sudden stops and turning by trucks shall be avoided while on the grid. No tracked vehicles should be allowed on the grid until there is a minimum of six inches of material between the tracks and the grid.

Any ruts which might develop during spreading or compacting the aggregate shall be filled with aggregate.

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. Contamination and segregation of aggregate base materials prior to or during placement shall be minimized.

Registered Professional Engineer (Civil)
CERTIFICATE NO. 49430
GREGORY PATRICK FLY
Date Signed 5-26-20
ARIZONA U.S.A.
EXPIRES: 3-31-21

SECTION 401 PORTLAND CEMENT CONCRETE PAVEMENT:

401-1 Description:

The work under this section shall consist of furnishing all materials and constructing a pavement surface using Portland cement concrete and shall include coring operations, furnishing and placing dowels and tie bars, furnishing and placing miscellaneous reinforcing steel and joint materials, and constructing joints in accordance with the details shown on the plans and the requirements of the specifications.

The producer shall proportion and mix in accordance with the requirements of the specifications. The contractor shall place, finish, and cure concrete in accordance with the requirements of the specifications.

401-2 Materials:

Portland cement concrete for pavement shall consist of a mixture of hydraulic cement, fine aggregate, coarse aggregate, water, and admixtures.

Unless otherwise provided, Portland cement concrete pavement shall conform to the requirements of Section 1006. Concrete shall be Class P.

Materials for expansion joint filler and joint seal shall conform to the requirements of Section 1011 unless otherwise shown on the project plans.

Materials for tie bars and dowel bars shall conform to the requirements of Section 1003. Materials for dowel bars shall conform to the requirements of Class P.

Materials for tie bars and dowel bars shall conform to AASHTO M 254 with Type B coating except that the core material shall conform to the requirements of ASTM A 615, Grade 40. When epoxy coated reinforcing steel is designated, it shall conform to the requirements of Subsection 1003-5.

Liquid membrane curing compound shall conform to the requirements of Subsection 1006-2.05.

401-3 Construction Requirements:

401-3.01 General:

Contractor shall prepare Paving Plans for each Project Segment. Each Paving Plan must include the following:

A. A detailed sequence and schedule of concrete placement operations, including the following:
   1. Width of pavement to be placed,

2. Proposed equipment,
3. Production rates,
4. Working hours,
5. Concrete hauling,
6. Placement methods, and
7. Curing, sawing, and sealing methods.

B. A detailed staking plan for subgrade controls, including offset requirements.

C. Details of the layout of all longitudinal, transverse, weakened plane, and expansions joints, including joint sequence, dimensions, and locations of dowels and dowel baskets shall be in accordance with ADOT Construction Standard Drawings (C-standards).

D. A Traffic Control Plan for pavement construction operations that includes provisions for the placement and maintenance of barriers required to protect the pavement from traffic for a minimum of 7 days after concrete placement.

Not less than 20 Business Days prior to paving, Contractor shall submit each Paving Plan(s) to ADOT for review and comment.

Unless otherwise shown on the plans, the main roadway, including concrete shoulders or distress lanes, shall be placed in a single monolithic pass, provided the finished surface of the pavement consistently conforms to the requirements for grade, alignment and pavement smoothness as specified. Paving widths which are less than the full main roadway width shall be constructed with longitudinal construction joints that are located on the lane line or at the edge of the main roadway.

Portland cement concrete pavement shall be constructed as required, smooth and true to the required lines, grades, and dimensions.

Use of 3-D Machine Control PCC Paving (wireless) with vertical and horizontal control (any combination of Global Positioning System (GPS), total stations, and/or laser) may be used.

401-3.02 Pavement Base:

The surface of asphaltic concrete upon which the concrete pavement is to be placed shall conform to the finish and elevation requirements specified for the material involved. The surface shall be free of all loose and extraneous material and the surface shall be uniformly moistened immediately prior to placing concrete.

401-3.03 Forming:

(A) General:

If 3-D Machine Control PCC Paving (wireless) is utilized, the contractor shall stake for vertical and horizontal control on each side of the roadway, identify all points of curve (P.C.), points of tangent (P.T.), and other alignment changes, and shall be at intervals of not less than 100 feet on curves and 200 feet on tangents.

(B) **Slip-Form Method:**

The contractor shall set taut guide lines to control both line and grade, or develop a 3-D slope model if 3-D Machine Control PCC Paving (wireless) is utilized.

Slip-form equipment shall be equipped with automatic sensing and control devices and shall operate such that the machine automatically follows the guide line (wire) or the 3-D slope model if 3-D Machine Control PCC Paving (wireless) is utilized. The contractor shall provide electronic data from the 3-D slope model for approval 10 days prior to paving. The contractor shall check and recalibrate the 3-D Machine Control system every day that paving will be performed.

The contractor shall set taut guide lines to control both line and grade.
No abrupt changes in longitudinal alignment of the pavement will be permitted. The horizontal deviation from the alignment shown on the plans shall not exceed 0.10 feet.

(C) **Fixed Form-Manual Method:**

Forms shall be set to the required lines and grades well in advance of placing concrete.

Forms shall be made of steel and have an approved section with a base width of at least four inches and a depth equal to or greater than the thickness of the pavement. The forms shall be staked with steel stakes of appropriate lengths. Each form section shall have a stake pocket at each end and at intervals of not more than five feet. The stake pockets shall have a device for locking the form to the steel stakes. Each form section shall be straight and free of bends and warps at all times. The top of each form section shall not vary from a true plane by more than 1/8 inch in 10 feet and the inside face shall not vary more than 1/4 inch in 10 feet.

Wood or other rigid forms may be used in irregular areas.

Forms shall be thoroughly cleaned and oiled each time they are used.

Before forms are placed, the underlying material shall be finished to the required grade and shall be firm and smooth. The forms shall be uniformly supported upon the subgrade or base and shall be placed to the required grade and alignment. Forms shall be supported so that they will not deviate more than 1/8 inch from the proper elevation during paving operations.

Forms shall remain in place until the day after placing the concrete and shall be removed in a manner that will prevent damage to the pavement. Pry bars shall not be used between the forms and the pavement under any circumstances.

401-3.04 Placing and Finishing:

(A) General:

When daytime ambient temperatures are expected to exceed 100 degrees F, concrete shall only be placed at the direction of the Developer between the hours of 8:00 p.m. and 8:00 a.m.

Immediately prior to placing concrete, the contractor shall verify that the elevations of guide wires controlling slip-form pavers and the elevations of fixed forms are such that the thickness and finished grade of the pavement will be in accordance with the requirements of the project plans.

Concrete shall be placed using methods that result in a minimum of handling and segregation and in a manner that will result in the concrete being distributed uniformly across the front of the paving machine.

Concrete placement shall be continuous between expansion or construction joints. The concrete shall be struck off, consolidated and floated by mechanical methods.

If surface drying or cracking should occur prior to the application of curing material, the entire surface of the concrete shall be kept damp by applying water and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.

The contractor shall protect the base or subgrade when equipment is cleaned at the end of each days production. All concrete deposited on the base or subgrade during the cleaning operation shall be removed from the base or subgrade immediately after cleaning is completed. Any damage to the base or subgrade, shall be repaired, as approved by the Independent Quality Firm, prior to commencing paving operations. Water will not be permitted to pond on the roadway.

Any concrete which is spilled, splattered, or scattered on existing pavement shall be removed before the end of each day's paving operations.

(B) Slip-Form Method:

The equipment shall spread, consolidate, screed and float-finish the concrete so that a minimum of hand finishing will be necessary and a well consolidated and homogeneous pavement is produced.

The machine shall vibrate the concrete for the full width and depth of the concrete. Such vibration shall be accomplished with vibrating tubes or arms working in the concrete and spaced not more than 24 inches center-to-center. Vibrators shall operate at a minimum of 8,000 impulses per minute. Concrete placement shall cease immediately if a vibrator fails to function and cannot be immediately repaired, replaced, or supplemented with additional vibrators.

The machine shall be operated with as nearly a continuous forward movement as possible and all mixing, delivering, and concrete spreading operations shall be coordinated to provide uniform progress. If for any reason it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped simultaneously.

Pavement edge slump in excess of 0.02 feet, exclusive of edge rounding, shall be corrected. If correction is not possible while the concrete is plastic, pavement with excessive edge slump shall be corrected by one of the following methods:

The pavement shall be removed by saw-cutting a distance not greater than one foot from the pavement edge between adjacent transverse joints. Tie bars shall be placed as specified in Subsection 401-3.05 and the pavement shall be replaced as part of adjacent Portland cement pavement construction.

If excessive edge slump can not be corrected by method one (1) above, then the pavement shall be removed for the full lane width between adjacent transverse joints and replaced as specified in Subsection 401-4.03(C).

When concrete is being placed adjacent to previously constructed pavement, work bridges for placing and finishing the pavement and the tracks on one side of the paver may be allowed on the new pavement provided that:

(1) The previously placed pavement has met at least 75% strength or 3,000 psi, as determined by Arizona Test Method 318, Estimating the Development of Concrete Strength by The Maturity Method or Arizona Test Method 314b, Compressive Strength of Cylindrical Concrete Specimens.

(2) Pressure exerted on the pavement by the paver shall not exceed 20 pounds per square inch.

(3) Tracks on the paver shall be equipped with protective pads, or the surface of the existing pavement shall be protected so that the surface is not damaged.

(4) No part of the track shall be operated within one foot of the edge of the existing pavement.

Any pavement which is damaged by the contractor's equipment shall be repaired as approved by the Independent Quality Firm and at no additional cost to the Developer.

(C) Fixed Form Method

Three types of self-propelled mechanical equipment: the spreader, the finisher, and the float will be required; however, a single machine combining two or more of these operations may be used if it has been demonstrated that such a machine will accomplish satisfactory results. All wheels of all machines that ride on finished concrete surfaces shall be equipped with rubber tires.

The concrete shall be spread uniformly between the forms, immediately after it is placed, by means of the spreading machine. The spreader shall be followed by the finishing machine equipped with not less than two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine or to the finishing machine. Vibrators shall not rest on new pavements or side forms or contact any tie bars, and power to the vibrators shall be such that when the motion of the machine is stopped, vibration will cease. Vibrators shall operate at a minimum of 8000 impulses per minute.

The concrete shall be spread full width before being struck off by the finishing machine. The concrete shall be struck off and consolidated so that the surface will conform to the finished grade and cross section shown on the project plans and at the same time leave sufficient material for the floating operation. The spreading or finishing machine shall move over the pavement as many times and at such intervals as may be required to insure thorough consolidation.

After the pavement has been struck off and consolidated, it shall be floated with a longitudinal float.

If any spreading, finishing and floating equipment is not maintained in full working order or if the equipment used by the contractor proves inadequate to obtain results prescribed, such equipment shall be improved or satisfactory equipment substituted or added.

(D) Fixed Form-Manual Methods:

Manual methods may be used in areas inaccessible to mechanical equipment.

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 motion 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.

The concrete shall be consolidated by internal vibration. Vibrators shall operate at a minimum of 8000 impulses per minute. Use of vibrators for shifting of the concrete mass will not be permitted.

After consolidation, the concrete shall be tamped to the proper surface elevation and continue until the required cross section is obtained and the mortar is flushed slightly to the surface.

(E) Joint Finishing and Edging:

The pavement edges and joints shall be edged in accordance with the details shown on the plans.

(F) Surface Texturing:

Surface texturing of the plastic concrete shall begin immediately after placement and finishing of the concrete. All excessive surface water shall be dispersed prior to commencing texturing operations.

Grooves that close following texturing will not be permitted, and texturing shall be completed so that the surface is not torn or unduly roughened by the texturing operation.

Tine texturing shall be performed so that the grooves produced will be uniform in spacing, depth, and width. Texture shall be parallel to the center line of the roadway and shall extend over the entire roadway width to within three inches of the pavement edge. Swerving groove patterns will not be permitted.

Texture grooves shall be 1/8 ± 1/32 inch in width and 5/32 ± 2/32 inch in depth. The textured groove depth will be measured in accordance with the requirements of Arizona Test Method 310. The center-to-center spacing of the grooves shall be 3/4 ± 1/8 inch.

(G) Curing:

Curing compound shall be applied to the concrete after surface texturing operations and before any drying shrinkage or craze cracks begin to appear. In the event of surface drying or cracking, application of water shall be started immediately and shall be continued until application of curing material is begun and shall not result free standing water.

Liquid curing compound shall be applied in one or more applications totaling not less than one gallon per 100 square feet. The curing compound container shall be equipped with a calibrated sight glass for verification of quantities used.

When the ambient temperature is above 85 degrees F, the contractor shall fog the surface of the concrete. The surface of the pavement shall be kept moist until initial joint sawing is completed; fogging done after curing material has been applied shall not begin until the curing compound has set sufficiently to prevent displacement.

When misting is required, the entire surface of the concrete shall be kept damp by applying water and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.

401-3.05 Joints:

(A) General Requirements:

Joints in concrete pavement will be designated as transverse expansion joints; longitudinal or transverse construction joints; or longitudinal or transverse weakened plane joints.

The faces of all joints shall be constructed perpendicular to the surface of the concrete pavement.

Joints shall be constructed of the type, to the dimensions, and at the locations shown on the per the Paving Plan in Section 401-3.01.

Concrete placed in lanes adjacent to previously placed concrete shall have transverse weakened plane joints located to align with the weakened plane joints in the previously placed concrete.

(B) Longitudinal Joints:

Longitudinal joints in the main roadway shall be weakened plane joints or construction joints. Weakened plane joints shall be constructed by sawing.

Longitudinal weakened plane joints shall be constructed between traffic lanes and also between traffic lanes and shoulders if concrete shoulders wider than five feet are specified.

Longitudinal joints in ramps and tapers shall be either weakened plane joints or construction joints. The location of longitudinal joints in ramps and tapers shall be shown on the approved Paving Plan.

Load transfer bars shall be provided as shown on the plans, and shall be placed in all longitudinal construction and weakened plane joints while the concrete is still plastic or after the concrete has hardened. Bars placed in hardened concrete shall be anchored with an adhesive. Bars placed in adjacent slabs of different thicknesses shall be placed within one inch of the mid-depth of the thinner slab.

(C) Transverse Joints:

Transverse expansion joints shall be located at the junction of roadway pavement slabs and bridge approach slabs. Transverse expansion joints at locations other than bridge approaches shall be located as shown on the plans. The joints shall be formed in accordance with the plans.

Transverse construction joints shall be constructed as shown on the plans.

Load transfer bars shall be provided as shown on the plans, while the concrete is still plastic or after the concrete has hardened. Bars placed in hardened concrete shall be anchored with an adhesive. Bars placed in adjacent slabs of different thicknesses shall be placed within one inch of the mid-depth of the thinner slab.

Transverse construction joints shall be formed perpendicular or skewed to the center line of the roadway, as shown on the plans.

Transverse weakened plane joints shall be formed by sawing and shall be constructed perpendicular or skewed to the centerline of the roadway, as shown on the plans.

The location of transverse weakened plane joints shall be as shown on the Paving Plans.

401-3.06 Joint Construction:

(A) Sawed Joints:

Longitudinal or transverse weakened plane joints shall be sawed to the dimensions shown on the approved Paving Plans. Excess water from the sawing operation will not be permitted to stand on any subgrade to be paved. The contractor shall provide and maintain acceptable methods to control the water used in the sawing so the subgrade is not damaged.

Sawed joints shall be constructed before uncontrolled pavement cracking occurs; however, joints shall not be sawed until the concrete has hardened enough to prevent excessive tearing or raveling during sawing operations. The exact time when sawing will be done shall be determined by the contractor.

If joints are sawed in stages, the initial saw cut shall be of the minimum specified width and shall be sawed to the depth shown on the Paving Plans.

Suitable guide lines or other devices shall be used to assure that joints are constructed at the locations shown on the approved Paving Plans.

After sawing, the joints shall be sealed in accordance with the following:

(1) Prior to applying the sealant, each joint face shall be thoroughly cleaned. The method of cleaning may be subject to regulation by Developer or local environmental quality enforcement agencies. When not otherwise mandated by law or regulation, the contractor shall clean the joints by sand blasting. The joints shall then be cleaned so that each face is clean, dry, and dust free.

(2) Asphalt-rubber joint sealant conforming to Subsection 1011-3 shall be used when Portland cement concrete pavement is overlaid with an asphaltic concrete (asphalt-rubber) friction course. Silicone joint sealant conforming to the requirements of Subsection 1011-8 shall be used when Portland cement concrete pavement is not overlaid with an asphaltic concrete (asphalt-rubber) friction course. Both types of sealant shall be applied in accordance with the manufacturer's recommendations.

(3) All recommended manufacturer's field testing shall be done by the Independent Quality Firm. Necessary repairs resulting from field testing shall be immediately repaired by the contractor at no additional cost to the Developer. Any sealant spilled on the concrete pavement shall be removed.

(4) Immediately prior to applying silicone joint sealant, an expanded closed cell polyethylene foam backer rod, shall be inserted along the joint as shown on the plans. The backer rod shall be compatible with the joint sealant to be applied, and its diameter shall be at least 25 percent larger than the nominal width of the sawed joint.

Joints shall be sealed within 10 working days after the concrete has been placed and prior to opening the pavement to any traffic.

(B) Construction Joints:

Longitudinal and transverse construction joints shall be formed in accordance with the details shown on the approved Paving Plans.

When concrete is not finished, textured, and protected with curing material within one hour after placement, a transverse construction joint by sawing at the location established. All concrete placed beyond the construction joint shall be removed and disposed of , prior to continuing paving operations.

If contractor constructs paving widths that are less than the full main roadway width, contractor shall locate longitudinal construction joints on the lane line or at the edge of the main roadway. contractor shall not locate longitudinal construction joints in the wheel-paths.

(C) Transverse Expansion Joints:

Transverse expansion joints shall be formed in accordance with the details shown on the approved Paving Plans.

401-3.07 Opening Pavement to Traffic:

Pavement shall not be opened to traffic less than three days after placement, and until all joints are sealed and the concrete has attained a compressive strength of at least 75% strength or 3,000 psi, as determined by Arizona Test Method 318, Estimating the Development of Concrete Strength by The Maturity Method or Arizona Test Method 314b, Compressive Strength of Cylindrical Concrete Specimens.

401-4 Pavement Evaluation and Remedial Measures:

401-4.01 Pavement Surface Texture:

The depth of surface texture grooves, will be measured in accordance with the requirements of Arizona Test Method 310.

401-4.02 Pavement Smoothness:

Pavement smoothness shall be evaluated by testing with a profilograph.

Profilograph equipment will be furnished by the Developer. All profilograph measurements shall be made by a team composed of one Independent Quality Firm employee and one Developer employee operating the profilograph equipment. The work shall be shared equally. At the completion of each profilograph run both operators shall sign the profilogram, certifying that they are in agreement that the equipment was found to be operating correctly and that the profilogram is a correct representation of the surface profile.

A pavement Profile Index shall be obtained as soon as possible after concrete placement.

Two profilograph readings shall be taken in each mainline traffic lane, each distress lane and each ramp lane including tapers. The profilograph readings shall be taken in the vehicle wheel paths, three feet from each lane edge of traffic lanes or 18 inches from the lane edge or pavement edge of distress lanes.

The tested profile shall begin 50 feet prior to the concrete placed during any day's production and shall end 50 feet before the end of the placed concrete. The tested profile will include bridge approaches and 50 feet of any pavement which abuts the new pavement.

If, during any day's production, less than 3,000 lane-feet of pavement is placed, that pavement shall be tested with the subsequent day's production.

The contractor shall broom the pavement or clean the pavement by other approved methods immediately prior to profilograph testing.

Surface profiles will be evaluated in accordance with the provisions of Arizona Test Method 801. The Profile Index for a traffic lane will be the average of the two Profile Indexes obtained for that lane.

All mainline traffic lanes, distress lanes, ramp lanes and tapers shall have a Profile Index of nine (9) inches or less per mile in any 0.1-mile section.

Profile Indexes greater than nine (9) inches per mile per 0.1-mile section shall be reduced to nine (9) inches or less per mile per 0.1-mile section by grinding or pavement removal and replacement as specified herein.

When pavement will not be overlaid with asphaltic concrete prior to opening to traffic, grinding of pavement which has a Profile Index of nine (9) inches or less per mile per 0.1-mile section will only be permitted to correct deviations in excess of 0.3 inches in 25 feet ("must-grinds") as specified herein and when directed by the Independent Quality Firm.

The contractor shall remove high pavement areas with vertical deviations greater than 0.3 inches in 25 feet or less. High pavement areas shall be removed with grinding devices or multiple-saw devices. Grinding machines shall be of the rotary type with a wheel base of at least 10 feet and with vertically adjustable grinding wheels. Bush hammers or other impact devices shall not be used.

After removal of high areas, the affected 0.1-mile pavement section shall be reprofiled; however, if the original Profile Index for the pavement section was within the specified range, only that portion of the pavement which originally contained high areas shall be reprofiled.

Evaluations of pavement depressions will be made based on the presumed correction of adjacent high areas. When the pavement contains depressions greater than 0.3 inches in 25 feet or less, the contractor shall grind adjacent pavement and the pavement shall be reprofiled as specified above.

When the pavement contains depressions greater than 0.5 inches in 25 feet or less, the pavement shall be repaired. Such repairs may include additional grinding or full-depth pavement replacement. Upon completion of repairs, the pavement shall be reprofiled as required.

If, after the repair of high and/or depressed areas, the pavement does not conform to the specified profile requirements, additional pavement grinding and profile measurements shall be performed.

In addition to the Surface Profile Index requirements, the pavement surface will be tested with a 10-foot straightedge. The surface shall not vary in any direction by more than 1/8 inch, except at longitudinal and transverse construction joints. The surface shall not vary by more than 1/4 inch across any longitudinal or transverse construction joint. Grinding will be required to insure that these requirements are satisfied.

The pavement shall be ground in a manner that does not form a smooth or polished pavement surface.

401-4.03 Pavement Cracks:

(A) General:

Cracks penetrating the full depth of the pavement shall be repaired or the cracked pavement shall be removed and replaced, as specified herein, prior to opening the pavement to public traffic.

Within 28 days after concrete placement and prior to acceptance of the work (i.e. opening to traffic), the Independent Quality Firm will perform a pavement crack survey. The pavement shall be cleaned prior to the crack survey.

Cracks which are visible without magnification and which require repair and pavement slabs which require replacement will be marked by the Independent Quality Firm and shall be repaired or replaced.

Cracks observed later than 28 days after concrete placement and prior to final acceptance (i.e. turning the facility over to maintenance activities) of the work shall be repaired by the contractor as specified and the cost of such repairs will be shared equally by the contractor and the Developer.

The contractor shall provide the Independent Quality Firm with detailed information concerning the methods and materials to be used for crack repair and the contractor shall obtain the Independent Quality Firm approval of the proposed methods and materials prior to beginning the required repairs.

The contractor, at its option, may core cracked pavement to determine the extent of cracking.

(B) Crack Repair:

(1) General:

Random cracks shall be repaired using the methods and under the conditions specified herein.

Crack repair shall begin within seven days after completion of the pavement crack survey and shall be completed within 30 days after the start of repairs.

(2) Crack Repair Requirements:

(a) Cracks in Jointed Pavement Constructed With Load-Transfer Dowel Assemblies:

Longitudinal cracks which occur more than 54 inches from a longitudinal joint or less than 12 inches from a longitudinal joint shall be repaired by the routing-and-sealing method.

Transverse cracks shall be repaired by the epoxy-injection method after any immediately adjacent uncracked joints are deepened to 1/2 inch above the dowels.

(b) Cracks in Jointed Pavement Constructed Without Load-Transfer Dowel Assemblies:

Longitudinal cracks which occur more than 54 inches from a longitudinal joint or less than 12 inches from a longitudinal joint shall be repaired by the routing-and-sealing method.

When a transverse crack crosses or terminates in a transverse contraction joint, the uncracked portion of the joint shall be filled with a gray colored epoxy and the crack shall be repaired by the routing-and-sealing method.

When a transverse crack approximately parallels and is within five feet of an uncracked contraction joint, the uncracked joint shall be cleaned and filled with a gray colored epoxy and the crack shall be repaired by the routing-and-sealing method.

When a transverse crack is more than five feet from a transverse joint, either cracked or uncracked, the joint shall be resawed and resealed as originally specified, and the crack shall be repaired by the routing-and-sealing method.

(c) Cracks Occurring Within Wheel Path:

Cracks occurring within the wheel paths, which are exclusive of the areas defined under subsections (a) and (b) above, shall be considered unrepairable and the pavement shall be removed and replaced.

(3) Crack Repair Methods:

(a) Routing-and-Sealing Method:

When the routing-and-sealing crack repair method is specified, the top of the crack shall be routed to a depth of at least 3/4 inch and to a width not less than 3/8 inch or more than 5/8 inch. Loose and fractured concrete shall be removed and the routed crack shall be thoroughly cleaned and then sealed with a gray colored silicon sealant as approved by the Independent Quality Firm.

(b) Epoxy-Injection Method:

When the epoxy-injection crack repair method is specified, the crack shall be pressure injected with a gray colored epoxy.

(C) Pavement Removal and Replacement:

Portland cement concrete pavement, having cracks not repairable, shall be removed and replaced.

Cracked pavement shall be removed and replaced and will generally require removal of the full lane width of the slab over a length of at least six feet.

Pavement slabs containing a single diagonal crack intersecting the transverse and longitudinal joints within 1/3 of the width and length of the slab from the corner shall be repaired by removing and replacing the smaller portion of the slab.

Pavement slabs containing multiple cracks through the full depth of the slab, separating the slab into three or more parts, shall be entirely removed and replaced.

Excessively cracked pavement shall be removed and replaced over the full pavement width. Pavement to be removed shall be cut full-depth prior to removal.

Base material which is damaged as a result of pavement removal shall be repaired or replaced as approved by the Independent Quality Firm.

After removal of cracked pavement, dowel bars shall be placed by drilling and anchoring, using an approved epoxy, at approximately mid-depth in the existing concrete pavement. Dowel bars placed in longitudinal construction joints shall be 24-inch long, epoxy-coated, 5/8-inch diameter smooth dowels spaced at 30 inches, center-to-center. Dowel bars placed in transverse construction joints shall be 24-inch long, epoxy-coated, 1-1/2 inch diameter smooth dowels spaced at 12 inches, center-to-center. Dowel bars shall be placed in construction joints which coincide with existing transverse weakened plane joints. These dowel bars shall be 24-inch long, epoxy-coated, 1-1/2 inch diameter smooth dowels placed at distances of 6, 24, 42, 90, 117, and 135 inches from the adjacent longitudinal joint which is nearest to the outside shoulder.

Replacement concrete shall be placed, finished and cured in accordance with the requirements specified for the original pavement.

401-4.04 Pavement Thickness:

Concrete pavement shall be constructed to the specified thickness. Tolerances allowed for base and subgrade construction and other provisions of the specifications which may affect thickness shall not be construed to modify such thickness requirements.

Pavement will be evaluated for thickness by the lot. A thickness lot shall not contain more than one thickness depth and will normally be one full shift's production. For partial shifts, more than one shift may be included in a thickness lot. In addition, when more than one thickness depth is placed in the same shift, each individual thickness depth placed in that shift may be combined with portions of other shifts that have the same thickness depth to form a thickness lot. When a thickness lot includes more than one shift's production, it shall not exceed 5,000 square yards unless otherwise approved by the Independent Quality Firm. The contractor shall submit a thickness lot layout plan to the Independent Quality Firm for approval prior to paving.

The contractor shall obtain ten cores per lot, in accordance with Arizona Test Method 317, under the observation of an Independent Quality Firm representative, and at randomly selected locations designated by the Independent Quality Firm. However, the Independent

Quality Firm may exclude certain locations from random sampling should the Independent Quality Firm determine that the location of the work precludes normal construction operations. The Independent Quality Firm representative shall take immediate custody of the cores. All cores will be measured in accordance with the provisions of AASHTO T 148, except that individual measurements on each core will be determined to the nearest thousandth of an inch, and the average of such measurements will be determined to the nearest hundredth of an inch. If any core indicates a deficiency of 0.60 inches or more from the specified thickness, that core shall not be used for determining the thickness property of the lot, and additional cores shall be drilled at intervals not exceeding ten feet in each direction from the deficient core location, measured parallel to the center line, until one core is obtained in each direction which is not deficient by 0.60 inches or more. Pavement between these two cores shall be considered as rejected. The average of the measurements of the two cores will replace the measurement of the original deficient core in determining the thickness property of the lot.

At all locations where cores have been drilled, the resulting holes shall be filled with concrete.

401-6 Basis of Payment:

Payment for thickness and compressive strength will be by the lot. Lot limits are described in Subsection 401-4.04 and Subsection 1006-7.03. For each lot, pay factors will be determined for increasing or decreasing the unit price of the lot or rejection of the lot. The "Percent of Lot Within Limits (PWL)" for thickness and compressive strength shall be determined in accordance with the requirements of Subsection 109.11 of the Specifications. Pay factors for thickness and compressive strength shall be determined by entering Table 401-1 with PWL.

TABLE 401-1	
Pay Factors for Thickness and Compressive Strength	
PWL	**Pay Factor (Dollars/Square Yard)**
100	+1.00
95-99	+0.75
90-94	+0.50
85-89	0.00
80-84	-0.25
75-79	-0.75
70-74	-1.75
65-69	-3.25
60-64	-5.00
Below 60	Reject

When all work has been completed by the contractor as scoped in the subcontract, the overall pay factor for all of the project lots will be determined for the properties in Table 401-1. The maximum overall available pay factor for compressive strength and thickness shall be $0.00.

Pay Factors for thickness and compressive strength will be determined and applied separately. A total Pay Factor shall be determined for each lot by summing the individual pay factors for thickness and compressive strength. Any lot with a total Pay Factor less than minus $5.00 will be rejected. Any lot with a PWL below 60 for either thickness or compressive strength will be rejected.

When pavement will not be overlaid with asphaltic concrete prior to opening to traffic, the unit price paid for pavement on mainline traffic lanes and freeway-to-freeway ramps which have a Profile Index less than or equal to 9.0 inches per mile per 0.1-mile section after correction of all deviations in excess of 0.3 inches in 25 feet ("must-grinds") will be adjusted in accordance with Table 401-2.

TABLE 401-2 (Use when pavement **will not** be overlaid with asphaltic concrete prior to opening to traffic.)	
Profile Index (P.I.) [inches per mile per 0.1 mile section]	**Unit Price Adjustment**
7.0 or Less	Plus ($0.20) x [7.0 - (P.I.*)] per square yard ($1.00 Maximum) (See Notes)
7.1 to 8.0	Minus $0.50 per square yard
8.1 to 9.0	Minus $1.00 per square yard
Notes: 1. P.I.* = Profile Index (P.I.) rounded to the nearest whole number. 2. The "plus" unit price adjustment will not be made for pavement placed within each 0.1-mile section which has grinding in excess of 1.5 percent of the area included in any traffic lane involved.	

When all work has been completed by the contractor as scoped in the subcontract, the overall pay factor for all of the project lots will be determined for the properties in Table 401-2. The maximum overall available pay factor for pavement smoothness shall be $0.00.

When pavement will be overlaid with asphaltic concrete prior to opening to traffic, the unit price paid for pavement on mainline traffic lanes and freeway-to-freeway ramps which have a Profile Index less than or equal to 9.0 inches per mile per 0.1-mile section will be adjusted in accordance with Table 401-3.

TABLE 401-3 (Use when pavement **will** be overlaid with asphaltic concrete prior to opening to traffic.)	
Profile Index (P.I.) [inches per mile per 0.1 mile section]	**Unit Price Adjustment**
7.0 or Less	Plus ($0.10) x [7.0 - (P.I.*)] per square yard ($0.50 Maximum) (See Note)
7.1 to 8.0	Minus $0.25 per square yard
8.1 to 9.0	Minus $0.50 per square yard
Note: P.I.* = Profile Index (P.I.) rounded to the nearest whole number.	

When all work has been completed by the contractor as scoped in the subcontract, the overall pay factor for all of the project lots will be determined for the properties in Table 401-3. The maximum overall available pay factor for pavement smoothness shall be $0.00.

Unit price adjustments for pavement smoothness will not be made for pavement in distress lanes, shoulders, service interchange ramps, tapers, cross roads, or frontage roads.

Unit price adjustments for pavement smoothness will be made independently of all unit price adjustments made for pavement thickness, compressive strength, and cracked pavement slabs which require repair.

Pavement rejected in accordance with this Section or Section 1006 shall be removed and replaced with pavement meeting the requirements of both sections.

ITEM 4010312 - LOAD TRANSFER DOWEL ASSEMBLY (12-FT LANE):

Description:

The work under these items consists of furnishing all material for load transfer dowel assemblies including load transfer dowels and placing the assemblies in portland cement concrete pavement at the locations and in accordance with the details shown on the project plans and the requirements of these specifications.

Materials:

Dowel bars shall be plain round bars, 1 1/2 inches in diameter and 18 inches in length and shall conform to the requirements of AASHTO M 254 with Type B coating, except that the core material shall conform to the requirements of ASTM A 615, Grade 40.

The powdered epoxy resins which may be used for coating the dowel bars shall be in accordance with the requirements of Subsection 1003-5.02 of the Standard Specifications.

The approved powders are based on specified dowel bar preparation and powder application and curing methods, and these identical methods shall be followed during fabrication.

General Requirements:

Certification:

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, and name and address of manufacturer. A statement shall also be submitted certifying that production bars and prequalification bars have been identically prepared and applied with epoxy powders.

Material for Repair:

Patching or repair material, compatible with the coating and inert in concrete, shall be made available by the epoxy manufacturer. This material shall be suitable for repairs of areas of the coating damaged during fabrication and/or handling in the field.

Application Requirements:

Coating Applicator:

The coating applicator's facilities shall be subject to approval by the Developer. Applications for approval of facilities shall be made to the Developer by the coating applicator.

Surface Preparation:

The surface of bars to be coated shall be blast cleaned in accordance with the Society for Protective Coatings, Surface Preparation Standard SSPC-10, Near White Blast Cleaning. After blasting, the cleaned surface of the bar shall be as defined by SSPC-VIS 1, Pictorial Standards A Sa 2 1/2, or B Sa 2 1/2 as applicable.

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.

Coating Application:

The powdered epoxy resin coating shall be applied in accordance with the requirements of the coating manufacturer. The epoxy coating may be applied before or after fabrication of the dowel bars.

Coating Thickness:

The epoxy coating shall be applied as a smooth uniform coat. After curing, the coating thickness shall be a minimum of 7 mils. Coating thickness shall be controlled by taking measurements on a representative number of bars from each production lot.

Continuity of Coating:

The coating shall be checked visually after cure for continuity. It shall be free of 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 of the coated bar. A holiday detector shall be used, in accordance with the manufacturer's instructions, to check the coating for holidays.

Coating Cure:

The coating applicator shall check each production lot to determine that the entire production lot of coated bars is in a fully-cured condition.

Quality Control:

The coating applicator shall be responsible for performing quality control and tests. This will include inspection for compliance with the requirements of Coating Thickness, Continuity of Coating and Coating cure.

Plant Inspection:

The Independent Quality Firm reserves the right to have its authorized representative observe the preparation, coating and test of the dowel bars. The representative shall have free access to the plant, and any work done when access has been denied shall 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 Independent Quality Firm.

Certificate of Compliance:

The contractor shall furnish a Certificate of Compliance, conforming to the requirements of Subsection 106.05, from the coating applicator with each shipment of coated bars to the Developer. The Certificate of Compliance shall also include (1) a statement that the coated bars and coating material have been tested in accordance with the requirements of these specifications, (2) the actual test results for each requirement, and (3) a statement that the actual test results comply with the requirements.

Shop Repair of Coated Bars:

Epoxy coated dowel bars which do not meet the requirements for Coating Thickness, Continuity of Coating, or Coating Cure 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 these specifications.

Coating breaks due to fabrication and handling shall be repaired with patching material if the defective area is greater than the cross-sectional area of the reinforcement bar. Defects which are smaller than the cross-sectional area need not be repaired.

The repair of coating breaks shall be limited to bars of which the total of the defective coating areas does not exceed five percent of the surface area of the dowel 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.

Field Repair:

The contractor shall be required to field repair damaged areas of the bar coating, and to replace bars exhibiting severely damaged coatings. The material used for field repair shall be that supplied by the coating applicator.

Field repair shall be performed wherever the area of coating damaged exceeds the cross-sectional area of the dowel bar.

Field repair shall not be allowed on bars which have severely damaged coatings. A severely damaged coating is defined as coating which has a total damaged area greater than five percent of the surface area of the dowel bar. Dowel bars having severely damaged coating, shall not be incorporated in the work and shall be removed from the work site. All such bars shall be replaced in kind by the contractor .

Anchor straps shall conform to the requirements on the project plans.

All legs, spacer bars and tie bars shall conform to the requirements of Section 1003.

Construction Requirements:

Load transfer dowel assemblies shall be placed at each transverse weakened plane joint on the lanes designated on the project plans.

Dowel assemblies shall be constructed to conform to the lane widths specified on the plans. Lane width refers to the traffic lane as defined in the typical sections. The actual width of the dowel assembly shall be in accordance with the plans or standard drawings. Dowel assemblies shall be constructed such that the dowels are placed at mid-depth of the slab and centered about the weakened plane joint.

Dowel bars shall be placed to a vertical and a horizontal tolerance of ± 1/2 of an inch of the specified depth, centering, and spacing, unless otherwise shown on the project plans.

Dowel bars shall be placed parallel to the pavement center line and pavement surface within a tolerance of ± 3/8 inch for the full dowel length.

Dowel assemblies shall be secured in position on the prepared base in a manner that will hold the assembly in position without disruption throughout construction. Wires or bars used to maintain the assemblies' shape for shipment shall be removed prior to placing concrete if the wires or bars will offer restraint to early shrinkage of concrete or if the wires or bars extend across transverse joints.

The location of each dowel assembly shall be marked outside the limits of the pavement construction operations in such a manner as to insure the centering of the saw cut about the dowel location.

The contractor shall supply equipment and methods of operation such that there is no interference with or movement of dowel assemblies. Final dowel positions shall not exceed the placement tolerances specified above.

Immediately prior to concrete placement, the dowel bars shall be uniformly coated with a thin film of heavy waterproof grease for the full length of the dowel.

Basis of Payment:

The accepted quantities of load transfer dowel assemblies, measured as provided above, will be paid for at the contract unit price, complete in place, except that when sawed joints are placed inaccurately over load transfer dowel assemblies, as determined by the Independent Quality Firm, payment will be made as specified in Table 1.

TABLE 1	
Horizontal Misalignment of Sawed Joint Over Load Transfer Dowel Assembly, Inches	Percent of Contract Unit Price Allowed For Load Transfer Dowel Assembly
0 – 1.5	100
1.5 2.0	90
2.0 – 2.5	75
2.5 – 3.0	50
Greater than 3.0	Reject

SECTION 402 PORTLAND CEMENT CONCRETE PAVEMENT REPAIRS:

402-1 Description:

The work under this section shall consist of furnishing all labor, materials and equipment necessary to repair Portland cement concrete pavement in accordance with the requirements of these specifications and as shown on the project plans.

The kind of Portland cement concrete pavement repair may consist of one or a combination of the following:

Spall Repairs
Slab Repairs
Pavement Grinding
Pavement Grooving
Joint and Crack Repair
Edge Sealing

402-2 Spall Repairs:

402-2.01 Description:

The work shall consist of furnishing all materials and removing loose material and temporary bituminous patch material from potholes, damaged joints, and spalled areas, thoroughly cleaning the repair area and placing new patch material in accordance with the details shown on the project plans and as specified herein, and in reasonably close conformity with the existing pavement cross-section.

402-2.02 Material Requirements:

(A) General:

Patch materials shall attain compressive strength of 2,000 pounds per square inch within six hours. The patch material shall attain the required compressive strength prior to opening to traffic.

(B) Accelerated Strength Portland Cement Concrete Patch Material:

The patch material shall be an Accelerated Strength Portland Cement Concrete mixture consisting of Type III Portland Cement and calcium chloride or other accelerators meeting AASHTO M 144 and shall attain a compressive strength of at least 2,000 pounds per square inch in six hours. Materials for the concrete mix shall conform to the requirements of Section 1006 for Class S concrete. The coarse aggregate shall be as designated for size No. 67 in accordance with AASHTO M 43.

(C) Rapid Setting Patch Material:

Rapid setting patch material shall be a product approved by the Independent Quality Firm. A list of approved patch materials is maintained on the Department's approved product list.

(D) Epoxy Resin Grout Patch Material:

Epoxy resin patch material shall be a low modulus moisture insensitive epoxy mortar grout prepared in accordance with the manufacturer's recommendations. Fine aggregate incorporated into the grout shall meet the fine aggregate gradation requirements specified in Subsection 1006-2.03 (B). The epoxy binder: aggregate ratio shall be between 1:7 and 1:10. The epoxy binder materials shall meet the requirements specified in ASTM C 881.

(E) Flexible Epoxy Patching Material:

(1) Description:

The patching material shall be a mixture of a solventless, medium curing time, stress relieved flexible coating epoxy and 100 percent vulcanized granulated rubber.

(2) Materials:

The epoxy shall be a two component, low viscosity mixture and have a gray color when mixed. The curing period shall be seven days at standard laboratory conditions. The cured epoxy shall meet the following physical requirements:

Test Method Requirements	Test	Material
ASTM D 638	Tensile Strength: psi	900 (minimum)
ASTM D 638	Tensile Elongation: %	85 (minimum)
Gardner	Impact Resistance: pounds Direct Reverse	 greater than 160 greater than 80
AASHTO T 237	Tensile Bond Strength: psi	310 (minimum)
ASTM D 648	Heat Deflection Temperature: ºF	25
ASTM D 2240	Hardness: Shore D	62 (minimum)
AASHTO T 237	Slant Shear Strength: psi	2,000 (minimum)

The ground rubber shall be free of fabric, wire or other contaminating materials.

(3) Packaging and Marking:

The ground rubber shall be introduced into each of the two components by the manufacturer at the place of production, not at the job site. Each container of both components shall be labeled and legibly marked with the manufacturer's name, the trade name of the product, component identification and the expiration date of the manufacturer's shelf life warranty. Material that has exceeded the shelf life warranty expiration date shall not be used.

(4) Certification Requirements:

A Certification of Compliance conforming to the requirements of Subsection 106.05 shall be submitted to the Developer.

402-2.03 Construction Requirements:

(A) General:

Spalled areas to be repaired shall be repaired prior to any required pavement grinding. The extent of the repair area will be marked by the Independent Quality Firm and will be no less than three inches outside the area of delamination. The Independent Quality Firm will be the final authority if questions arise in regard to the need for patching or the extent of a required patch.

Spalled areas less than six inches in length and 1-1/2 inches in width, which are adjacent to joints, shall not be repaired under this specification.

Patching material shall not be placed under conditions which will adversely affect the quality of work.

Concrete within the patch area shall be broken out, to the minimum depth specified for the patch material being used, with light to medium pneumatic tools until sound clean concrete is exposed. If the depth of the spalled area exceeds half the thickness of the concrete pavement slab, the affected pavement shall be removed and replaced, in accordance with the requirements of Subsection 402-3.

Asphaltic concrete shoulders adjacent to a patch shall be cut longitudinally to the depth of the patch and to a width of not more than 12 inches. The cut shall extend one foot beyond both transverse limits of the patch to facilitate placement of form work. Shoulders shall be patched with material similar to the existing shoulder material.

Prior to patching, the exposed faces of the concrete shall be sandblasted free of loose particles, oil, dust, traces of asphaltic concrete and other contaminates. Prior to placement of the bonding agent, all sandblasting residue shall be removed with compressed air and high suction vacuums. Sand for sandblasting shall be sharp and clean and capable of passing a No. 10 sieve and shall leave the exposed concrete face clean and dry.

The surface of the spalled area or breakup shall be clean and dry so that patching material will form a proper bond. The area to be cleaned and patched shall be limited to the area designated by the Independent Quality Firm. Patching material shall be confined to the limits of the repair and shall not lap onto the surrounding pavement.

Patch material shall be placed or consolidated to eliminate voids at the interface of the patch and existing concrete. If a partial depth repair area abuts a working joint or crack which penetrates the full depth of the slab, a temporary insert or other bond-breaking medium such as styrofoam strips shall be used to maintain the working joint or crack for the full depth of the patch and at the same width as the existing joint or crack while placing patch material. Repair material shall not bear on an adjacent slab.

The patch shall be finished to the cross-section of the existing pavement and textured with a stiff bristled brush. Texturing shall conform to that of the existing pavement. The patch surface shall be struck off flush with the existing pavement surface.

(B) Accelerated Strength Portland Cement Concrete Pavement Patch:

Patch boundaries shall be saw cut and broken out to a depth of at least 1-1/2 inches.

Following the removal and cleaning of the area to be patched, and prior to placing patch material, an approved bonding agent shall be applied to the patch area. The bonding agent shall be applied in a thin coating and scrubbed into the surface with a stiff bristled brush. Placement of patch material shall be delayed until the bonding agent becomes tacky.

(C) Rapid Setting Patch:

Rapid set patch materials shall be installed in accordance with manufacturer's instructions. In order to assure proper mixing and placement, a qualified manufacturer's representative for the approved product shall be present at the start of spall repair operations, and shall remain until the Independent Quality Firm is satisfied that the contractor is conforming to the recommended procedures.

Patch boundaries shall be saw cut and broken out to a depth of at least 1-1/2 inches, or as recommended by the manufacturer, whichever is greater.

If recommended by the manufacturer, the area to be patched shall be primed with a bonding agent compatible with the patch material being used.

(D) Epoxy-Resin Grout Patch:

Patch boundaries shall be saw cut and broken out to a minimum depth of 1-1/2 inches.

Prior to placement of epoxy-resin grout, the contractor shall furnish a grout mix design for review and approval.

The epoxy-components shall be mixed in strict compliance with the manufacturer's recommendations before aggregate is added to the mixture.

(E) Flexible Epoxy Patch:

Use of flexible epoxy materials shall be in accordance with the manufacturer's recommendations.

The contractor shall remove the spall area to be replaced to a minimum depth of two inches or to a solid surface by saw cutting and chipping with a pneumatic hammer, without damaging the underlying intact concrete. All loose particles shall be removed before applying the flexible epoxy inlay.

The contractor shall mix only the amount of material that can be used before the expiration of the pot life for the material. The two parts shall be thoroughly mixed in their own containers before combining the parts together as recommended by the manufacturer. The contractor shall blend the mix thoroughly for the length of time recommended by the manufacturer, making sure the material contains no lumps or streaks, and carefully scraping the sides and bottom of the container.

The material shall be placed in the area to be patched, the surface leveled off even with the surrounding pavement, and any excess material removed.

402-3 Full Depth Slab Repairs:

402-3.01 Description:

The work shall consist of furnishing all materials and removing existing concrete pavement and constructing full depth patches of Portland cement concrete pavement at the locations shown on the project plans, as specified herein, and in reasonably close conformity with the existing pavement cross-sections.

402-3.02 Material Requirements:

Patching material shall be an Accelerated Strength Portland Cement Concrete Mixture which includes Type III Portland Cement and calcium chloride or other accelerator conforming to the requirements of AASHTO M 144. The patch material shall attain a compressive strength of at least 2,000 pounds per square inch in six hours. The contractor shall not place concrete patch material until the mix design has been approved by the Independent Quality Firm.

Materials for Portland Cement Concrete shall conform to the requirements of Section 1006. Concrete shall be Class S, with size 57 coarse aggregate as designated in AASHTO M 43.

Materials furnished for joint seal shall conform to the requirements of Subsection 1011-3.

Materials furnished for tie bars shall conform to the requirements of Section 1003.

Materials furnished for dowel bars shall conform to the requirements of AASHTO M 254 with Type B coating except that the core material shall conform to the requirements of ASTM A 615, Grade 40.

Liquid membrane-forming curing compound shall conform to the requirements of Subsection 1006-2.05.

402-3.03 Construction Requirements:

Areas to be repaired will be designated by the Independent Quality Firm and shall be repaired before any specified pavement grinding.

Patching material shall not be placed under any conditions which will adversely affect the quality of the work.

Pavement slabs containing multiple cracks through the full depth of the slab, separating the slab into three or more parts shall be entirely removed and replaced. Pavement slabs containing a single diagonal crack intersecting the transverse and longitudinal joints within 1/3 of the width and length of the slab from the corner shall be repaired by removing and replacing the smaller portion of the slab.

Areas to be patched shall have the configuration and minimum dimensions shown in the plans. The area shall be saw cut to the full depth of the slab. An additional full depth saw cut shall be made interior to one of the initial transverse saw cuts and shall be made such that a wedge tapering from four inches to six inches from the initial cut is created.

The area inside the wedge shall be removed with light to medium weight jackhammers or other approved equipment prior to removing the larger remaining pavement section. The remaining pavement shall be lifted out in a manner approved by the Independent Quality Firm. Any disturbed granular subbase shall be removed and replaced with concrete patch material and any spalls which are caused by the removal operations and which are greater than one inch wide or one inch deep, shall be repaired by resawing full depth and full width of the traveled lane.

When the patch boundary is at an existing contraction joint, the new joint shall be formed with plain round dowel bars, 1-1/4 inches in diameter and 18 inches in length. Dowel bars shall be placed as shown in the plans, and shall be placed at mid-depth of the existing slab. Holes drilled for the dowel bars shall not be less than 1-3/8 inches in diameter and shall extend nine inches into the existing slab. The bars shall be anchored into the existing concrete with an approved high viscosity epoxy. Prior to concrete placement for the replacement slab, the nine-inch long free end of the dowel bar shall be uniformly coated with a thin film of heavy waterproof grease.

When the patch boundary is at an existing longitudinal joint, the patch shall be tied to existing concrete with two-foot long No. 5 deformed steel tie bars placed in the joint at 30-inch intervals as shown on the plans. Holes drilled in the existing slab shall be one foot deep and of a diameter sufficient to accommodate the tie bars. The tie bars shall be anchored into the existing slab using an approved high viscosity epoxy.

When the patch boundary is located near mid slab, the patch shall be tied to existing concrete with two-foot long No. 8 deformed steel tie bars placed in the transverse joint at 18-inch intervals and No. 5 deformed steel tie bars placed in the longitudinal joint at 30-inch intervals as shown in the plans. Holes drilled in the existing slab shall be one foot deep and of a diameter sufficient to accommodate the tie bars. The tie bars shall be anchored into the existing slab using an approved high viscosity epoxy.

Patch material shall be placed and consolidated to eliminate voids at the interface of the patch and existing concrete. A new sealant reservoir shall be sawed or formed at the interface of the patch and existing concrete, as shown on the plans.

The patch shall be finished to the cross-section of the existing pavement and textured with a stiff bristled brush to match the existing pavement. The patch surface shall be within 1/8 inch of the existing pavement surface. No texturing will be required if pavement grinding or grooving is to be done after patching.

402-4 Pavement Grinding:

402-4.01 Description:

The work shall consist of furnishing all materials and grinding the surface of existing concrete pavement at the locations shown on the project plans and in accordance with the requirements of these specifications.

402-4.02 Blank

402-4.03 Construction Requirements:

(A) General:

Prior to grinding, spalled areas shall be repaired as specified. Grinding shall be done prior to any specified sawing and sealing of existing transverse and longitudinal joints.

Pavement surfaces shall be ground longitudinally.

The entire area of pavement designated to be ground shall be ground in a manner that results in a uniform surface appearance. Grinding shall continue for the full lane width until the pavement surface on both sides of all transverse joints and all cracks is in the same plane. Longitudinal ridges in adjacent passes of the grinding equipment shall not exceed 1/8 inch in depth.

In any one lane, a maximum distance of 1,000 linear feet of unfinished work area between the lead grinder and the last grinder in that lane will be allowed at the end of any work shift.

Ground surfaces shall not be smooth or polished and shall have a wet Arizona Mu-Meter number of not less than 60 at 40 miles per hour.

The surface shall have a finished texture that has grooves between 0.090 and 0.130 inches wide, spaced 0.060 to 0.110 inches apart and not less than 0.030 inches or more than 0.115 inches in depth.

Residue and excess water resulting from grinding shall be removed from the roadway. After grinding has been completed, the pavement surface will be tested in accordance with the requirements of Arizona Test Method 801. Two Profilograph readings shall be taken in the vehicle wheel paths three feet from the edge of the traffic lane.

To be acceptable, a Profile Index shall not exceed 9 inches per mile in any 0.1-mile section. In addition, all areas representing high points having deviations in excess of 0.3 inches in 25 feet, shall be reground until such deviations, as indicated by reruns of the Profilograph, do not exceed 0.3 inches in 25 feet.

Additional grinding shall be performed, if necessary, to reduce the overall Profile Index, as measured by the Profilograph, to 9 inches per mile in any 0.1-mile section or remaining portion thereof, along any line parallel to the edge of the pavement. In any areas requiring regrinding, the regrinding shall be done over the full lane width.

The contractor shall test the PCCP surface with a 10-foot-long straightedge in accordance with Section 401-4.02 of the ADOT Standard Specifications for Road and Bridge Construction and the Contract Documents. The pavement surface must not vary in any direction by more than 1/8 inch, except at longitudinal and transverse construction joints. The pavement surface must not vary by more than 1/4 inch across any longitudinal or transverse construction joint. contractor must grind high areas or bumps not meeting the required pavement tolerances.

The contractor shall broom the surface of the concrete so that Profilometer readings can be taken. Profilograph measurements shall be the responsibility of the Developer.

(B) Equipment and Procedures:

Grinding shall be done with diamond blades, mounted on a self-propelled machine that has been designed for grinding and texturing of pavements. The equipment shall be designed such that it will not cause strain or damage to the underlying surface of the pavement. Grinding equipment that causes excessive ravels, aggregate fractures, spalls, or disturbances of the transverse and/or longitudinal joints shall not be used.

All grinding machines used in the cross-section of a lane shall have the same wheel or grinding head configuration. Overlapping of grinding passes will not be allowed.

402-5 Pavement Grooving:

402-5.01 Description:

The work consists of furnishing all materials and grooving the surface of existing Portland Cement Concrete Pavement at the locations shown on the project plans.

402-5.02 Blank

402-5.03 Construction Requirements:

(A) General:

The pavement surface shall be grooved longitudinally.

The methods used and tolerances employed shall provide a surface which will provide good wet or dry driving characteristics.

Longitudinally grooved areas shall begin and end at lines normal to the pavement center line and shall be centered within the lane width.

Residue from grooving operations shall not be permitted to flow across shoulders or lanes occupied by public traffic or to flow into gutters or other drainage facilities.

(B) Equipment and Procedures:

Grooving shall maintain the specified groove depth.

The grooved area of any selected two-foot by 100-foot longitudinal area of pavement specified to be grooved shall not be less than ninety percent of that area. Ungrooved pavement within the selected area shall be limited to that which occurs as a result of pavement irregularities.

(C) Tolerance:

Longitudinal grooving shall begin six inches from the outside edge of pavement or reflective marker and run in a continuous pattern across the lane surface to within six inches of the longitudinal joint. The groove pattern shall be 0.125 inches in width by 3/16 inch in depth with a center-to-center spacing of 3/4 inch. The groove spacing tolerance shall be plus or minus 1/8 inch. The width of the groove shall have a tolerance of plus or minus 0.015 inches. The depth of the groove shall have a tolerance of plus or minus 1/16 inch.

On curves and/or superelevations, the width of the groove may exceed the above dimensions.

Grooving shall be terminated a minimum of one foot from any device in place in the pavement, such as manholes, inlet casting, valve boxes, etc.

402-6 Joint and Crack Repair:

402-6.01 Description:

The work shall consist of furnishing all materials and renovating longitudinal and transverse contraction control joints and routing and sealing random cracks in existing Portland Cement Concrete Pavement, as specified herein, detailed on the project plans.

402-6.02 Material Requirements:

Joint sealant shall conform to the requirements of Section 1011.

Grout for filling wide joints shall be a low modulus moisture insensitive epoxy-resin grout of a viscosity suitable for flowing into the irregular cracked portion of the joint. The ratio of epoxy-resin: sand shall be between 1:7 and 1:10 or as specified by the epoxy manufacturer. Epoxy binder material shall conform to the requirements of ASTM C 881.

Sand used in epoxy grout shall conform to the requirements of Subsection 1006-2.03 (B) except that the gradation shall be as follows:

Sieve Size	Percent Passing
No. 8	100
No. 16	95 - 100
No. 50	10 - 40
No. 200	0 - 4.0

A rapid set Portland cement concrete pavement patching material may be substituted for epoxy grout.

402-6.03 Construction Requirements:

(A) General:

Joint and crack repairs shall be accomplished by first removing old sealant and joint inserts, then refacing and cleaning the joints and cracks followed by installation of a backer rod (if required) and installation of new sealant.

(B) Joint and Crack Preparation:

Cracks shall be sawed or routed to the dimensions shown on the plans.

Inserts shall be removed from insert formed joints by sawing to provide a clean vertical face. The width and depth of the saw cuts shall be sufficient to insure complete removal of the insert and to provide a finished joint of the dimensions specified for the sealant material to be used. If the insert is not vertical, additional parallel saw cuts shall be provided as required to insure full removal of the inserts.

Joints that are not insert formed shall be sawed to the widths and depths specified herein. Joints previously sawed and sealed will be inspected to assure the proper dimensions and shall be resawed to the proper widths and depths, when required.

Joints shall be sawed as follows:

Initial Joint Width "W": Inches	**Sawed Width: Inches**	**Sawed Depth"D": Inches, (1)**
W ≤ 1/2	1/2	D = 1-3/4
1/2 < W ≤ 3/4	3/4	D = 2-1/8
3/4 < W ≤ 1-1/2	No Sawing Required	D = 2W + 3/4
(1) "D" is distance from pavement surface to bottom of backer rod.		

Immediately after saw cutting a joint or routing a crack, old sealant shall be removed and the internal surfaces of the joint or crack shall be thoroughly cleaned by sandblasting. Sand for sandblasting shall be sharp and clean and shall be capable of passing a No. 10 sieve. The amount of compressed air and the nozzle pressure shall be such that the joints and cracks will be thoroughly cleaned and the edges will have etched surfaces.

(C) Dowel Placement:

Dowel bars shall be placed in transverse joints when the initial joint width is greater than 1-1/2 inches. Slots for dowel bar placement shall be made with two saw cuts perpendicular to the joint and 1-1/2 ± 1/8 inches apart. Saw cuts shall be one half the depth of the slab plus 1/2 inch. Concrete shall be removed between the saw cuts and smooth, epoxy coated dowels which are 1-1/4 inches in diameter and 18 inches long shall be inserted into the formed slot. Dowels shall be supported above the bottom of the slot so that epoxy grout can flow around the circumference of the dowel. Dowels shall be placed so that the dowel is embedded equal distance into the two slabs. Dowel bars shall conform to the requirements of AASHTO M 254 with Type B coating, except that the core material shall conform to the requirements of ASTM A 615, Grade 40. Dowel bars shall be placed as shown on the plans, and shall be placed at approximately mid-depth of the existing slab. The bar shall be thoroughly and uniformly coated with a waterproof grease prior to placement into the slot then covered with an approved epoxy grout. A 1/2-inch thickness of preformed joint filler shall be placed next to one edge of the joint such that a one ± 1/8-inch deep sealant reservoir can be formed at the top, as shown on the plans. The wide joint shall be filled with epoxy grout.

On longitudinal joints where the joint opening exceeds 1-1/2 inches, the saw cuts for placement of tie bars perpendicular to the joint, shall be 7/8 inch apart so that a No. 5 deformed tie bar 24 inches long can be inserted into the slot. This 24-inch tie bar shall be placed at mid slab depth and equal distance into each slab, then covered with an approved epoxy grout. The bars shall be at 36-inch spacing. The wide joint shall also be filled with epoxy grout.

(D) Cleaning Prior to Sealing:

Prior to sealing, all foreign or loosened particles shall be removed from the joints to the full depth of the original sawed joints. The removal of all foreign or loosened particles shall be accomplished with compressed air or by other methods. Air compressors shall be capable of furnishing a sufficient amount of compressed air to clean the joints properly.

(E) Separating or Blocking Medium (Backer Rod):

Immediately following the cleaning of joints and prior to the application of sealant, a backer rod composed of an inert, compressible material shall be inserted along the lower portion of the joint groove at a uniform depth as shown on the project plans.

The backer rod shall be compatible with the sealant in accordance with the manufacturer's recommendations. The product shall be clean, free of scale, foreign matter, oil or moisture and shall be non-absorbing.

Backer rod sizes shall be as follows:

Joint Width: Inches	Backer Rod Diameter: Inches
1/2	5/8
3/4	1
1	1-1/4
1-1/4	1-1/2
1-1/2	2

(F) Installation of Sealant:

Sealant compound shall not be placed unless the joint is dry, clean and free of dust. The face of the joint shall be surface dry and the ambient and pavement temperatures shall both be at least 50 degrees F at the time of application of the sealant. Installation of the sealant shall be such that the in-place sealant shall be well bonded to the concrete and free of voids or entrapped air. The joints shall be sealed in a neat and workmanlike manner, so that upon completion of the work, the surface of the sealant material will be 1/4 ± 1/8 inch below the adjacent pavement surface. The contractor shall refill all low joints before final acceptance. Any excess material on the surface of the pavement shall be removed and the pavement surface shall be left in a clean condition. Vehicular or heavy equipment traffic shall not be permitted on the pavement in the area of the joints during the curing period.

SECTION 403 ASPHALTIC CONCRETE HOT PLANT REQUIREMENTS:

403-1 Description:

When referenced in individual specifications, the asphaltic concrete hot plant shall meet the requirements specified herein.

403-2 Requirements:

Mixing plants shall conform to the requirements of AASHTO M 156 except as modified herein.

Mineral admixture shall be proportioned by weight.

The mineral admixture shall be added and thoroughly mixed with the mineral aggregate by means of a mechanical mixing device prior to the mineral aggregate and mineral admixture entering the dryer. For all asphaltic concrete mixes except AR-ACFC (Specification Section 414), the moisture content of the combined mineral aggregate shall be a minimum of three percent by weight of the aggregate during the mixing process. For AR-ACFC mixes, the mineral aggregate shall be wet with free moisture on the surface of the aggregate just prior to the mixing process. To ensure that adequate mixing water is available on the surface of the aggregate, the Independent Quality Firm may require that the mineral aggregate for AR-ACFC mixes have a moisture content of up to 1-1/2 percent above the combined water absorption.

The mineral admixture shall be weighed utilizing an approved weigh system, with a weight totalizer prior to entry into the mechanical mixing device. The mechanical mixing device shall be a pugmill type mixer which is in good working condition and which consists 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 three feet. The rate of aggregate feed shall not exceed the mixing device's rated capacity in tons per hour. The mixer shall be constructed to minimize the loss of mineral admixture. The mixer shall be located in the aggregate delivery system at a location where the mixed material can be readily inspected on a belt prior to entry into the dryer. The mixing device shall be capable of effective mixing in the full range of asphaltic concrete production rates.

A positive signal system shall be provided and utilized during production whereby the mixing shall automatically be stopped if the mineral admixture is not being introduced into the mineral aggregate. The plant will not be permitted to operate unless the signal system is in good working condition.

The producer's plant and equipment shall be constructed and operated so that there is not a significant loss of mineral admixture through the dust collection system of the plant.

For mixing plants other than batch plants, bituminous material and mineral aggregate shall be proportioned by either volume or weight.

When a batch plant is used, bituminous material and mineral aggregate shall be proportioned by weight. Weighing shall be performed with all receptacles and scales insulated against the vibration or movement of the rest of the plant. The insulated receptacles and scales shall be such that the error in weighing, while the entire plant or any part of the plant is operating, shall not exceed two percent for the bituminous material and the individual mineral aggregate components, or 1-1/2 percent for any batch. Weighing of bituminous material shall be done in a heated, insulated bucket suspended from a springless dial scale system.

Mineral aggregate from each individual stockpile/hot bin shall be properly proportioned and introduced into the asphaltic concrete.

A positive signal system shall be provided and utilized during production to indicate the low level of mineral aggregate in the bins. The plant will not be permitted to operate unless the 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 introduction of bituminous material shall be controlled by an automated system fully integrated with the controls for mineral aggregate and mineral admixture.

The producer shall provide daily documentation of the weight and proportion of each individual component (mineral aggregate, mineral admixture, and bituminous material) incorporated into the mix. In addition, when reclaimed asphaltic pavement (RAP) is used, the producer shall provide daily documentation of the weight, determined by a belt scale, and proportion of material from each individual RAP stockpile incorporated into the mix.

When Warm Mix Asphalt (WMA) technologies are used, the producer shall provide the percent of water (for WMA water foaming processes) and/or the percent of WMA additive incorporated in the mix. The percent of each WMA technology shall be reported either by weight of total mix or by weight of total binder.

When incorporating WMA technologies, the hot plant shall be modified as required by the WMA technology manufacturer to introduce the WMA technology. Plant modifications may include additional plant instrumentation, the installation of asphalt binder foaming systems and/or WMA additive delivery systems, adjusting the plant burner and/or the mixing drum flights in order to operate at lower production temperatures, and/or reducing the production rate of WMA.

The producer shall provide daily documentation of the proportion of each individual component (mineral aggregate, mineral admixture, and bituminous material) incorporated into the mix.

The production of the plant shall be governed by the rate required to obtain a thorough and uniform mixture of the materials.

Drying and heating shall be accomplished in such a manner as to preclude the mineral aggregate from becoming coated with fuel oil or carbon.

A continuous recording pyrometer sensitive to a rate of temperature change not less than 10 degrees F per minute shall automatically record the temperature of asphaltic concrete or mineral aggregate at the discharge chute of the dryer. A copy of the pyrometer reading shall be provided to the Independent Quality Firm daily.

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.

SECTION 404 BITUMINOUS TREATMENTS:

404-1 Description:

The work under this section shall consist of furnishing all materials and constructing or applying a single course bituminous treatment in accordance with the requirements of the specifications and in reasonably close conformity to the lines shown on the project plans or established by the Developer.

The kind of bituminous treatment may consist of Tack Coat.

404-2 Materials:

404-2.01 Bituminous Materials:

The bituminous material shall be of the type and grade specified in the Specifications and shall conform to the requirements of the following subsections:

Asphalt Cement	1005-3.01
Liquid Asphalt	1005-3.02
Emulsified Asphalt	1005-3.03
Emulsified Asphalt (Special Type)	1005-3.04
Recycling Agents	1005-3.05
Emulsified Recycling Agents	1005-3.06

Application temperatures of bituminous materials shall conform to the requirements of Table 1005-6.

404-3 Construction Requirements:

404-3.01 Weather Limitations:

The application of bituminous material shall be stopped when the ambient temperature is 70 degrees F or less 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 degrees F and when the existing aggregate surface is slightly damp.

At any time, the Developer may require that the work cease or that the work day be reduced in the event that weather conditions, either existing or expected, are anticipated to 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 at readily determined and controlled rates of from 0.03 to 1.00 gallons per square yard, with uniform pressure, and with an allowable transverse variation from any specified rate not to exceed 10 percent or 0.02 gallons per square yard, whichever is less.

Prior to the spreading of bituminous material, all distributor trucks proposed for use shall have been tested for rate of transverse spread, in accordance with the requirements of Arizona Test Method 411, and certified within 12 months prior to the date of spreading in accordance with ADOT Materials Policy and Procedure Directive No. 14, “Testing and Certification of Bituminous Distributor Trucks”. However, the Independent Quality Firm may at any time require that each distributor truck be tested to determine the rate of the transverse spread.

404-3.04 Preparation of the Surface:

The surface to be treated shall be thoroughly cleaned prior to applying the bituminous material.

404-3.05 Application of Bituminous Material:

The types, grades, and approximate rates of application of bituminous material will be as specified herein.

The Developer will specify the exact rates based on the surface to be treated and the characteristics of the aggregate material. The rates to be applied may vary substantially because of different surface conditions within the project limits. The actual bituminous material application shall not vary more than 10 percent from the application rate specified by the Developer.

The bituminous material shall be uniformly applied to the prepared surface at the rate specified by the Developer and in one application.

The various types or grades of bituminous materials shall be mixed with materials or applied at temperatures within the limits given in Table 1005-6, and at no time shall the producer increase the temperature of the bituminous material above the higher limit specified.

In order to obtain uniform distribution, the distribution shall be promptly started or stopped at the junction of two applications in a manner that will not result in overlaps or gaps in the applications.

The distribution shall be promptly cut off prior to the 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 by the Developer.

Care shall be taken to prevent the spraying or splattering of bituminous material on adjacent pavements, structures, curb, guardrail, trees and shrubbery or any other object outside of the area designated for spraying.

Unused bituminous material shall not be disposed of within the right-of-way lines.

404-3.12 Tack Coat:

Tack coat shall be applied prior to placing a bituminous mixture on a primed surface, an existing bituminous surface, or an existing Portland cement concrete pavement surface. Tack coat shall also be applied between layers of bituminous mixtures, unless subsequent layer is placed before previously placed layer temperature has fallen below 100 degrees and the surface has not been fouled in the opinion of the Independent Quality Firm. Fouling of the pavement surface is considered material track out that would impact the bond between the two pavement layers. A light coat of bituminous material shall also be applied to edges or vertical surfaces against which a bituminous mixture is to be placed.

The contractor shall use an SS-1h for the bituminous material to be used for tack coat.

The rate of application for the specific usage will be per the approximate tack coat application rates:

Type of Bituminous Material	Approximate Tack Coat Application Rates: Gallons / Square Yard		
	Prior to Placing ACFC or AR-ACFC	All Other Tack Coats	
Emulsified Asphalt (Special Type) – See Note Below.	Not Allowed	0.12	
Emulsified Asphalt (Other than Special Type)	0.08	0.08	
Asphalt Cement	0.06 to 0.08	0.06 to 0.08	
Note: Emulsified Asphalt (Special Type) shall consist of Type SS-1 or CSS-1 emulsified asphalt diluted with water to provide an asphalt content of not less than 26 percent.			

If emulsified asphalt of any type is used, it shall have broken before the bituminous mixture is placed.

If emulsified asphalt of any type is held over night, it shall be reheated and agitated prior to further application.

For asphaltic concrete friction course, asphaltic concrete friction course (asphalt-rubber), or asphaltic concrete (asphalt-rubber), application of the tack coat immediately prior to placing such pavements shall not be eliminated, although the Developer may adjust the application rate.

Tack coat shall be applied only as far in advance of the placement of the bituminous mixture as is necessary to obtain the proper condition of tackiness. In no event shall more tack coat be applied in one day than will be covered by the bituminous mixture during that same day.

ITEM 4040300 - CRACK SEALING (ASPHALTIC CONCRETE PAVEMENT):

1. Description:

The work under this item shall consist of furnishing all materials, personnel and equipment to rout and clean cracks in existing bituminous pavement and seal the cracks with asphalt-rubber sealant in accordance with the details shown on the project plans and the requirements of the Specifications.

2. Material Requirements:

2.01 General:

Crack sealant shall be one of the following:

(A) A mixture of asphalt and 100-percent vulcanized granulated rubber.

(B) Premixed block material consisting of asphalt and 100-percent vulcanized granulated rubber.

2.02 Asphalt Cement:

The asphalt cement shall be PG 58-22 conforming to the requirements of Section 1005.

2.03 Rubber:

Rubber shall meet the following gradation requirements when tested in accordance with Arizona Test Method 714.

Sieve Size	Percent Passing
No. 8	100
No. 10	95 - 100
No. 30	0 - 10

The rubber shall have a specific gravity of 1.15 ± 0.02 and shall be free of fabric, wire or other contaminating materials. Calcium carbonate, up to four percent by weight of the granulated rubber, may be added to prevent the particles from sticking together.

2.04 Material Mixing Requirements:

The mixture shall consist, by weight, of 75 ± two percent asphalt and 25 ± two 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 mixture approaches that of a semi-fluid material.

2.05 Certification Requirements:

Certificate of Compliance conforming to the requirements of Subsection 106.05 shall be submitted to the Developer.

3. Construction Requirements:

The equipment used in the application of asphalt-rubber material shall have a mixing system in the heating unit in order to maintain a consistent, uniform, homogeneous mixture throughout the crack sealing operation. The equipment shall be designed to provide a continuous supply so that operations may proceed without delays.

Asphalt-rubber mixture shall not be placed during wet weather or under other conditions which may adversely affect the operations. The sealant shall not be placed in cracks which are wet. If weather conditions are such as to adversely affect the operations, the Developer will determine whether or not the operations should cease. The Developer will be the sole judge.

Cracks which have an average clear opening of less than 1/4 inch shall not be sealed. Cracks which have an average clear opening of 1/4 to 1/2 inch shall be routed to a minimum 1/2-inch opening. Cracks which are 1/2 inch or larger shall be cleaned and sealed.

Immediately prior to sealant application, the cracks shall be thoroughly cleaned with high velocity compressed air or by other methods. Cracks shall be cleaned to a depth equal to at least two times the clear opening of the crack.

Asphalt-rubber sealant shall be applied in accordance with the manufacturer's recommendations.

SECTION 407 ASPHALTIC CONCRETE FRICTION COURSE (AR-ACFC REPAIRS):

407-1 Description:

The work under this section shall consist of constructing Asphaltic Concrete Friction Course, hereinafter asphaltic concrete, by furnishing all materials, mixing at a plant, hauling and placing a mixture of aggregate materials, mineral admixture, and bituminous material (asphalt cement) to form a pavement course or to be used for other specified purposes, in accordance with the details shown on the project plans and the requirements of the specifications. This Project Specification may be followed specifically for repairs to AR-ACFC in accordance with the approved C202P Deviation Request (ADOT-C202P-L 491)

407-2 Asphaltic Concrete Mix Design:

Mix designs will be developed on the basis of and tested in accordance with the requirements of Arizona Test Method 814. The allowable range of percent absorbed asphalt shall be 0-1.0, when tested in accordance with Arizona Test Method 806.

407-3 Materials:

For comparative purposes, quantities shown in the bidding schedule have been calculated based on the following data:

Spread Rate (lb./ sq. yd.)	**59 for AC 0.5” and 100 for AC 1”**
Asphalt Cement, %	6.0 (6.5 when PG TR+ is used)
Mineral Admixture, %	1.0

The estimated target spread rate specified above includes **25%** percent for leveling to provide a minimum **0.5/1-**inch thickness above the leveling thickness

407-3.01 Mineral Aggregate:

The contractor shall provide a source of mineral aggregate in accordance with the requirements of Section 1001 of the specifications.

Mineral aggregate shall be separated into at least two stockpiles. No individual stockpile or hot bin usage shall be less than three percent of the total mineral aggregate.

Coarse mineral aggregate shall consist of crushed gravel, crushed rock, or other approved inert materials 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, sand prepared from rock, or other approved inert materials, or a combination thereof, conforming to the requirements of these specifications.

Mineral aggregate furnished for mix designs shall be representative of the source(s) and sampled from the material stockpiles to be used in asphaltic concrete production. Mix designs shall conform to the grading limits in Table 407-1, when tested in accordance with Arizona Test Method 201.

TABLE 407-1
MIX DESIGN GRADING LIMITS

Sieve Size	Percent Passing	
	Without Admixture	**With Admixture**
3/8 Inch	100	100
No. 4	35 – 55	36 - 55
No. 8	9 – 14	10 - 15
No. 200	0 - 2.0	0 - 3.0

Mineral aggregate shall conform to the requirements in Table 407-2 when tested in accordance with the applicable test methods.

Tests on aggregates outlined in Table 407-2, other than abrasion, shall be performed on materials furnished for mix design purposes and composited to the mix design gradation. Abrasion shall be performed separately on samples from each source of mineral aggregate. All sources shall meet the requirements for abrasion.

TABLE 407-2
MINERAL AGGREGATE CHARACTERISTICS

Characteristic	Test Method	Requirement
Combined Bulk Oven Dry Specific Gravity	Arizona Test Method 251	2.350 – 2.850
Combined Water Absorption	Arizona Test Method 251	0 – 2.5%
Sand Equivalent	Arizona Test Method 242 (After thoroughly sieving the sample, no additional cleaning of the fines from the plus No. 8 material is required.)	Minimum 55
Fractured Coarse Aggregate Particles	Arizona Test Method 212	Minimum 85% (at least two fractured faces) and minimum 92% (at least one fractured face)
Flakiness Index	Arizona Test Method 233	Maximum 25%
Carbonates	Arizona Test Method 238	Maximum 20%
Abrasion	AASHTO T 96	100 Rev., Max. 9% 500 Rev., Max. 40%

407-3.02 Mineral Admixture:

Mineral admixture will be required. The amount used shall be 1.0 percent, by weight of the mineral aggregate. Mineral admixture shall be either Portland cement, blended hydraulic cement, or hydrated lime conforming to the requirements of Table 407-3.

TABLE 407-3 MINERAL ADMIXTURE	
Material	**Requirement**
Portland Cement, Type I or II	ASTM C 150
Blended Hydraulic Cement, Type IP	ASTM C 595
Hydrated Lime	ASTM C 1097

Certification and acceptance of Portland cement, blended hydraulic cement, and hydrated lime shall be in accordance with ADOT Materials Practice and Procedure Directive No. 13, "Certification and Acceptance of Hydraulic Cement, Fly Ash, Natural Pozzolan, Silica Fume, and Lime".

407-3.03 Bituminous Material:

Asphalt cement shall be a performance grade (PG) asphalt binder, conforming to the requirements of Section 1005. The type of asphalt binder shall be PG **76-22 TR+**.

The percent of asphalt cement used shall be based on the weight of total mix (asphalt cement, mineral aggregate, and mineral admixture).

The percent of asphalt cement to be used will be specified by the mix design.

407-4 Mix Design:

The supplier will furnish a mix design which meets the requirements of Section 407.

Asphaltic concrete friction course production shall not begin until there is an approved mix design.

407-5 Mix Design Revisions:

At any time after production of asphaltic concrete has been started using the approved mix design, changes may be proposed by the contractor or supplier. Approval of these changes resides with the Independent Quality Firm.

During production of asphaltic concrete the supplier, on the basis of field test results, may request a change to the approved mix design.If, at any time, unapproved changes are made by the supplier in the source or type of bituminous material, source(s) of mineral aggregate, production methods, or proportional changes in violation of approved mix design stipulations, production shall cease until a new mix design is developed, or the supplier complies with the approved mix design.

At any time after the mix design has been approved, the supplier may request a new mix design.

407-6 Acceptance of Materials:

407-6.01 General:

The acceptance of the mineral aggregate gradation and the bituminous material content will be determined on the basis of the tests as specified in Subsection 407-6.03.

407-6.02 Mineral Aggregate:

Aggregate shall be free of deleterious materials, clay balls, and adhering films or other material that prevent thorough coating of the aggregate with the bituminous material.

Prior to asphaltic concrete production, the supplier shall obtain and test samples of mineral aggregate for determination of the sand equivalent, fractured coarse aggregate particles, and flakiness index. Samples shall be obtained from the cold feed belt prior to the addition of mineral admixture, or from the stockpiles when sampling from the cold feed belt is not possible. Should such testing indicate results not meeting the requirements of Table 407-2 for sand equivalent, fractured coarse aggregate particles, and flakiness index, operations shall cease and the supplier shall have the option of providing a new mix design or correcting deficiencies in the aggregate stockpiles. Results of the testing shall be provided to IQF upon completion for acceptance.

407-6.03 Asphaltic Concrete:

(A) Mineral Aggregate Gradation:

Prior to thethe daily startup of asphalt concrete production, and prior to startup after any subsequent mix design revisions affecting gradation, a sample of the combined mineral aggregate shall be tested by the supplier. If the mineral aggregate does not meet these requirements, production shall not begin until the mineral aggregate is in compliance with this requirement.

Samples will be tested for conformance to the mix design gradation, with or without mineral admixture as appropriate, in accordance with the requirements of Arizona Test Method 201.

The gradation will be considered to be acceptable if the result of any test varies from the mix design gradation percentages as follows:

Passing Sieve	Number of Tests	
		One
No. 4		± 6
No. 8		± 6
No. 200		± 2.0

One hundred percent of the material shall pass the 3/8-inch sieve.

At any time that test results indicate that the gradation does not fall within all of the limits indicated, the production of asphaltic concrete shall cease immediately and shall not begin again until a calibration test indicates that the gradation is within the test limits indicated.

(B) Bituminous Material Content:

During production of asphaltic concrete, the supplier shall maintain a nuclear asphalt content gauge calibrated and operated in accordance with Arizona Test Method 421. The supplier shall determine the asphalt content by means of the nuclear asphalt content gauge a minimum of one time for each days production. The supplier's technicians performing the testing, including the calibration of the nuclear gauge, shall meet the technician requirements given in ADOT Materials Practice and Procedure Directive No. 19, "ADOT System for the Evaluation of Testing Laboratories. Results of the testing performed by the supplier shall be provided to the IQF once complete for acceptance.

Production of asphaltic concrete shall cease immediately and the plant and/or the nuclear asphalt content gauge re-calibrated if any test result varies by an amount greater than ± 0.60 from the mix design specified value. Material that has already been produced may be used on the project if the test value representative of that material varies by an amount from ± 0.61 to ± 0.75, inclusive. Material that has already been produced may not be used on the project if the test value representative of that material varies by an amount greater than ± 0.75 unless, by retesting, the material is found to be acceptable.

407-7 Construction Requirements:

407-7.01 Quality Control:

Quality control of mineral aggregate production and asphaltic concrete production shall be the responsibility of the supplier. The supplier shall perform sufficient testing to assure that mineral aggregate and asphaltic concrete are produced which meet all specified requirements.

407-7.02 Stockpiling:

Mineral aggregate shall be separated and stockpiled so that segregation is minimized. An approved divider of sufficient size to prevent intermingling of stockpiles shall be provided.

407-7.03 Proportioning, Drying, Heating, and Mixing:

The asphaltic concrete hot plant shall conform to the requirements of Section 403 of the Specifications.

Unless approved by the Engineer, no individual mineral aggregate stockpile or hot bin usage shall be less than three percent of the total mineral aggregate.

No fine material which has been collected in the dust collection system shall be returned to the mixture unless the collected fines are accurately and uniformly metered into the mixture.

The moisture content of the asphaltic concrete shall not exceed 0.5 percent. The moisture content will be determined in accordance with the requirements of Arizona Test Method 406.

The temperature of asphaltic concrete or mineral aggregate upon discharge from the dryer shall not exceed 275 degrees F (325 degrees F when PG TR+ asphalt cement is used), unless otherwise approved by the supplier.

407-7.04 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 shall be wetted with water, or if necessary soapy water, or a release agent in order to prevent the sticking of asphaltic concrete. All other equipment surfaces shall be treated when necessary with a release agent. Only release agents evaluated through NTPEP are acceptable for use. The results from NTPEP testing, when tested in accordance with AASHTO TP 102, shall meet the following criteria:

RELEASE AGENT TEST	REQUIREMENT
Asphalt Stripping Test Diluted Non-Diluted (Full Strength)	 No Stripping No Stripping
Mixture Slide Test	10 g Retained, Max.
Asphalt Performance Test	Less than or equal to 10.0% after the third cycle

Release agents which degrade, dissolve, or in any way damage the bituminous material shall not be used. Diesel fuel shall not be used as a release agent.

Before asphaltic concrete is placed, the surface to be paved shall be cleaned of all objectionable material and tacked with bituminous material in accordance with the requirements of Section 404.

(1) Placement Dates and Weather Requirements:

Asphaltic concrete shall be placed only when the temperature on the surface on which the asphaltic concrete is to be placed is at least 85 degrees F and the ambient temperature at the beginning of the placement is at least 65 degrees and rising. The placement shall be stopped when the ambient temperature is 70 degrees F or less and falling.

At any time, the contractors quality department may require that the work cease or that the work day be reduced in the event that weather conditions, either existing or expected, are anticipated to have an adverse effect upon the asphaltic concrete.

Overnight ambient temperatures shall be greater than 40°F on the day before placement and shall be forecast to be greater than 40°F on the day of and the day after placement of the asphaltic concrete.

No placement of asphaltic concrete shall occur if the ambient temperatures exceed, or are forecast to exceed, 110°F the day before, the day of, or the day after paving.

No placement of the asphaltic concrete shall occur if the sustained wind velocities in excess of 15 MPH are forecast on the day of scheduled placement. Placement of asphaltic concrete shall cease for the day if the sustained wind velocities in excess of 15 MPH occur at the project. The contractor may allow placement of the asphaltic concrete during high wind conditions if the ambient temperature is 85°F and rising.

No asphaltic concrete placement shall occur if a high probability (greater than 80 percent chance) of rain is forecast within three days of the placement of the asphaltic concrete.

No traffic (including construction traffic, with the exception of required striping equipment) shall be allowed on the ACFC overlay until at least 3 applications of lime water have been completed.

(2) Delivery to Screed Unit:

Asphaltic concrete delivered to the screed unit shall be a free flowing, homogeneous mass in which there is no segregation, crusts, lumps, or migration of the bituminous material. Should any of these conditions be evident in the material delivered to the screed unit, the contractor shall take the necessary corrective action to eliminate such conditions. If any of these conditions persist, the Independent Quality Firm will request the work to be stopped until satisfactory corrective action has been taken.

(B) Loading Material into the Paving Machine:

If the asphaltic concrete is dumped directly into the paving machine from the hauling 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, it shall not be dumped at a distance greater than 150 feet in front of 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.

(C) 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 use of self-propelled paving machines impractical.

In order to achieve, as far as practical, a continuous operation, the speed of the paving machine shall be coordinated with the production of the plant.

Self-propelled paving machines shall spread the mixture within the specified tolerances, without segregation or tearing, true to the line, grade, and crown indicated on the project plans. Pavers shall be equipped with hoppers and augers which will distribute the mixture uniformly in front of adjustable screeds.

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 eight feet in width, or widened sections not exceeding four feet in width may be placed and finished by other means.

(D) Automatically Actuated Control System:

Except under certain conditions or at certain locations where the contractor deems the use of automatic controls impractical, asphaltic concrete shall be placed and finished by means of self-propelled paving machines equipped with an automatically actuated control system.

The control 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 control system shall be capable of working with the following devices which shall be furnished with the machine:

Ski-type device at least 30 feet in length, supported throughout its entire length.

Short ski.

Failure of the control system to function properly shall be cause for the suspension of the asphaltic concrete operations.

407-7.05 Joints:

Longitudinal joints shall be staggered a minimum of one foot with relation to the longitudinal joint of the immediate underlying course.

The contractor shall schedule its paving operations to minimize exposed longitudinal edges when the roadway is open to live public traffic. The contractor shall limit the placement of asphaltic concrete courses, in advance of adjacent courses, to one shift of asphaltic concrete production.

Longitudinal joints shall be located within one foot of the centerline between two adjacent lanes.

407-7.06 Compaction:

(A) General Requirements:

The temperature of the asphaltic concrete just prior to compaction shall be at least 200 degrees F (250 degrees F when PG TR+ asphalt cement is used).

(B) Equipment:

Compacting and smoothing shall be accomplished by the use of static steel wheel compactors. Vibrator compactors may be used in the static mode only. The compactors shall be self-propelled and shall be operated with the drive wheel in the forward position. Sufficient compactors shall be provided so that the drums of the compactors when staggered will cover the entire width of the paving machine during initial breakdown.

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.

Compactors shall weigh not less than eight tons.

(C) Rolling Procedure:

A pass shall be defined as one movement of a compactor in either direction. Coverage shall be the number of passes as are necessary to cover the entire width being paved.

Compaction shall consist of the following rolling sequence:

Rolling Sequence	Number of Coverages
Initial	1
Finish	1 – 2

A sufficient number of compactors shall be used for initial breakdown so that when the compactors are staggered the entire width of the mat being laid is compacted with one forward pass of the compactors. The distance between the paving machine and the initial rolling shall not exceed approximately 300 feet.

A separate roller(s) shall be used for final compaction. The roller(s) used for final compaction shall follow as closely behind the initial breakdown rollers as possible.

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 in accordance with the manufacturer's recommendations and with the number of coverages of the compactors as specified.

407-7.07 Compacting Miscellaneous Items and Surfaces:

Asphaltic concrete used in the construction of miscellaneous items and 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 contractor.

407-7.08 Smoothness and Surface Tolerances:

Asphaltic concrete shall be compacted as required, smooth and true to the required lines, grades, and dimensions.

The following requirements shall be met:

(1) The finished asphaltic concrete surface shall be tested and shall not vary by more than 1/8 inch from the lower edge of a ten-foot straightedge when it is placed in the longitudinal direction (including across transverse joints), and when it is placed in the transverse direction across longitudinal joints.

(2) All deviations exceeding the specified tolerances above shall be corrected by the contractor, to the satisfaction of the Engineer of Record.

407-7.09 Acceptance:

Asphaltic concrete will be accepted complete in place if the asphaltic concrete reasonably conforms to the requirements specified herein. Asphaltic concrete that is not acceptable and is rejected shall be replaced.

SECTION 409 ASPHALTIC CONCRETE (MISCELLANEOUS STRUCTURAL):

409-1 Description:

The work under this section shall consist of constructing Asphaltic Concrete (Miscellaneous Structural), hereinafter asphaltic concrete, by furnishing all materials, mixing at a plant, hauling and placing a mixture of aggregate materials, reclaimed asphalt pavement (RAP) if used, mineral admixture, and bituminous material (asphalt cement) to form a pavement course or to be used for other specified purposes, in accordance with the details shown on the project plans and the requirements of the specifications.

The material producer shall acquire and make all arrangements for a source or sources of material, furnish a mix design which will meet the design criteria specified hereinafter. The paving contractor shall provide all the equipment, materials, and labor necessary to complete the work.

Asphaltic concrete shall consist of furnishing all materials, mixing, hauling, and placing a mixture of aggregates, mineral admixture, and bituminous material to form a pavement course or to be used for other specified purposes, in accordance with the details shown on the project plans and as directed by the Developer.

409-2 Materials:

For comparative purposes, quantities shown in the bidding schedule have been calculated based on the following data:

Unit Weight (lb./cu. ft.)	147
Asphalt Content, %	5.0-5.5
Mineral Admixture, %	1.0

Producer shall prepare and submit Pavement Mix Designs to the Developer. Pavement Mix Designs are considered Shop Drawings and Working Drawings. Not less than 20 Business Days prior to paving, Developer shall submit Pavement Mix Designs to the Department for review and comment.

409-2.01 Mineral Aggregate:

Mineral aggregate shall conform to the following requirements when tested in accordance with the applicable test methods.

Mineral Aggregate Characteristics	Test Method	Requirement
Combined Bulk Oven	Arizona Test	2.350 - 2.850

Mineral Aggregate Characteristics	Test Method	Requirement
Dry Specific Gravity	Method 251	
Combined Water Absorption	Arizona Test Method 251	0 - 2.5%
Abrasion	AASHTO T 96	100 Rev., Max 9% 500 Rev., Max 40%
Sand Equivalent	AASHTO T 176 (After thoroughly sieving the sample, no additional cleaning of the fines from the plus No. 4 material is required.)	Minimum 55
Fractured Coarse Aggregate Particles	Arizona Test Method 212	Minimum 70% (plus No. 4 material)
Carbonates (1)	Arizona Test Method 238	Maximum 20%

(1): Testing for carbonates only applies if either of the following conditions exist:

(a) The asphaltic concrete is the designed final pavement surface normally used by traffic.

(b) The asphaltic concrete, temporary or otherwise, will be subject to traffic for more than 60 days

The gradation will be determined in accordance with Arizona Test Method 201, and shall conform to the requirements given below.

Mix Design Grading Limits						
Sieve Size	**Percent Passing**					
	Lift Thickness Less Than 1½ Inches		**Lift Thickness 1½ to 2 Inches**		**Lift Thickness Greater Than 2 Inches**	
	Without Admixture	**With Admixture**	**Without Admixture**	**With Admixture**	**Without Admixture**	**With Admixture**
1 Inch					100	100
3/4 Inch			100	100	90 – 100	90 – 100
1/2 Inch	100	100	90 – 100	90 – 100	---	---
3/8 Inch	90 – 100	90 – 100	70 – 85	70 – 85	70 – 85	70 – 85
No. 8	41 – 55	42 – 56	41 – 51	42 – 52	41 – 51	42 – 52
No. 40	9 – 19	10 – 20	---	---	---	---
No. 200	2.0 – 5.0	3.0 – 6.5	2.0 – 5.0	3.0 – 6.5	2.0 – 5.0	3.0 – 6.5

(1) The ratio of the mix design composite gradation target for the No. 200 sieve, including mineral admixture, to the effective asphalt content shall be within the range specified below:

$$\frac{\text{Mix Design Composite Gradation Target}}{\text{Effective Asphalt Content}} = \underline{\mathbf{0.6}} \text{ to } 1.2$$

409-2.02 Bituminous Material:

Asphalt cement shall be a performance grade (PG) asphalt binder conforming to the requirements of Section 1005. The type of asphalt binder shall be as shown on the plans.

The percent of asphalt cement used shall be based on the weight of total mix (asphalt cement, mineral aggregate, and mineral admixture).

The producer shall provide the laboratory mixing and compaction temperature ranges to the mix design laboratory for each PG asphalt binder used for mix design purposes. The laboratory mixing temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.17 ± 0.02 Pascal·seconds, measured in accordance with AASHTO T 316. The laboratory compaction temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.28 ± 0.03 Pascal·seconds, measured in accordance with AASHTO T 316. The testing required in AASHTO T 316 shall be performed at 275 °F and 350 °F, and a viscosity-temperature curve developed in accordance with ASTM D 2493. The viscosity-temperature curve shall be included in the mix design report. For PG asphalt binders that have a maximum laboratory mixing temperature exceeding 325 °F or a maximum laboratory compaction temperature exceeding 300 °F, the laboratory mixing and compaction temperature ranges shall be specified in writing by the asphalt binder supplier. The laboratory mixing and compaction temperature ranges, as well as the actual laboratory mixing and compaction temperatures used, shall be reported on the mix design. The producer shall ensure that the asphalt binder supplier information required in this paragraph is provided to all appropriate parties in a timely manner, and that copies are included in the mix design report. The laboratory mixing and compaction temperatures are for mix design purposes only. Field mixing and compaction temperatures are specified in Subsection 409-3.

409-2.03 Mineral Admixture:

Mineral admixture shall be either Portland cement, blended hydraulic cement, or hydrated lime conforming to the following requirements:

Material	Requirement
Portland Cement, Type I or II	ASTM C 150
Blended Hydraulic Cement, Type IP	ASTM C 595
Hydrated Lime	ASTM C 1097

The mineral admixture content shall be 2.0 percent, by weight, of the mineral aggregate. However, a minimum of 1.0 percent mineral admixture may be used if the producer submits test information showing a lowered percentage of mineral admixture produces mix design results for Index of Retained Strength of at least 60 percent and a Minimum Wet Strength of 150 psi when tested in accordance with Arizona Test Method 802.

The certification and acceptance of Portland cement, blended hydraulic cement, and hydrated lime shall be in accordance with Materials Policy and Procedure Directive No. 13, "Certification and Acceptance of Hydraulic Cement, Fly Ash, Natural Pozzolan, Silica Fume, and Lime". The applicable requirements from this document are presented below for ease of reference:

5. CERTIFICATION AND ACCEPTANCE OF PORTLAND CEMENT, BLENDED HYDRAULIC CEMENT, OR HYDRATED LIME FOR USE AS A MINERAL ADMIXTURE IN ASPHALTIC CONCRETE MIXES

5.1 Portland Cement shall meet the requirements of ASTM C 150 for Type I or Type II cement. Blended Hydraulic Cement shall meet the requirements of ASTM C 595 for Type IP cement. Hydrated Lime shall meet the requirements of ASTM C 1097.

5.2 A Certificate of Analysis conforming to the requirements of Subsection 106.05 shall be submitted for each delivery of Portland cement, blended hydraulic cement, or hydrated lime.

5.3 No samples of Portland cement, blended hydraulic cement, or hydrated lime are required.

5.4 The Department reserves the right to sample and test material which has been accepted on the basis of a Certificate of Analysis.

409-2.04 Mix Design:

Utilizing mineral aggregate which has been crushed, processed, separated and stockpiled, a mix design shall be formulated and submitted by the producer to the Developer. The mineral aggregate samples used for mix design purposes shall be representative of aggregate materials to be used during production.

The mix design shall be based on the mix design criteria and other requirements specified herein, utilizing asphalt cement and mineral admixture of the type and from the sources proposed for use in the production of asphaltic concrete.

The mix design shall be prepared by or under the direct supervision of a professional engineer experienced in the development of mix designs and mix design testing. Reclaimed asphalt pavement (RAP) may be used in the mixture if properly designed per Arizona Test Method 833; however, RAP will not be allowed in the mixture when asphalt cement type PG 76-22 is specified. Limits for the usage of RAP shall be per ADOT Materials Policy and Procedure Directive No. 20, "Guidance on the Use of Reclaimed Asphalt Pavement (RAP) in Asphaltic Concrete". The mix design engineer shall meet the requirements given in ADOT Materials Policy and Procedure Directive No. 4, "Asphaltic Concrete Mix Design Proposals and Submittals". The mix design shall be provided in a format that clearly indicates all the mix design requirements and shall be sealed, signed, and dated by the mix design engineer.

The mix design shall be prepared by a mix design laboratory that has met the requirements of ADOT Materials Policy and Procedure Directive No. 19, "ADOT System for the Evaluation of Testing Laboratories".

If approved by the Developer, as an alternative to meeting the mix design requirements specified herein, a 1/2 inch or 3/4 inch mix design meeting the requirements of Section 416 of the specifications may be substituted for use. The type of asphalt binder used in the alternative mix design must be the same as that specified the Developer. The alternative mix design may include reclaimed asphalt pavement (RAP) if properly designed per Arizona Test Method 833. The lift thickness for the alternative mix design shall conform to the following table.

Alternative Mix Design	**Minimum Lift Thickness**
Section 416 (1/2 inch mix)	1-1/2 inches
Section 416 (3/4 inch mix)	2 inches

A previously used mix design shall not be allowed for use.

The mix design shall be prepared under the direct supervision of a professional engineer experienced in the development of mix designs and mix design testing. The mix design shall be provided in a format that clearly indicates all the mix design requirements and shall be sealed, signed, and dated by the mix design engineer.

The mix design shall be prepared by a mix design laboratory that has met the requirements of the Department's "System for the Evaluation of Testing Laboratories". The requirements may be obtained from ADOT Materials Group, 1221 North 21st Avenue, Phoenix, Arizona 85009.

Test results used in the formulation of the mix design must be from testing performed no earlier than 45 days prior to the date the mix design is signed by the mix design engineer. Historical abrasion values may be supplied on sources provided the testing was conducted within the past two years.

The mix design shall be submitted to the Developer under a cover letter signed by an authorized representative of the producer.

The mix design shall be submitted to the Independent Quality Firm and ADOT by the Developer for review a minimum of 20 business days prior to the start of production.

The mix design shall meet the following criteria when tested in accordance with the requirements of the following test methods:

Criteria	**Requirement**	**Arizona Test Method**
1. Voids in Mineral Aggregate: %, Range	14.5 - 18.5	815
2. Effective Voids: %, Range	5.5 - 6.5	815
3. Absorbed Asphalt: %, Range	0-1.0	815

The Developer reserves the right to adjust the asphalt content during production from the mix design value without additional compensation to the producer in order to obtain desirable effective voids. The Developer may waive the requirements for a mix design if the intended use of the material is temporary in nature.

409-2.05 Sampling and Testing:

Sampling and testing the materials or mixture for quality control purposes shall be the producer's responsibility. The Independent Quality Firm reserves the right to sample and test the materials and mixture when necessary to determine that they reasonably conform to the requirements specified herein.

409-3 Producer and Construction Requirements:

409-3.01 General:

All courses of asphaltic concrete shall be compacted as required, smooth and true to the required lines, grades, and dimensions.

The following smoothness requirements shall be met:

(1) The surface of the final lift of asphaltic concrete placed under this section of the specifications shall be tested and shall not vary by more than 1/8 inch from the lower edge of a ten-foot straightedge when it is placed in the longitudinal direction (including across transverse joints), and when it is placed in the transverse direction across longitudinal joints.

(2) The surface of any lift of asphaltic concrete placed under this section of the specifications, other than the final lift, shall be tested and shall not vary by more than 1/4 inch from the lower edge of a ten-foot straightedge when it is placed in the longitudinal direction (including across transverse joints), and when it is placed in the transverse direction across longitudinal joints.

(3) All deviations exceeding the specified tolerances above shall be corrected by the contractor, to the satisfaction of the Independent Quality Firm.

The asphaltic concrete hot plant shall conform to the requirements of Section 403 of the Specifications.

No fine material which has been collected in the dust collection system shall be returned to the mixture unless the collected fines are accurately and uniformly metered into the mixture.

The temperature of asphaltic concrete or mineral aggregate upon discharge from the drier shall not exceed 325 degrees F, unless a higher temperature is recommended in writing by the asphalt binder supplier and approved by the Developer. The moisture content of the asphaltic concrete immediately behind the paver shall not exceed 0.5 percent. The moisture content will be determined in accordance with the requirements of Arizona Test Method 406.

Asphaltic concrete shall be placed only when the temperature of the surface on which the asphaltic concrete is to be placed is at least 65 degrees F.

At any time, the Developer may require that the work cease or that the work day be reduced in the event that weather conditions, either existing or expected, are anticipated to have an adverse effect upon the asphaltic concrete.

Asphaltic concrete immediately behind the laydown machine shall be in a thoroughly mixed, free-flowing, and workable condition, be free of lumps and crusts, and have a minimum temperature of 275 degrees F.

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 Developer deems the use of self-propelled paving machines impractical.

The speed of the paving machine shall be coordinated with the production of the plant and an adequate number of trucks for hauling asphaltic concrete shall be available in order to achieve, as far as practical, a continuous operation

Self-propelled paving machines shall spread the mixture within the specified tolerances, without segregation or tearing, true to the line, grade, and crown indicated on the project plans. Pavers shall be equipped with hoppers and augers which will distribute the mixture uniformly in front of adjustable screeds.

Pavers shall be equipped with a screed for the full width being paved, heated if necessary, and capable of spreading and finishing all courses of asphaltic concrete.

Pavers shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed, and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope.

Failure of the control system to function properly shall be cause for the suspension of the placing of asphaltic concrete.

The base or subgrade upon which asphaltic concrete is to be placed shall be prepared and maintained in a firm condition until asphaltic concrete is placed. It shall not be excessively wet.

Before asphaltic concrete is placed, the surface to be paved shall be cleaned of all objectionable material and tacked with bituminous material in accordance with the requirements of Section 404.

Longitudinal joints of each course shall be staggered a minimum of one foot with relation to the longitudinal joint of any immediate underlying course. Longitudinal joints shall be located within one foot of the center of a lane or within one foot of the centerline between two adjacent lanes.

The producer shall schedule its paving operations to minimize exposed longitudinal edges. Unless otherwise approved by the Developer, the producer shall limit the placement of asphaltic concrete courses, in advance of adjacent courses, to one shift of asphaltic concrete production. The producer shall schedule its paving operations in such a manner to eliminate exposed longitudinal edges over weekends or holidays if that portion of the facility has been opened to traffic.

409-3.02 Compaction:

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 as are 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**		**Number of Coverages**	
	Option No. 1	**Option No. 2**	**Option No. 1**	**Option No. 2**
Initial	Static Steel	Vibrating Steel	1	1
Intermediate	Pneumatic Tired	Vibrating Steel	2 – 6*	2 - 4*
Finish	Static Steel	Static Steel	1 - 3	1 - 3
* Based on the roller pattern which exhibits the best performance.				

The Developer shall select the option for compaction and, when pneumatic-tired compactors are used, will designate the tire pressure.

Steel wheel compactors shall not be used in the vibratory mode for courses of one inch or less in nominal thickness nor when the temperature of the asphaltic concrete falls below 180 degrees F. Steel wheel compactors shall weigh not less than eight tons.

Initial and intermediate compaction shall be completed before the temperature of the asphaltic concrete falls below 200 degrees F. All edges shall be rolled with a pneumatic tired compactor, or other methods approved by the Independent Quality Firm, while the mixture is still hot.

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.

409-3.03 Acceptance:

Asphaltic concrete will be accepted complete in place, if, in the judgment of the Independent Quality Firm, the asphaltic concrete reasonably conforms to the requirements specified herein. Asphaltic concrete that is not acceptable and is rejected shall be replaced to the satisfaction of the Independent Quality Firm.

SECTION 414 ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER):

414-1 Description:

The work under this section shall consist of constructing Asphaltic Concrete Friction Course (Asphalt-Rubber), hereinafter asphaltic concrete, by furnishing all materials, mixing at a plant, hauling and placing a mixture of aggregate materials, mineral admixture, and bituminous material (asphalt-rubber) to form a pavement course or to be used for other specified purposes.

The producer shall be responsible for all adjustments to its equipment necessary to properly accommodate the use of asphalt-rubber as a bituminous material.

414-2 Asphaltic Concrete Mix Design Criteria:

Mix designs will be performed in accordance with Arizona Test Method 814, modified as necessary for Asphaltic Concrete Friction Course (Asphalt-Rubber). The allowable range of percent absorbed asphalt-rubber shall be 0-1.0, when tested in accordance with Arizona Test Method 806.

414-3 Materials:

For comparative purposes, quantities have been calculated based on the following data:

Location	Over AC (0.5” thick)	Over PCCP (1.0” thick)
Spread Rate (lb./sq. yd.)	59	100
Asphalt-Rubber, %	9.5	
Mineral Admixture, %	1.0	

The estimated target spread rate specified above includes **25** percent for leveling to provide a minimum **0.5/1**-inch thickness above the leveling thickness.

414-3.01 Mineral Aggregate:

The producer shall provide a source of mineral aggregate in accordance with the requirements of Section 1001 of the specifications.

When the producer selects a source or sources, it shall notify the Developer. The producer shall be solely responsible for assuring that the mineral aggregate meets all requirements and, when processed, is fully capable of providing asphaltic concrete which meets all the requirements of these specifications.

Mineral aggregate shall be separated into at least two stockpiles. No individual stockpile or hot bin usage shall be less than three percent of the total mineral aggregate.

Coarse mineral aggregate shall consist of crushed gravel, crushed rock, or other approved inert materials 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, sand prepared from rock, or other approved inert materials, or a combination thereof, conforming to the requirements of these specifications.

Mineral aggregate furnished for mix designs shall be representative of the source(s) and sampled from the material stockpiles to be utilized in asphaltic concrete production. Mix designs shall conform to the grading limits in Table 414-1, when tested in accordance with Arizona Test Method 201.

TABLE 414-1
MIX DESIGN GRADING LIMITS

Sieve Size	Percent Passing	
	Without Admixture	**With Admixture**
3/8 Inch	100	100
No. 4	30-45	31-46
No. 8	4-8	5-9
No. 200	0-2.0	0-3.0

Mineral aggregate shall conform to the requirements in Table 414-2 when tested in accordance with the applicable test methods.

Tests on aggregates outlined in Table 414-2, other than abrasion, shall be performed on materials furnished for mix design purposes and composited to the mix design gradation. Abrasion shall be performed separately on samples from each source of mineral aggregate. All sources shall meet the requirements for abrasion.

TABLE 414-2 MINERAL AGGREGATE CHARACTERISTICS		
Characteristic	**Test Method**	**Requirement**
Combined Bulk Oven Dry Specific Gravity	Arizona Test Method 251	2.350 - 2.850
Combined Water Absorption	Arizona Test Method 251	0 – 2.5%
Sand Equivalent	Arizona Test Method 242 (After thoroughly sieving the sample, no additional cleaning of the fines from the plus No. 8 material is required.)	Minimum 55
Fractured Coarse Aggregate Particles	Arizona Test Method 212	Minimum 85% (at least two fractured faces) and minimum 92% (at least one fractured face)
Flakiness Index	Arizona Test Method 233	Maximum 25%
Carbonates	Arizona Test Method 238	Maximum 20%
Abrasion	AASHTO T 96	100 Rev., Max. 9% 500 Rev., Max. 40%

414-3.02 Mineral Admixture:

Mineral admixture will be required. The amount shall be 1.0 percent, by weight of the mineral aggregate. Mineral admixture shall be either Portland cement, blended hydraulic cement, or hydrated lime conforming to the requirements of Table 414-3.

TABLE 414-3 MINERAL ADMIXTURE	
Material	**Requirement**
Portland Cement, Type I or II	ASTM C 150
Blended Hydraulic Cement, Type IP	ASTM C 595
Hydrated Lime	ASTM C 1097

The certification and acceptance of Portland cement, blended hydraulic cement (Type IP), and hydrated lime shall be in accordance with Materials Policy and Procedure Directive No. 13, "Certification and Acceptance of Hydraulic Cement, Fly Ash, Natural Pozzolan, Silica Fume, and Lime". The applicable requirements from this document are presented below for ease of reference:

5. CERTIFICATION AND ACCEPTANCE OF PORTLAND CEMENT, BLENDED HYDRAULIC CEMENT, OR HYDRATED LIME FOR USE AS A MINERAL ADMIXTURE IN ASPHALTIC CONCRETE MIXES

5.1 Portland Cement shall meet the requirements of ASTM C 150 for Type I or Type II cement. Blended Hydraulic Cement shall meet the requirements of ASTM C 595 for Type IP cement. Hydrated Lime shall meet the requirements of ASTM C 1097.
5.2 A Certificate of Analysis conforming to the requirements of Subsection 106.05 shall be submitted for each delivery of Portland cement, blended hydraulic cement, or hydrated lime.
5.3 No samples of Portland cement, blended hydraulic cement, or hydrated lime are required.
5.4 The Department reserves the right to sample and test material which has been accepted on the basis of a Certificate of Analysis.

414-3.03 Bituminous Material:

Bituminous material shall be asphalt-rubber conforming to the requirements of Section 1009 of the specifications. The asphalt-rubber shall be CRA Type **1**. The crumb rubber gradation shall be Type B conforming to the requirements of Section 1009.

The percent of asphalt-rubber used shall be based on the weight of total mix (asphalt-rubber, mineral aggregate, and mineral admixture).

The percent of asphalt-rubber to be used will be specified by the Developer.

In no case shall the asphalt-rubber be diluted with extender oil, kerosene, or other solvents. Any asphalt-rubber so contaminated will be rejected.

Any kerosene or other solvents used in the cleaning of equipment shall be purged from the system prior to any subsequent use of that equipment.

414-4 Mix Design:

Approximately 300 pounds of produced mineral aggregate, in proportion to the anticipated percent usage, shall be obtained by the producer and witnessed by the Developer so that both parties are satisfied that samples are representative of the mineral aggregate to be utilized in the asphaltic concrete production.

In addition to the mineral aggregate samples, the producer shall also furnish the Developer with representative samples of the following materials: a five-pound sample of the crumb rubber proposed for use, one gallon of asphalt cement from the intended supplier, three gallons of the proposed mixture of asphalt and rubber, and a one-gallon can of the proposed mineral admixture. These materials must be representative of the material which will subsequently be used in the production of asphaltic concrete.

If the mineral aggregate does not meet the requirements of Subsection 414-3.01, no mix design will be prepared. The producer shall take the necessary steps to provide material meeting the specified requirements.

Along with the samples furnished for mix design testing, the producer shall submit a letter explaining in detail its methods of producing mineral aggregate including wasting, washing, blending, proportioning, etc., and any special or limiting conditions it may propose. The producer's letter shall also state the source(s) of mineral aggregate, the source and type of asphalt cement, the source and type of crumb rubber, and the source and type of mineral admixture.

Within 10 working days of receipt of all samples and the producer's letter in the Independent Quality Firm identified Laboratory, the Developer will provide the producer with a mix design containing the type and percentage of asphalt-rubber; the type and source of asphalt cement; the type and source of crumb rubber; the type, source, and percentage of mineral admixture; the source(s) of mineral aggregate and the percentage from each of the stockpile; the composite mineral aggregate gradation; the combined mineral aggregate and mineral admixture gradation; and any special or limiting conditions.

Asphaltic concrete friction course production shall not begin until there is an approved mix design.

The producer may not propose the use of a mix design that has been developed for a previous project.

414-5 Mix Design Revisions:

At any time after production of asphaltic concrete has been started using the approved mix design, changes may be proposed by the producer or directed by the Developer or Independent Quality Firm.

The producer shall not change its methods of crushing, screening, washing, or stockpiling from those used during production of material used for mix design purposes without approval of the Independent Quality Firm, or without requesting a new mix design.

If the producer elects to change its source or type of bituminous material, the type of mineral admixture, or the source(s) of mineral aggregate equal to or greater than five percentage points, or if the producer adds or deletes the use of a mineral aggregate stockpile(s) regardless of source, testing to the extent deemed necessary by the Independent Quality Firm will be performed in order that the Independent Quality Firm may be satisfied that the mix design criteria will be met.

During production of asphaltic concrete, the producer, on the basis of field test results, may request a change to the approved mix design. The Independent Quality Firm will evaluate the proposed changes and notify the producer of the Independent Quality Firm's decision.

If, at any time, unapproved changes are made by the producer in the source of bituminous material, source(s) of mineral aggregate, production methods, or proportional changes in violation of approved mix design stipulations, production shall cease until a new mix design is developed at no additional cost to the Developer, or the producer complies with the approved mix design.

At any time after the mix design has been approved, the producer may request a new mix design. The costs associated with the testing of materials in the developing of mix designs requested by the producer after a mix design acceptable to the Developer has been developed shall be borne by the producer.

If the Developer or Independent Quality Firm determines that a new mix design is necessary due to changes in mineral aggregate characteristics or gradation, costs associated with the development of the new mix design shall be borne by the producer.

A new mix design can be developed by the Developer at any time the Developer deems necessary. Should such a new mix design require revisions to the producer's operations which result in additional cost to the producer, it will be reimbursed for these costs. However, the Developer reserves the right to modify the asphalt-rubber content without compensation being made to the producer involving additional operation costs.

414-6 Acceptance of Materials:

414-6.01 General:

If the production of asphaltic concrete is stopped either for failure to meet the requirements specified in Subsection 414-6.03 or because changes are made in the mix design, samples will be taken for calculating new consecutive averages either after production resumes or after the changes in the mix design have been made. The acceptance of the mineral aggregate gradation and the bituminous material content will be determined on the basis of the tests specified in Subsection 414-6.03. The Independent Quality Firm reserves the right to increase the frequency of sampling and testing upon the resumption of asphaltic concrete production.

414-6.02 Mineral Aggregate:

Aggregate shall be free of deleterious materials, clay balls, and adhering films or other material that prevent thorough coating of the aggregate with the bituminous material.

See Developer's Guide Schedule for sampling frequency.

414-6.03 Asphaltic Concrete:

(A) Mineral Aggregate Gradation:

Prior to the initial startup of asphaltic concrete production, and prior to startup after any subsequent mix design revisions affecting gradation, a sample of the combined mineral aggregate shall be tested. The mineral aggregate shall meet the gradation requirements for the 3-consecutive test limits indicated below. If the mineral aggregate does not meet these requirements, production shall not begin until the mineral aggregate is in compliance with this requirement. If any single test falls outside of the requirements for gradation, sand equivalence, flakiness index, or fractured faces, an immediate re-sample and re-test shall be performed in an expedited manner, to confirm the results. The results of the re-sample will be binding.

See Developer's Guide Schedule for sampling frequency.

The gradation will be considered to be acceptable unless the average of any three consecutive tests or the result of any single test varies from the mix design gradation percentages as follows:

Passing Sieve	Number of Tests	
	3 Consecutive	One
No. 4	± 4	± 6
No. 8	± 3	± 4
No. 200	± 1.0	± 1.5

One hundred percent of the material shall pass the 3/8-inch sieve.

At any time that test results indicate that the gradation does not fall within all of the limits indicated after a re-sample and re-test confirm the original result, the production of asphaltic concrete shall cease immediately and shall not begin again until a calibration test indicates that the gradation is within the 3-consecutive test limits indicated.

(B) Asphalt-Rubber Content:

During production of asphaltic concrete, the producer shall maintain at the plant site a nuclear asphalt content gauge calibrated and operated in accordance with Arizona Test Method 421. At the discretion of the Developer, the Developer may choose to prepare the calibration samples for use by the producer. Under the observation of the Independent Quality Firm, the producer shall determine the asphalt-rubber content by means of the nuclear asphalt content gauge a minimum of four times per full shift. The Independent Quality Firm shall determine the times that the samples are taken. The producer's technicians performing the testing, including the calibration of the nuclear gauge, shall meet the technician requirements given in Materials Policy and Procedure Directive No. 19, "ADOT System for the Evaluation of Testing Laboratories".

Production of asphaltic concrete shall cease immediately and the plant and/or the nuclear asphalt content gauges re-calibrated if any single test result varies by an amount greater than ± 0.60, or the average of three consecutive test results varies by an amount greater than ± 0.40, from the amount directed by the Developer. Material that has already been produced may be used on the project if the single test value representative of that material varies by an amount from ± 0.61 to ± 0.75, inclusive, from the amount directed by the Developer. Material that has already been produced may not be used on the project if the single test value representative of that material varies by an amount greater than ± 0.75 from the amount directed by the Developer unless, by retesting, the material is found to be acceptable.

414-6.04 Material Spread:

The estimated target spread rate will be as shown in the table in Subsection 414-3. The Developer may adjust the estimated target spread rate, and establish a new target spread rate, as necessary to maintain a suitable thickness by the following guidelines:

1. New target spread rate shall be determined by the average bulk density of the last three days of production;
2. All new target spread rate values shall be concurred by the Independent Quality Firm prior to implementation.

The thickness behind the screed shall be measured by the contractor continuously throughout each spread lot to ensure that the minimum compacted thickness specified in Subsection 414-3 is being met.

A spread lot shall be considered to be one-half shift of production. The contractor shall record information pertaining to each spread lot on forms provided by the Independent Quality Firm. Information shall include the project number, date and period of time that each spread lot was placed, the spread lot number, beginning and ending station, the plans thickness, target spread rate, and tons placed in each spread lot. Completed spread lot forms shall be signed by the producer and given to the Independent Quality Firm at the end of each shift.

The Independent Quality Firm will calculate the quantity required in each spread lot using the target spread rate.

The calculated quantity required in each spread lot will be compared to the actual quantity placed. A spread lot will be considered to be acceptable if the actual quantity placed does not vary by more than -5.0 percent from the required quantity.

414-7 Producer and Construction Requirements:

414-7.01 Quality Control:

Quality control of mineral aggregate production and asphaltic concrete production shall be the responsibility of the producer. The producer shall perform sufficient testing to assure that mineral aggregate and asphaltic concrete are produced which meet all specified requirements. The Developer reserves the right to obtain samples of any portion of any material at any point of the operations for the Developer's own use.

414-7.02 Stockpiling:

The producer will not be allowed to feed the hot plant from stockpiles containing less than two full days of production unless only two days production remain to be done or special conditions exist where the Developer deems this requirement waived.

Mineral aggregate shall be separated and stockpiled so that segregation is minimized. An approved divider of sufficient size to prevent intermingling of stockpiles shall be provided.

414-7.03 Proportioning, Drying, Heating, and Mixing:

The asphaltic concrete hot plant shall conform to the requirements of Section 403 of the Specifications.

Changes in individual stockpile or hot bin use in excess of five percent from the approved mix design will not be permitted without the approval of the Developer.

No fine material which has been collected in the dust collection system shall be returned to the mixture unless the collected fines are uniformly metered into the mixture.

The moisture content of the asphaltic concrete shall not exceed 0.5 percent. The moisture content will be determined in accordance with Arizona Test Method 406.

The temperature of asphaltic concrete or mineral aggregate upon discharge from the dryer shall not exceed 350 degrees F.

414-7.04 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 equipment surfaces shall be treated when necessary with a release agent approved by the Developer in order to prevent the sticking of asphaltic concrete. Release agents which degrade, dissolve, or in any way damage the bituminous material shall not be used. Diesel fuel shall not be used as a release agent.

Before asphaltic concrete is placed, the surface to be paved shall be cleaned of all objectionable material and tacked with asphalt cement in accordance with the requirements of Section 404 of the specifications. The cleaning of the surface, the tacking of the surface, and the amount and grade of asphalt cement used shall be as directed by and acceptable to the Developer.

Unless otherwise specified on the project plans, asphaltic concrete shall not be placed on the two-foot widened section where guardrail is to be installed.

(1) Placement Dates and Weather Requirements:

Asphaltic concrete shall be placed only when the temperature of the surface on which the asphaltic concrete is to be placed is at least 85 degrees F and the ambient temperature at the beginning of placement is at least 70 degrees F and rising.
At any time, the Developer may require that the work cease or that the work day be reduced in the event that weather conditions, either existing or expected, are anticipated to have an adverse effect upon the asphaltic concrete.

Prior to opening to any traffic, the Developer may require up to three applications of lime water (a minimum of 50 pounds of lime per 2,000 gallons of water). Lime water shall be applied in a manner that uniformly covers the entire surface of the paving pass.

(2) Delivery to Screed Unit:

Asphaltic concrete delivered to the screed unit shall be a free flowing, homogeneous mass in which there is no segregation, crusts, lumps, or migration of the asphalt-rubber.

Should any one or more of such conditions be evident in the material delivered to the screed unit, and which cannot be eliminated by one or more of the following methods, the Developer will order the work to be stopped until conditions are conducive to the delivery of the material in the condition as hereinbefore required:

(a) Covering hauling units with tarpaulins.

(b) Dumping material directly into the paver.

(c) Moving the hot plant nearer to the point of delivery.

Other measures proposed by the contractor which will deliver asphaltic concrete meeting the above requirements will be considered by the Developer.

(B) Loading Asphaltic Concrete into the Paving Machine:

If the asphaltic concrete is dumped directly into the paving machine from the hauling 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 machine 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, it shall not be dumped at a distance greater than 150 feet in front of 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.

(C) 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 Developer deems the use of self-propelled paving machines impractical.

In order to achieve, as far as practical, a continuous operation, the speed of the paving machine shall be coordinated with the production of the plant.

Self-propelled paving machines shall spread the mixture within the specified tolerances, without segregation or tearing, true to the line, grade, and crown indicated on the project plans. Pavers shall be equipped with hoppers and augers which will distribute the mixture uniformly in front of adjustable screeds.

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 eight feet in width, or widened sections not exceeding four feet in width may be placed and finished by other means approved by the Developer.

(D) Automatically Actuated Control System:

Except under certain conditions or at certain locations where the Developer deems the use of automatic controls impractical, asphaltic concrete shall be placed and finished by means of self-propelled paving machines equipped with an automatically actuated control system.

The control 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 control system shall be capable of working with the following devices which shall be furnished with the machine:

Ski-type device at least 30 feet in length, supported throughout its entire length.

Short ski.

Failure of the control system to function properly shall be cause for the suspension of the asphaltic concrete operations.

414-7.05 Joints:

Longitudinal joints shall be staggered a minimum of one foot with relation to the longitudinal joint of the immediate underlying course.

The contractor shall schedule its paving operations to minimize exposed longitudinal edges. Unless otherwise approved by the Developer, the contractor shall limit the placement of asphaltic concrete courses, in advance of adjacent courses, to one shift of asphaltic concrete production. The contractor shall schedule its paving operations in such a manner to eliminate exposed longitudinal edges over weekends or holidays if that portion of the facility has been opened to traffic.

Longitudinal joints shall be located within one foot of the centerline between two adjacent lanes.

414-7.06 Compaction:

(A) General Requirements:

The temperature of asphaltic concrete just prior to compaction shall be at least 275 degrees F.

The wheels of compactors shall be wetted with water, or if necessary soapy water, or a release agent approved by the Developer, to prevent the asphaltic concrete from sticking to the steel wheels during rolling. Release agents which degrade, dissolve, or in any way damage the bituminous material shall not be used. Diesel fuel shall not be used as a release agent. The Developer may change the rolling procedure if in the Developer's judgment the change is necessary to prevent picking up of the asphaltic concrete.

(B) Equipment:

Compacting and smoothing shall be accomplished by the use of static steel wheel compactors. Vibrator compactors may be used in the static mode only. The compactors shall be self-propelled and shall be operated with the drive wheel in the forward position. Sufficient compactors shall be provided so that the drums of the compactors when staggered will cover the entire width of the paving machine during initial breakdown.

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.

The compactors shall weigh not less than eight tons.

(C) Rolling Procedure:

A pass shall be defined as one movement of a compactor in either direction. Coverage shall be the number of passes as are necessary to cover the entire width being paved.

Compaction shall consist of the following rolling sequence:

Rolling Sequence	Number of Coverages
Initial	1
Finish	1 - 2

A sufficient number of compactors shall be used for initial breakdown so that when the compactors are staggered the entire width of the mat being laid is compacted with one forward pass of the compactors. The distance between the paving machine and the initial rolling shall not exceed 300 feet.

A separate roller(s) shall be used for final compaction. The roller(s) used for final compaction shall follow as closely behind the initial breakdown rollers as possible.

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 in accordance with the manufacturer's recommendations, and with the number of coverages of the compactors as specified.

414-7.07 Compacting Miscellaneous Items and Surfaces:

Asphaltic concrete used in the construction of miscellaneous items and 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 Developer.

414-7.08 Smoothness and Surface Tolerances:

Asphaltic concrete shall be compacted as required, smooth and true to the required lines, grades, and dimensions.

Developer shall evaluate the asphalt rubber-asphaltic concrete friction course (AR-ACFC) surface treatment for smoothness for each 0.1 lane-mile increment in accordance with the provisions of Arizona Test Method 829. Developer shall not perform smoothness testing when the ambient air temperature is less than 40 °F, or during rain or other precipitation. Developer shall perform smoothness testing within 10 Business Days of placement of the AR-ACFC surface treatment. Developer shall perform smoothness testing on traffic lanes longer than 0.3 mile.

The contractor shall repair full lane widths in any segment of AR-ACFC having an international roughness index (IRI) greater than 50 inches/mile.

Upon completion of any necessary corrective actions, Developer shall retest the 0.1 lane-mile increments containing repaired areas in accordance with the provisions of Arizona Test Method 829.

The following requirements shall be met:

(1) The finished asphaltic concrete surface shall be tested and shall not vary by more than 1/8 inch from the lower edge of a ten-foot straightedge when it is placed in the longitudinal direction (including across transverse joints), and when it is placed in the transverse direction across longitudinal joints.

(2) All deviations exceeding the specified tolerances above shall be corrected by the contractor, to the satisfaction of the Developer.

414-7.09 Acceptance:

Asphaltic concrete will be accepted complete in place, if, in the judgment of the Independent Quality Firm, the asphaltic concrete reasonably conforms to the requirements specified herein. Asphaltic concrete that is not acceptable and is rejected shall be replaced to the satisfaction of the Independent Quality Firm.

414-8 Method of Measurement:

Asphaltic concrete will be measured by the ton for the mixture actually used, which will include the weight of mineral aggregate, mineral admixture and asphalt-rubber. Measurement will include any weight used in construction of intersections, turnouts, or other miscellaneous items or surfaces.

414-9 Basis of Payment:

The accepted quantities of asphaltic concrete, measured as provided above, will be paid for at the contract unit price per wet ton, which price shall be full compensation for the work, complete in place, as specified herein.

Smoothness pay factors will not be incorporated into the project and the contractor is required to follow the criteria outlined in Subsection 416-7.06.

When lime water is used, no separate payment will be made for the lime water or its application, the cost being considered as included in this contract item.

SECTION 416 ASPHALTIC CONCRETE - END PRODUCT AND AC END PRODUCT (BASE MIX – PCCP BASE):

416-1 Description:

The work under this section shall consist of constructing Asphaltic Concrete-End Product and Asphaltic Concrete-End Product (Base Mix – PCCP Base), hereinafter asphaltic concrete, by furnishing all materials, mixing at a plant, hauling and placing a mixture of aggregate materials, mineral admixture, and bituminous material (asphalt cement) to form a pavement course or to be used for other specified purposes, in accordance with the details shown on the project plans.

Reclaimed asphalt pavement (RAP), as defined in Subsection 416-3.04, may be used in the mixture provided all requirements of the specifications are met; however, RAP will not be allowed in the mixture when asphalt cement type PG 76-22, PG 76-22 (SBS Modified), or PG 70-22 (SBS Modified) is specified in Subsection 416-3.03(B). References to the use of RAP in this section apply only if RAP is utilized as part of the mixture. ADOT Materials Policy and Procedure Directive No. 20, "Guidance on the Use of Reclaimed Asphalt Pavement (RAP) in Asphaltic Concrete," shall be used in conjunction with the requirements of the specifications.

Warm Mix Asphalt (WMA) technologies may be used in the mixture at the option of the producer provided all requirements of the specifications are met. WMA is defined as asphaltic concrete that is produced within the temperature range of 215 to 275 °F. WMA can be produced by one or a combination of several WMA technologies including plant water foaming processes, mineral additives, and chemical additives. The requirements for incorporating WMA technologies in the mixture are given in these specifications and in Materials Policy and Procedure Directive No. 23, "Requirements for the Use of Warm Mix Asphalt (WMA) Technologies in Asphaltic Concrete".

The producer shall acquire and make all arrangements for a source or sources of material, furnish a mix design which will meet the design criteria specified hereinafter, and provide all the equipment, materials, and labor necessary to complete the work.

416-2 Asphaltic Concrete Mix Design Criteria:

Mix designs shall be developed by the producer on the basis of the following criteria and tested in accordance with the requirements of the following test methods:

Criteria	Requirements			Arizona Test Method
	1/2” Mix	3/4” Mix	Base Mix	
1. Voids in Mineral Aggregate: %, Range	15.5 - 18.5	15.0 - 18.0	14.5 - 17.0	Note (1)
2. Effective Voids: %, Range	**4.0** ± 0.2	**4.0** ± 0.2	**4.0** ± 0.2	Note (1)
3. Absorbed Asphalt: %, Range	0 - 1.0	0 - 1.0	0 - 1.0	Note (1)
4. Index of Retained Strength: %, Minimum	60 Note (2)	60 Note (2)	60 Note (2)	Note (3)
5. Wet Strength: psi, Minimum	150	150	150	Note (3)
6. Stability: pounds, Minimum	2,000	2,000	2,000	Note (1)
7. Flow: 0.01-inch, Range	8 - 16	8 – 16	8 - 16	Note (1)
8. Mix Design Grading Limits:				201

Sieve Size	Percent Passing					
	1/2 inch Mix		3/4 inch Mix		Base Mix	
	Without Admix.	With Admix.	Without Admix.	With Admix.	Without Admix.	With Admix.
1-1/4 in.					100	100
1 inch			100	100	90 -100	90 – 100
3/4 inch	100	100	90 – 100	90 – 100	85 – 95	85 – 95
1/2 inch	90 – 100	90 – 100	---	---	---	---
3/8 inch	67 – 82	67 – 82	62 – 77	62 – 77	57 – 72	57 – 72
No. 8	40 – 48	41 – 49	37 – 46	38 – 47	32 – 42	33 – 43
No. 40	10 – 18	11 – 19	10 – 18	11 – 19	8 – 16	9 – 17
No. 200	1.5 – 4.5	2.5 – 6.0	1.5 – 4.5	2.5 – 6.0	1.5 – 3.5	2.5 – 5.0

(1) For mixes without RAP, Arizona Test Method 815. For mixes with RAP, Arizona Test Method 833.

(2) Not Used.

(3) For mixes without RAP, Arizona Test Method 802 (as modified by Arizona Test Method 815). For mixes with RAP, Arizona Test Method 802 (as modified by Arizona Test Method 833).

(4) The ratio of the mix design composite gradation target for the No. 200 sieve, including mineral admixture, to the effective asphalt content shall be within the range specified below:

$$\frac{\text{Mix Design Composite Gradation Target}}{\text{Effective Asphalt Content}} = \underline{\mathbf{0.6}} \text{ to } 1.2$$

Producer shall prepare and submit Pavement Mix Designs to the Developer. Pavement Mix Designs are considered Shop Drawings and Working Drawings. Not less than 20 Business

Days prior to paving, Developer shall submit Pavement Mix Designs to the Department for review and comment.

416-3.01 Mineral Aggregate:

(A) General:

Mineral aggregate shall consist of virgin aggregate, or a combination of virgin aggregate and aggregate from RAP (RAP aggregate). When the terms "mineral aggregate" or "aggregate" are used without being further described as "virgin" or "RAP", the intended meaning is the total aggregate material used in the mixture.

No individual stockpile or hot bin usage of either virgin aggregate or RAP aggregate shall be less than three percent of the total mineral aggregate.

(B) Virgin Mineral Aggregate:

The producer shall provide a source in accordance with the requirements of Section 1001, except that sub-paragraph (3) under Subsection 1001-3.01(B) shall not apply.

Coarse virgin 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 virgin mineral aggregate shall consist of natural sand or of sand prepared from rock, or other approved inert materials, or a combination thereof, conforming to the requirements of these specifications.

(C) RAP Mineral Aggregate:

RAP aggregate shall consist of the aggregate portion of the reclaimed asphalt pavement. A maximum of 15 percent RAP aggregate, by weight of total aggregate in the mix, may be used in mixes placed in a lower lift (minimum 3" below finished surface). No RAP will be allowed in the upper 3" of a finished pavement surface.

(D) Mineral Aggregate Characteristics:

Aggregates shall be free of deleterious materials, clay balls, and adhering films or other material that prevent the thorough coating with the asphalt cement.

Mineral aggregate shall conform to the following requirements when tested in accordance with the applicable test methods.

Mineral Aggregate Characteristics	Test Method	Requirement
Combined Bulk Oven Dry	Arizona Test Method 251	2.350 - 2.850

Specific Gravity (1)		
Combined Water Absorption (1)	Arizona Test Method 251	0 - 2.5%
Sand Equivalent (1)	AASHTO T 176 (After thoroughly sieving the sample, no additional cleaning of the fines from the plus No. 4 material is required.)	Minimum 55
Abrasion (2)	AASHTO T 96	100 Rev., Max. 9% 500 Rev., Max. 40%
Fractured Coarse Aggregate Particles (3)	Arizona Test Method 212	Minimum 70% (4) (at least one fractured face, determined on plus No. 4 material)
Uncompacted Void Content (1) (Special Mix Only)	Arizona Test Method 247	Minimum 45.0%
Carbonates (3)	Arizona Test Method 238	Maximum 20%
Notes: (1) When the mix design contains RAP, the requirements shall be for the virgin aggregate portion only. (2) Abrasion shall be performed separately on materials from each source of mineral aggregate, including RAP aggregate. All sources shall meet the requirements for abrasion. (3) When the mix design contains RAP, the requirements shall be for the composite of virgin and RAP aggregate.		

Tests on aggregates outlined above, except for abrasion, shall be performed on materials furnished for mix design purposes and composited to the mix design gradation. When RAP is used in the mixture, RAP aggregates for testing shall be obtained from the RAP material using Method A of AASHTO T 164, prior to combining with the virgin aggregate.

Virgin mineral aggregate from a source or combination of sources which does not meet the requirements given in the table above for combined bulk oven dry specific gravity, and/or combined water absorption (up to a maximum of 3.0 percent), but meets the other specified requirements, will be considered for acceptance by the Developer 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.

416-3.02 Mineral Admixture:

Mineral admixture will be required. The amount used shall be 1.0 percent, by weight of the mineral aggregate, unless testing demonstrates that additional admixture is required in order to meet the mix design criteria for Wet Strength and Index of Retained Strength. A maximum of 2.0 percent admixture will be permitted. The exact amount of admixture required shall be specified in the mix design. Mineral admixture shall be either Portland cement, blended hydraulic cement or hydrated lime conforming to the following requirements.

Material	Requirement
Portland Cement, Type I or II	ASTM C 150
Blended Hydraulic Cement, Type IP	ASTM C 595
Hydrated Lime	ASTM C 1097

The certification and acceptance of Portland cement, blended hydraulic cement (Type IP), and hydrated lime shall be in accordance with ADOT Materials Policy and Procedure Directive No. 13, "Certification and Acceptance of Hydraulic Cement, Fly Ash, Natural Pozzolan, Silica Fume, and Lime". The applicable requirements from this document are presented below for ease of reference:

5. CERTIFICATION AND ACCEPTANCE OF PORTLAND CEMENT, BLENDED HYDRAULIC CEMENT, OR HYDRATED LIME FOR USE AS A MINERAL ADMIXTURE IN ASPHALTIC CONCRETE MIXES

5.1 Portland Cement shall meet the requirements of ASTM C 150 for Type I or Type II cement. Blended Hydraulic Cement shall meet the requirements of ASTM C 595 for Type IP cement. Hydrated Lime shall meet the requirements of ASTM C 1097.

5.2 A Certificate of Analysis conforming to the requirements of Subsection 106.05 shall be submitted for each delivery of Portland cement, blended hydraulic cement, or hydrated lime.

5.3 No samples of Portland cement, blended hydraulic cement, or hydrated lime are required.

5.4 The Department reserves the right to sample and test material which has been accepted on the basis of a Certificate of Analysis.

416-3.03 Bituminous Material:

(A) General:

Bituminous material shall consist of performance grade (PG) asphalt binder (virgin binder), or a combination of virgin binder and binder from RAP (RAP binder). When the terms “bituminous material”, “asphalt cement”, “asphalt binder” or “binder” are used without being further described as “virgin” or “RAP”, the intended meaning is the total bituminous material used in the mixture.

The percent of asphalt cement used shall be based on the weight of total mix (asphalt cement, mineral aggregate, and mineral admixture).

(B) Virgin Bituminous Material:

Virgin asphalt cement shall be a performance grade (PG) asphalt binder, conforming to the requirements of Section 1005. The type of virgin asphalt binder shall be PG 70-10 or PG 76-22 as prescribed in the project plans or, if RAP is used in the mixture, the virgin asphalt binder shall be as required to meet the blending requirements in Subsection 416-3.03(C) and Arizona Test Method 833.

The producer shall provide the laboratory mixing and compaction temperature ranges to the mix design laboratory for each PG asphalt binder used for mix design purposes. The laboratory mixing temperature range is defined as the range of temperatures where the un-aged virgin asphalt binder has a rotational viscosity of 0.17 ± 0.02 Pascal·seconds, measured in accordance with AASHTO T 316. The laboratory compaction temperature range is defined as the range of temperatures where the un-aged virgin asphalt binder has a rotational viscosity of 0.28 ± 0.03 Pascal·seconds, measured in accordance with AASHTO T 316. The testing required in AASHTO T 316 shall be performed at 275 °F and 350 °F, and a viscosity-temperature curve developed in accordance with ASTM D 2493. The viscosity-temperature curve shall be included in the mix design report. For PG asphalt binders that have a maximum laboratory mixing temperature exceeding 325 °F or a maximum laboratory compaction temperature exceeding 300 °F, the laboratory mixing and compaction temperature ranges shall be specified in writing by the virgin asphalt binder supplier. A viscosity-temperature curve will meet this requirement for written documentation if the viscosity-temperature curve is developed and submitted by the binder supplier and includes language that the recommended laboratory mixing and compaction temperatures are within acceptable ranges, and the submittal includes a statement indicating the maximum laboratory mixing temperature to which the binder can be heated without damage. The laboratory mixing and compaction temperature ranges, as well as the actual laboratory mixing and compaction temperatures used, shall be reported on the mix design. The producer shall ensure that the asphalt binder supplier information required in this paragraph is provided to all appropriate parties in a timely manner, and that copies are included in the mix design report. The laboratory mixing and compaction temperatures are for mix design purposes only. Field mixing and compaction temperatures are specified in Subsections 416-6 and 416-7.

(C) RAP Bituminous Material:

RAP binder shall consist of the asphalt binder portion of the reclaimed asphaltic pavement. RAP will not be allowed in the upper lift (at finished grade or the lift directly below an AR-ACFC) for mainline pavement and ramps. RAP will not be allowed in the mixture when asphalt cement type PG 76-22, PG 76-22 (SBS Modified), or PG 70-22 (SBS Modified) is specified.

When less than or equal to 15 percent RAP binder is used, by weight of total binder in the mix, no testing is required on the RAP binder. The virgin binder grade shall be modified if necessary to ensure the blend of virgin and RAP binder meets the PG grade specified in the Subsection 416-3.03(B). However, a change of only one virgin PG binder grade (6 °C on either or both the high and low temperatures) will be allowed from that shown in Subsection 416-3.03(B).

416-3.04 Reclaimed Asphalt Pavement (RAP):

RAP shall consist of salvaged, milled, pulverized, broken, or crushed asphalt pavement. If RAP is generated by milling, the minimum removal depth shall be 1-1/2 inches. The source of RAP may be from ADOT or other projects. The producer shall be responsible for determining the suitability of the RAP for use in the mixture, regardless of its source.

For asphaltic concrete containing less than or equal to 15 percent RAP aggregate, all RAP material shall pass the 1-1/4" sieve. The use of more than two RAP stockpiles is prohibited. The gradation, when tested in accordance with Arizona Test Method 240, shall meet the following requirements:

Stockpile	Sieve Size	Percent Passing
Coarse	1-1/4 inch	100
	3/8 inch	0-25
Fine	3/4 inch	100
	3/8 inch	75-100

The producer may propose gradation bands differing from those shown in the table above. The proposal shall be submitted to the Developer prior to the start of RAP processing. If approved, the required gradation bands will be adjusted accordingly.

RAP shall be stockpiled so that segregation is minimized. When two RAP stockpiles are used, acceptable methods to prevent intermingling of stockpiles shall be provided.

The Developer reserves the right to reject obviously defective salvaged material or salvaged material that is not representative of the material used in the mix design.

416-3.05 Warm Mix Asphalt Technologies:

Warm Mix Asphalt (WMA) technologies include plant water foaming processes, mineral additives, and chemical additives. WMA technologies must be approved prior to their use in accordance with Materials Policy and Procedure Directive No. 23, "Requirements for the Use of Warm Mix Asphalt (WMA) Technologies in Asphaltic Concrete".

416-4 Mix Design:

Utilizing mineral aggregate and RAP which has been crushed, processed, separated and stockpiled, a mix design shall be formulated and submitted by the producer to the Independent Quality Firm. The mineral aggregate and RAP samples used for mix design purposes shall be representative of materials to be used during production.

The mix design shall be based on the mix design criteria and other requirements hereinbefore specified, utilizing asphalt cement and mineral admixture of the type and from the sources proposed for use in the production of asphaltic concrete.

The mix design shall be prepared by or under the direct supervision of a professional engineer experienced in the development of mix designs and mix design testing. The mix design engineer shall meet the requirements given in ADOT Materials Policy and Procedure Directive No. 4, “Asphaltic Concrete Mix Design Proposals and Submittals”. The mix design shall be provided in a format that clearly indicates all the mix design requirements and shall be sealed, signed, and dated by the mix design engineer.

The mix design shall be prepared by a mix design laboratory that has met the requirements of ADOT Materials Policy and Procedure Directive No. 19, “ADOT System for the Evaluation of Testing Laboratories”.

The contactor may not propose the use of a mix design that has been developed for a previous project.

The mix design shall contain as a minimum:

(1) The name and address of the testing organization and the person responsible for the mix design testing.

(2) The specific location(s) of the source(s) of mineral aggregate.

(3) The supplier, refinery, type of asphalt cement and any modifiers including polymers. The source and type of mineral admixture. The percentage of asphalt cement and mineral admixture to be used.

(4) The anticipated mineral aggregate gradation in each stockpile.

(5) Mix design gradation. The mix design shall contain the mineral aggregate gradation, and also the gradation with mineral admixture.

(6) The results of all testing, determinations, etc., such as: specific gravity of each component, water absorption, sand equivalent, loss on abrasion, fractured coarse aggregate particles, uncompacted void content (for Special Mix), percent carbonates (if required), 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.

(7) Viscosity-temperature curve along with the laboratory mixing and compaction temperature ranges, as well as the actual laboratory mixing and compaction temperatures used.

When RAP is used in the mixture, the following additional information shall be included in the mix design:

(1) The specific location(s) of the source(s) of RAP.

(2) The anticipated RAP gradation, RAP aggregate gradation, and RAP binder content in each stockpile.

(3) If greater than 15 percent RAP binder is used in the mixture, the results of all tests on the recovered RAP binder, as well as all tests on the blend of virgin binder and recovered RAP binder.

(4) The percent RAP binder, virgin binder, and total binder in the mixture

(5) The composite gradation of virgin and RAP aggregates, with and without mineral admixture. The composite gradation of the virgin aggregate and RAP, with and without mineral admixture.

(6) The results of all testing, determinations, etc., for the RAP, virgin aggregate, RAP aggregate, and composite of virgin and RAP aggregates as required, such as: specific gravity, water absorption, sand equivalent, loss on abrasion, fractured coarse aggregate particles, uncompacted void content (for Special Mix), and percent carbonates.

(7) The viscosity-temperature curve along with the laboratory mixing and compaction temperature ranges for the blended binder, if greater than 15 percent RAP binder is used in the mixture, as well as the actual laboratory mixing and compaction temperatures used.

When Warm Mix Asphalt (WMA) technologies are used in the mixture, the additional mix design requirements specified in Materials Policy and Procedure Directive No. 23, “Requirements for the Use of Warm Mix Asphalt (WMA) Technologies in Asphaltic Concrete”, shall also be included in the mix design.

Historical abrasion values may be supplied on sources provided the testing was conducted within the past two years.

A copy of the mix design and representative samples of the materials used in the mix design shall be submitted for calibration of the ignition furnace, and for the determination of sand equivalent and fractured coarse aggregate particles. When Special Mix is used, the uncompacted void content shall also be determined. Approximately 300 pounds of virgin mineral aggregate (proportional to the mix design gradation), three gallons of asphalt cement, and one gallon of mineral admixture shall be submitted. When RAP is used, a minimum of 40 pounds of representative RAP material and a minimum of 10 pounds of solvent-extracted RAP aggregate, per AASHTO T 164, Method A, shall be submitted. If RAP is fractionated, the RAP and RAP aggregate from each stockpile shall be kept separate. The Independent Quality Firm shall witness the sampling of the virgin mineral aggregate and RAP. The mix design and samples shall be submitted to the Independent Quality Firm at least five working days prior to the start of asphaltic concrete production.

The Independent Quality Firm will review the mix design to assure that it contains all required information. If it does not, it will be returned within five working days of receipt of all samples and mix design information, for further action and resubmission by the producer.

If the producer elects to change its source(s) of mineral aggregate, bituminous material source, bituminous material, admixture source or RAP, or adds or deletes the use of a stockpile(s) regardless of source, the producer shall furnish the Independent Quality Firm with a new mix design which meets the requirements specified herein.

The producer may make self-directed target changes to the approved mix design within the limits shown below. Requests for self-directed target changes shall be made in writing and acknowledged by the Independent Quality Firm prior to start of production for a lot. Self-directed target changes shall meet contract requirements for mix design criteria and grading limits.

MEASURED CHARACTERISTICS	ALLOWABLE SELF-DIRECTED TARGET CHANGES
Gradation (sieve size):	
3/8 inch	±4% from mix design target value
No. 8	±4% from mix design target value
No. 40	±2% from mix design target value
No. 200	±0.5% from mix design target value
Asphalt Cement Content	±0.2% from mix design target value
Effective Voids	None

The producer may propose target changes to the approved mix design for the Independent Quality Firm's approval. The Independent Quality Firm will determine if the proposed target change will result in mix production that meets the contract requirements for mix design criteria and grading limits. For acceptance purposes, target changes will not be retroactive.

In no case shall the approval of mix design changes relieve the producer of the responsibility for the results obtained by the use of such approved changes.

Should a mix design prove unsatisfactory to the producer during production, the producer shall furnish the Independent Quality Firm with a revised mix design. For acceptance purposes, the revised mix design will not be retroactive.

The producer shall not change its methods of crushing, screening, washing, or stockpiling from those used during production of material used for mix design purposes without approval of the Independent Quality Firm or without preparing a new mix design

416-5 Producer and Contractor Quality Control:

Quality control of mineral aggregate production and asphaltic concrete production shall be the responsibility of the producer. The producer shall perform sufficient testing to assure that mineral aggregate and asphaltic concrete are produced which meet all specified requirements. Compaction quality control testing shall be the responsibility of the contractor. The contractor shall perform sufficient testing to assure that compaction meets all specified requirements. The Developer reserves the right to obtain samples of any portion of any material at any point of the operations for the Developer's own use.

416-6 Construction Requirements:

The contractor shall be responsible for the proportioning of all materials, for the hauling, placing, loading, spreading, and finishing of asphaltic concrete and for the applying of bituminous material, such as tack coats, prime coats, and provisional seals, all in accordance with the appropriate portions of the specifications.

The asphaltic concrete hot plant shall conform to the requirements of Section 403 of the Specifications.

During production, the percent RAP aggregate and percent RAP binder shall not exceed the maximum allowed in Subsections 416-3.01(C), 416-3.03(C), and 416-3.04. In addition, the percent RAP material shall be maintained to within plus 2 percent and minus 5 percent of the mix design value(s). When two RAP stockpiles are used, this tolerance shall apply to the total percent RAP material in the mixture, as well as the percent RAP material from each stockpile.

The temperature of asphaltic concrete or mineral aggregate upon discharge from the drier shall not exceed 325 °F unless a higher temperature is recommended in writing by the asphalt binder supplier.

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 Developer deems the use of self-propelled paving machines impractical.

Self-propelled paving machines shall spread the mixture within the specified tolerances, without segregation or tearing, true to the line, grade, and crown indicated on the project plans. Pavers shall be equipped with hoppers and augers which shall distribute the mixture uniformly in front of adjustable screeds.

Pavers shall be equipped with a screed for the full width being paved, heated if necessary, and capable of spreading and finishing all courses of asphaltic concrete.

Pavers shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed, and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope.

Failure of the control system to function properly shall be cause for the suspension of the placing of asphaltic concrete.

The base or subgrade upon which asphaltic concrete is to be placed shall be prepared and maintained in a firm condition until asphaltic concrete is placed. It shall not be frozen or excessively wet.

At any time, the Developer may require that the work cease or that the work day be reduced in the event that weather conditions, either existing or expected, are anticipated to have an adverse effect upon the asphaltic concrete.

All wheels and tires of compactors and other equipment surfaces shall be treated when necessary with a release agent in order to prevent the sticking of asphaltic concrete. Release agents which degrade, dissolve, or in any way damage the bituminous material shall not be used. Diesel fuel shall not be used as a release agent.

Longitudinal joints of each course shall be staggered a minimum of one foot with relation to the longitudinal joint of any immediate underlying course.

When surfacing courses are placed on 10 foot or wider shoulders which are to receive rumble strips, the contractor shall place any longitudinal joints approximately one foot away from the travel lane side of the rumble strip.

Longitudinal joints shall be located within one foot of the center of a lane or within one foot of the centerline between two adjacent lanes. Joints shall be formed by a slope shoe or hot-lapped, and shall result in an even, uniform surface.

Before a surface course is placed in contact with a cold transverse construction joint, the 416cold existing asphaltic concrete shall be trimmed to a vertical face by cutting or milling the existing asphaltic concrete back for its full depth of the lift and exposing a fresh face. After placement and finishing of the new asphaltic concrete, both sides of the joint shall be dense and the joint shall be well sealed. The surface in the area of the joint shall conform to the requirements hereinafter specified for surface tolerances when tested with the straightedge placed across the joint.

All locations where plate samples are taken from the roadway shall be immediately repaired by the contractor utilizing hot asphaltic concrete. In lieu of plate samples, the contractor may elect to sample asphalt concrete from the windrow when windrow paving is utilized. All holes where cores are taken shall be repaired within 48 hours after coring using a material approved by the Independent Quality Firm. All holes shall be in a dry condition prior to repair. The patching material shall be thoroughly compacted in the holes by the contractor.

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.

Before asphaltic concrete is placed, the surface to be paved shall be cleaned of all objectionable material and tacked in accordance with the requirements of Section 404. The cleaning of the surface, the tacking of the surface, and the type of bituminous material used shall be acceptable to the Independent Quality Firm.

A light coat of bituminous material shall be applied to edges or vertical surfaces against which asphaltic concrete is to be placed.

The contractor shall schedule its paving operations to minimize exposed longitudinal edges. Unless otherwise approved by the Independent Quality Firm, the contractor shall limit the placement of asphaltic concrete courses, in advance of adjacent courses, to one shift of asphaltic concrete production. The contractor shall schedule its paving operations in such a manner to eliminate exposed longitudinal edges over weekends or holidays if that portion of the facility has been opened to traffic.

The moisture content of the asphaltic concrete immediately behind the paver shall not exceed 0.5 percent. The moisture content will be determined in accordance with Arizona Test Method 406.

When Warm Mix Asphalt (WMA) technologies are used, the producer shall comply with the manufacturer's recommendations for incorporating additives and WMA technologies into the mixture. The contractor shall comply with the manufacturer's recommendations regarding transporting, storage, and delivery of additives and water foaming processes. The producer shall maintain a copy of the manufacturer's recommendations on file at the asphalt mixing plant and make those recommendations available for reference while using WMA technologies.

416-7 Acceptance:

416-7.01 General:

In addition to the random acceptance samples taken from each lot, the Independent Quality Firm may sample and reject material which appears to be defective. Such rejected material shall not be used in the work. The results of tests run on rejected material will not be included with the lot acceptance tests.

Acceptance will be on the basis of the following:

Sand Equivalent
Fractured Coarse Aggregate Particles
Uncompacted void Content (for Special Mix)
Core Thickness
Gradation
Asphalt Cement Content
Effective Voids
Stability
Compaction
Smoothness

416-7.02 Sand Equivalent, Fractured Coarse Aggregate Particles, and Uncompacted Void Content of Mineral Aggregate:

During asphaltic concrete production, the Independent Quality Firm shall obtain and test samples of material for the determination of the sand equivalent and fractured coarse aggregate particles. When Special Mix is used, the uncompacted void content shall also be determined. When RAP is used in the mixture, the sand equivalent and uncompacted void content shall be determined on the composite of virgin aggregates only. Samples shall be obtained from the cold feed belt prior to the addition of mineral admixture, or from the stockpiles when sampling from the cold feed belt is not possible.

When RAP is used in the mixture, the material for determining the fractured coarse aggregate particles shall come from an asphaltic concrete sample taken and tested in accordance with Arizona Test Method 428, as specified in Subsection 416-7.04(A). However, if the Independent Quality Firm determines that excessive breakdown of the aggregate has occurred due to the use of the ignition furnace, the fractured coarse aggregate particles testing shall be performed on the combination of RAP aggregate, as obtained in accordance with Arizona Test Method 428, and virgin mineral aggregate.

Virgin mineral aggregate will be acceptable for sand equivalent if it meets the minimum requirements specified in Subsection 416-3.01.

The fractured coarse aggregate particles shall meet the minimum requirements specified in Subsection 416-3.01.

For Special Mix, the uncompacted void content shall meet the minimum requirements specified in Subsection 416-3.01. Additional testing of the uncrushed and crushed fine aggregate for uncompacted void content will be required if the method of producing either fine aggregate is modified.

If the mineral aggregate fails to meet the requirements specified herein, operations shall cease and the producer shall have the option of submitting a revised mix design conforming to the requirements of Subsection 416-4 or correcting deficiencies in the aggregate stockpiles.

416-7.03 Core Thickness:

A lot for measuring core thickness shall be considered to be one shift of production of asphaltic concrete.

The contractor will obtain cores from representative, randomly selected locations from the lot. Cores taken for compaction may be used for determination of thickness. The Independent Quality Firm may exclude certain locations from random sampling should the Independent Quality Firm determine that the location of the work precludes normal construction operations. In cases where an individual compaction lot contains different thicknesses, the IQF will provide core locations with a minimum of 7 cores on mainline and 3 on any other thickness is present. All cores will be measured in accordance with the provisions of ASTM D3549, except that individual measurements on each core will be determined to the nearest thousandth of an inch, and the average of such measurements will be determined to the nearest hundredth of an inch.

A lot will be considered to be acceptable, if the Percent of Lot Within Limits (PWL) of the actual asphaltic concrete thickness placed for each completed profile section is greater than 85 of the required thickness. Any pavement lift that contains a PG 76-22 asphalt binder must meet or exceed a PWL of 85 as an individual lift within the pavement section.

It is the responsibility of the contractor to fill all cores either with the Section 416 Asphalt Concrete or an Independent Quality Firm approved concrete mix design.

416-7.04 Gradation, Asphalt Cement Content, Effective Voids, and Stability:

(A) General:

A mixture properties lot shall be considered to be one shift's production. In the event a shift's production is less than 1200 tons, multiple shifts may be combined to form a lot. When a lot consists of production from more than one shift, the following conditions apply: at least one sample shall be taken each shift, at least one sample shall be taken every 500 tons, and no mix design or target value changes shall be made within the lot. If changes are made in the mix design or target values, new lots will be established.

Four samples of the asphaltic concrete shall be taken for each lot by the contractor, under the observation of the Independent Quality Firm, at random locations. Samples will be taken in accordance with the requirements of Section 2 or 3 of Arizona Test Method 104 and delivered to the Independent Quality Firm immediately after being taken. The minimum weight of the sample shall be 75 pounds. The Independent Quality Firm will split the sample and save one-half for 15 days after written notification to the contractor of test results for that lot has been made. The material will be tested by the Independent Quality Firm for the properties identified in the Project Guide Schedule.

Acceptance testing results will be furnished to the contractor within four working days of receipt of samples by the Independent Quality Firm.

A mixture-properties lot placed with an average stability below 1,750 pounds for base mixes, or 1,750 pounds for 1/2 or 3/4 inch mixes shall be rejected. Production shall cease until the producer proposes a corrective action the Independent Quality Firm finds acceptable. If the Independent Quality Firm rejects the proposed corrective action, the producer shall submit a revised mix design.

The target values for gradation, asphalt cement content, and effective voids are given in the producer's mix design. The Upper Limits (UL) and Lower Limits (LL) of acceptable production of each of the measured characteristics are as follows:

Measured Characteristics	**LL** (Note 1)	**UL** (Note 1)
Gradation (Sieve size):		
3/8 inch (Note 2)	TV - 8.0	TV + 8.0
No. 8	TV 8.0	TV + 8.0
No. 40	TV - 5.0	TV + 5.0
No. 200	TV - 2.0	TV + 2.0
Asphalt Cement Content	TV 0.80	TV + 0.50
Effective Voids	TV - 2.0	TV + 3.0

Notes:
(1) The limits are used in the statistical calculations for Quality Index. Acceptance is controlled by the variability of the produced material and every effort should be made to strive for the applicable target value (TV).

(2) In the case of the 3/8 inch sieve requirement, for the base mix only, the lower limit shall be the target value minus 8.0, and the upper limit shall be the target value plus 8.0.

The Independent Quality Firm will determine the PT for each measured characteristic in accordance with Subsection 416-9(I), and utilizing Table 416-1 will determine the pay factor for each measured characteristic.

(B) Ignition Furnace Correction for Non-RAP Mixes:

For plants providing asphaltic concrete exclusively for the project, the difference between the asphalt cement content as measured by ignition furnace testing and the actual asphalt cement content shall be determined by the Independent Quality Firm for each of the first five lots of asphaltic concrete produced for each mix design. If there are less than five lots for the mix design, the total number of available lots shall be used. If approved by the Independent Quality Firm, a plant may be considered exclusive to the project if an asphalt cement tank is dedicated for the shift of asphaltic concrete production. The determination of the actual asphalt cement content may include weighing of asphalt cement deliveries, invoice quantities, volumetric tank measurements using a calibrated rod (tank stickings) corrected for temperature, computerized mass-flow meter, and accounting for wasted materials. If a computerized mass-flow meter is used, documentation of its calibration shall be submitted prior to asphaltic concrete production. At any time during asphaltic concrete production, the Independent Quality Firm may require that a new calibration of the mass-flow meter be performed. If the average difference exceeds $\pm$ 0.10 percent asphalt cement content between the asphalt cement content measured by ignition furnace testing and the actual asphalt cement content, the producer may request that a correction to the asphalt cement content by ignition furnace testing be made. The producer must make such a request in writing within two working days after receiving the test results for the fifth lot of asphaltic concrete production. If referee testing is performed on a lot of asphaltic concrete for which a correction, based on the actual asphalt cement content, was made to the asphalt cement content by ignition furnace testing, referee testing shall not apply to the determination of asphalt cement content. The correction, once documented and approved by the Independent Quality Firm, shall be applied to test results from the beginning of asphaltic concrete production through the remainder of asphaltic concrete production using that mix design; however, a new correction may be determined at any time the Independent Quality Firm believes it is necessary due to a change in material or other circumstances. If the producer submits a new mix design, a new correction must be established and applied as specified above. For plants not providing asphaltic concrete exclusively for this project, no correction will be made to asphalt cement content values measured by ignition furnace testing.

(C) Ignition Furnace Correction for Mixes Containing RAP:

For mixes containing RAP, an asphalt cement tank shall be dedicated to the project for each shift of asphaltic concrete production. The difference between the asphalt cement content as measured by ignition furnace testing and the actual asphalt cement content shall be determined by the Independent Quality Firm for each of the first five lots of asphaltic concrete produced for each mix design. If there are less than five lots for the mix design, the total number of available lots shall be used. The actual asphalt cement content shall be determined by adding the virgin asphalt cement content to the RAP binder content determined in Subsection 416-7.04(D), both expressed as a percent of the total mix. The determination of the virgin asphalt cement content may include weighing of asphalt cement deliveries, invoice quantities, volumetric tank measurements using a calibrated rod (tank stickings) corrected for temperature, computerized mass-flow meter, and accounting for wasted materials. If a computerized mass-flow meter is used, documentation of its calibration shall be submitted to the Independent Quality Firm prior to asphaltic concrete production. At any time during asphaltic concrete production, the Independent Quality Firm may require that a new calibration of the mass-flow meter be performed. If the average difference exceeds ± 0.10 percent asphalt cement content between the asphalt cement content measured by ignition furnace testing and the actual asphalt cement content, a correction to the asphalt cement content by ignition furnace testing shall be made. The correction shall be applied to test results from the beginning of asphaltic concrete production through the remainder of asphaltic concrete production using that mix design; however, a new correction may be determined at any time the Independent Quality Firm believes it is necessary due to a change in material or other circumstances. If the producer submits a new mix design, a new correction must be established and applied as specified above. Referee testing shall not apply to the determination of asphalt cement content for asphaltic concrete containing RAP.

(D) RAP Binder Content:

(2) RAP Binder Content Correction Factor:

A RAP binder correction factor shall be determined for each RAP stockpile used in the mixture.

At the start of asphaltic concrete production, the first two samples of RAP material from each stockpile will be split and tested for asphalt binder content; one split is tested in accordance with Arizona Test Method 428 (ignition furnace) and the other split is tested in accordance with AASHTO T 164 (solvent extraction). A RAP binder correction factor will be determined by subtracting the average ignition furnace result from the average solvent extraction result. The appropriate correction factor shall be added to each asphalt binder test result determined on the material from each RAP stockpile in accordance with Arizona Test Method 428 to determine the RAP binder content. The correction factor may be determined prior to the start of asphaltic concrete production provided representative RAP samples are available. A new correction factor may be determined at any time the Independent Quality Firm believes it is necessary due to a change in material or other circumstances.

416-7.05 Compaction:

(A) Courses 1 1/2 Inches or Less in Nominal Thickness:

(1) General Requirements:

Asphaltic concrete shall be placed only when the temperature of the surface on which the asphaltic concrete is to be placed is at least 65 degrees F and the ambient temperature at the beginning of placement is at least 65 degrees F and rising. The placement shall be stopped when the ambient temperature is 70 degrees F or less and falling.

When Warm Mix Asphalt (WMA) technologies are not used in the mixture, asphaltic concrete immediately behind the laydown machine shall be a minimum of 275 degrees F.

When Warm Mix Asphalt (WMA) technologies are used in the mixture, the recommended temperature range for compaction during production shall be shown on the mix design and shall be approved by the Independent Quality Firm.

All edges shall be rolled with a pneumatic tired compactor, or other methods while the mixture is still hot.

(2) Equipment:

Compacting and smoothing shall be accomplished by the use of self-propelled equipment. Compactors shall be pneumatic-tired and/or steel wheel.

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.

Steel wheel compactors shall weigh not less than eight 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 and maintained so that the air pressure will not vary more than five pounds per square inch 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. 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.

(3) Rolling Method Procedure:

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 as are 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:

Registered Professional Engineer (Civil)
CERTIFICATE NO.
49430
GREGORY
PATRICK
FLY
Date Signed 12-5-19
ARIZONA U.S.A.
EXPIRES: 3-31-21

SECTION 501 PIPE CULVERT AND STORM DRAINS:

501-1 Description:

The work under this section shall consist of furnishing pipe and all other materials required and the installing of pipe, including excavating, and furnishing, placing and compacting backfill material, all in accordance with the details shown on the plans and the requirements of the specifications. Except for Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP), shall conform to the requirements of Section 508.

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 the wall thickness, corrugation configuration, coatings, linings, class and strength.

At each such specified location, pipe of one kind and material shall be selected by the Developer.

501-2.01 All Pipe Except Nonreinforced, Cast-In-Place and Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP):

Except for nonreinforced, cast-in-place concrete pipe and Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP), materials shall conform to the requirements of Section 1010. Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP) materials shall conform to the requirements of Section 508.

501-2.02 Nonreinforced, Cast-In-Place:

Concrete for constructing the cast-in-place concrete 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 3,000 pounds per square inch 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 pipes 48 inches or less in diameter shall be one inch and for pipes larger than 48 inches in diameter shall be 1-1/2 inches.

501-3 Construction Requirements:

501-3.01 Preparation of Foundations, Trenches, and Embankments:

A trench condition is defined as a trench which has vertical slopes to a point at least one foot above the top of the pipe and its maximum width is as detailed on the plans.

The Developer may install pipe in either a non-trench condition or a trench condition in natural ground or in embankment.

501-3.02 Bedding:

(A) Bedding Material:

(1) General:

Bedding material for all pipe shall conform to the following aggregate gradation:

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	90 - 100
No. 8	35 - 80
No. 200	0 - 8.0

The plasticity index of the bedding material for all pipe shall not exceed 8 when tested in accordance with the requirements of AASHTO T 90.

Bedding material for all pipe shall have a value of resistivity not less than 2,000 ohm-centimeters. Bedding material shall have a pH value between 6.0 and 10.0, inclusive, for all metal pipe installations except aluminum. 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.

(2) Standard Aggregate Bedding Material:

Standard aggregate bedding material shall conform to the requirements specified in Subsection 501-3.02 and may be compacted, jetted, or placed as an aggregate slurry.

(3) Cement-Treated Slurry Bedding Material:

One sack of cement shall be added to each cubic yard of aggregate. When bedding material is required within 24 hours of placement, the mix design for pipe bedding material shall be increased to two sacks of cement for each cubic yard of aggregate. Cement-treated slurry shall be thoroughly mixed in a mixer or at a central batch plant and shall have a slump of 6 to 11 inches.

(B) 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 under and around the pipe from the bottom of the trench or bedding limits to the elevation at the point of maximum width of the pipe (springline). At the Developer's option, bedding material may be placed above the springline of the pipe.

For pipes placed in a non-trench condition, as shown on the plans, standard aggregate bedding material shall be used from 6-inches below the pipe to the springline.

(2) Standard Aggregate Bedding Material:

Standard aggregate bedding material shall be placed in uniform horizontal layers not exceeding eight inches in depth before compaction. Bedding material horizontal lift thickness will not exceed four feet in depth when compaction is done by jetting.

(3) Cement-Treated Slurry Bedding Material:

Cement-treated slurry bedding material shall be placed in a uniform manner that will prevent voids in, or segregation of, the bedding material, and will not float or shift the culvert or pipe. Cement-treated slurry bedding material shall be placed from bottom of pipe to pipe springline. An additional 4 feet of slurry can be placed above the springline in less than a 24 hour period once the layer has solidified. The minimum period between lifts should be 4 hours. The initial set of the cement-treated slurry bedding shall be confirmed in accordance with the approach in Subsection 604.4
Performance Testing of the MAG Uniform Std Specs for Public Works Construction, before placing the additional lifts or cement treated slurry backfill of compacted trench backfill. Cement-treated slurry pipe backfill placement above springline shall not commence until after initial set is achieved.

(C) Compaction of Bedding Material:

(1) General:

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.

(2) Standard Aggregate Bedding Materials:

Standard aggregate 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.

When standard aggregate bedding material is placed as an aggregate slurry or compacted by jetting, the material placed below the springline of the pipe shall be compacted prior to placement of material above the springline of the pipe.

Ponding will not be permitted in any case.

Jetting shall be done in such a manner that water will not be impounded.

(3) Cement-Treated Slurry Bedding Material:

Cement-treated slurry bedding material shall not require additional compaction after placement up to pipe springline if it meets the material requirements No density tests will be required in the cement-treated slurry bedding material as placed up to pipe springline.

501-3.03 Installation:

(A) General:

Pipe shall be handled carefully. Proper facilities shall be provided for handling and lowering the sections of pipe.

Pipe shall be installed in reasonably close conformity with the lines, grades and dimensions shown on the project plans. Tracer wire for all underground facilities shall be installed in conformance with Section 104.

Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream.

When using metal safety end sections, the embankment slope shall be warped to match the end section.

For a skewed pipe installation, the toe of the embankment slope shall be warped to match the toe of the skewed metal safety end section in order to provide effective drainage.

(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. Coupling bands and gaskets shall conform to the requirements of Subsection 1010-2.01.

(2) Watertight and Water Resistant Joints:

Watertight joints shall be provided for siphon and irrigation pipe installation and when 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 the manufacturer.

(C) Slotted Pipe:

Slotted pipe shall be joined per manufacturer's recommendations. Prior to backfilling and paving operations, the slot shall be covered to prevent infiltration of material into the pipe. 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 1010. Grout shall not be placed when a descending air temperature falls below 40 degrees F.

(D) 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, or plastic sealing compound.

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.

When required, flexible watertight gasket joints shall be installed on the pipe in accordance with the requirements of AASHTO M 198, Paragraph 5.1.

(E) Spiral Rib Corrugated Metal Pipe:

Spiral rib corrugated metal pipe shall be installed in accordance with the requirements specified in Subsection 501-3.03(B) 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.

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, 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,

501-3.04 Backfilling and Compacting:

(A) Backfill Material:

(1) Pipe Backfill:

Pipe backfill material shall be selected from excavation and shall not contain frozen lumps, stones larger than three inches in diameter, chunks of clay or other objectionable material. Backfill material to be used for pipes, pipe-arches or arches made of metal shall have a value of resistivity not less than 2,000 ohm-centimeters

Pipe backfill material shall conform to the following gradation:

Sieve Size	Percent Passing
3 inch	100
3/4 inch	60 - 100
No. 8	35 - 80
No. 200	0 - 20

The plasticity index shall not exceed 12 when tested in accordance with the requirements of AASHTO T 90.

As an alternate, pipe backfill may be standard aggregate bedding material or cement-treated slurry bedding material.

(2) Trench Backfill:

Trench backfill material shall not contain organic material, rubbish, debris and other deleterious material and shall not contain solid material which exceeds eight inches in greatest dimension and shall be soil selected from excavation or from a source selected by the Developer.

As an alternate, trench backfill may conform to the material requirements listed for bedding material as specified in Subsection 501-3.02(A) for standard aggregate bedding material or cement-treated slurry bedding material.

(B) Placement of Backfill Material:

(1) General:

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.

Backfill compacted by pneumatic or mechanical tamping devices, shall be placed in layers not more than eight inches in depth before compaction.

Pipe backfill shall be brought up evenly on both sides of the pipe for the full length to an elevation one foot above the top of the pipe.

Trench backfill shall be placed from one foot above the top of the pipe to the elevation at which base or surfacing materials are to be placed or to the top of the trench.

(2) Standard Aggregate Slurry:

Pipe backfill or trench backfill mixed as a standard aggregate slurry shall be placed in uniform horizontal layers not exceeding four feet in depth.

(3) Cement-Treated Slurry:

One-sack cement-treated slurry pipe backfill placement above springline shall not commence within 24 hours of the placement of the underlying cement-treated bedding material below springline. Two-sack cement-treated slurry pipe backfill placement above springline shall not commence until after initial set is achieved. Cement-treated pipe backfill shall be placed in a uniform manner that will prevent voids in or segregation of the backfill to an elevation one foot above the top of the pipe.

(C) Compaction of Backfill Material:

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.

Ponding will not be allowed in any case.

Cement-treated slurry bedding material used for trench backfill shall meet the requirements listed above for pipe backfill up to 6” above pipe.

501-3.06 Encasement of Pipe:

When shown on the project plans, pipe shall be encased in Class B concrete. Portland cement concrete shall conform to the requirements of Section 1006.

501-3.07 Nonreinforced, Cast-In-Place Concrete Pipe:

(A) General Requirements:

The contractor shall have previously installed cast-in-place pipe similar to the pipe specified in this contract. When the project plans include cast-in-place concrete pipe as an alternate, the contractor shall review the geotechnical investigation report. The contractor shall be responsible to determine if the in-place soil conditions will allow the specified trench to be constructed. Nonreinforced, cast-in-place concrete pipe shall be cast monolithically in a prepared trench at the locations and in accordance with the details shown on the project plans and the requirements of these specifications. The pipe shall be constructed with equipment specifically designed for constructing cast-in-place, monolithic concrete pipe. Pipe shall be constructed in trenches which have been excavated in either native soil or compacted fill. The trench walls shall be stable so that the planned shape of the trench is maintained.

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 as specified on the project plans for each pipe size.

(B) 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 one inch per ten linear feet, with a total departure not to exceed 1.5 inches. Departure from and return to specified alignment for the trench shall not exceed two inches per ten linear feet, with a total departure not to exceed four inches. The bottom of the trench shall be shaped in accordance with the details shown on the project plans and prepared to provide full, firm and uniform support over the bottom 210 degrees of the pipe to be constructed. The bottom of the trench must consist of either undisturbed native soil or compacted backfill.

When, unsuitable material is encountered in the bottom of the trench, such unsuitable material shall be removed to the depth and width directed by the IQF. The resulting area shall be backfilled with material conforming to the requirements of Subsection 501-3.04When boulders, bedrock, 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 six inches 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 one foot 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.

(C) 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.

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 and tamping of 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 one inch per ten linear feet, with a total departure not to exceed 1.5 inches. The surface of the invert shall not vary by more than 0.10 feet when tested with a ten foot straight edge. Departures from and return to specified alignment for the pipe shall not exceed two inches per ten linear feet, with a total departure not to exceed four inches.

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 No. 4 dowels one foot into the center of the pipe wall at approximately 18-inch 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 1.25 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, and thoroughly wetted.

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, form indentation, and excessive form lap. Any necessary repairs shall be made within 24 hours and to the satisfaction of the IQF. Cracks shall be repaired in accordance with Subsection 501-3.07.

(D) Finishing:

The interior surface and exterior top surface of the pipe shall be as smooth as a wood-float finish and shall be essentially free of fractures, cracks and roughness.

(E) Curing:

Within 15 minutes after the pipe is cast, the concrete forming the exposed top portion of the pipe shall be cured as follows:

The 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. The film shall be white opaque or clear and shall be held in place with loose soil to assure continuous contact. The loose soil shall not be greater than six inches in depth at any point, and shall

Registered Professional Engineer (Civil)
CERTIFICATE NO. 49430
GREGORY PATRICK FLY
Date Signed 5-26-20
ARIZONA U.S.A.
EXPIRES 3-31-21

SECTION 501 PIPE CULVERT AND STORM DRAINS:

501-1 Description:

The work under this section shall consist of furnishing pipe and all other materials required and the installing of pipe, including excavating, and furnishing, placing and compacting backfill material, all in accordance with the details shown on the plans and the requirements of the specifications. Except for Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP), shall conform to the requirements of Section 508.

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 the wall thickness, corrugation configuration, coatings, linings, class and strength.

At each such specified location, pipe of one kind and material shall be selected by the Developer.

501-2.01 All Pipe Except Nonreinforced, Cast-In-Place and Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP):

Except for nonreinforced, cast-in-place concrete pipe and Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP), materials shall conform to the requirements of Section 1010. Corrugated High-Density Polyethylene Plastic Pipe (CHDPEPP) materials shall conform to the requirements of Section 508.

501-2.02 Nonreinforced, Cast-In-Place:

Concrete for constructing the cast-in-place concrete 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 3,000 pounds per square inch 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 pipes 48 inches or less in diameter shall be one inch and for pipes larger than 48 inches in diameter shall be 1-1/2 inches.

501-3 Construction Requirements:

501-3.01 Preparation of Foundations, Trenches, and Embankments:

A trench condition is defined as a trench which has vertical slopes to a point at least one foot above the top of the pipe and its maximum width is as detailed on the plans.

The Developer may install pipe in either a non-trench condition or a trench condition in natural ground or in embankment.

501-3.02 Bedding:

(A) Bedding Material:

(1) General:

Bedding material for all pipe shall conform to the following aggregate gradation:

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	90 - 100
No. 8	35 - 80
No. 200	0 - 8.0

The plasticity index of the bedding material for all pipe shall not exceed 8 when tested in accordance with the requirements of AASHTO T 90.

Bedding material for all pipe shall have a value of resistivity not less than 2,000 ohm-centimeters. Bedding material shall have a pH value between 6.0 and 10.0, inclusive, for all metal pipe installations except aluminum. 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.

(2) Standard Aggregate Bedding Material:

Standard aggregate bedding material shall conform to the requirements specified in Subsection 501-3.02 and may be compacted, jetted, or placed as an aggregate slurry.

(3) Cement-Treated Slurry Bedding Material:

One sack of cement shall be added to each cubic yard of aggregate. When bedding material is required within 24 hours of placement, the mix design for pipe bedding material shall be increased to two sacks of cement for each cubic yard of aggregate. Cement-treated slurry shall be thoroughly mixed in a mixer or at a central batch plant and shall have a slump of 6 to 11 inches.

(B) 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 under and around the pipe from the bottom of the trench or bedding limits to the elevation at the point of maximum width of the pipe (springline). At the Developer's option, bedding material may be placed above the springline of the pipe.

For pipes placed in a non-trench condition, as shown on the plans, standard aggregate bedding material shall be used from 6-inches below the pipe to the springline.

(2) Standard Aggregate Bedding Material:

Standard aggregate bedding material shall be placed in uniform horizontal layers not exceeding eight inches in depth before compaction. Bedding material horizontal lift thickness will not exceed four feet in depth when compaction is done by jetting.

(3) Cement-Treated Slurry Bedding Material:

Cement-treated slurry bedding material shall be placed in a uniform manner that will prevent voids in, or segregation of, the bedding material, and will not float or shift the culvert or pipe. Cement-treated slurry bedding material shall be placed from bottom of pipe to pipe springline. An additional 4 feet of slurry can be placed above the springline in more than a 10 hour period once the layer has solidified. The minimum period between lifts should be 4 hours. The initial set of the cement-treated slurry bedding shall be confirmed in accordance with the approach in Subsection 604.4

Performance Testing of the MAG Uniform Std Specs for Public Works Construction, before placing the additional lifts or cement treated slurry backfill of compacted trench backfill. Cement-treated slurry pipe backfill placement above springline shall not commence until after initial set is achieved.

(C) Compaction of Bedding Material:

(1) General:

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.

(2) Standard Aggregate Bedding Materials:

Standard aggregate 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.

When standard aggregate bedding material is placed as an aggregate slurry or compacted by jetting, the material placed below the springline of the pipe shall be compacted prior to placement of material above the springline of the pipe.

Ponding will not be permitted in any case.

Jetting shall be done in such a manner that water will not be impounded.

(3) Cement-Treated Slurry Bedding Material:

Cement-treated slurry bedding material shall not require additional compaction after placement up to pipe springline if it meets the material requirements No density tests will be required in the cement-treated slurry bedding material as placed up to pipe springline.

501-3.03 Installation:

(A) General:

Pipe shall be handled carefully. Proper facilities shall be provided for handling and lowering the sections of pipe.

Pipe shall be installed in reasonably close conformity with the lines, grades and dimensions shown on the project plans. Tracer wire for all underground facilities shall be installed in conformance with Section 104.

Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream.

When using metal safety end sections, the embankment slope shall be warped to match the end section.

For a skewed pipe installation, the toe of the embankment slope shall be warped to match the toe of the skewed metal safety end section in order to provide effective drainage.

(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. Coupling bands and gaskets shall conform to the requirements of Subsection 1010-2.01.

(2) Watertight and Water Resistant Joints:

Watertight joints shall be provided for siphon and irrigation pipe installation and when 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 the manufacturer.

(C) Slotted Pipe:

Slotted pipe shall be joined per manufacturer's recommendations. Prior to backfilling and paving operations, the slot shall be covered to prevent infiltration of material into the pipe. 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 1010. Grout shall not be placed when a descending air temperature falls below 40 degrees F.

(D) 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, or plastic sealing compound.

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.

When required, flexible watertight gasket joints shall be installed on the pipe in accordance with the requirements of AASHTO M 198, Paragraph 5.1.

(E) Spiral Rib Corrugated Metal Pipe:

Spiral rib corrugated metal pipe shall be installed in accordance with the requirements specified in Subsection 501-3.03(B) 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.

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, 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,

501-3.04 Backfilling and Compacting:

(A) Backfill Material:

(1) Pipe Backfill:

Pipe backfill material shall be selected from excavation and shall not contain frozen lumps, stones larger than three inches in diameter, chunks of clay or other objectionable material. Backfill material to be used for pipes, pipe-arches or arches made of metal shall have a value of resistivity not less than 2,000 ohm-centimeters

Pipe backfill material shall conform to the following gradation:

Sieve Size	Percent Passing
3 inch	100
3/4 inch	60 - 100
No. 8	35 - 80
No. 200	0 - 20

The plasticity index shall not exceed 12 when tested in accordance with the requirements of AASHTO T 90.

As an alternate, pipe backfill may be standard aggregate bedding material or cement-treated slurry bedding material.

(2) Trench Backfill:

Trench backfill material shall not contain organic material, rubbish, debris and other deleterious material and shall not contain solid material which exceeds eight inches in greatest dimension and shall be soil selected from excavation or from a source selected by the Developer.

As an alternate, trench backfill may conform to the material requirements listed for bedding material as specified in Subsection 501-3.02(A) for standard aggregate bedding material or cement-treated slurry bedding material.

(B) Placement of Backfill Material:

(1) General:

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.

Backfill compacted by pneumatic or mechanical tamping devices, shall be placed in layers not more than eight inches in depth before compaction.

Pipe backfill shall be brought up evenly on both sides of the pipe for the full length to an elevation one foot above the top of the pipe.

Trench backfill shall be placed from one foot above the top of the pipe to the elevation at which base or surfacing materials are to be placed or to the top of the trench.

(2) Standard Aggregate Slurry:

Pipe backfill or trench backfill mixed as a standard aggregate slurry shall be placed in uniform horizontal layers not exceeding four feet in depth.

(3) Cement-Treated Slurry:

One-sack cement-treated slurry pipe backfill placement above springline shall not commence within 10 hours of the placement of the underlying cement-treated bedding material below springline. Two-sack cement-treated slurry pipe backfill placement above springline shall not commence until after initial set is achieved. Cement-treated pipe backfill shall be placed in a uniform manner that will prevent voids in or segregation of the backfill to an elevation one foot above the top of the pipe.

(C) Compaction of Backfill Material:

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.

Ponding will not be allowed in any case.

Cement-treated slurry bedding material used for trench backfill shall meet the requirements listed above for pipe backfill up to 6” above pipe.

501-3.06 Encasement of Pipe:

When shown on the project plans, pipe shall be encased in Class B concrete. Portland cement concrete shall conform to the requirements of Section 1006.

501-3.07 Nonreinforced, Cast-In-Place Concrete Pipe:

(A) General Requirements:

The contractor shall have previously installed cast-in-place pipe similar to the pipe specified in this contract. When the project plans include cast-in-place concrete pipe as an alternate, the contractor shall review the geotechnical investigation report. The contractor shall be responsible to determine if the in-place soil conditions will allow the specified trench to be constructed. Nonreinforced, cast-in-place concrete pipe shall be cast monolithically in a prepared trench at the locations and in accordance with the details shown on the project plans and the requirements of these specifications. The pipe shall be constructed with equipment specifically designed for constructing cast-in-place, monolithic concrete pipe. Pipe shall be constructed in trenches which have been excavated in either native soil or compacted fill. The trench walls shall be stable so that the planned shape of the trench is maintained.

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 as specified on the project plans for each pipe size.

(B) 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 one inch per ten linear feet, with a total departure not to exceed 1.5 inches. Departure from and return to specified alignment for the trench shall not exceed two inches per ten linear feet, with a total departure not to exceed four inches. The bottom of the trench shall be shaped in accordance with the details shown on the project plans and prepared to provide full, firm and uniform support over the bottom 210 degrees of the pipe to be constructed. The bottom of the trench must consist of either undisturbed native soil or compacted backfill.

When, unsuitable material is encountered in the bottom of the trench, such unsuitable material shall be removed to the depth and width directed by the IQF. The resulting area shall be backfilled with material conforming to the requirements of Subsection 501-3.04When boulders, bedrock, 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 six inches 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 one foot 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.

(C) 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.

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 and tamping of 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 one inch per ten linear feet, with a total departure not to exceed 1.5 inches. The surface of the invert shall not vary by more than 0.10 feet when tested with a ten foot straight edge. Departures from and return to specified alignment for the pipe shall not exceed two inches per ten linear feet, with a total departure not to exceed four inches.

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 No. 4 dowels one foot into the center of the pipe wall at approximately 18-inch 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 1.25 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, and thoroughly wetted.

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, form indentation, and excessive form lap. Any necessary repairs shall be made within 24 hours and to the satisfaction of the IQF. Cracks shall be repaired in accordance with Subsection 501-3.07.

(D) Finishing:

The interior surface and exterior top surface of the pipe shall be as smooth as a wood-float finish and shall be essentially free of fractures, cracks and roughness.

(E) Curing:

Within 15 minutes after the pipe is cast, the concrete forming the exposed top portion of the pipe shall be cured as follows:

The 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. The film shall be white opaque or clear and shall be held in place with loose soil to assure continuous contact. The loose soil shall not be greater than six inches in depth at any point, and shall conform to the requirements herein before specified under pipe backfill. This curing method shall be used when the ambient temperature exceeds 100 degrees F.

For ambient air temperatures equal to or less than 100 degrees F, the pipe may be sprayed with a liquid membrane-forming compound conforming to the requirements of Subsection 1006-6(C). If the contractor elects to spray the pipe with a liquid membrane, such procedure shall be completed within 30 minutes.

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, 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.

(F) Backfilling:

Backfilling shall not start until the concrete has developed a compressive strength of at least 2,500 pounds per square inch.

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.

(G) Pipe Repair:

The contractor shall perform all interior crack repairs only after backfilling.

Transverse cracks 0.05 inches or more in width shall be cleaned and filled with an elastomeric compound The elastomeric compound shall penetrate into the crack at least 0.38 inches.

A longitudinal crack shall be defined as one which is generally oriented within 30 degrees of the alignment of the pipe.

Longitudinal cracks will be a cause for rejection under any of the following conditions.

(1) A crack which has caused a surface fault within the pipe with a displacement greater than 0.08 inches.

(2) A crack width greater than that determined by the formula 0.0005 x O.D. and that can be penetrated by a standard machinist gauge leaf designated in AASHTO T 280.

(3) A crack width greater than 0.05 inches and that can be penetrated by a standard machinist gauge leaf designated in AASHTO T 280.

Longitudinally cracked pipes meeting any of the three rejection criteria above may be allowed to remain in place if approved by the IQF, all longitudinal cracks meeting any of the three criteria above shall be repaired by full depth epoxy grouting.

(H) Pipe Wall Thickness:

The contractor shall measure the thickness at the invert and crown by probing at 25-foot intervals during the placement of concrete. The probe shall be a 3/8-inch round bar at least two inches longer than the wall thickness to be measured. The measurements shall be reported on the daily observation form.

The wall thickness will be measured for acceptance. One hole each shall be drilled at the invert and on each side of the springline, within 200-foot intervals. The drill locations will be determined by the Developer. IQF may require additional holes on curves or in areas which appear to be defective. All holes shall have a minimum diameter of 3/4 inch. If the wall thickness is less than the specified minimum thickness, a core shall be drilled adjacent to the drilled hole. All cores shall have a minimum diameter of three inches. The length of the core will be determined in accordance with the requirements of AASHTO T 148.

If the length of the drilled core is deficient, additional cores shall be taken at intervals not to exceed ten feet in each direction from the deficient core until one core which is not deficient is obtained in each direction. The pipe between these two acceptable cores will be rejected. The rejected pipe section shall be removed and replaced with pipe of the specified thickness.

ITEM 5010600 – JACKING, BORING OR TUNNELING PIPE

Description:

The work under this item consists of jacking and boring a steel sleeve under the freeway corridor as shown in the project plans. Included in this item is the internal backfilling of the space between the carrier pipe and the sleeve.
The Contractor is advised that shoring for the excavation will be required. The Contractor is responsible for the installation and removal of the shoring devices.

Materials:

Casing diameter shall be as shown on the plans. The casing shall consist to welded steel pipe (ASTM A-283, Grade C). Shop and field joints shall be butt welded. Fabrication and welding shall be in accordance with AWWA C-200. Weld or hydrostatic testing is not required.

Construction Requirements:

The boring and jacking operations shall be done simultaneously, with continuous installation, until the casing pipe is in final position. Correct line and grade shall be carefully maintained. Add-on sections of casing pipe shall be full-ring welded to the preceding length, developing watertight total pipe strength joints. The casing installation shall produce no upheaval, settlement, cracking, movement, or distortion of the existing roadbed or other facilities.

The casing pipe shall be adequately protected to prevent crushing or other damage under jacking pressures. Backstops shall be provided for adequately distributing the jack thrust without causing deformation of the soil or other damage. Should the casing pipe be damaged, such damaged portion not in the hole shall be replaced; however, if installed, the encasement pipe shall be abandoned in place, grouted full, and suitable plugged, and an alternate installation made.

Required boring and jacking pits or shafts shall be excavated and maintained to the minimum dimensions necessary to perform the operation, never to extend beyond the limits indicated on the plans. Said excavations shall be adequately barricaded, sheeted, braced and dewatered as required.

The carrier pipe shall be centered inside the encasement. The space between the pipe and the encasement shall be properly filled with sand or slurry and sealed at all ends of the sleeve.

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.

503-2 Materials:

503-2.01 Concrete:

Portland cement 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. Re-tempering of mortar will not be permitted.

503-2.04 Structural Steel:

Structural steel parts shall conform to the requirements of Section 1004.

503-3 Construction Requirements:

503-3.01 Catch Basins:

Catch basins shall be cast-in-place or, at the option of the Developer, may be precast units. The "H" dimension for catch basins shall be determined in the field prior to casting
Cast-in-place catch basins shall be constructed in accordance with the requirements of Section 601, except for backfill, and reinforced where called for on the plans in accordance with the requirements of Section 605 in reasonably close conformity to the lines and grades shown on the plans Catch Basins sides with pipe penetrations shall be backfilled in the pipe zone following 501-3.04(A)1. Above the pipe zone, the catch basin may be backfilled per 501-3.04(A)2. Catch basins sides without pipe penetrations may be backfilled per 501-3.04(A)2.

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 to the dimensions shown on the project plans.

Project calls for some modifications to the existing drainage structures. The Developer shall construct these modifications to the details and requirements as shown in the plans.

503-3.03 Frame and Grate:

The fabrication of frame and grate units shall conform to the requirements of Subsection 604-3.06. Catch Basin frame and grates shall be fabricated and installed, so that the bearing surfaces of the grate rest securely on the bearing surfaces of the frame.

When reconstruct catch basin is specified, the existing frame and grate may be re-installed at the option of the Developer.

SECTION 505 MANHOLES:

505-1 Description:

The work under this section shall consist of furnishing all materials and constructing complete manholes including frames and covers; furnishing and installing manhole frames and covers; or removing and resetting existing manhole frames and covers, as shown on the project plans.

505-2.01 Concrete:

Materials furnished for Portland cement concrete shall conform to the requirements of Section 1006 for Class B concrete, except precast manholes. Precast manholes shall conform to the requirements of AASHTO M 199

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 Frames and Covers:

Frames and covers shall conform to the requirements of Subsection 1004-6 for drainage structure castings.

505-3 Construction Requirements:

505-3.01 Manhole:

All connections for lateral pipes will be considered a part of the manhole.
Manhole side-walls shall be constructed of cast-in-place or precast concrete, or brick, as determined by the Developer. The base of all manholes shall be precast or cast-in-place concrete.

Where frames and covers for new manholes are to be set in new bituminous mix or asphaltic concrete surfaces, they shall not be set or adjusted to final grade until the roadway has been surfaced. Where a bituminous seal coat or asphaltic concrete finishing course is to be placed on the new surfacing, the frames and covers shall be set or adjusted to final grade after the surface course has been completed and prior to the placement of the seal coat or the finishing course.

Project calls for some modifications to the existing drainage structures. Developer shall construct these modifications to the details and requirements shown in the plans.

505-3.02 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. 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 detailed on the project plans.

505-3.03 Reset Manhole Frame and Cover:

Existing frames and covers to be reset shall be carefully removed and reset to the required grade.

SECTION 508 CORRUGATED HIGH-DENSITY POLYETHYLENE PLASTIC PIPE (CHDPEPP):

508-1 Description:

The work under this section shall consist of furnishing CHDPEPP and all other materials required for the installation, including excavating, and furnishing, placing and compacting backfill material, all in accordance with the details shown on the plans and the requirements of the specifications.

All contiguous pipe 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 unless otherwise stated in the specifications, or shown on the plans.

508-2 Materials:

CHDPEPP (12-inch to 60-inch diameter) shall meet AASHTO M294-15 Type S (full circular cross section, with an outer corrugated pipe wall and a smooth inner liner) including rubber gaskets at joints. CHDPEPP shall have a 75-year design service life with Manning n value of 0.012, and have a minimum cell classification of 435400 C in accordance with ASTM 3550. Resin must not contain less than 2% carbon black UV stabilizer.

Developer will submit manufacturer Certificate of Compliance for all CHDPEPP material placed.

508-3 Construction Requirements

508-3.01 Preparation of Foundations, Trenches, and Embankments:

Where rock, hardpan, or other unyielding material is encountered, such material shall be removed 12 inches below the vertical limits as shown on the plans. The over-excavated area shall be backfilled with pipe zone material and compacted in layers not exceeding 6-inches 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 of 12 inches. The unstable soil removed shall be replaced with pipe zone material and compacted in 6-inch lifts.

A trench condition is defined as a trench which has vertical slopes to a point at least one foot above the top of the pipe. Install CHDPEPP in trench condition in natural ground or in embankment.

Minimum trench width for CHDPEPP, in accordance with AASHTO LRFD Section 30, shall not be less than 1.5 times the pipe outside diameter plus 12 inches.

Parallel pipes installed in the same trench shall have a minimum spacing of 12-inches for diameters 24-inch and less; for pipe 30-inch diameter and over, the minimum spacing is one half the ID (of the largest diameter pipe), unless otherwise shown on the plans.

CHDPEPP 18-inch diameter shall have a minimum cover depth of 1 foot (between finished subgrade elevation and top of pipe) and a maximum cover depth of 24 feet (between finished subgrade elevation and top of pipe).

CHDPEPP 24-inch to 48-inch diameter shall have a minimum cover depth of 1 foot (between finished subgrade elevation and top of pipe) and a maximum cover depth of 18 feet (between finished subgrade elevation and top of pipe).

CHDPEPP 54-inch to 60-inch diameter shall have a minimum cover depth of 2 feet (between finished subgrade elevation and top of pipe) and a maximum cover depth of 18 feet (between finished subgrade elevation and top of pipe).

Minimum temporary cover of all CHDPEPP increases to 3 foot (from top of pipe to subgrade surface elevation) for construction traffic over 30 tons, gross vehicle weight crossing the pipe.

508-3.02 Bedding & Backfill Material:

Bedding and backfill material used within the pipe zone (material placed 6-inches below

pipe to 12-inches above pipe) shall be aggregate pipe zone material, (per ASTM D2321-14) Class II (Clean, coarse grained soils, SW, SP, GW, or GP at 6-inch depth minimum); or Class I (Crushed angular rock at 4-inch depth minimum) or
1-sack cement slurry.

Bedding and backfill material shall have the following aggregate gradation:

Sieve Size	Percent Passing
1-1/2 inch	100
No. 4	25-70
No. 200	0 - 12

- Plasticity index < 8 (AASHTO T 90)
- Resistivity > 2,000 ohm-centimeters (Arizona Test Method 236)
- pH value between 6.0 and 12.0 (Arizona Test Method 236)

Aggregate for cement-treated slurry pipe zone material, prior to the addition of cement and water, shall conform to the requirements for aggregate pipe zone material. One sack of cement shall be added to each cubic yard of aggregate. Cement-treated slurry shall be thoroughly mixed and shall have a slump, at time of placement of 8 to 11 inches.

All trash, forms, sheeting, bracing, and loose rock or loose earth shall be removed from the area into which pipe zone material is to be placed.

A minimum 6-inch layer of aggregate pipe zone material shall be placed, between the bottom of the trench and the bottom of the pipe. The remaining pipe zone from the bottom of the pipe to 12-inches above the pipe, may be backfilled with aggregate pipe zone material or cement-treated slurry.

Bedding and backfill material shall be placed in a manner which will prevent distortion, damage to, or displacement of the pipe from its intended location, and provide adequate support to prevent floating. Voids or loose soils which are found to occur due to improper placement or compaction of pipe zone materials will result in rejection of that portion of the pipe installation.

Pipe zone material shall be placed either in uniform horizontal layers not exceeding 8-inches in depth before compaction. Aggregate pipe zone material may not be compacted by jetting, or placed as an aggregate slurry. Ponding for compaction of pipe zone material will not be permitted in any case.

Cement-treated slurry material shall be placed in a uniform manner that will prevent voids in, or segregation of the bedding material, and will not float or shift the culvert or pipe. Cement-treated slurry pipe backfill placement above spring-line shall not commence within 24 hours of the placement of the underlying cement-treated bedding material below spring-line. Cement-treated pipe backfill shall be placed in a uniform manner that will prevent voids in or segregation of the backfill to an elevation one foot above the top of the pipe. No backfilling above the cement-treated slurry pipe backfill shall be commenced until 24 hours after the cement-treated slurry has been placed.

Compaction of pipe zone 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.

Aggregate pipe zone 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. No density tests will be required in the cement-treated slurry pipe zone material.

508-3.03 Installation:

Pipe shall be handled carefully. Proper facilities shall be provided for handling and lowering the sections of pipe. Pipe shall be installed in reasonably close conformity with the lines, grades and dimensions shown on the project plans. Tracer wire for all underground facilities shall be installed in conformance with Section 104.

Corrugated high density polyethylene plastic pipe, shall be assembled and installed in accordance with the manufacturer's instructions.

Water resistant joints will be required for storm drains, culverts, or other drainage pipes. Watertight joints shall be provided for siphon and irrigation pipe installations. Watertight and water resistant joints shall be joined together using an integral bell and spigot joint that meets the 10.8 psi watertight requirement of ASTM D3212. Vertical installations of CHDPEPP is not permitted.

Bell or groove ends and outside circumferential laps shall be placed facing upstream. To prevent damage and to assure that proper line and pipe grade are maintained throughout the backfilling operation, special care shall be taken in the handling and installation of corrugated high density polyethylene plastic pipe and fittings.

When a shoring/trench box is necessary for installation of CHDPEPP, bottom of shoring/trench box shall not be lower than top of pipe or more than 24-inches above bottom of trench; if shoring/trench box is below top of pipe a sub-trench is required.

When end sections are called for on the plans, metal safety end sections shall be used unless otherwise specified on the plans. The embankment slope shall be warped to match the end sections. For a skewed pipe installation, the toe of the embankment slope shall be warped to match the toe of the skewed metal safety end section in order to provide effective drainage.

CHDPEPP pipe installed within an MSE wall reinforcement zone will be detailed in MSE shop drawings by manufacturer. CHDPEPP may not be placed within the foundation zone of walls or structural foundations, except as detailed on the plans.

508-3.04 Trench Backfilling and Compacting:

Trench backfill material shall be placed above pipe zone bedding and backfill material to top of trench shall meet embankment specified in Section 200.

Trench backfill material shall not contain organic material, rubbish, debris and other deleterious material and shall not contain solid material which exceeds eight inches in greatest dimension and shall be soil selected from excavation or from a source selected by the Developer.

As an alternate, trench backfill may conform to the material requirements listed for aggregate pipe zone material or cement-treated slurry material.

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 shall be placed from one foot above the top of the pipe to the elevation at which base or surfacing materials are to be placed or to the top of the trench.

Trench backfill mixed as a standard cement treated slurry shall be placed in uniform horizontal layers not exceeding four feet in depth.

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.

Cement-treated slurry bedding material used for trench backfill shall meet the requirements listed above for pipe backfill up to the elevation which it is placed.

508-3.05 Inspection & Testing:

Visual inspection shall be performed on all CHDPEPP for line and grade, joint gaps and misalignments, cracks, deformation, damage, and debris. Visual inspection shall be 30 days after placement of all pipe zone material or prior to placement of AC Section (whichever is first); but no sooner than 7 days after pipe zone material installation.

The maximum allowable vertical deflection is 5%, in accordance with AASTHO M294, using the Certified Mean Diameter (CMD) provided by the pipe manufacturer. If any deflection is noted during the visual inspection, the pipe shall be secondarily tested by mandrel. A minimum of 10% of CHDPEPP (less than 10 feet depth to subgrade) will be inspected with a mandrel, and all CHDPEPP with fill depths greater than 10 feet to subgrade, as shown on the plans.

Based on the results of secondary testing, the inspector may request a remedy for pipes with deflections between 5% of CMD and 7% of CMD, or direct the Contractor to remove and replace the pipe. Remedy options may include, but are not limited to, excavating the affected portion of the pipe run and reconstructing the pipe, or removing and replacing the affected portion to the nearest pipe joint or drainage structure. For pipe deflections greater than 7.0% of CMD, the Contractor shall remove and replace the affected length of pipe to the nearest pipe joint or drainage structure. Use of mechanical re-rounding technology on installed pipe shall not be accepted as a remediation technique in any circumstance.

SECTION 509 ARTICULATED CONCRETE BLOCK (ACB) REVETMENT SYSTEM

509-1 Description:

The work under this section shall consist of constructing the Articulated Concrete Block (ACB) Revetment System in accordance with the project plans and these specifications.

509-2 Materials:

The Articulated Concrete Block Revetment System shall consist of a single color, type and variety of interlocking and overlapping Articulated Concrete Blocks from a single lot manufactured by a single source. Materials shall be available and consistent in quality, appearance and physical properties without delaying the progression of work.
Contractor shall coordinate with the Manufacturer to procure an open cell Articulated Concrete Block Revetment System that meets the minimum Safety Factor (SF) and the hydraulic data provided below:

CULVERT I.D.	*DISCHARGE*	*VELOCITY*	*SIDE SLOPE*	*CHANNEL SLOPE*	*HYDRAULIC RADIUS*	τ_o	*ACB USAGE*	*STATION, OFFSET*
(-)	(ft^3/sec)	(ft/sec)	(X:1, X:1)	(ft/ft)	(ft)	(lb/ft^2)	(-)	(-)
B22	373	9.31	6:1, 6:1	0.068	0.47	2.0	CL	2490+95.4, 143.0' Lt
WLC#1	122	11.05	6:1, 6:1	0.10	0.32	2.0	CL	2494+74.7, 214.5' Rt
B23A US	121	17.80	4:1, 4:1	0.238	0.63	9.4	CL	2505+46.3, 224.8' Rt
B23A DS	121	9.56	4:1, 4:1	0.02	1.00	1.2	CL	2504+35.5, 114.9' Lt
B23E	149	16.61	4:1, 2:1	0.25	0.30	4.7	SBP	2520+87.5, 119.0' Lt
B23B	85	14.72	4:1, 4:1	0.25	0.25	3.9	SBP	2522+19.2, 124.0' Lt
B23C	116	19.54	4:1, 4:1	0.25	0.38	5.9	SBP	2530+48.1, 117.6' Lt
B23D	1276	19.37	4:1, 4:1	0.064	1.46	5.8	SBP	2533+83.8, 129.9' Lt
B24	60	15.32	3:1, 3:1	0.25	0.26	4.1	SBP	2543+92.0, 175.2' Lt
B25	270	13.63	3:1, 3:1	0.10	0.82	5.1	SBP	2547+06.8, 180.3' Lt
B25A	172	19.75	4:1, 4:1	0.25	0.39	6.1	SBP	2571+74.1, 112.7' Lt
B25B	29	12.56	4:1, 4:1	0.25	0.20	3.1	SBP	2578+33.9, 102.4' Lt
B26B	99	18.50	4:1, 4:1	0.25	0.35	5.5	SBP	2588+95.2, 115.9' Lt
B27	229	12.02	4:1, 4:1	0.033	0.97	2.0	SBP	2595+04.9, 113.8' Lt
B27A	124	18.82	4:1, 4:1	0.25	0.36	5.6	SBP	2600+07.8, 158.6' Lt
B28	149	20.08	4:1, 4:1	0.25	0.40	6.2	SBP	2604+22.4, 175.6' Lt

ACB USAGE	*MINIMUM SAFETY FACTOR*
Stilling Basin Protection (SBP)	1.8
Channel Lining (CL)	1.3

For velocity not exceeding 20 ft/s and shear stress less than 7.0 lb/ft^2, Contech ArmorFlex 70 or approved equal can be used. Contractor shall submit, to the Engineer, supporting documentation showing that the revetment system meets the hydraulic safety factor requirements as provided in Tables 1 & 2.

Additional Material Requirements:

ACB revetment system shall be manufactured in accordance with the requirements of ASTM 6684 (Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems).

Manufacturer testing of the ACB revetment system shall be in accordance with ASTM D7276 (Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow) and ASTM D7277 (Standard Test Method for Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow).

509-3 Construction Requirements:

Open Cell Articulated Concrete Blocks shall be installed in accordance with requirements specified below, Manufacturer's recommendations and the requirements of ASTM D6884 (Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems.

Prior to commencing the work of this section, Contractor shall verify the accuracy of layout and grading and verify that sub-grades and base and/ or drainage course aggregate conditions are as specified. Notify the Engineer of discrepancies and coordinate the correction of those discrepancies with other trades as necessary.

Subgrade should be prepared in accordance with Section 203-3.03 of the C202P Project Specifications and Section 6.1 of ASTM D6884, with the exception that compaction of subgrade should be to a minimum of 95 percent of the maximum dry density as determined by the Inspector using the applicable test method from the CQMP.

Geotextile for geotextile underlayment should consist of high-survivability separation geotextile fabric meeting the requirements of Section 1014-4, 1014-5, and be installed in accordance with Section 913-2.05 and 913-3.02 (Bank Protection Fabric) of the Project Specifications except where superseded by the requirements of Section 6.2 of ASTM D6884. Overlaps between adjacent panels or strips of geotextile should be in the direction of flow wherever possible. Upstream panels/strips should overlap downstream panels/strips, and upslope panels/strips should overlap downslope panels/strips. Overlaps at longitudinal and transverse joints should be a minimum of 1.5 feet (18 inches). The geotextile should extend beyond the top, toe and side termination points of the outlet basin.

Placement of blocks should be in accordance with Section 6.3 of ASTM D6884. Placement of blocks should begin at the upstream section of the culvert outlet and proceed downstream. On sloped sections, placement should begin at the toe of the slope and proceed upslope. During placement of the blocks, ensure that the individual blocks are in intimate contact with the geotextile and subgrade. The joint spacing between adjacent blocks should be maintained so that binding of blocks does not occur and block-to-block interconnection is achieved. Damage to the geotextile and subgrade during block placement should be avoided. Tolerance of individual blocks within the plane of the finished system should not exceed a 0.5-inch protrusion.

Per ASTM D6884, termination of blocks should be in excavated trenches located on the upslope sides and at the downstream end of the culvert outlet. Termination trenches should be properly backfilled with compacted approved fill material placed to be flush with the top of the finished surface of the blocks.

Per ASTM D6884, backfill to fill the open area of the blocks should consist of locally available native soils, or 3/8 inch to ¾ inch in size pea gravel to make the finished surface relatively uniformly flat. The finished surface shall meet the Technical Provision requirement and no grade change exceeding 4” is allowed.

Registered Professional Engineer (Civil)
CERTIFICATE NO. 49430
GREGORY PATRICK FLY
Date Signed 2-4-19
ARIZONA U.S.A.

EXPIRES: 3-31-21

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. When the structures or parts of structures are precast, the work shall also include transporting and erecting the units.

601-2.01 General:

Portland cement concrete shall conform to the requirements of Section 1006 for Class S or Class B concrete as shown on the project plans.

Where a strength is shown on the project plans but a class of concrete is not indicated it shall be construed to mean Class S concrete having the required minimum compressive strength shown at 28 days.

Liquid membrane-forming compound shall conform to the requirements of Subsection 1006-2.05.

Materials furnished for expansion joint filler and joint seal shall conform to the requirements of Section 1011.

Materials furnished for water stops shall conform to the requirements of Section 1011.

Preformed bearing pads and elastomeric bearing pads shall conform to the requirements of Section 1013.

Reinforcing steel shall conform to the requirements of Section 1003.

601-3 Construction Requirements:

601-3.01 Foundations:

Foundations for structures shall be placed on suitable earth or rock bearing or on a concrete foundation seal 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 a tremie concrete procedure is allowed by the Engineer.

601-3.02 Falsework and Forms:

(A) Design and Drawings:

The Developer 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.

Forms shall be any system of structural elements which provides horizontal support or restraint to the lateral pressure of concrete.

Falsework shall be any system of structural elements that provides temporary support for loads from plastic concrete, forms, reinforcing steel, structural steel, loads from placement operations or other related loads, and continues to provide support until the concrete has attained adequate strength and the structure is capable of self-support.

Falsework shall be designed in accordance with the AASHTO Guide Design Specifications for Bridge Temporary Works.

Developer shall submit falsework drawings that include the design and construction requirements of the falsework and forms. Falsework Drawings shall be sealed by a Professional Engineer licensed in the State of Arizona.

(B) Falsework Construction:

The falsework shall be constructed to conform to the falsework drawings, and in accordance with the AASHTO Construction Handbook for Bridge Temporary Works and the AASHTO LRFD Bridge Construction Specifications.

No concrete shall be placed in any forms supported by falsework until the Developer's professional engineer has inspected the completed falsework and has issued a properly signed and sealed certificate that the falsework has been constructed according to the approved falsework drawings.

(C) Forms Construction:

Forms shall be constructed in accordance with the AASHTO Construction Handbook for Bridge Temporary Works and the AASHTO LRFD Bridge Construction Specifications.

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.

All forms shall be treated with a 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.

(D) Removal of Falsework and Forms:

Falsework 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. In no case shall falsework be removed within five days of concrete placement.

Falsework for cast-in-place non-prestressed structures or composite superstructures, excluding concrete above the bridge deck, shall not be removed until either:

(1) At least 10 days after the last concrete has been placed in each continuous span and until the compressive strength of all placed concrete has attained at least 70 percent of the required 28-day compressive strength; or

(2) At least five days after the last concrete has been placed in each continuous span and until the concrete has attained the required 28-day compressive strength.

Side forms for footings, beams, girders, box culverts, columns, railings, curbs or other members wherein the forms do not resist dead load bending may be removed after the concrete has set, and the Developer shall cure and protect the concrete thus exposed in accordance with the requirements of Section 1006. Forms for cast-in-place concrete, unless otherwise specified herein, shall not be removed until at least seven days after concrete has been placed in the forms, without the approval of the Engineer.

Forms for precast concrete shall stay in place a minimum of eight hours.

The period of time between the placement of concrete in the top slab of a standard concrete box culvert (12 foot 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 Developer 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 decks 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.

All forms shall be removed.

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.

601-3.03 Placing Concrete:

(A) General Requirements:

Reinforcing steel shall be placed in accordance with the requirements of Section 605 and the plans.

Concrete shall be placed and consolidated by methods that will not cause harmful segregation and will result in a dense homogeneous concrete free of honeycomb or voids.

Concrete shall be placed in horizontal layers not over 48 inches in depth unless otherwise approved by the Independent Quality Firm.

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 eight feet without the use of approved pipes or tubes will not be allowed.

Care shall be taken to fill all areas within the forms 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, or interruptions sufficient to permit loss of plasticity between successive increments.

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 the type specified under Subsection 401-3.04(D), Fixed Form-Manual Methods.

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.

(B) Bridge Deck:

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.

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 supported by adjustable steel supports. 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 and deck thickness shall be checked. The clearance shall be as indicated on the project plans with a permissible variation of ± 1/4 inch. 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.

(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 8,000 vibration cycles per minute.

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 six inches into the preceding layer. The vibration shall be of sufficient duration and intensity to consolidate the concrete thoroughly.

The Developer shall provide sufficient equipment to insure uninterrupted and continuous vibration of concrete.

(H) Bridge Barriers and Transitions:

This work shall consist of furnishing and constructing Bridge Concrete Barrier and Transition, including all hardware and materials, in accordance with the requirements of the project plans.

(I) Approach Slabs:

This work shall consist of furnishing and constructing reinforced concrete approach slabs for bridges, including all tools, equipment, labor, and materials. All work shall be in accordance with the details shown on the project plans and the requirements of these specifications.

601-3.04 Joints in Major Structures:

(A) Construction Joints:

Except as otherwise specified herein, construction joints shall be constructed at the locations specified on the project plans. All construction joints shown on the project plans are considered optional unless the construction joint is shown as part of a required construction sequence. The Engineer shall approve construction joints not shown in the plans, including relocation of construction joints that are shown in the plans.

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. 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 the concrete surfaces have been treated as specified, they shall be cleaned of all dust and abrasive material.

(B) Deck Joint Assemblies:

(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 Subsection 1011-5.

Steel shapes and plates shall conform to the requirements of ASTM A 36 or A 588.

(3) Construction Requirements:

(a) General:

Deck joint assemblies 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 assembly 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, one piece of the material supplied shall be at least 18 inches longer than required by the project plans. The additional length will be removed by the Inspector. Certificates of Compliance shall be submitted.

(b) Shop Drawings:

Prior to fabrication, the Developer shall submit shop drawings.

(c) Elastomer Seals:

Seals shall conform to the requirements hereinbefore specified.

(d) Welding:

All welding shall be in accordance with the requirements of Subsection 604-3.06.

(e) Armor:

All metal for cast-in-place seal assemblies shall be steel conforming to the requirements hereinbefore specified.

(f) Galvanizing:

All metal parts of strip seal assemblies shall be galvanized after fabrication in accordance with the requirements of ASTM A 123 and A 153, unless ASTM A 588 steel is used. Bolts shall be high strength, conforming to the requirements of ASTM A 325, with a protective coating of cadmium or zinc followed by a chromate and baked organic coating according to ASTM F 1135, Grade 3, 5, 6, 7 or 8 and Color Code A.

Metal parts of compression seal assemblies do not require galvanizing, plating, or painting.

(g) Joint Preparation and Installation:

The Developer shall form the joint with a secondary concrete pour. The surface of the existing concrete shall be coated prior to the concrete being placed with an adhesive specifically formulated for bonding new concrete to old concrete as approved by the Inspector.

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. 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 cause 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 the joint is provided for, the water stops shall be of a type permitting such movement without injury. They shall be spliced, welded or soldered, to form continuous watertight joints.

(D) Joints in Deck Units:

After erection, the longitudinal joints or shear keys shall be thoroughly packed with a pre-packaged non-shrink grout or a sand-cement grout with an expansion agent approved by the Independent Quality Firm. The Developer shall transversely connect the deck units with the connection rods, stressing and anchoring them as shown on the project plans.

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 after the removal of forms in accordance with the requirements specified herein. 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, preformed metal forms, paper tubing forms, or specially-coated forms. If a pleasing appearance has not been achieved, the Inspector may require the surface be finished in accordance with the requirements for a Class II Finish.

(B) Class I Finish:

All bolts, wires, snap-ties, and rods shall be clipped and recessed one inch 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 . 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. Brushing or sacking shall be carried in one direction so as to produce a uniform texture and color.

(D) Finishing Bridge Deck:

(1) General:

Bridge decks exposed directly to traffic shall be grooved as specified in Subsection 601-3.05(D)(2).

The finishing operation shall be completed before the water sheen disappears. The deck surface shall be finished to a smooth floated surface, free of mortar ridges, hollows, and any other projections.

The finished surface of the concrete shall be tested with a 10 foot straightedge placed on the deck surface. For deck surfaces exposed directly to traffic, the surface plane shall not vary by more than 1/8 inch, as measured from the bottom of the straightedge.

Should the deck surface require additional corrections or repair after the concrete has cured, all corrected areas shall be re-textured with sawed grooves to match the finish of the surrounding deck surface. After such corrective grinding and re-grooving is completed, the minimum remaining cover over the reinforcing steel shall be not less than 2 1/4 inches.

(2) Grooving:

(a) General Requirements:

The bridge deck and approach slab shall be textured with sawed longitudinal grooves after the concrete has been cured.

A uniform textured surface of grooves shall be installed for the entire length of the bridge deck and approach slabs except for those areas occupied by devices installed on the deck. The grooves for decks exposed directly to traffic shall be rectangular in shape and shall be 1/8 inch ± 1/32 inch deep by 1/8 inch ± 1/32 inch wide. Spacing of the grooves shall be 3/4 inches ± 1/8 inch center to center.

Bridge sidewalks shall be textured to a light broomed finish during the plastic concrete state.

(c) Sawed Grooves:

(1) General:

Sawed groove texturing shall occur after the finished surface, and after the concrete has cured for at least seven days, but before the roadway is opened to traffic.

A self-propelled texturing machine built for grooving of concrete surfaces shall be used for making the sawed grooves. The saw grooving equipment shall be capable of producing grooves which meet the dimensional requirements specified in Subsection 402-5.

Sawed groove texturing shall terminate at 12 inches ± 3 inches from the face of curbs, bridge rails or median dividers along each edge of the bridge deck surface. Texturing shall be stopped 9 inches to 12 inches from any devices installed on the bridge deck, such as scuppers and expansion devices that are perpendicular to the grooves.

For skewed expansion devices or deck and approach slab terminations, the direction of the grooves as specified above shall not be altered, and texturing shall terminate no closer than six inches nor farther than four feet from the joint armor. The maximum gap in texturing, from one side to other of skewed expansion devices, shall not exceed five feet.
Overlapping of grooves by succeeding passes will not be permitted.

(3) Construction:

Prior to grooving operations, the Developer shall provide two gauges, designed for verification of groove depth. The gauges shall be accompanied by the manufacturer's instructions for their use. During grooving operations the Developer shall check the groove dimensions at random locations. If the minimum groove depth has not been achieved, the grooving operation shall stop and the necessary adjustments shall be made.

601-3.06 Curing Concrete:

Curing cast-in-place concrete and curing precast concrete members shall be in accordance with the requirements of Subsection 1006-6.

601-3.07 Supporting, Handling, Transporting, and Erecting Precast Concrete Items:

(A) General:

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. 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 at the point of delivery.

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 two inches, and will not interfere with the placement of reinforcing steel or concrete.

(B) Bridge Girder Erection:

Girders shall be placed accurately on bearings to avoid creating eccentricities capable of initiating imbalance.

Girders with shapes that exceed a height to width ratio of two shall be temporarily braced. The girder width shall be determined from the outside dimension of the bottom flange.

The Developer shall secure such girders in position on the structure with temporary lateral bracing to resist loads as specified in the AASHTO Guide Design Specifications for Bridge Temporary Works. Lateral bracing shall be designed to allow for girder temperature movements. The bracing shall be placed prior to the release of the erection equipment from each girder.

Prior to erection of any girders, the Developer shall provide a lateral bracing plan, prepared and sealed by a professional engineer registered in the State of Arizona, for the Engineer's review. Such bracing plan shall be included with the working drawings and shall include supporting calculations. A girder pre-erection meeting will be scheduled following the review and prior to erection of any girders. All parties involved in the installation shall be represented, and no girders shall be placed until the plan has been approved.

No traffic shall be allowed under each newly erected girder until the girder has been laterally braced.

Temporary bracing shall remain in place until after permanent concrete diaphragms are installed at the bents, or the girder is integrated with a permanent feature that restricts the girder's lateral movement.

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:

601-4.02 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-or-less length:	3/8 inch
Maximum for the entire length:	1 inch

(2) Variation in cross-sectional dimensions of columns, piers, girders, and in the thickness of slabs and walls:

+ 1/4 inch
- 1/8 inch

(3) Girders alignment (deviation from straight line parallel to center line of girder measured between diaphragms):

1/8 inch per every 10 feet in length

(4) Variation in footing cross sectional dimensions in project plans:

+ 2 inches
- 1/2 inch

(5) Variation in footing thickness:

*Greater than specified: No Limit

Less than specified: 5 percent of specified thickness up to a maximum of one inch

*Does not apply to reinforcing steel placement.

(6) Subgrade Tolerances:

Slab poured on subgrade excepting footing thickness:

+ 1/4 inch
- 3/4 inch

(7) Girder Bearing Seats:

Deviation from level surface:

± 1/8 inch in ten feet.

Deviation from required elevation:

- 1/4 inch
+ 3/8 inch

(8) Cast-In-Place concrete box girder superstructures:

Deviation in overall depth:

+ 1/4 inch
- 1/8 inch

Deviation in slab and wall thickness:

+ 1/4 inch
- 1/8 inch

Deviation of post-tensioning ducts:

± 1/4 inch

(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 of deviations from dimensions and details shown on the project plans or the approved shop drawings shall be as follows:

(a) Length: ± 3/4 inch

(b) Width (flanges and fillets): + 3/8 inch, - 1/4 inch

(c) Depth (overall): + 1/2 inch, - 1/4 inch

(d) Width (web): + 3/8 inch, - 1/4 inch

(e) Depth (flanges and fillets): ± 1/4 inch

(f) Bearing plates (ctr. to ctr.): ± 1/8 inch per 10, but not greater than ± 3/4 inch

(g) Horizontal alignment (deviation from straight line parallel to center-line of member): 1/8 inch per every 10 feet in length

(h) Stirrup bars (deviation from top of beam): + 1/4 inch
- 3/4 inch

(i) Tendon position: ± 1/4 inch c.g. of strand group and individual strands

(j) Horizontal position of deflection points for deflected strands: ± 20 inches

(k) Position of handling devices: ± 6 inches

(l) Bearing plates (ctr. to end of beam): ± 1/4 inch

(m) Side inserts (ctr. to ctr. and ctr. to end): ± 1/2 inch

(n) Exposed beam ends (deviation from square or designated skew):

Horizontal: ± 1/4 inch

Vertical: ± 1/8 inch per foot of beam depth

(o) Bearing area deviation from plane: ± 1/8 inch

(p) Stirrup bars (longitudinal spacing): ±1 inch

(q) Position of post-tensioning duct: ±1/4 inch

(r) Position of weld plates: ± 1 inch

(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

(b) Width (over-all): ± 1/4 inch

(c) Depth (over-all): ± 1/4 inch

(d) Width (web): ± 3/8 inch

(e) Depth (top slab): ± 1/4 inch

(f) Depth (bottom slab): + 1/4 inch, - 1/8 inch

(g) Horizontal alignment (deviation from straight line parallel to center line of member): 1/8 inch per every 10 in length

(h) Camber differential between adjacent units:

Not greater than 3/4 inch

(i) Position of tendons: ± 1/4 inch c.g. of strand group

(j) Longitudinal spacing of stirrup bars: ± one inch

(k) Position of handling devices: ± 6 inches

(l) Slab Void position: ± 1/2 inch from end of void to center tie hole + 1 inch adjacent to end block

(m) Square ends (deviation from square): ± 1/2 inch

(n) Skew ends (deviation from designated skew): ± 1/2 inch

(o) Beam seat bearing area (variation from plane surface when tested with a straightedge through middle half of member):

± 1/8 inch

(p) Dowel tubes (spacing between the centers of tubes and from the centers of tubes to the ends and sides of members):

± 1/2 inch

(q) Tie rod tubes (spacing between the center of tubes and from the centers of tubes to the end of the member): ± 1/2 inch

(r) Tie rod tubes (spacing from centers of tubes to the bottom of the beams):± 3/8 inch

(s) Total width of deck: Theoretical width ± 1/2 per joint

(t) Position of side inserts: ± 1/2 inch

(u) Position of weld plates: ± 1 inch

(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 per 10 feet; maximum of ± 3/4 inch

(b) Cross-sectional dimensions:

Sections six inches or less: ± 1/8 inch

Sections 18 inches or less and over 6 inches: ± 3/16 inch

Sections 36 inches or less and over 18 inches: ± 1/4 inch

Sections over 36 inches: ± 3/8 inch

(c) Deviations from straight line:

Not more than 1/4 inch per 10 feet

All exposed, sharp corners of the concrete shall be filleted 3/4 inch with a maximum allowable deviation of ± 1/8.

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 of this section and Subsection 1006-7.

601-4.04 Opening to Traffic:

No vehicular traffic will be allowed on the structure until after all cast-in-place concrete has reached the required 28-day compressive strength, and for cast-in-place prestressed structures, the structure has been prestressed, tendons grouted, and all falsework removed from under the superstructure.

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 and hold-ups for pretensioning systems.

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 furnished as shown on the project plans.

All prestressing steel shall be satisfactorily protected 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 post-tensioning steel shall be rigid galvanized ferrous metal.

602-2.03 Grout:

Cement grout for bonding post-tensioning tendons shall consist of not more than five gallons of water to one 94-pound bag of Portland cement and may contain chemical admixtures if approved by the Independent Quality Firm. Chemical admixtures shall conform to the requirements of Subsection 1006-2.04, except 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 of 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 Requirements:

602-3.01 Shop Drawings:

(A) General:

Shop drawings of the proposed prestressed concrete members shall be submitted.

The drawings shall show the method and procedure of jacking and the type, size, and properties of the strands and number of strands. The size, shapes, dimensions, and concrete cover shall be shown for the reinforcing steel, including any reinforcing steel to be relocated or added.

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 and force in thousands of pounds 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 Developer 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 Developer 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 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 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, block-outs, and all other data pertaining to the post-tensioning system or operations.

602-3.02 Approval of Prestressing Systems:

The Developer 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.

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 Developer 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 Developer 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. The Developer shall provide records of the acceptance test in conformance with Division II, Article 10.3.2.3.12 to the Independent Quality Firm 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 Developer shall provide a calibration of the post-tensioning jacking system and shall provide the appropriate control settings for the Inspector's transducer, electro-hydraulic load cell system by testing the jacking system in a manner that has been pre-approved by the Inspector.

Any deviation from the approved materials and details will not be permitted unless new details are submitted by the Developer and approved in advance of use.

The approval of any proposed method, material or equipment shall not operate to relieve the Developer 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, per delivery, of prestressing bars, wire, and strand, and from each lot of 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 Compliance stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

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 job 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 job site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies or bar couplers recovered at the job site will be rejected.

602-3.04 Anchorage and Distribution for Post-Tensioned Structures:

All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

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 by meeting the requirements of a basic anchorage device or a special anchorage device.

Both basic and special anchorage devices must also meet the following anchor efficiency test criteria: the anchorage device shall hold the prestressing steel without exceeding anticipated set at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.

602-3.05 Duct Installation for Post-Tensioned Structures:

Duct enclosures for prestressing steel shall be mortar-tight and accurately placed at the locations shown on the approved shop drawings.

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 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 Developer shall demonstrate to the satisfaction of the Inspector 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 Developer shall demonstrate to the satisfaction of the Engineer Inspector 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 Developer shall demonstrate to the Inspector, by aerostatic or hydrostatic tests, that the duct system 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. Once the charging pressure is attained, the mechanical shut-off valve shall be closed for a period of not less than five minutes. A retained pressure of 20 pounds per square inch, or greater, after five minutes, will be considered an indication of acceptable performance.

Ducts not completely encased in concrete shall have the exposed areas sealed with an epoxy compound and then pressure tested to 20 pounds per square inch for five minutes. A retained pressure of 10 pounds per square inch 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 Inspector may accept the ducts if the Engineer Inspector 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:

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 either a reading dial at least six inches in diameter or a digital display indicator. The increments shown on the reading dial gauge shall not exceed two percent of the jacking force. The digital display indicator shall be readable by normal vision at a distance greater than 10 feet. All gauges shall show a load accuracy of one percent of the load, from one percent to one hundred percent of the capacity of the gauge.

The certified calibration charts for the hydraulic jacks and pressure gauges may be checked before and during jacking operations with the Inspector's 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 Developer.

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.

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. If the actual measured elongation differs by more than five percent of the theoretical calculated elongation, the entire operation shall be carefully checked and the source of the error determined and corrected before proceeding with the tensioning. A record of the prestressing force and elongations shall be kept at all times and submitted to the Inspector for approval.

(B) Pretensioning Precast Concrete:

The tensioning force in pretensioned strands shall not be transferred to the member until tests on cylinder specimens made and cured under the same conditions as the member indicates the required compressive release strength has been attained. This shall constitute the end of the curing period.

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 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 Inspector, prestressing strands in precast members, if tensioned individually, shall be checked by the Developer 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 Inspector. 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 seventy-two 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 Inspector 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 10 calendar days after the installation of the prestressing steel, rust which may form during the 10 days will not be 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, has reached the required strength for jacking.

Prestressing steel may be tensioned by jacking from one end only for simple span structures.

Should the Developer 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.

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 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 Inspector 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 degrees F and the minimum 50 degrees F.

Grouting equipment shall be capable of grouting at a pressure of at least 150 pounds per square inch and shall be furnished with a pressure gauge having a full scale reading of not more than 300 pounds per square inch. Maximum grouting pressure shall not exceed 250 pounds per square inch.

Standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch and of sufficient capacity to flush out any partially grouted ducts shall be provided and available at the job site. Equipment capable of providing dry, oil free compressed air for removing water from the ducts shall be available at the 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. Draped tendons exceeding 400 feet shall be vented at all high points. Grout vents shall be made of rigid tubing or pipe with threaded fittings and shutoff valves.

Grout shall be injected at the low end of 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 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. The use of an approved chemical admixture should also be considered for increasing the pumping efficiency and/or time of set.

When freezing weather conditions will prevail during and following the placement of grout, the Developer shall provide adequate means to protect the grout in the ducts from damage by freezing.

The surfaces of concrete against which concrete encasement over anchorage assemblies is to be placed shall be abrasive blast cleaned and aggregate exposed after grouting of the ducts has been completed.

602-3.08 Finishing Precast Concrete:

The finishing of precast concrete bridge members shall comply with the requirements of Subsection 601-3.05. In addition, those exterior surfaces of exterior bridge members normally in the view of vehicular or pedestrian traffic shall be finished in accordance with the requirements for a Class II Finish.

Unless otherwise specified on the plans, the top surface of I-beams, box beams, and flat slabs shall be roughened with a hand tine rake while the concrete is still plastic.

All projecting strands that are not scheduled to remain for future embedment shall be cut off at the surface of the concrete, unless noted otherwise. Strands that are to remain shall be cut and bent to the dimensions shown on the plans. If the end of the precast bridge member will not be embedded in cast-in-place concrete, then all the strands shall be cut or ground flush with the surface of the concrete and thoroughly coated with a bitumastic type sealant.

Exposed uncoated reinforcing bars and strand shall be cleaned of concrete laitance and other foreign materials. If concrete laitance are allowed to harden and other foreign materials to remain on the bars, then abrasive blast methods will be conducted for cleaning.

The work described in this subsection shall be accomplished in the production yard of the precast manufacturer. When the fabrication of any precast bridge member has been successfully completed, as determined by inspection, the unit will then be approved for transportation.

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 572 and A 588. The P (Piece) frequency of testing shall be used for structural steel conforming to ASTM A 514. Charpy V-notch impact values shall be determined in accordance with ASTM E 23.

Charpy V-notch (CVN) impact values shall conform to the following minimum values:

Material		Impact Value: (foot-pounds at Temp. °F)
ASTM A 36		15 at 40 °F
ASTM A 572*		15 at 40 °F
ASTM A 588*	2 inches and under	15 at 40 °F
ASTM A 588*	Over 2 to 4 inches	20 at 40 °F
ASTM A 514	2-1/2 inches and under	25 at 0 °F
ASTM A 514	Over 2-1/2 to 4 inches	35 at 0 °F
*If yield point of material exceeds 65,000 psi, the temperature for CVN impact value for acceptability shall be reduced 15 °F for each increment of 10,000 psi above 65,000 psi.		

604-2.03 High-Strength Bolts, Nuts and Washers:

High Strength Bolts shall conform to ASTM A 325 except as may be modified herein.

The maximum hardness for ASTM A 325 bolts shall be 34 R_C.

Nuts and washers, appropriate to the type of high strength bolt to be used, shall conform to ASTM A 563 or A 194, for nuts, and F 436, for washers, respectively.

Nuts shall be Grade 2H or DH for black or galvanized bolts. For galvanized bolts the nuts shall be over tapped to the minimum amount required for the bolt assembly.

All nuts, bolts and washers shall have the manufacturers' 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 the 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, Section 6.2) 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 Specification, 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, in foot-pounds

P = Measured Bolt Tension, in pounds

D = Diameter, in feet

(2) Proof Load Tests:

Proof load tests, performed by the manufacturer, are required for the bolts (ASTM A 325) and for the nuts (ASTM A 563 or A 194). The proof load tests for nuts to be used with galvanized bolts shall be performed after galvanizing, over tapping and lubricating.

(B) Acceptance Testing:

High-strength bolts, nuts and washers will be field sampled at random by the Independent Quality Firm, according to the "shipping lot" method, upon receipt of the bolt shipment by the Developer. A minimum of three bolts, with corresponding nuts and washers, or 0.1 percent 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 an Independent Quality Firm designated testing laboratory for the following tests:

(1) Wedge Test:

Bolts shall be tested in accordance with ASTM Test Method F 606 – 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 E 18 within the specified maximum shown above for bolts. Nuts and washers will only be tested for Rockwell hardness, in accordance with ASTM E 18, to confirm compliance with ASTM A 563 or A 194 for nuts and F 436 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 paragraph 11.5.6.4, "Installation," of the AASHTO Bridge Specifications. Of particular importance is obtaining the "snug tight" condition as defined in paragraph 11.5.6.4.4 for any method of final tightening.

A Skidmore-Wilhelm Calibrator or other acceptable bolt tension indicating device will be provided by the Independent Quality Firm at each job site for use during bolt installation. Periodic tests (daily when calibrated wrench tightening is used) will be performed by the Independent Quality Firm 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].

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.

604-2.08 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 11, Division II, Construction - Steel Structures, of the AASHTO Standard Specifications for Highway Bridges.

604-2.10 Certification of Structural Steel:

Certificates of Analysis shall be submitted. The certificates shall include mill heat test reports showing the properties of each heat number. Mill test reports for structural steel used for those items specified in Subsection 604-2.01 shall also include the results of the Charpy V-notch impact test values.

604-3 Construction Requirements:

604-3.01 Shop and Working Drawings:

Prior to fabrication, the Developer shall prepare shop and working drawings.

Working drawings for steel structures shall show complete fabrication and erection details including full 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 for Highway Bridges, except as specified herein.

The structural steel fabricating plant shall be certified under the 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 planning 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.

604-3.05 Galvanizing:

(A) 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 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 most recent edition of the ANSI/AASHTO/AWS Bridge Welding Code. All other references to the American Welding

Society (AWS) structural welding code AWS D1.1-80 and the AASHTO Standard Specifications for welding of structural steel highway bridges are deleted.

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.

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 Requirements

605-3.01 General:

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. Bars shall not be rebent at the same location, unless approved by the Engineer.

Reinforcement shall be accurately fabricated and placed as shown on the plans and shall be firmly held in place by wire ties at all intersections and splices with 16 gauge or heavier tie wires and with precast mortar blocks or ferrous metal chairs, spacers, metal 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, metal pipe or wood blocks will not be permitted for the purpose of spacing or support. Where reinforcement spacing is less than 12 inches in each direction alternate intersections may be tied. Tack welding of reinforcement will only be permitted if reinforcement is deformed and conforms to the requirements of ASTM A 706.

Before placing the pier column and superstructure reinforcement, the Developer shall insure that the vertical reinforcing steel will not interfere with the horizontal cap reinforcing steel and tendon ducts. Reinforcing steel shall not be cut to facilitate installation.

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, 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 of the clearance shown on the plans.

In slabs or walls, long runs of bars may vary up to two inches in spacing; however, the specified number of bars shall be placed.

605-3.02 Splicing and Lapping:

All reinforcement shall be furnished in the full lengths indicated on the project plans. Splicing of bars will not be permitted except as shown on the plans.

The Developer may use either lap splices, full welded splices or mechanical connections for reinforcement bars up to and including bar size No. 11. Where the bar size exceeds No. 11, full welded splices or mechanical connections shall be used.

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 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.

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.

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:

Not Used

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.

The diameter of dowel holes shall be 1/4 inch 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.

SECTION 606 OVERHEAD SIGN STRUCTURES:

606-1 Description:

The work under this section shall consist of furnishing and installing overhead sign structures in accordance with the details shown on the plans.

606-2 Materials:

606-2.01 General:

Certificates of Analysis shall be submitted for all structural steel. Mill test reports for structural steel used as specified under Subsection 606-2.02 shall include the results of the Charpy V-notch impact test values.

606-2.02 Structural Shapes, Plates and Bars:

Shapes, plates and bars for trusses, columns and walkway assemblies of the sign structures shall be fabricated from structural steel conforming to the requirements of ASTM A 36.

Structural steel used for the fabrication of column or girder flanges, web plates and truss chord angles shall be in accordance with longitudinal Charpy V-notch impact test values specified in Subsection 604-2.01.

606-2.03 Tapered Tubes:

Tapered tube beams, arms and poles for the bridge single beam sign structures and for the cantilever double arm sign structures shall be fabricated from structural steel conforming to the requirements of ASTM A 595, Grade A.

606-2.04 Pipe Poles for Cantilever Truss:

Poles shall be welded or seamless steel pipe conforming to the requirements of ASTM A 53, Type E or S, Grade B.

606-2.05 Bolts, Nuts and Washers:

High-strength steel bolts, nuts and washers shall conform to the requirements of ASTM A 325. All other bolts and nuts shall conform to the requirements of ASTM A 307, and shall be furnished with commercial quality washers.

Anchor bolts for the sign foundations shall conform to the requirements of ASTM A 36.

All bolts, nuts, and washers, except high-strength bolts and anchor bolts, shall be cadmium plated in accordance with the requirements of ASTM B 766 or zinc plated in accordance with the requirements of ASTM B 633.

606-2.06 Concrete:

Concrete for all sign structure foundations shall be Class S (f'_c = 3,000 pounds per square inch) conforming to the requirements of Section 1006.

606-2.07 Reinforcing Steel:

Reinforcing steel bars shall conform to the requirements of ASTM A 615. Unless otherwise specified, steel bars meeting the requirements of ASTM A 706 may be substituted for ASTM A 615 steel bars. When ASTM A 706 bars are used, tack welding of the reinforcement will be permitted. Reinforcing steel wire shall conform to the requirements of ASTM A 82.

606-2.08 Nonshrink Grout:

Nonshrink grout shall conform to the requirements of the Corps of Engineers Specification for Nonshrink Grout CRD-C 621 and shall be approved by the Independent Quality Firm. Grout shall be mixed, handled and placed in accordance with the manufacturer's recommendations.

606-3 Construction Requirements:

606-3.01 Shop Drawings:

Prior to fabrication, the Developer shall submit shop drawings.

606-3.02 Fabrication:

Fabrication of component parts of the sign 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 the AASHTO Standard Specifications for Highway Bridges.

606-3.03 Welding:

Welding of tubular structural steel shall conform to the requirements of Section 10 of AWS D1.1-80, Structural Welding Code, of the American Welding Society. The welding of all other structural steel shall conform to Subsection 604-3.06.

606-3.04 Galvanizing:

All steel surfaces of sign structures shall be galvanized after fabrication. Galvanizing shall conform to the requirements of ASTM A 123 and A 153.

606-3.05 Foundations:

Reinforced concrete foundations for the sign structures shall be constructed to conform to the details shown on the plans and in accordance with the requirements of Subsection 609-1 through 609-3.

Concrete shall be placed, finished and cured in accordance with the requirements of Section 601.

SECTION 607 ROADSIDE SIGN SUPPORTS:

607-1 Description:

The work under this section shall consist of furnishing and installing roadside sign supports in accordance with the details shown on the plans.

607-2 Materials:

607-2.01 General:

Certificates of Analysis shall be submitted for breakaway sign post shapes

Certificates of Compliance shall be submitted for perforated sign posts and U-channel sign posts.

607-2.02 Breakaway Sign Post Shapes:

Posts shall be fabricated from structural steel conforming to the requirements of ASTM A 572, Grade 50 or ASTM A 588 at the option of the Developer. Base plates for the breakaway connections and friction fuse plates and back plates for the post hinge assembly shall be fabricated from the same type structural steel selected for the sign posts.

All plate holes shall be drilled and all plate notches shall be saw cut, except that flame cutting will be permitted provided all edges are ground. Flange holes shall be drilled or sub-punched and reamed. The posts shall be saw cut for the hinge and bolted as detailed on the plans.

Bolts, nuts and washers shall conform to the requirements of ASTM A 325.

Posts and plates shall be galvanized after fabrication in accordance with the requirements of ASTM A 123. Bolts, nuts and washers shall be cadmium plated in accordance with the requirements of ASTM B 766, or zinc plated in accordance with the requirements of ASTM B 633.

607-2.03 Perforated Sign Posts:

Single and telescoping perforated posts shall be square tube fabricated from galvanized sheet steel. The sheet steel shall have a thickness as shown on the project plans. Sheet steel shall conform to the requirements of ASTM A 653 for either SQ Grade 40 or SQ Grade 50 Class 1, and be galvanized in accordance with the requirements of Coating Designation G-90. The posts shall have a wall thickness, including coating, as shown on the plans.

Posts shall be welded directly in the corner by high frequency resistance welding or equal. The outside edges of the posts shall be scarfed as necessary to produce a standard corner radii of 5/32 ± 1/32 inch.

External welded surfaces and scarfed areas shall be re-galvanized after fabrication.

Holes 7/16 ± 1/64 inch in diameter shall be provided on one-inch centers along all four sides over the entire length of the post. The holes shall be laterally centered on the longitudinal centerline of each face. Hole positioning and spacing shall be the same on all four faces, such that the hole centerlines for each group of four holes shall pass through a common point on the longitudinal centerline of the tube. For telescoping posts, holes shall be in proper alignment to allow 3/8-inch diameter bolts to pass through the entire post.

The finished posts shall be straight and have a smooth, uniform finish. All consecutive sizes of posts shall be freely telescoping for not less than 10 feet of their length without the necessity of matching any particular face to any other face.

Perforated sign posts shall be manufactured by an approved manufacturer on the Department's Approved Products List (APL).

Bolts shall conform to the requirements of SAE Specification J 429, Grade 5, or ASTM A 449, Type 1. Nuts shall conform to the requirements of ASTM A 563, Grade A. Washers shall conform to the requirements of ASTM F 844.

Bolts, nuts and washers shall be zinc coated in accordance with the requirements of ASTM B 633 or cadmium plated in accordance with the requirements of ASTM B 766.

607-2.04 U-Channel Sign Posts:

U-channel posts shall be fabricated from rerolled rail steel or hot-rolled carbon steel bars.

Prior to rerolling the rail steel, the rail nominal weight shall be 91 pounds per yard and shall meet the requirements of ASTM A 1 pertaining to quality assurance.

Yield Point of the steel shall be 80,000 pounds per square inch minimum.

The cast heat analysis of the steel shall conform to the following requirements:

Element	Composition (Percent)
Carbon	0.67 - 0.82
Manganese	0.70 - 1.10
Phosphorus: Max.	0.04
Sulfur: Max.	0.05
Silicon	0.10 - 0.25

Posts shall be a uniform, modified, flanged channel-section as shown in the plans. Weight of the posts shall be three pounds per lineal foot, plus or minus five percent. The post shall be punched with continuous 3/8-inch diameter holes on one-inch centers. The first hole shall be one inch from top and bottom of post.

The post shall consist of two parts, a sign post and a base post. The sign post lengths shall be supplied in six-inch increments up to 12 feet as required for the installation location. The base posts shall be 42 inches in length, pointed at one end, and have at least eighteen holes in the base post, starting one inch from the top and continuing at one-inch increments.

Posts shall be machine straightened to have a smooth uniform finish, free from defects affecting their strength, durability, or appearance. All holes and rough edges shall be free from burrs. The permissible tolerance for straightness shall be within 1/16 inch in three feet.

Posts shall be galvanized after fabrication in accordance with the requirements of ASTM A 123. Bolts, nuts, washers and spacers shall be cadmium plated in accordance with the requirements of ASTM B 766 or zinc plated in accordance with the requirements of ASTM B 633.

U-channel base posts shall be driven into the ground to a depth of 38 inches. Where rock is encountered, the rock shall be cored, drilled or removed to a minimum diameter of eight inches and to a depth sufficient to place Portland cement concrete two inches below the bottom of the base post and fill the hole to within one inch of the top. Solid rock coring or drilling is not required to continue beyond 24 inches in depth regardless of the depth at which the rock is encountered. The base post may be cut at the bottom prior to being set in Portland cement concrete where rock does not permit use of full length base post.

607-2.05 Concrete:

Concrete for breakaway sign post foundations shall be Class B, conforming to the requirements of Section 1006.

Foundation stub posts shall be fabricated from the same type of steel selected for the appropriate sign posts

Reinforcing steel bars for breakaway sign post foundations shall conform to the requirements of ASTM A 615. Unless otherwise specified, steel bars meeting the requirements of ASTM A 706 may be substituted for ASTM A 615 steel bars. When ASTM A 706 bars are used, tack welding of the reinforcement will be permitted. Reinforcing steel wire shall conform to the requirements of ASTM A 82.

607-3 Construction Requirements:

Fabrication of the breakaway sign posts, stub posts and base plates shall conform to the requirements of Subsection 604-3.02, except that shop drawings will not be required.

Breakaway sign post lengths will be determined at the time of construction staking and will be determined prior to ordering fabrication of the sign posts.

Perforated and U-channel sign post lengths shall be determined by the Developer at the time of construction staking. Posts shall be cut to the proper lengths in the field. Splicing will be permitted for single perforated posts; however, splices will be limited to one per each post installation and the splicing shall be accomplished in accordance with the details shown on the plans. The minimum length of any spliced piece of post shall be two feet.

Foundations for the breakaway sign posts, perforated sign posts and when required, U-channel posts shall be constructed to the details and dimensions shown on the plans. Concrete shall be placed in accordance with the requirements of Section 601 or 922, as the case may be. Excavation shall conform to the requirements of Subsection 203-5.03(A).

Sign posts shall be erected plumb and shall be bolted to the foundation stub or base posts in accordance with the procedure specified on the plans.

SECTION 608 SIGN PANELS:

608-1 Description:

The work under this section shall consist of furnishing and installing sign panels in accordance with the details shown on the plans and the requirements set forth herein.

The sign panels shall be of the following types:

- Extruded Aluminum Sign Panels with Direct-Applied, Digitally-Imaged, or Demountable Characters

- Flat Sheet Aluminum Sign Panels With Direct-Applied, Digitally-Imaged, Electronic-Cut, or Screen-Printed Characters

- Warning, Marker, and Regulatory Sign Panels

- Route Shields for Installation on Sign Panels

- EXIT ONLY Panels for Installation on Sign Panels

608-2 Materials:

608-2.01 General:

Certificates of Compliance shall be submitted for all materials required for fabricating sign panels, including retroreflective sheeting.

Shipment, storage, and handling of sign panels shall conform to the recommendations of the manufacturers of the sign panel components. Fabricated signs and overlay sheets shall be shipped on edge. Damage to the sign panel or legend resulting from banding, crating or stacking may be cause for rejection of the signs.

Signs shall be fabricated in accordance with the recommendations established by the manufacturer of the sign sheeting. All processes and materials used to make a sign shall in no way impact the performance, uniform appearance (day and night), or durability of the sheeting, or invalidate the sign sheeting manufacturers' warranty.

All sheeting used for background and legend shall be from the same manufacturer. Sign panels shall not be overlaid.

All text and numerals shall all be installed at the same orientation: either zero degrees or 90 degrees.

Design of letters and numbers shall be in accordance with the project plans with a tolerance of ± 1/16th of an inch.

The Developer shall not paint the bolts or the washers unless otherwise specified.

608-2.02 Extruded Aluminum Sign Panels With Direct-Applied, Digitally-Imaged, or Demountable Characters:

Panels shall be fabricated from 12-inch wide aluminum extrusions formed from Aluminum Alloy 6063-T6 conforming to the requirements of ASTM B 221 and fastened together by bolt connections as shown on the plans.

Panel facing shall be covered with retroreflective sheeting of the color specified on the plans. The retroreflective sheeting shall conform to the requirements of Section 1007.

The letters, numerals, symbols, borders and other features of the sign message shall be direct-applied, digitally-imaged, or demountable, and shall conform to the requirements of Subsection 608-2.14, Demountable Characters, Subsection 608-2.15, Screen-Printed, Direct-Applied, or Electronic-Cut Characters, or Subsection 608-2.16, Digitally-Imaged Characters.

Panel surfaces to be covered with retroreflective sheeting shall be prepared in accordance with the recommendations of the sheeting manufacturer. Panel surfaces not covered with sheeting shall be etched in accordance with the recommendations of the extrusion manufacturer to reduce glare from reflected sunlight.

After all fabrication has been completed, including the cutting and punching of holes, except holes for demountable letters, numerals, symbols and borders, the aluminum extrusions shall be degreased and the retroreflective sheeting shall be applied.

Aluminum extrusions shall be flat with 1/4 inch of tolerance allowed in an eight-foot length, with proportionally greater tolerances permitted on lengths greater than eight feet. Flatness tolerance across the face of each extrusion shall be 0.5 percent of the width.

Aluminum extrusions shall be bolted together on 12-inch centers with a maximum allowable gap of 1/32 inch between extrusions.

Shop fabricated sub-assemblies shall be rigidly braced for transportation and erection. Hardware utilized to fasten panels to supports shall conform to the panel manufacturer's recommendations.

Each completed sign panel shall be provided with a side trim molding fabricated from extruded Aluminum Alloy 6063-T6 conforming to the requirements of ASTM B 221. The trim molding shall be fastened to each individual 12-inch aluminum extrusion with two 5/32-inch diameter self-plugging aluminum blind rivets, 2-1/2 inches from either edge. The exposed surface of the side trim molding shall be treated by etching as recommended by the manufacturer to reduce glare from reflected sunlight.

Each completed sign panel shall be shipped with sufficient bolt clamps placed to install the panel on the sign posts as shown in the plans. Bent bolt channels will be cause for rejection of the sign panel.

608-2.03 Blank

608-2.04 Blank

608-2.05 Blank

608-2.06 Blank

608-2.07 Flat Sheet Aluminum Sign Panels With Direct-Applied, Digitally-Imaged, Electronic-Cut, or Screen-Printed Characters:

Panels shall be fabricated from 0.125-inch thick 5052-H36, or 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209.

Panel facing shall be prepared and covered with retroreflective sheeting in accordance with the recommendations of the sheeting manufacturer. The color of the sheeting shall be as specified on the plans or as shown in the Manual of Approved Signs.

All surfaces not covered shall be etched to reduce glare from reflected sunlight.

The retroreflective sheeting shall conform to the requirements of Section 1007. Splicing of retroreflective sheeting shall not be allowed on sign panels having a minimum dimension up to and including four feet.

Messages shall be reflectorized white or, if called for on the plans, opaque black, and shall be produced by either screen printing, direct-applying, digital imaging, or electronic cutting, as specified under Subsections 608-2.15 and 608-2.16.

608-2.08 Blank

608-2.09 Warning, Marker, and Regulatory Sign Panels:

Panels shall be fabricated from flat sheet aluminum and shall be reflectorized as specified herein.

Panels shall be fabricated in one piece from 0.125-inch thick 5052-H36, 5052-H38, or 6061-T6 Aluminum Alloy conforming to the requirements of ASTM B 209.

All surfaces of panels to be covered with retroreflective sheeting shall be prepared in accordance with the recommendations of the sheeting manufacturer. Surfaces not covered shall be etched to reduce glare from reflected sunlight. Retroreflective sheeting shall conform to the requirements of Section 1007.

Warning signs shall be reflectorized with fluorescent yellow retroreflective sheeting.

Regulatory signs shall be reflectorized with white retroreflective sheeting.

Reflectorized red signs shall be reflectorized with white retroreflective sheeting. The red color shall be produced by screen printing.

Regulatory signs with reflectorized red circles and slashes shall be reflectorized with white retroreflective sheeting. The red color shall be produced by screen printing.

Interstate route markers shall be cut to shape. The colors and legend shall be as shown on the plans and shall be reflectorized with white retroreflective sheeting. The Interstate route colors shall be screen-printed. The numerals may be screen-printed, electronic-cut, or direct-applied characters.

United States, State Route, and Cardinal Direction markers shall be reflectorized with white retroreflective sheeting unless otherwise shown on the plans.

Splicing of retroreflective sheeting shall not be allowed on sign panels having the minimum dimension up to and including four feet.

608-2.10 Blank

608-2.11 Route Shields (For Installation on Sign Panels):

Route shields may be demountable, direct-applied, or digitally-imaged.

Demountable route shields shall be cut to shape and shall consist of 0.063-inch thick, 5052-H36, or 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209. The aluminum shall be degreased and etched in accordance with the recommendations of the sheeting manufacturer. Retroreflective sheeting shall be white and shall conform to the requirements of Section 1007. Route shields shall be attached to the sign panel with self-plugging aluminum blind rivets.

608-2.12 EXIT ONLY Panels (For Installation on Sign Panels):

EXIT ONLY panels may be demountable, direct-applied, or digitally-imaged. Demountable EXIT ONLY panels shall be attached to the sign panel with self-plugging aluminum blind rivets.

Demountable EXIT ONLY panels shall be fabricated from 0.063-inch thick, 5052-H36 or 5052-H38 Aluminum Alloy conforming to the requirements of ASTM B 209 with fluorescent yellow retroreflective sheeting adhered to the face side. The aluminum shall be degreased and etched in accordance with the recommendations of the sheeting manufacturer. Retroreflective sheeting shall conform to the requirements of Section 1007.

608-2.13 Retroreflective Sheeting, Inks and Opaque Film:

Retroreflective sheeting, sign-making inks, and opaque films shall conform to the requirements of Section 1007.

608-2.14 Demountable Characters:

(A) General:

Letters, numerals, symbols, route shields, borders, and other features of the sign message shall consist of cut-out, flat sheet aluminum legends, with direct-applied sign sheeting or other finishes, that are mounted to the sign panel with rivets as described herein. All characters shall be placed on the signs in a straight and true fashion.

Flat sheet aluminum substrates used for characters and borders shall be either aluminum alloy 3105-H14, 3003-H14, 5052-H36, or 5052-H38 as specified in ASTM B 209. Characters produced from the flat sheet aluminum alloy shall sit flat on the face of the sign panel without visible gap or deformation.

The thickness for letters and numbers shall be 0.032 inches. The thickness for symbols, route shields, and borders shall be 0.063 inches.

All aluminum shall be chemically treated with a chromate acid conversion type coating, or equivalent, to form an oxidation resistant barrier film that is suitable for long term outdoor application. The coating shall prevent the occurrence of oxidation that may cause streaking or discoloration on the sign. The coating shall be applied in accordance with the manufacturer's specifications, and shall have a minimum thickness of 0.002 inches.

All corners and edges of the characters shall be clean and well-defined with no apparent waviness, tears, delamination, deformation or flaws. Burrs and waste material generated from the cutting process shall be removed so characters have a clean, flat, and correct appearance.

Design of letters and numbers shall be in accordance with the project plans.

Splicing of aluminum panels will be acceptable for diagrammatic arrows or other large symbols and shields exceeding 48 inches in more than one direction. Splices, when required, shall include a continuous four- to six-inch wide aluminum back plate that overlaps the joint. The back plate shall ensure no gap at the splice joint when the symbol is assembled and attached to the sign.

Borders on signs with demountable characters shall also be made of aluminum substrate panels, unless otherwise specified. However, in all cases borders on signs with demountable characters shall be made of the same material as the legend.

(B) Sheeting and Colors:

Sheeting or film applied to demountable characters shall be a continuous monolithic piece, without splice or patch, that covers the entire front face of the character. Splicing of the sheeting for demountable borders or characters which have a dimension larger than 48 inches in more than one direction will be allowed. Only one splice shall be allowed every four feet. When a splice is necessary, the adjoining edges shall be placed so there is no visible gap between the two pieces.

The adhesive system for sheeting and opaque films shall form a durable bond which tightly adheres to the aluminum or sign background. After attachment, the sheeting and opaque films shall not discolor, crack, craze, blister, bubble or delaminate. Sheeting and film adhesives must be warranted by the manufacturer against such defects as specified in Section 1007. Only those sheeting and film products which provide the specified warranty will be acceptable.

The color for demountable letters, numbers, symbols, and route shields on green, blue, and brown background signs shall be white, and shall conform to the requirements of Section 1007. Demountable legends on white and yellow background signs shall be black, and shall be opaque and non-reflective. Black characters shall be finished with laminated black opaque acrylic film.

When borders are used with demountable characters, white legend and border shall be used on green, blue, or brown sign backgrounds, and black legend and border shall be used on white or yellow sign backgrounds. Sign sheeting conforming to Section 1007 shall be used for white borders. Black borders shall be laminated black opaque acrylic film.

Laminated black opaque acrylic film to be used for characters or borders, as specified above, shall be applied in accordance with the coating manufacturer's recommendations. The contractor shall provide copies of any warranties provided by the manufacturer to the Engineer.

On combination signs, such as a green background sign with white characters that also includes a smaller panel with yellow background and black characters, the color scheme used for the characters and border for each portion of the sign shall be as specified above, i.e. white legend and border shall be used on the green background portion of the sign and black legend and border shall be used on the yellow background portion.

(C) Attachment of Characters and Borders:

Self plugging aluminum, protruding, regular head blind rivets shall be used to secure all demountable characters. The rivets shall conform to the applicable requirements of International Fasteners Institute (IFI) 114 standard for break mandrel blind rivets. All rivets shall be 5/32 inch in diameter with the appropriate grip range.

Rivets shall be either IFI 114 Grade 10 or 11 aluminum alloy rivets. The rivets shall have an ultimate shear and tensile strength that has been determined by IFI 135 Specification 2.1 and 2.2. The ultimate shear and tensile strength shall meet or exceed those values specified for a 5/32 inch (0.1562) nominal rivet diameter per IFI 114 Table 6 for Grades 10 or 11. A higher strength and grade aluminum rivet can be used at the option of the sign fabricator.

Rivets securing the characters to the back panel shall be of sufficient length to ensure a secure attachment and conform to the grip length specifications of the rivet manufacturer. The determination of rivet grip length shall include the total thickness of the joint. This thickness shall include the character (sheeting and aluminum sheet), spacer (if applicable) and the sign back panel (sheeting and aluminum extrusion).

The hole size used to install the rivets shall conform to the recommendation of the rivet manufacturer and Table 2 of IFI 114. Rivets shall be placed a minimum of four times the diameter of the rivet from the edge of the character being attached, e.g., 5/8 inch clearance for a 5/32 inch diameter rivet. Clearance shall be measured to the outside of the rivet head.

Minimum requirements for attaching demountable characters shall be as follows:

Straight numerals and letters such as "1" shall have three rivets, one at the top, middle and bottom. The more complex numerals and letters shall have from four to seven rivets. Letters such as "W" and "M" typically require seven rivets. Letters and numerals such as "P", "H" and "9" typically require six rivets. Letters and numerals such as "G", "S", "2", "3" and "7" typically require five rivets. A rivet shall secure each corner of the letter or numeral. For shields and symbols, rivets shall be spaced evenly around the entire perimeter. Additional rivets shall be added in the middle of the shield or symbol as necessary to eliminate bowing. Rivets for borders shall be spaced evenly around the border.

The actual number of rivets used will depend on the thickness, configuration, weight, position (with or without spacers), size of the character being attached, and the recommendations of the rivet manufacturer. The number and location of rivets shall be sufficient to secure the character to the panel so it shall not miss-align, bend or move when subjected to wind loading. Additionally, the number of rivets used shall ensure that the character does not bow or pull away from the back panel for the life of the sign. Rivets shall be placed in a defined, evenly spaced pattern which is consistent from character to character. The placement and pattern of rivets shall not interfere with the appearance of the sign from normal drive-by viewing distances. The contractor shall supply standard punch details prior to fabrication.

The protruding head and shaft of the rivets shall closely match the color of the character on which they are being applied, e.g., black characters shall be applied with black rivets. Aluminum colored rivets are acceptable for mounting white characters.

The coating used to color the rivets shall be a factory-applied anodized type finish, or equivalent, that is suitable for long term outdoor application. The coating shall have durable colorfastness and shall be capable of preventing the occurrence of oxidation that may cause streaking or discoloration on the sign. Non-factory painting of the protruding heads of the rivets is not acceptable.

608-2.15 Screen-Printed, Direct-Applied, and Electronic-Cut Characters:

Screen-printed letters, numerals, arrows, symbols, and borders, shall be applied on the retroreflective sheeting background of the sign by direct or reverse screen process. Messages and borders of a color darker than the background shall be applied to the retroreflective sheeting by direct process. Messages and borders of a color lighter than the sign background shall be produced by the reverse screen process.

Opaque or transparent colors, inks, and paints used in the screen process shall be of the type and quality recommended by the manufacturer of the retroreflective sheeting.

The screening shall be performed in a manner that results in a uniform color and tone, with sharply defined edges of legends and borders and without blemishes on the sign background that will affect intended use.

Signs, after screening, shall be air dried or baked in accordance with the manufacturer's recommendations to provide a smooth hard finish. Any signs on which blisters appear during the drying process will be rejected.

Direct-applied letters, numerals, symbols, borders, and other features of the sign message shall be cut from black opaque or retroreflective sheeting of the color specified and applied to the retroreflective sheeting of the sign background in accordance with the instructions of the manufacturer of the retroreflective sheeting.

Direct-applied legend may be moved vertically 1/2 inch to avoid placing only a small amount of material over the adjacent extruded panel. The bottom of all characters for a line of legend shall line up within 1/8 of an inch.

Electronic-cut characters shall be cut from translucent acrylic sheeting using computerized automated cutting processes.

608-2.16 Digitally-Imaged Characters:

Digitally-imaged characters shall consist of characters produced through ultraviolet jet-printing or thermal transfer. Signs with digitally-imaged characters shall be manufactured using matched component ink, transparent electronic-cuttable film, and/or overlay film as supplied by the reflective sheeting manufacturer. For digitally-imaged copy on white sheeting, the coefficient of retroreflection shall be not less than 70 percent of the original values for the corresponding integral color. When characters are spread over two adjacent extruded panels, the characters shall align with each other within 1/16th of an inch.

608-3 Construction Requirements:

608-3.01 Fabrication:

Fabrication of the sign panels shall be in accordance with the details shown on the plans and the requirements of these specifications. If additional details for sign panel fabrication are required, the Developer shall submit shop drawings.

Panels shall be cut to size and shape and shall be free of buckles, warps, dents, cockles, burrs and defects resulting from fabrication.

Fabricated signs shall be stored indoors and kept dry during storage. If packaged signs become wet, all packaging material shall be removed immediately and the signs allowed to dry. The signs may be repackaged using new dry materials. If outdoor storage is necessary, all packaging materials shall be removed. Signs shall be stored on edge, above ground, in an area where dirt and water will not contact the sign face. Materials used to support stored signs shall not contact sign faces.

During fabrication of the sign panels, the Developer shall ensure the bolt holes on each sign panel are placed so the holes will not coincide with any legend and any bolts, washers, or other hardware used will not cover any portion of the legend. If the bolt holes on a sign panel do not comply with these requirements, the Inspector may reject the sign panel or accept the sign panel and require the Developer to paint the bolts, washers, and any hardware coinciding with the sign legend to match the color of the legend.

608-3.02 Installation of Sign Panels:

The sign panels shall be installed on overhead sign structures and roadside sign supports in accordance with the recommendations of the manufacturers of the sign panel components.

Minor scratches and abrasions resulting from fabrication, shipping and installation of panels may be patched; however, patching shall be limited to one patch per 50 square feet of sign area with the total patched area being less than five percent of the sign area. Panels requiring more patching than the specified limit will be rejected. Patches shall be edge sealed by a method approved by the retroreflective sheeting manufacturer.

Sign panels shall be attached to the posts with hex head bolts; slotted head bolts shall not be used. A cadmium-plated or zinc-plated fender washer shall be placed between the bolt head and panel face.

For flat sheet panels, bolts shall be fastened with a cadmium-plated or zinc-plated fender washer and two standard nuts. Nylon washers shall not be used. The fender washer shall be placed against the sign post, the first nut shall be tightened against the fender washer, and the second nut shall be tightened against the first nut. Bolts shall be tightened from the back by holding the bolt head stationary on the face of the panel. Twisting of the bolt head on the panel face will not be allowed.

SECTION 609 DRILLED SHAFT FOUNDATIONS:

609-1 Description:

609-1.01 General:

The work under this section shall include furnishing all materials and constructing reinforced concrete shafts formed within a drilled excavation. Each drilled shaft foundation shall consist of a shaft section with or without casing left in place, as directed or specified, with or without a rock socket or a belled footing, and shall be constructed in reasonably close conformity with the details and dimensions shown on the plans and the requirements of these specifications.

609-1.03 Installation Plan:

The Developer shall provide to the Engineer for review and approval a detailed installation plan containing the following information:

(1) List of proposed equipment to be used including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, sampling equipment, tremies or concrete pumps, casing, etc.

(2) Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.

(3) Details of shaft excavation methods, including equipment and procedures for checking the dimensions and alignment of each shaft excavation.

(4) When slurry is required, details of the method proposed to mix, circulate and desand slurry, and methods proposed.

(5) Details of methods to clean the shaft excavation.

(6) Details of reinforcement placement, including support and centralization methods, lifting equipment, and staging location for tied steel reinforcement cages prior to placement.

(7) Details of concrete placement, including concrete volumetric charts.

(8) Details of casing dimensions, material and splice details.

(9) Details of concrete mix designs and mitigation of possible loss of slump during placement.

(10) List of work experience in previous similar projects.

(11) Other information shown on the plans or requested by the Engineer.

(12) Emergency horizontal construction joint method if unforeseen stoppage of work or interruption in concrete delivery occurs.

(13) Details of any special access or setup requirements needed to position the drill equipment to advance excavations.

Light standard and sign post foundations four feet in diameter and less and 30 feet in length and less shall be exempt from the requirement to submit an installation plan, conduct a drilled shaft preconstruction meeting, construct a confirmation shaft and conduct integrity testing.

609-2 Materials:

609-2.01 Concrete:

Concrete shall conform to the requirements of Section 1006 for the design criteria shown on the plans, with the following additions or modifications:

(A) Cement:

Where concrete is placed in drilled shaft excavations containing slurry or water, the cement content of the concrete shall be between 660 and 750 pounds per cubic yard.

(B) Aggregate:

Maximum aggregate size shall be limited to 1/5 of minimum clear bar spacing (vertical and horizontal), not to exceed 3/4 inch for drilled shafts constructed with a wet method or with temporary casing (excluding collar-only casings), and one inch for drilled shafts constructed with a dry method.

(C) Air-Entraining Admixtures:

Air-entraining admixtures may be used at the option of the Developer.

609-2.02 Reinforcing Steel:

Reinforcing steel shall conform to the requirements of Section 1003. Grade 75 steel bars meeting all requirements of these Specifications will be allowed. The Developer's installation plan shall specify whether all bars are to be Grade 75, or mixed with other grades. Welded splices will not be allowed except as shown on the plans.

609-2.03 Casing:

Permanent casings may be used in accordance with the requirements shown on the project plans.
Casing shall be steel and may be of unit or sectional construction. The casing shall be of sufficient strength to withstand handling and driving stresses, to withstand the pressure of concrete and the surrounding earth and to prevent seepage of water. Steel shall conform to the requirements of ASTM A 36.Temporary casing shall be clean, inside and out, prior to placement in the excavation. All casing shall be handled so as to limit distortion to plus or minus two percent of diameter.

609-3 Construction Requirements:

609-3.01 General:

The allowable methods are the dry method, wet method, temporary casing method or permanent casing method, or a combination of these methods may be used.

609-3.03 Excavation:

The Developer shall perform all excavation required for the shafts or rock sockets, through whatever substances encountered, to the dimensions and elevations shown on the plans. Unless otherwise shown on the plans, the maximum deviation from plumb shall be not more than one and one half percent. The maximum permissible variation of the design center axis for both the borehole and rebar cage at the top shall be five percent of the shaft diameter, not to exceed three inches from its project plan location. The Developer shall determine plumbness by plumb lines in dry excavations and by Kelly bar position readings at 10-foot intervals in wet excavations.

If satisfactory material is not encountered at plan elevation, the bottom of any shaft excavation may be lowered. Reinforcing steel, integrity testing tubes and concrete shall not be placed in the shaft until this final elevation has been established by measurement. If the bottom of the drilled hole is lower than the plan elevation, the integrity testing tube lengths shall be adjusted per the requirements of Subsection 609-3.05 (B) (1) to ensure the bottom of the tubes are within 6” of the bottom of the excavated bottom of the drilled hole. The drilled shaft reinforcing cage is not required to be extended except to keep the unsupported length of the tubes to 3 feet or less.

If caving conditions are encountered, no further drilling will be allowed until a construction method is employed that will prevent excessive caving and which is acceptable to the Engineer. If casing is proposed, the shell shall be clean and shall extend to the top of the drilled shaft excavation. The inside diameter of the casing shall not be less than the specified size of the shaft.

Temporary or permanent surface casings may be used to aid shaft alignment and position, and to prevent sloughing of the top of the shaft excavation as described on the project plans. The annular space shall be backfilled as described on the plans using appropriate equipment to place the cement-treated aggregate slurry from the bottom of the annular space and working upwards to ensure the space is completely filled and free of large voids or trapped air pockets. A free fall tailgating method may be used if it can be demonstrated that the annular space can be filled from the bottom working up. If necessary, the aggregate slurry may be vibrated to ensure adequate consolidation. Aggregate slurry shall meet the requirements of Subsection 501-3.04.If the use of drilling slurry is to be employed, either with or without the use of casing, the contractor shall use a method of construction which will allow completion of the drilled shaft in a continuous manner without any mixing of concrete and drilling slurry.

After the completion of the drilled shaft excavation and prior to the placement of the reinforcing steel cage and concrete, all loose material shall be machine cleaned from the shaft.

609-3.04 Drilling Slurry:

(A) General Requirements:

The Developer shall provide a manufacturer's representative with experience in the slurry drilling process to design and monitor the slurry. The manufacturer's representative shall be present at all times while the slurry method is under development, and shall supervise the testing. Once a method that consistently produces acceptable excavations has been developed, the Developer may substitute one of its employees for the representative provided that the employee has been suitably trained in the procedure. The Developer shall also ensure that the manufacturer's representative remains available to return to the site and supervise changes to the drilling slurry if needed.

Only commercially prepared mineral slurries or synthetic slurries shall be employed when slurry is used in the drilling process. Mineral slurry shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. For all slurries the percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. During construction, the level of the mineral slurry in the shaft excavation shall be maintained at a level not less than five feet above the highest expected piezometric pressure head along the depth of the shaft. The level of polymer slurry shall be maintained at or near the ground surface or higher, if required to maintain boring stability. Unless otherwise approved in advance by the Engineer, slurry shall be injected into the excavation immediately upon encountering ground water. No further excavation shall be completed until slurry has been introduced into the boring. In the event of a sudden significant loss of slurry to the hole, the construction of that foundation shall be stopped until either a method to stop slurry loss or an alternative construction procedure has been approved by the Engineer.
The slurry shall be premixed thoroughly with clean, fresh water. Adequate time, as prescribed by the slurry manufacturer, shall be allotted for hydration prior to introduction into the shaft excavation. Slurry tanks of adequate capacity shall be required for slurry circulation, storage, and treatment. No excavated slurry pits shall be allowed in lieu of slurry tanks. No mixing of slurry shall be allowed in the drilled shaft excavation. Slurry shall

not stand for more than four hours in the excavation without agitation. If this is not possible, excavation sidewalls shall be cleaned to remove filter cake. Mineral slurry density shall be increased by adding barite only when sodium bentonite is the mineral.

(B) Slurry Inspection and Testing:

The contractor shall have suitable apparatus available at the site capable of obtaining slurry samples at any depth within the drilled shaft excavation. All equipment required for the tests specified in this section shall be provided by the contractor, and the tests shall be performed by the contractor under the observation of the Inspector.

Tests to determine density, viscosity or yield point, and pH value shall be done by the Developer during the shaft excavation to establish a consistent working pattern. A minimum of four sets of tests shall be made during the first eight hours of slurry use. When the results show consistent behavior, the testing frequency may be decreased to one set every four hours of slurry use.
The Developer shall ensure that heavily contaminated slurry suspension, which could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Developer shall take slurry samples using a sampling tool suitable for recovery of slurry samples at any desired elevation in the excavation. Slurry samples shall be extracted from the base of the shaft and at 10 feet up the shaft until samples produce acceptable values for density, viscosity or yield point, pH, and sand content.

When any slurry samples are found to be unacceptable, the Developer shall take whatever action is necessary to bring the slurry within specification requirements. Concrete shall not be placed until resampling and testing results produce acceptable values.

Reports of all tests required above, signed by an authorized representative of the Developer, shall be furnished to the Inspector on completion of each drilled shaft.

609-3.05 Integrity Testing

(A) General:

Developer shall preform integrity testing on each drilled shaft foundation completed by a wet excavation method, 10 percent of the shafts on a bridge constructed using the dry excavation method (2 tests minimum per bridge) and all drilled shafts supporting straddle bents and single column piers. Integrity testing must include cross-hole sonic logging survey, in accordance with ASTM D6760, and a gamma-gamma logging survey, in accordance with ASTM D6274. If a defect is found in a drilled shaft constructed using the dry excavation method and tested as part of the 10 percent of the shafts on a bridge, all drilled shafts for that bridge shall be tested.

The Developer shall furnish and install 2-inch Schedule 80 PVC pipes for the surveys as shown on the plans. The pipes shall be joined to provide a clean, watertight, and unobstructed opening as specified in Subsection 609-3.05(B). If testing cannot be performed because of blockage of the tubes, the Developer shall core drill or otherwise determine the extent of any potential anomalies in the concrete.

Cross-hole sonic log testing and gamma-gamma log testing shall be performed by a qualified subcontractor selected by the Developer. The subcontractor performing the gamma-gamma logging shall provide proof that it is licensed to possess and use radioactive material in accordance with the Arizona Radiation Regulatory Agency. Recorded measurements shall be interpreted and the required reports shall be prepared and sealed by a licensed professional engineer, registered in the State of Arizona.

Integrity testing shall be performed no sooner than 24 hours after placement of the concrete. Cross-hole sonic logging tests shall be completed within four days after concrete placement, and gamma-gamma tests shall be completed within seven days of concrete placement.

The cross-hole sonic logging survey and the gamma-gamma survey requirements shall be as specified in Subsection 609-3.05(B). Inspection reports containing the acquired raw data, and evaluation reports, shall be provided as specified in Subsection 609-3.05(B). All reports shall be provided to the Independent Quality Firm within three days of test completion.

If the testing indicates the presence of anomalies, as defined herein, or the Engineer determines that construction defects may have occurred, the Developer shall conduct remedial testing and make repairs, as specified in Subsection 609-3.05(B)(4).

Concrete volumetric charts shall be completed for every drilled shaft.

After all inspection has been completed, all holes and test pipes in all drilled shaft foundations shall be filled with an approved grout from the bottom up.

(B) Testing Requirements:

(1) General:

The inspection tubes shall have a round, regular, internal diameter free of defects or obstructions, including at any pipe joints, in order to permit the free, unobstructed passage of source and receiver probes from top to bottom. The tubes shall be watertight and free from corrosion, with clean internal and external faces, to ensure passage of the probes and to ensure a good bond between the concrete and the tubes. Standard glue-on PVC couplings shall be used. No compression, rubber, or clamp fittings will be allowed. Care shall be taken during reinforcement installation operations to not damage the tubes or break the fasteners of the tubes. Before placement of concrete, pipes shall be checked to ensure they are free from blockages, bends, crimps or other impediments to the free passage of the testing probes. The tubes' exterior surfaces shall be roughened by abrasion prior to installation to ensure a good bond between the tube surface and surrounding concrete.

Each pipe shall be fitted with a watertight shoe on the bottom and a removable cap on the top. The bottom cap of each tube shall be adequately secured such that it can withstand the hydrostatic pressure for the full depth of the shaft without water leakage. The pipes shall be securely attached to the interior of the reinforcement cage in a straight line, and in a regular, symmetrical pattern. The tubes shall be adequately secured to the reinforcing cage such that the tubes stay in position during placement of the rebar cage and concrete placement. At a minimum, the tubes shall be securely fastened to the reinforcing cage at least every 10 feet vertically. Tubes that are required to extend below the bottom of the reinforcing cage may be unsupported for up to 3 feet. Additional support reinforcing shall be added to keep this unsupported length within this requirement for tubes that are required to extend more than 3 feet below the bottom of the reinforcing cage. The tubes shall be as near to vertical and parallel as possible. The tubes shall extend from within 6 inches of the excavated bottom of the drilled shaft to at least four feet above the shaft top or two feet above the ground surface if the shaft top is below ground. Under no circumstance shall the tubes be allowed to rest on the bottom of the drilled excavation. Any joints required to achieve full length tubes shall be made watertight. Care shall be taken to not damage the tubes during reinforcement installation operations in the drilled shaft hole.

The tube tops shall be bare clean pipe (no pipe joints), level cut, and capped to keep debris out of the tubes. If the rebar cage extends above the top of the tubes, the circular or spiral tie-raps shall temporarily be cleared away from one foot below the tube top to approximately three feet above. After placement of the reinforcement cage and not later than 1 hour after concrete placement, the tubes shall be filled with clean water. Care shall be exercised in the removal of caps or plugs from the pipes after installation so as to not apply excess torque, hammering, or other stresses which could break the bond between the tubes and the concrete.

Before the start of testing:

- Run a 1.5" diameter six-foot long rigid cylinder through the complete length of each access tube to check for tube blockage.
- Clean the top of the shaft. The shaft top shall serve as the reference zero depth for all cross-hole sonic and gamma-gamma testing. Therefore, the shaft top must be level and, if mud covered, be cleaned before testing.
- Provide proper access to each access tube.
- Provide any special safety equipment required.
- Make sure the access tubes extend to at least four feet from the top of the concrete, and are capped and filled with water all the way to the top.
- Make sure each access tube is bare (no pipe joints) clean pipe (grind edges and concrete residue), level cut, and capped.
- Provide an independent and stable source of 110 Volt, 1000-Watt power.
- Using a permanent pen marker, mark each access tube with the shaft designation and tube number. For example, P2S3-T4 denotes Pier 2 Shaft 3 Tube 4. By definition, Tube 1 is the Northernmost tube, with other tubes

referenced in a clockwise direction from Tube 1. Tube 1 shall also be marked in the field with paint.

- Provide documentation that the testing equipment has been calibrated and is functioning properly.

(2) Requirements for Cross-hole Sonic Logging (CSL) Tests:

The minimum equipment requirements for cross-hole sonic logging shall be as follows:

(a) The ultrasonic source and receiver probes shall be capable of producing records with good signal amplitude and energy through uniform, good quality concrete. The probes shall be of a diameter and have cabling such that they descend freely through the two-inch internal diameter Schedule 80 PVC pipe for the full depth of the access tubes shown on the plans. Probes shall allow a generated or detected pulse within four inches of the bottom of the access tubes, and the transmitter probe shall generate an ultrasonic pulse with a minimum pulse frequency of 40,000 Hz. The weight of each probe shall in all cases be sufficient to allow it to sink under its own weight in the access tubes. The probe housing shall be waterproof to at least 1.5 times the maximum depth of the testing. The receiver probe shall be of a similar size and compatible design to the transmitter probe, and be used to detect the arrival of the ultrasonic pulse generated by the transmitter probe. The functionality of the CSL equipment shall be checked according to the manufacturer's operation instructions. Check that CSL test equipment and probes are functioning correctly prior to actual testing by verifying that ultrasonic pulses are received in the recording apparatus. Provide documentation, to the Inspector prior to beginning testing, that the testing equipment has been calibrated and is functioning properly.

(b) The depth of the probes shall be recordable with a measurement wheel or other suitable measuring device.

(c) The cross-hole sonic logging equipment shall include a microprocessor-based system for analog to digital conversion and recording of data, for display of individual records, and for analysis of receiver responses and printing of logs.

(d) The cross-hole sonic logging system shall have an appropriate filter for amplification of data and cable systems.

(e) Synchronized triggering of the recording system with the ultrasonic pulse shall be a feature of the cross-hole sonic logging system.

(f) The system shall be able to indicate zero depth at the shaft top and not at the bottom of access tubes. In addition, the system shall be able to log both from the top of the shaft to the bottom as well as from the bottom to the top.

(g) The winch unit shall be motorized and capable of recording logging speed in the data records.

The minimum testing procedure requirements for cross-hole sonic logging shall be as follows:

(a) **Preparation of the tubes for Cross-hole Sonic Logging Tests:** All inspection tubes shall be filled with water prior to testing. During testing, the water level in any tube shall not drop below the top of the tube.

(b) **Cross-hole Sonic Logging Procedure:** Information on the shaft bottom and top elevations, tube lengths and position, along with construction dates, shall be provided by the Developer to the cross-hole sonic logging subcontractor prior to the logging being performed.

All possible tube pairs shall be tested. The tests shall be carried out with the source and receiver probes in the same horizontal plane unless test results indicate potential defects, in which case the questionable zone shall be further evaluated with angled tests (source and receiver vertically offset in the tubes).

The electronic circuit shall be thoroughly checked. The choice of time base will be such that the "zero signal" and first arrival time are 2-3 divisions apart on the horizontal axis. Amplitude shall be such that the signal fills 2/3 to 3/4 of the screen vertically.

Once the slack is taken up out of the cables to provide accurate depth measurements of the logs, the probes shall be pulled simultaneously and uniformly with a motorized winch from the bottom of the tubes over the depth wheel or other measuring device. All slack shall be taken out of the cables before the analyzer is switched on. The speed of ascent should be less than 20 to 25 feet per minute. The cross-hole sonic measurements shall be taken at two-inch intervals or less from the bottom to top of shaft.

(c) **Anomaly Identification:** Anomaly in a drilled shaft shall be determined by evaluating the pulse arrival times and amplitude/energy signals. Zones where the measured sonic velocity is 10 percent or more lower than the local mean measured sonic velocity within a five-foot interval above and below the suspected anomalous zone shall be reported to the Engineer. The Engineer may require further tests such as offset elevation cross-hole sonic logging or tomographic testing to evaluate the extent of such defects.

(d) **Cross-hole Sonic Logging Results:** Results of the cross-hole sonic logging completed at a given substructure element shall be submitted to the Independent Quality Firm in a report(s) within three working days of completion of testing at that given substructure element. The report shall include:

1. Dates of shaft construction; shaft diameters; shaft lengths; shaft tip elevations; shaft cutoff elevations; permanent casing placement, including top and bottom elevations; type and size of drilling equipment; type of slurry if used; description of concrete mix; reinforcement details, including top and tip elevations; inspection tube placement, including top and tip elevations; concrete placement method; shaft layout with shaft numbers.

2. Dates of logging; brief description of the testing equipment; location of obstructions in PVC tubes; location of PVC couplers; calibration date, data and plot; summary of any unusual occurrences during testing; description and explanation of adjustments made to instrumentation or data (if any); identification of anomalies using the criteria described herein; delineation of affected tubes; vertical location and extent of anomalies; and estimated percentage of anomalous cross-sectional area.

3. The cross-hole sonic logs expressing the results in terms of velocity and pulse amplitude/energy versus depth. The cross-hole sonic logs shall be presented for each tube pair with all anomalous zones indicated on the logs.

4. Analyses of the initial pulse arrival time versus depth, velocity versus depth, and pulse amplitude/energy versus depth.

5. Appropriate discussion of the results in the text of the report shall be included.

6. Tomography of anomalous zones, as needed.

(3) Requirements for Gamma-Gamma Logging (GGL) Tests:

The minimum equipment requirements for gamma-gamma logging shall be as follows:

(a) The gamma-gamma probe shall consist of a rigid cylinder containing a gamma particle emitting source and a gamma particle detector. The probe shall be suspended by a cable of sufficient design and length that it is safely capable of raising and lowering the gamma-gamma probe within a two-inch internal diameter Schedule 80 PVC inspection pipe to the desired test depths.

(b) The cables affixed to the probe shall be of sufficient strength and durability to raise and lower the probe safely and at a controlled rate of speed. The winch mechanism shall be such that it does not damage the cables or compromise data collected in the test. A means of determining and recording probe depth shall be provided.

(c) The gamma particle emitting source shall be Cesium-137 in a sealed source form.

(d) The gamma-gamma probe detector shall consist of a proven method of gamma detection, such as Geiger Mueller or scintillation-based counters.

(e) The detector shall be connected to a readout device that is capable of displaying and/or recording counts, densities, and sampling duration or probe speed.

(f) The gamma-gamma probe shall possess a minimum density precision of 1.0 pounds per cubic foot.

(g) The gamma-gamma probe shall have a minimum radius of detection of 4.0 inches in concrete with density between 140 and 160 pounds per cubic foot. The probe shall have the capability of varying the radius of detection up to seven inches in concrete with density between 140 and 160 pounds per cubic foot. The radius of detection is defined as one half of the center to center distance between the source and the detector. The actual radius of detection used in the test shall be subject to the approval by the Inspector.

(h) Prior to use for gamma-gamma logging, the Developer shall provide the Independent Quality Firm with the calibration of the gamma-gamma probe and readout unit to correlate count rate and concrete density. The calibration shall not be more than one year old, and shall be performed using the same source and detector combination as that proposed for the GGL testing on the project. Furthermore, the calibration shall have been conducted in an environment (e.g., water-filled, Schedule 80 PVC pipes) similar to the shafts being tested for the project. Gamma-gamma logging shall not be performed until the Independent Quality Firm has approved the calibration records. Upon approval, the Developer shall perform the gamma-gamma tests exactly in the manner as the calibration of the probe and readout unit was performed.

The minimum testing procedure requirements for gamma-gamma logging shall be as follows:

(a) **Preparation of Gamma-Gamma Logging Access Tubes:** A gamma-gamma logging survey may be performed by an experienced subcontractor using inspection tubes completely filled with water only if the gamma-gamma probe has been calibrated in concrete calibration samples that contained inspection tubes filled with water, and the radius of detection and density precision calibration have been performed under water and found to be within the prescribed limits. In the event of gamma-gamma testing in water filled tubes, the water level during testing in any tube shall not drop below the top of the tube.

(b) Gamma-Gamma Logging Procedure. Information on the shaft bottom and top elevations, rebar bottom and top elevations, permanent casing bottom and top elevations, tube bottom and top elevation and position, along with construction dates shall be provided by the Developer to the gamma-gamma logging subcontractor prior to the logging being performed.

The test shall be started by lowering the probe to the bottom of the access tube. When extracting the probe, the readings shall be taken at depth intervals not exceeding 1.5 inches and within the density precision of 1.0 pounds per cubic foot. The probe shall be extracted at a rate of between 8 to 10 feet per minute, and recorded.

To evaluate the repeatability of the GGL tests, the Developer shall perform one repeat log for each shaft in which GGL tests have been performed. After all the tubes in a given shaft have been GGL tested, the repeat log shall be performed in the first tube that was tested.

(c) Gamma-Gamma Logging Data Analysis: The following steps shall be used in the analysis of the gamma-gamma logging data:

1. Apply the approved calibration parameters from the concrete calibration samples to the raw count readings and obtain bulk concrete densities. Verify that the data set contains no logging errors, duplicated data or skipped data points.

2. Determine the arithmetic mean of a set of bulk densities and record it on each log. A set shall consist of data collected from a single inspection pipe, using the same equipment, within the same time period. Data that shall not be included in the calculation of the mean density are: (1) repetitive data points collected at a single depth, (2) data collected at the top of the drilled shaft where the reading(s) were influenced by the gamma detector component exiting the shaft concrete, (3) data collected in the access tube above the top of the drilled shaft, (4) data affected by the anomalous zones of concrete, and (5) data that cause the population distribution to be statistically non-normal.

3. In the event that a known difference in the steel reinforcement layout (e.g., splices using overlapping bars, or tubes extending beyond reinforcing cage) exists in a segment of a drilled shaft that affects the apparent mean, a separate mean shall be generated and utilized as the mean for that portion of the data.

4. Subtract the mean from each data point in the set to obtain a data set that reflects the variation from the mean.

5. Repeat the above 4 steps for all inspection tubes contained within an individual shaft and plot and present that data as (1) a single plot from all tubes, and (2) an individual plot for each tube.

(d) Gamma-Gamma Logging Standard Deviation Analysis: The following steps shall be used in the standard deviation analysis of the gamma-gamma logging data:

1. Determine the standard deviation (SD) of a compilation of bulk densities. A compilation shall consist of data collected from the test drilled shaft using the same equipment, within the same time period. Data that shall not be included in the calculation of the mean density are: (1) repetitive data points collected at a single depth, (2) data collected at the top of the drilled shaft where the reading(s) were influenced by the gamma detector component exiting the shaft concrete, (3) data collected in the access tube above the top of the drilled shaft, (4) data affected by the anomalous zones of concrete, and (5) data that cause the population distribution to be statistically non-normal.

2. The SD value that is used in step 3 shall be between 2.5 pounds per cubic foot and 3.75 pounds per cubic foot. If the calculated value is below 2.5 pounds per cubic foot, then 2.5 pounds per cubic foot shall be used in step 3. If the calculated value is above 3.75 pounds per cubic foot, then 3.75 pounds per cubic foot shall be used in step 3.

3. Multiply the value obtained for SD from the above step by -2.0 and -3.0 to obtain values of “Minus Two Standard Deviations” (-2SD) and “Minus Three Standard Deviations” (-3SD), respectively.

(e) Anomaly Identification: Anomaly in a drilled shaft shall be determined by evaluating the data points developed by the above processes to the -3SD deviation criterion as follows:

1. In a single inspection tube over any 0.5-foot or greater depth interval, all of the density readings have a value less than the determined value for -3SD.

2. In the same inspection tube identified anomalous by the above step, any data point that falls below the value for -3SD within a one-foot vertical extent immediately above or below, then that

depth shall be considered as anomalous in addition to the depth identified in the previous step.

3. In all inspection tubes adjacent to inspection tubes already identified as anomalous, if at least one data point within two feet vertically above or below the adjacent tube anomaly falls below the value for the -3SD, then the depth in that tube at which the anomaly is found is also anomalous, in addition to the depths identified in the previous two steps.

(f) Gamma-Gamma Logging Results: Results of the gamma-gamma logging completed at a given substructure element shall be submitted to the Independent Quality Firm in a report(s) within three working days of completion of testing at that given substructure element. The report shall include:

1. Dates of shaft construction; shaft diameters; shaft lengths; shaft tip elevations; shaft cutoff elevations; permanent casing placement, including top and bottom elevations; type and size of drilling equipment; type of slurry if used; description of concrete mix; reinforcement details, including top and tip elevations; inspection tube placement, including top and tip elevations; concrete placement method; shaft layout with shaft numbers.

2. Dates of logging; brief description of the testing equipment; number of shafts logged; location of obstructions in PVC tubes; location of PVC couplers; calibration date, data and plot; summary of any unusual occurrences during testing; description and explanation of adjustments made to instrumentation or data (if any); identification of anomalies using the criteria described herein; delineation of affected tubes; vertical location and extent of anomalies; and estimated percentage of anomalous cross-sectional area.

3. Plots of each individual tube with the data points and the values of -2SD and -3SD. The plots shall indicate these points and values at all depths. Utilize symbols or line formats that permit lines corresponding to -2SD and -3SD to be distinguishable from data points.

4. Appropriate discussion of the results in the text of the report shall be included.

(4) Procedures in Case of Anomalies:

If the testing indicates the presence of anomalous zones, as identified by the sonic cross-hole and gamma-gamma tests, in the drilled shaft foundation, or if the Engineer determines that construction defects may have occurred, the Developer shall conduct three-dimensional tomographic surveys of the anomalies. The results of the tomographic surveys shall be presented in the form of concrete velocity images in two-dimensions (2-D) between each pair of tubes, and in three-dimensions (3-D) for the whole shaft. Should the Engineer determine that the anomalous zones reveal defects, the Developer shall submit a plan to repair, replace, or supplement the defective work for review by the Engineer. After review and acceptance by the Engineer, the Developer shall perform the work specified in the approved plan.

609-3.06 Reinforcing Steel, Cage Construction and Placement:

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. All reinforcing steel intersections shall be tied as specified herein. The reinforcing steel unit shall be placed in the shaft no sooner than two hours prior to the start of concreting operations, and shall be placed in accordance with the details shown on the plans.

The reinforcing cage shall be adequately supported and anchored from the top to prevent movement from the required location during and for four hours after completion of concrete placement. The rebar cage shall be kept plumb. The rebar cage shall not rest directly on the bottom of the excavation. Spacers shall be at sufficient intervals along the shaft to ensure concentric location of the reinforcing cage for the entire length of shaft. Spacers shall be placed at a maximum vertical spacing of 15 feet, with a minimum of four spacers around the circumference at each vertical elevation

If the bottom of the final drilled shaft excavation is 3 feet or less below the tip elevation shown in the plans, the reinforcing need not be extended. If the bottom of the final drilled shaft excavation is more than 3 feet below the tip elevation in the plans, then longitudinal and transverse reinforcing shall be added to the bottom of the reinforcing cage to support the integrity testing tubes that must be placed to within 6 inches of the bottom of the drilled shaft. The reinforcing is not required for the structural capacity of the drilled shaft.

The Developer shall submit a written request to the Engineer for approval of any variation from the splices for reinforcing steel specified in the plans.

Reinforcing cages shall be placed with splices in the lowest possible position within the excavation.

609-3.07 Concrete Placement:

(A) General:

The Developer shall begin placement of concrete within 24 hours after the completion of the drilled shaft excavation and placement of reinforcing steel cage. All concrete shall be placed in accordance with Section 601 and as specified herein. Final cleanout will occur right before cage and concrete placement. Unless otherwise specified in the project documents, the slump shall be five ± one inches for dry, uncased excavations. For all others, the concrete slump shall be eight ± one inches at the time placement begins.

Prior to concrete placement, the Developer shall make all necessary arrangements to assure the uninterrupted delivery of concrete so that all drilled shaft foundations will be constructed without cold joints.

Tremie downpipes and pump pipes shall be made of steel; no aluminum shall be allowed. The inside diameter of the tremie pipe shall be at least ten inches for all drilled shafts four feet or greater in diameter. The inside diameter of the pump pipe shall be at least five inches.

(B) Placement in Dry Excavations:

For placement in dry excavations, concrete may be placed by free fall except in fragile, cohesionless soils where bottom scour is likely to occur, or where other caving conditions exist. The Developer shall prevent concrete from striking either the reinforcing cage or excavation side walls during free fall. Where free fall cannot be used, concrete shall be placed through a suitable clean downpipe.

Concrete vibration for the full height of the shaft is not necessary to achieve proper consolidation of the concrete. However, the shafts shall be vibrated in the top 10 feet. If temporary casing is used, the vibration shall occur after the casing has been removed.

To be considered a dry shaft, the maximum depth of water in the bottom of a drilled shaft excavation at the time of concrete placement shall be no more than three inches.

(C) Placement under Slurry or Water:

Concrete shall be placed by tremie methods or by pumping. Care shall be taken to ensure that all the fluid and suspended solids are expelled from the excavation during concrete placement. If concrete is placed by pumping, it shall be in accordance with the requirements of Subsection 601-3.03(C).

The Developer's installation plan shall demonstrate the procedures used to determine when the tremie pipe is to be raised during concrete placement. The procedure shall assure that the opening of the tremie pipe will be deeper than five feet below the surface of the concrete at all times for shaft diameters less than six feet, and deeper than ten feet below the surface of the concrete for shaft diameters six feet and larger. A rapid raising or lowering of the tremie will not be permitted.

In order to prevent contamination of concrete placed initially, the lower end of the pump or tremie pipe shall be provided with either a valve, sealable cap, or plug ("pig"). The discharge end shall be placed at the bottom of the excavation prior to commencement of concrete placement. If a plug is used, it shall be inserted at the top after the pipe has been set in place. Concrete shall then be placed by pushing the plug ahead, separating the concrete from the drilling fluid. Only when the tremie pipe is completely filled shall the open end be lifted off the bottom. The concrete flow that comes to the top of the shaft shall be displaced out of the shaft excavation in a continuous flow until clean, fresh concrete is expelled.

Slurry ejected during concrete placement may be reused provided that it is screened to remove gravel chips or other granular materials, and providing the slurry meets acceptance criteria. Slurry to be discarded shall be disposed of.

Concrete placed under slurry or water shall not be vibrated, except that the top five feet of the shaft shall be vibrated after the slurry or water and contaminated concrete have been totally expelled from the shaft. If temporary casing is used, the vibration shall occur after the casing has been removed.

609-3.08 Casing Removal:

During removal of any casing, a sufficient head of not less than ten feet of fluid concrete in the tremie pipe shall be maintained above the level of concrete in the shaft (outside the tremie pipe), except at the top of the shaft. All contaminated concrete shall be removed from the shaft. Temporary casings shall be removed while the concrete slump is a minimum of four inches. The Developer shall maintain a minimum five-foot head of concrete for shaft diameters of less than six feet, and a minimum ten-foot head of concrete for shaft diameters six feet or greater, in the casing as it is being removed. Movement of the casing by exerting upward pressure and tapping to facilitate extraction, or extraction with a vibratory hammer will be permitted. Casing extraction shall be at a slow, uniform rate with the force in-line with the shaft axis. The removal method shall prevent the intrusion of water, grout, and soil into the excavation, displacement of the reinforcing steel, and lifting of the concrete.

Due care shall be exercised to prevent upward movement of the shaft concrete and reinforcing steel during casing extraction. Upward movement beyond one inch, excluding movement due solely to tension on the top anchoring system, may indicate serious concrete separation or necking problems at the bottom of the casing. The Developer shall be responsible for corrective action which may include leaving the casing in place and compensating for the loss of frictional capacity in the resulting cased zone.

SECTION 610 PAINTING:

610-1 Description:

The work under this section shall consist of furnishing paint and other materials and painting concrete, structural steel, or other surfaces where shown on the plans in accordance with the requirements of the 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:

Paint shall conform to the requirements of Section 1002, unless otherwise specified.

610-3 Construction Requirements:

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 35 degrees F to 120 degrees 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 degrees 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 Developer. The Developer may provide suitable enclosures to permit painting during inclement weather.

610-3.02 Surface Cleaning:

(A) Metal Surfaces:

All surfaces of structural steel or other metals, except galvanized surfaces, shall be cleaned prior to painting.

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 SSPC Standard SP10, unless otherwise specified.

When repainting existing steel structures, the method of cleaning will be specified. Areas not designated for repainting which are damaged as a result of the Developer's operations shall be repaired by the Developer.

(1) Blast Cleaning:

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 leave all surfaces with a dense, uniform anchor pattern or profile of 1.0 to 3.0 mils, as measured with an approved surface profile comparator or pressed film replica tape.

Abrasives used for blast cleaning shall be clean dry sand, mineral grit, steel shot, or steel grit and shall be graded to produce satisfactory results.

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. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, they shall be recleaned by the Developer.

(2) Steam Cleaning:

All dirt, grease, loose chalky paint or other foreign material which has accumulated on previously painted surfaces shall be removed with a steam cleaning apparatus prior to all other phases of cleaning. It is not intended that sound paint be removed by this process. After steam cleaning, any paint which has become loose, curled, lifted or loses its bond to the preceding coat or coats shall be removed to sound paint or metal surface by the Developer.

A detergent shall be 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 specified cleaning 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.

(3) Hand Cleaning:

Manual or powered wire brushes, hand scraping tools, power grinders or sandpaper shall be used to remove all dirt, loose rust, mill scale, or paint which is not firmly bonded to the surfaces.

(4) Water Blast Cleaning:

Water blast cleaning shall be done in accordance with NACE (National Association of Corrosion Engineers) 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 Developer 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.

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.

(B) Concrete Surfaces:

Prior to painting concrete surfaces, laitance and curing compounds shall be removed from the surface by abrasive blast cleaning in accordance with the requirements of ASTM D 4259. The cleaned surface shall have a roughened, textured appearance consistent with the surrounding concrete surface.

Concrete surfaces shall be thoroughly dry and free of dust at the time the paint is to be applied. Any artificial drying procedures and methods shall be subject to approval by the Independent Quality Firm.

(C) Surfaces other than Metal or Concrete:

Prior to painting any surfaces other than metal or concrete, the surface shall be in accordance with the manufacturer recommendations.

610-3.03 Application:

Painting shall be accomplished in a neat and professional manner.

For painting metal surfaces, paint shall normally be applied by spraying with limited use of hand brushes or rollers.

For painting concrete surfaces, the Developer shall develop an Application Plan according to the manufacturer's written recommendations. The Plan shall include:

(1) Rate of application.
(2) Number of necessary coats (minimum of two coats).
(3) Ambient air temperature.
(4) Ambient surface temperature.
(5) Application equipment.
(6) Qualification of workers.

(7) Safety and damage protection.
(8) Proposed surface preparation.

For painting concrete surfaces, the Developer shall apply all paint applications to a test specimen or to the concrete surface, according to Application Plan.

610-3.05 Painting:

(A) Metal Surfaces:

(1) General:

All surfaces of new metals shall be painted with one shop coat (primer) and two field coats (the intermediate coat and topcoat), unless otherwise specified.

All paints used shall be appropriately chosen from among the types described in Subsections 1002-2.01 through 1002-2.05 and shall conform to the requirements given therein.

The dry film thickness of the paint will be measured in place with a calibrated magnetic film thickness gauge in accordance with SSPC Standard 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) Primer:

The dry film thickness of the primer shall not be less than 2.0 mils, and be sufficient to cover the blast profile pattern.

A deep profile pattern from steel shot blasting may require additional applications of primer to obtain sufficient coating of the steel surface.

After structural steel has been fabricated and blast cleaned, all surfaces, except metal surfaces which are to be embedded in concrete, or within three inches of a high strength bolted connection, shall be painted with a primer.

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 coat of primer after the shop welding is completed. Areas of structural steel to be field welded shall be masked and the remainder of the steel shall be given one coat of primer.

As soon as practicable after being accepted by the Inspector and prior to removal from the shop, machine-finished surfaces shall be coated with a rust inhibitor which can easily be removed. Surfaces of milled or finished iron and steel castings shall be painted with one coat of primer.

Erection marks for field identification of steel members and weight marks shall be painted upon surface areas previously painted with the primer.

(3) Intermediate Coat:

The intermediate coat shall be appropriately tinted to contrast with the primer. The dry film thickness of the intermediate coat shall not be less than 2.0 mils.

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 and other foreign material shall be removed as specified under Subsection 610-3.02. All areas where the primer is damaged or deteriorated shall be thoroughly cleaned and spot painted with the same type of paint used for the primer and to the specified dry film thickness.

When the spot painting coat is thoroughly dry, the intermediate 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.

(4) Topcoat:

All small cracks and cavities which have not become sealed in a watertight manner by the intermediate coat shall be filled before the topcoat is applied.

At the option of the Developer, the intermediate coat and the topcoat may be applied in the shop. When finished coats are applied in the shop, the Developer shall repaint all damaged or deteriorated areas in the field.

The dry film thickness of the topcoat shall be not less than 2.0 mils.

The topcoat shall be painted using a semi-gloss finish.

(B) Concrete Surfaces:

When painting is specified on the plans, paint conforming to the requirements of Subsection 1002-2.06, shall be applied to the exposed concrete surfaces tabulated below, except that sidewalks, appurtenant curbs, downdrains, and bridge deck surfaces shall be excluded.

Concrete surfaces shall be painted using a flat finish except that accent colors on concrete surfaces shall be painted using a gloss finish.

All concrete shall be finished and cured in accordance with the requirements of the specifications prior to the application of the paint.

(1) Cast-in-Place Box Girder Bridges:

All surfaces of the superstructure, including the sides and bottoms of the box girders, shall be painted.

(2) Pre-cast I-Girder Bridges:

Bridge structures with vehicular traffic passing beneath shall be painted on all surfaces of the superstructure with the exception of the sides of the interior girders, the interior side of exterior girders, and the underside of the deck.

(3) Pre-cast Box and Slab Girder Bridges:

All surfaces of the superstructure including the sides of exterior girders and the bottom surfaces of the box or slab girder when exposed to traffic view shall be painted.

(4) Bridge Substructure and Walls:

All surfaces of bridge piers, including the pier caps and bottoms of integral pier caps, piles, columns, parapet walls and abutments, concrete retaining walls and noise barrier walls shall be shall be painted to at least two feet below finished grade.

(5) Barriers:

The side not adjacent to the traveled way and the top of the barrier shall be painted. Lined drainage, drainage headwalls, and roadside and median barriers shall not be painted.

(6) Light and Sign Foundations:

Light and sign foundations that are located on the outside shoulder of the roadway, that are exposed by 2 feet or more, shall be painted.

(7) Drainage Structures:

Lined drainage channels and drainage headwalls shall not be painted.

(C) Surfaces other than Metal or Concrete:

Surfaces other than metal or concrete shall be painted as recommended by the paint manufacturer.

All masonry shall be painted using a gloss finish.

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.

610-3.06 Painting Damaged Galvanized Coating:

Damaged areas of galvanized coating shall be roughened by sanding or acid treatment. The roughened areas shall be painted with two coats of zinc-rich primer, conforming to the requirements of Subsection 1002-2.02.

Professional Engineer
CERTIFICATE NO. 49430
GREGORY PATRICK FLY
Date Signed 2-4-19
ARIZONA U.S.A.
EXPIRES: 3-31-21

SECTION 701 MAINTENANCE AND PROTECTION OF TRAFFIC

701-1 Description:

The work under this section shall consist of providing flagging services and pilot trucks, and furnishing, installing, maintaining, moving and removing barricades, warning signs, lights, signals, cones, and other traffic control devices to provide safe and efficient passage through and/or around the work and to protect workers in or adjacent to the work zone. The work shall be done in accordance with the requirements of Part 6 of the Manual on Uniform Traffic Control Devices (MUTCD) and the associated Arizona Department of Transportation supplement. When referred to herein, these documents will be referred to as MUTCD and associated ADOT Supplement.

The requirements of the MUTCD and associated ADOT Supplement shall be considered as the minimum standards for the protection of workers and the traveling public.74-2

701-2 Materials (Equipment, Workers, Devices and Facilities):

701-2.01 General:

(A) Conformance

Except as specified herein, all equipment, procedures used by workers, devices and facilities shall conform to the requirements of the MUTCD.

All traffic control devices listed below as Category I and Category II devices shall meet the evaluation criteria for Test Level III per NCHRP (National Cooperative Highway Research Program) Report 350 or AASHTO Manual for Assessing Safety Hardware (MASH).

(1) Category I Devices:

Category I devices are low-mass traffic control devices that will not cause an appreciable change in speed of an impacting vehicle, nor is it likely that any part of the device will intrude into the passenger compartment. The following traffic control devices will be considered Category I devices: rubber or plastic traffic cones, rubber or plastic tubular markers, single piece plastic drums, plastic or fiberglass delineators. No warning lights, signs, flags or other auxiliary devices are allowed on Category I devices. Should any of these attachments be added to a Category I device, the Category I device will be considered a Category II device. Ballast at the base, such as a rubber tire, is an acceptable attachment to Category I devices. The single piece plastic drum refers to the construction of the body of the drum exclusive of a separate base, if any.

(2) Category II Devices:

Category II devices are low-mass traffic control devices that will not cause a significant change in speed of an impacting vehicle. The following traffic control devices will be considered Category II devices: type I, II, and III barricades with or without warning lights; vertical panels with or without warning lights; signs and sign stand (all types) with or without warning lights and/or flags; drums, other than those listed in Category I, with or without warning lights; and any Category I devices with attached warning lights.

701-2.02 Flashing Arrow Panels:

Flashing arrow panels shall conform to the requirements of the MUTCD and associated ADOT Supplement 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 adequate energy source to provide for at least 12 hours of continuous operation without refueling or recharging.

701-2.03 Temporary Concrete Barrier:

Temporary concrete barrier shall be precast sections conforming to the requirements of Signing and Marking Standard Drawing C-3 and Subsections 910-2 and 910-3 of the specifications.

Developer shall provide, at the preconstruction conference, a certificate of compliance, conforming to the requirements of Subsection 106.05, stating that any temporary concrete barrier to be used on the project conforms to Signing and Marking Standard Drawing C-3. Developer shall include the project number on the submittal.

701-2.04 Temporary Impact Attenuation Devices:

Temporary impact attenuation devices shall conform to the requirements for the type of device shown on the project plans or approved equal. . .

Temporary Impact attenuation devices shall also meet evaluation criteria for Test Level II or III per NCHRP (National Cooperative Highway Research Program) Report 350 as applicable for the preconstruction posted speed and in accordance with the temporary impact attenuation device manufacturer. The Developer shall provide, at the preconstruction conference, a letter certifying that all temporary impact attenuation devices meet the above requirement. The letter shall also include the project number, and the name, title, and signature of a person having legal authority to bind the manufacturer or supplier of the attenuation devices. The binding authority shall be in accordance with Subsection 106.05(B)(5).

701-2.05 Temporary Pavement Markings:

(A) Temporary Raised Pavement Markers and Chip Seal Pavement Markers:

Temporary Pavement Markers may be Temporary Reflective Markers, Permanent Reflective Markers (used as Temporary) or Non-Reflective Markers, as required on the Project Plans.

Temporary Pavement Markers shall be in conformance with Standard Drawings M-19 and M-20, and Subsection 706-2 of these specifications, and will be included on a list of pre-approved products maintained by ADOT.

Chip Seal Pavement Markers shall conform to Standard Drawing M-20. The Chip Seal marker body and cover shall be manufactured from a polyurethane material conforming to the following requirements:

	Requirement	ASTM Test Method
Specific Gravity (Min.)	1.19	D 792
Hardness (Min.)	80A	D 2240
Tensile Strength (Min. PSI)	4,600	D 412
Ultimate Elongation (Min. %)	330	
Modulus @ 300% PSI	1,000	
Stiffness @ -20 ^{o}F (Min. PSI) 70 ^{o}F (Min. PSI)	17,000 900	D 1053
Compression Set 22 hrs. @ 70 ^{o}C	65	D 395
Taber Abrasion; CS 17 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 1,800 candelas per foot-candle per square foot at 0.10-degree observation and zero-degree entrance angles.

(B) Pavement Marking Paint:

Paint for temporary striping, arrows, symbols and legends shall be white or yellow and shall conform to the requirements for permanent striping paint as set forth in Section 708 of these specifications and as indicated on the project plans . Paint for temporary symbols and legends shall be white and shall meet the same requirements as temporary striping.

(C) Preformed Pavement Markings:

Preformed Pavement Markings shall be either Type II (Temporary-Removable) or III (Temporary-Nonremovable), as indicated on the project plans. Preformed Pavement Markings shall be in conformance with the requirements of Section 705 of these specifications.

701-2.06 Temporary Sign Supports:

Temporary Sign Supports may be wood, steel or aluminum, at the option of the Developer. Wood posts need not be treated. Embedded posts shall meet the criteria established under NCHRP Report 350 for breakaway sign supports.

701-2.07 Delineators:

Delineators shall be as shown on the plans and shall be in conformance with the Standard Drawings and Subsection 703-2 of these specifications.

701-2.08 Barricades and Other Channelizing Devices:

Type I barricades having a minimum of 270 square inches of retroreflective area facing traffic, and otherwise conforming to the MUTCD, All sheeting for barricades and other channelizing devices shall conform to the requirements of Section 1007.

701-2.09 Drums:

Sheeting type for drums shall conform to the requirements for work zone devices shown in Section 1007.

701-3 Construction Requirements:

701-3.04 Temporary Impact Attenuation Devices:

Energy absorbing terminals conforming to the requirements of Subsection 702-2.02 of these specifications shall be installed at the locations and in accordance with the details shown on the project plans and the manufacturer's instructions.

Devices that are damaged by the traveling public shall be repaired within 2 hours by the Developer utilizing a replacement parts package, which shall be on the job site whenever this system is in use. .

Crash cushions damaged by the traveling public shall be removed and disposed of by the Developer. New devices shall be furnished and installed by the Developer. The Developer shall repair any damaged installations within 2 hours. Sand barrel crash cushions will remain the property of the Developer upon completion of temporary use unless permanently incorporated into the project.

701-3.05 Temporary Pavement Markings (Application and Removal):

Application of temporary pavement markings shall conform to the requirements of the MUTCD and associated ADOT Supplement. Placement of new markings shall be done immediately when the need for each arises, in conjunction with changes in the traffic pattern.

(B) Raised Pavement Markers:

The adhesive shall be applied uniformly to the cleaned pavement surface and the raised 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, Type II, shall only be used on surfaces or finish pavement courses where eventual removal will be required.

Preformed Pavement Markings, Type III, shall only 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.

701-3.06 Obliteration of Existing Pavement Markings:

Pavement marking obliteration shall be accomplished by the Developer within the revised striping limits.

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.

701-3.07 Truck-Mounted and Trailer-Mounted Attenuators:

The Developer shall provide trucks and truck-mounted attenuators, or trailer-mounted attenuators and host vehicles, at the locations shown or noted on the project plans.

Attenuators shall meet either NCHRP Report 350, Test Level 3 criteria, or MASH (Manual for Assessing Safety Hardware), Test Level 3 criteria, passing both mandatory and optional tests. The truck and attenuator combination shall only be used in the configuration tested. The truck mounted attenuator shall have a type C sequential arrow display panel meeting NCHRP Report 350, Test Level 3 criteria.

For each proposed truck-mounted or trailer-mounted attenuator, a Certificate of Compliance shall be submitted prior to use. For truck-mounted attenuators, the certificate shall also include the certified weigh bill for the truck, and for trailer-mounted attenuators the certificate shall state the minimum weight for the host vehicle. The certificate shall state that the attenuator meets the specified criteria, and shall clearly state the roll-ahead distance. A copy of this documentation shall be kept in the truck cab or host vehicle, available for immediate inspection when requested by the Independent Quality Firm.

701-3.08 Changeable Message Board:

Changeable message boards shall be furnished and maintained by the Developer at the locations shown on the plan. The operations and messages programmed into the board controller shall be as directed. 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 changeable message board power supply shall be battery operated and rechargeable 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.

The Developer shall submit, at the pre-construction conference, a Certificate of Compliance that the changeable message board to be used on this project shall be as described herein.

The character formation system and components shall conform to the following requirements:

(1) The changeable message board shall be programmable, and 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.

(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 high by 1.625-inch wide rectangle (minimum), or equivalent area.

(4) Each character shall be 18 inches in height and 12 inches in width (minimum).

(5) The horizontal character separation shall be three inches 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 five to 12 inches.

(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 programmable message board shall be capable of displaying moving arrow patterns as one of the operator-selected programs.

(10) The message board shall also be capable of displaying up to two messages in sequence, with variable timing in a minimum of quarter-second increments.

(11) The message board shall be clearly visible and legible from a distance of 800 feet 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.

(12) 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 eight feet from the nearest edge of pavement. If the trailer is located behind temporary concrete barrier, a minimum offset of six feet will be required. Should the specified shoulder width not be available, a minimum two-foot offset from the nearest edge of pavement or temporary concrete barrier shall be required. When positioned on the highway, the changeable message board trailer shall be delineated with a minimum of 10 Type II barricades or vertical panels with Type C steady burn lights at a spacing of 10 to 20 feet, or as shown on the approved traffic control plan.

When not in operation, the changeable message board shall be moved a minimum of 30 feet from the edge of pavement.

The changeable message board trailer shall be placed on a level surface and be secured as recommended by the manufacturer. The Developer shall provide any necessary incidental grading and clearing work required to provide a level surface and clear area for the sign.

701-3.09 Chip Seal Pavement Marker:

Chip Seal Pavement Markers and covers shall be located and placed on the asphaltic concrete prior to any work being started on the chip seal coat. Immediately after application of the chip seal coat to the roadway pavement, the plastic covers shall be removed, exposing the reflective tape surfaces.

701-3.10 Sign Sheetings:

Sign sheeting for all temporary work zone signs shall conform to the requirements of Section 1007. The text for all temporary guide signs must be a least 10-inches in height.

701-3.11 Temporary Removal or Covering of Signs:

Where existing signs are not applicable during construction, they shall be removed or have the affected legends completely covered in place.

701-3.12 Temporary Sign Supports:

Temporary Sign supports installed 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.

701-3.13 Flagging Services:

Flagging services shall consist of either civilian, local enforcement officers and their vehicles, or DPS (Department of Public Safety) officers and their vehicles.

The Developer shall be responsible to procure civilian flaggers, DPS officers, and local enforcement officers. A DPS or local enforcement officer shall not work more than 12 consecutive hours unless an emergency situation exists which requires that the officer remain in the capacity of a flagger.

The developer shall furnish verification to IQF that all civilian flaggers have completed a recognized training and certification program as per the American Traffic Safety Services Association or approved equal.

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.

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. Other Energy-absorbing terminals and all components shall be installed per manufacturer specifications.

Energy-Absorbing Terminals shall meet NCHRP Report 350, Test Level 3 criteria.

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.

Modules shall be filled to the designated weight with clean concrete sand meeting the requirements of ASTM C33 or alternatively, sand (fine aggregate) meeting the requirements of the manufacturer.

Other crash cushions and all components shall be installed per manufacturer specifications.

Sand Barrel Crash Cushions shall meet NCHRP Report 350, Test Level 3 criteria.

SECTION 703 DELINEATORS AND MARKERS:

703-1 Description:

The work under this section shall consist of furnishing and installing delineators, reference markers, object markers, snow markers and milepost markers in conformance with the details shown on the plans and in accordance with the requirements of these specifications.

The types of delineators and markers to be installed and the locations will be shown on the project plans.

703-2 Materials:

703-2.01 General:

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

703-2.02 Metal Posts:

Posts for delineators and for all markers, including mileposts or reference markers installed on freeways shall conform to the details shown in the project plans.

703-2.03 Concrete:

Concrete for the milepost or reference marker foundations shall be utility concrete conforming to the requirements of Section 922.

703-2.04 Metal Plates:

Metal plates for the various types of object markers shall conform to the details shown on the plans and shall be fabricated in one piece from 0.063-inch thick aluminum-alloy sheet 3003-H 14, 5052-H 38, or 6061-T 6, all conforming to the requirements of ASTM B 209.

703-2.05 Paint:

Paint for use on the metal plates shall conform to the requirements of Section 1002 for the type and color of paint specified on the plans.

703-2.06 Retroreflective Sheeting:

Retroreflective sheeting for delineators and markers shall conform to the requirements of Section 1007.

The type of retroreflective sheeting to be applied shall be as specified on the plans.

703-2.07 Prismatic Reflectors:

Prismatic reflectors for delineators and markers shall conform to the requirements of Section 1008.

The type of prismatic reflectors to be used shall be as specified on the plans.

703-2.08 Hardware:

Steel bolts and nuts of the types shown on the plans shall be galvanized in accordance with the requirements of ASTM A 153 or shall be cadmium plated in accordance with the requirements of ASTM B 766.

703-3 Construction Requirements:

Metal posts shall be cut and perforated to the sizes and shape shown on the plans. The finished posts shall be straight with a permissible tolerance in straightness of 1/16 inch per three (3) feet of post length.

Posts on which galvanizing has been damaged in transporting, handling or erecting shall be repaired by the contractor at its expense in accordance with the requirements of Subsection 610-3.06.

Metal plates shall be cut to size and shape and the holes punched for mounting all in accordance with the details shown on the plans. The surfaces and edges of the plates shall be free of buckles, warps, dents, cockles, burrs, and defects resulting from fabrication.

Posts shall be set vertically to line at the locations designated on the plans. Posts, except mileposts or reference marker posts requiring concrete foundations, shall be set firmly in the ground by a method that will not bend the post or deface the top of the post. If ground conditions are such that the posts cannot be driven without damaging the posts, pilot holes shall be required. Metal plates shall be installed after the posts have been set in place.

Posts shall be placed in the ground to the depth shown on the plans.

Foundations for the milepost or reference marker posts installed on freeways shall be constructed to the details and dimensions shown on the project plans. Excavation shall conform to the requirements of Subsection 203-5.03(A).

Existing markers and delineators that are to remain in place and which have been damaged by the contractor shall be replaced with new ones at its expense.

SECTION 704 THERMOPLASTIC PAVEMENT 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 thermoplastic reflectorized pavement markings using extrusion or ribbon dispensing devices of the required shape and thickness to the prepared pavement surface at the locations and in accordance with the details shown on the project plans and the manufacturer's specifications.

704-2 Materials:

704-2.01 General Requirements:

The thermoplastic reflectorized material shall consist of a solid mixture of heat-stable resins, white or yellow pigment, inter-mixed glass beads, filler, and other materials in granular or block form specifically compounded for reflectorized pavement markings to be applied to the pavement in a moltenstate. The characteristics of the liquefied material shall be such that complete and even coverage of specified areas to the required thicknesses is provided by the required application method and rate. Upon cooling to normal pavement temperature, this material shall produce an adherent reflectorized marking capable of resisting deformation and wear in the roadway.

704-2.02 Composition:

(A) General:

The thermoplastic composition shall conform to the following requirements:

Component	Percent by Weight	
	White	Yellow
Binder (Min.)	20	20
Titanium dioxide (Min.)	10	-----
Yellow Lead-Free Pigment (Min.)	-----	1.5
Reflective glass inter-mix beads	30 – 45	30 – 45
Calcium carbonate or equivalent filler	20 – 42	20 - 42

The ingredients of the thermoplastic composition shall be thoroughly mixed and in a solid or sectionalized block, or free-flowing granular form. When heated in a melting apparatus, the material shall readily liquefy into a uniform solution. This solution shall be free from all skins, dirt, foreign objects or any other ingredient which would cause bleeding, staining, blotting, or discoloration when applied to the bituminous or concrete pavement surfaces.

The thermoplastic formulation shall utilize an alkyd binder. The alkyd binder shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature, and of high-boiling-point plasticizers. At least one third of the binder composition and no less than eight percent by weight of the entire material formulation shall be solid maleic-modified glycerol ester resin or solid maleic-modified pentaerythritol ester resin. The alkyd binder shall not contain any petroleum-based hydrocarbon resins.

(B) Reflective Glass Beads:

In addition to incorporating glass beads in the thermoplastic mix, glass beads shall be evenly applied to the surface of the molten material as specified in Subsection 704-3.02(G).

(C) 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.

(D) Titanium Dioxide:

Titanium Dioxide shall conform to the requirements of ASTM D 476 for Type II (92 percent).

(E) Yellow Pigment:

The yellow pigment shall be heat resistant and lead free. The type of yellow pigment shall be at the option of the manufacturer provided that the material conforms to all color requirements in a stable and durable fashion as specified herein

704-2.03 Physical Characteristics of the Composition:

(A) General Requirements:

The thermoplastic material shall not exude fumes which are toxic, injurious, or require specialized breathing apparatus when heated to the temperature range specified by the manufacturer for application. The material shall remain stable when held for four hours at this temperature, or when subjected to four reheatings, not exceeding a total of four 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 425 ± three degrees F and cooled to 77 ± three degrees F, shall meet the following:

White: Daylight reflectance at 45 degrees - 0 degrees shall be 70 percent minimum.

Color shall match Federal Test Standard Number 595, color chip no. 17925.

Yellow: Daylight reflectance at 45 degrees - 0 degrees shall be 43 percent minimum.

Color shall match Federal Test Standard Number 595, color chip no. 13538.

(C) Retroreflectance:

The white and yellow thermoplastic materials must have the minimum retro-reflectance values as identified in Section DR 460.3.3 Pavement Marking of the Conformed Technical Provisions.

(D) Softening Point:

After heating the thermoplastic material for four hours ± five minutes at 425 ± three degrees F and testing in accordance with ASTM D 36, the thermoplastic materials shall have a softening point of 215 ± 15 degrees F.

(E) 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 16 of AASHTO T 250, shall be between 1.85 and 2.15.

(F) Impact Resistance:

After heating the thermoplastic material for four hours ± five minutes at 425 ± three degrees F and forming test specimens, the impact resistance shall be not less than 10 inch-pounds when tested in accordance with Section 9 of AASHTO T 250.

(G) Bond Strength:

After heating the thermoplastic material for four hours ± five minutes at 425 ± three degrees F, the bond strength to Portland cement concrete shall be not less than 180 pounds per square inch. The bond strength shall be determined in accordance with the procedures specified in Section 7 of AASHTO T 250.

(H) Abrasion Resistance:

The abrasion resistance of the thermoplastic material shall be determined by forming a representative lot of the material at a thickness of 0.125 inches on a four-inch square monel panel (thickness 0.050 ± 0.001 inches), on which a suitable primer has been previously applied, and subjecting it to 200 revolutions on a Taber Abraser at 25 ^{o}C, using H-22 calibrated wheels weighted to 250 grams. The wearing surface shall be kept wet with distilled water throughout the test.

The maximum loss of thermoplastic material shall be 0.5 grams.

(I) Cracking Resistance at Low Temperature:

After heating the thermoplastic material for four hours ± five minutes at 425 ± three degrees F, applying to concrete blocks, and cooling to 15 ± three degrees, the material shall show no cracks when observed from a distance exceeding 12 inches. Testing for low temperature crack resistance shall be in accordance with the procedures specified in Section 8 of AASHTO T 250.

(J) Flowability:

After heating the thermoplastic material for four hours ± five minutes at 425 ± three degrees F, 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 21.

(K) Yellowness Index:

The white thermoplastic material shall not exceed a yellowness index of 0.12 when tested in accordance with Section 4 of AASHTO T 250.

(L) Flowability (Extended Heating):

After heating the thermoplastic material for eight ± 1/2 hours at 425 ± three degrees , 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.

(M) Flash Point:

The thermoplastic material shall have a flash point not less than 475 degrees F 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 month and year of manufacture shall be clearly marked on all packages of thermoplastic material. The thermoplastic material must also melt uniformly with no evidence of skins 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 not be used. The Developer shall replace any outdated material with material meeting the above performance and time requirements.

(O) Primer-Sealer:

Primer-sealers shall be used on Portland cement concrete, or existing hot mix asphaltic concrete surfaces prior to application of the thermoplastic material, and shall be applied as recommended by the thermoplastic material manufacturer. The primer-sealer shall be compounded specifically for use with the specified thermoplastic material.

Application of primer-sealer will not be required on newly placed hot-mix asphaltic concrete surfaces prior to application of the thermoplastic material.

(P) Color Stability:

Using accelerated weathering per ASTM G 155, Cycle 1, white color stability shall be measured for no color change after 500 hours of exposure, and yellow color stability shall be measured for no color change after 1000 hours of exposure.

704-2.04 Physical Requirements for Glass Beads:

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 Type I, 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.

Drop-on beads shall conform to the gradation requirements of AASHTO M 247 for Type I and Type III beads.

If recommended by the manufacturer, the drop-on beads shall have an adherence coating.

704-3.02 Application:

(A) Placement Locations:

Pavement markings shall be positioned as defined on the plans and in the specifications. Marking lines shall not be placed on parallel construction or expansion joints. Longitudinal lines shall be offset to provide two to four inches of clearance from parallel construction joints.

Placement of symbols and legends on construction joints, expansion joints or uneven pavement surfaces shall be avoided. Where the location of construction joints, expansion joints or otherwise unsuitable surfaces conflicts with specified locations for symbols or legends, the symbol or legend location may be adjusted.

(B) Materials Selection and Compatibility:

All thermoplastic material, drop-on glass beads, and primer-sealer will be inspected prior to their application.

All materials shall be properly packaged and stored. Each container to be used on the project shall be clearly labeled to indicate the following information:

- Nature, type, and formulation of the material;
- Manufacturer, batch number, and date of manufacture;
- Application requirements and constraints; and
- Compatibility requirements and constraints, particularly those pertaining to equipment, storage, and other materials to be used.

Preparation and application equipment shall be in accordance with the plans and specifications, and shall conform to the recommendations of the materials manufacturer.

Incompatible materials shall not be used together. The Developer shall not combine alkyd and hydrocarbon materials in preparation or application equipment. The Developer shall completely clean preparation and application equipment when materials are changed.

The Developer shall dispose of excess materials, cleaning fluids, and all empty material containers at a site.

(C) Equipment Inspections and Deficiencies:

The Developer shall make daily maintenance and operation inspections of all application equipment to ensure that it is operable within the requirements of the specifications.

(D) Pavement Surface:

The Developer shall remove built up dirt, grease, oil, loose surfacing materials, poorly adhered existing markings, or other detrimental material from the road surface prior to application of the thermoplastic material.

(E) Primer Application:

On both old and new Portland cement concrete pavement, a primer-sealer shall be used if recommended by the thermoplastic manufacturer. The primer-sealer shall be applied at the manufacturer's recommended application rates prior to placing the thermoplastic material. The primer-sealer shall be allowed to set up for the manufacturer's specified cure or evaporation time, and shall be free of solvent and water when the thermoplastic is applied.

(F) Pavement Temperatures:

Ribbon gun application procedures shall not be used if the wind chill factor is below 65 degrees F."

For other application procedures, the road surface temperature at the time of application shall be a minimum of 55 degrees F and rising.

If at any time during marking operations the air or pavement temperature falls below these requirements, all marking operations shall stop.

(G) Thermoplastic Application:

The thermoplastic pavement marking material shall be extruded on to the pavement surface at a material temperature between 385 and 415 degrees F, depending on manufacturer's recommendations, ambient air and pavement temperatures, and the nature of the pavement surface. The thermoplastic material temperatures shall not exceed 450 degrees F. Material temperatures exceeding 440 degrees F shall be allowed for short periods of time; however, in no case shall the material be held for more than four hours at temperatures above 440 degrees F. Total heating time for any batch of material shall not exceed six hours. The Developer shall note in the temperature log the time when each batch of thermoplastic material is first heated. The start of heating time shall also be marked on the side of the kettle to which it applies.

Specified temperature requirements shall be maintained at all times during application. The Developer shall monitor material temperature at thirty minute intervals, and maintain a log of temperature readings taken.

Drop-on glass beads shall be mechanically deposited into the thermoplastic material immediately after the thermoplastic marking is applied, using a double drop method. Each drop shall be comprised of a minimum of six pounds of glass beads per 100 square feet of line (200 linear feet of six-inch stripe). One drop shall be Type I glass beads and the other drop shall be Type III glass beads. The Developer shall determine which type of glass bead is to be applied in each drop; however, both types shall be used. Double drop methods using all Type I or Type III beads will not be allowed.

The dispensers shall evenly distribute the beads in the thermoplastic material. Both Type I and Type III glass beads shall be embedded in the surface of the thermoplastic to a depth of between 50 and 60 percent of the bead diameter. If the glass beads do not adhere to the thermoplastic marking, operations shall be stopped until the problem has been corrected.

Unless otherwise specified, all thermoplastic pavement markings shall be extruded, and shall be 0.090 ± 0.002 inches thick. The thermoplastic thickness shall be uniform and consistent throughout the total length of the marking project.

The Developer shall perform periodic spot checks of thermoplastic material to verify that the required thickness has been attained.

The finished thermoplastic line shall have well defined edges and be free from waviness. Lateral deviation of the thermoplastic line shall not exceed one inch in 100 feet. The longitudinal deviation of a painted segment and gap shall not vary more than six inches in a 40-foot cycle. The actual width of line shall be within the limits specified in the following table, according to the width of line called for on the plans:

Plan Width	Actual Width
4 inches	4 to 4-1/2 inches
8 inches	8 to 9 inches
Over 8 inches	± 1 inch

After application and sufficient drying time, the thermoplastic marking shall show no appreciable deformation or discoloration under local traffic conditions with air and road temperatures ranging from -10 to 180 degrees F. The drying time shall be defined as the minimum elapsed time, after application, when the thermoplastic pavement markings shall have and retain the characteristics required herein, and after which normal traffic will leave no impression or imprint on the newly applied marking. When applied within a temperature range of 400 ± 15 degrees F and thickness of 0.090 inches, the material shall set to bear traffic in not more than two minutes when the air and pavement surface temperatures are approximately 50 ± three degrees F and not more than 10 minutes when the air and road surface temperatures are approximately 90 ± three degrees. The Inspector may conduct field tests in accordance with ASTM D 711 to verify actual drying times.

SECTION 705 PREFORMED PAVEMENT MARKING:

705-1 Description:

(A) General:

The work under this section shall consist of furnishing all materials, preparing the pavement surface and applying preformed reflectorized pavement marking tape, and preformed thermoplastic arrows, symbols, and legends to the pavement in accordance with the details shown on the project plans

All markings shall be reflectorized with glass beads or other retroreflective particles uniformly distributed throughout the entire cross section and bonded to the top surface of the material. All markings shall comply with the retroreflectance requirements of the Technical Provisions. When glass beads are used to reflectorize markings, the glass bead properties shall also comply with Subsection 705-2.06.Certificates of Compliance shall be submitted.

(B) Preformed Pavement Markings - Type I (Permanent):

Type I shall be a general purpose high durability retroreflective, pliant, polymer film for preformed long line and short line striping, arrows, symbols, and legends to be used for final permanent pavement 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.

(C) Preformed Pavement Markings - Type II (Temporary – Removable):

Type II shall be a removable preformed retroreflective pavement marking capable of performing as temporary pavement markings for long line and short line striping, arrows, symbols, and legends for the duration of a normal construction season. It shall be a nonmetallic mixture of high quality materials 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.

(D) Preformed Pavement Markings - Type III (Temporary – Nonremovable):

Type III shall be a nonremovable preformed retroreflective film on a conformable metallic backing capable of performing as temporary long line pavement markings 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.

(E) Preformed Thermoplastic Pavement Markings – Type IV (Permanent):

Type IV shall be a high durability, retroreflective, pliant, preformed thermoplastic product to be used for final permanent arrows, symbols, legends, and short line (transverse) stripes. Type IV 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.

705-2 Materials:

705-2.01 Preformed Pavement Markings - Type I (Permanent):

(A) General:

Type I preformed pavement marking material shall consist of a homogeneous, extruded, pre-fabricated white or yellow film of specified thickness and width that shall be capable of being affixed to Portland cement concrete or non-bleeding bituminous pavements per the manufacturer's requirements, either on the pavement surface or, when specified on the plans, inlaid into a cut-out groove. The preformed plastic film shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting, loss of skid resistance, 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 0.065 inch 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 shall 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. A surface preparation primer shall also be applied if 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.

All white and yellow Type I pavement markings shall be warranted by the manufacturer to retain color and adherence to the pavement, and to retain a minimum retroreflectance of not less than 100 millicandelas/m^2/lux for a minimum of two years for symbols, legends, and transverse pavement markings, and five years for longitudinal pavement markings. The warranty period shall begin after all pavement markings are installed and accepted by the Independent Quality Firm. Failure to meet the specified retroreflectance on at least 90 percent of the longitudinal pavement marking in any 1000-foot segment, or 90 percent of a legend, symbol, or transverse pavement marking shall be considered a complete failure of that marking. The Developer shall submit a copy of the manufacturer's warranty to the Independent Quality Firm along with the certificate of compliance required in subsection 705-1(A).

(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*
*Applicable only when glass beads are used to reflectorize Type I markings.	

(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, when tested according to ASTM D 6628, throughout the expected life of the film.

(2) Bend Test:

The plastic film shall be sufficiently flexible so that at a temperature of 78 to 82 degrees F an unmounted piece of material (without adhesive and paper backing), three by six inches in size, may be bent over a one-inch mandrel until the end faces are parallel and one inch 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 when a specimen six inches long by one inch 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 per minute. The test shall be conducted at a temperature between 70 and 80 degrees F. The elongation shall be no greater than 75 percent.

(4) Plastic Pull Test:

A six-inch long by one-inch wide section of the plastic film (without adhesive and paper backing) shall support a dead load weight of four pounds for not less than five minutes at a temperature between 70 and 80 degrees F.

(5) Abrasion Resistance:

The plastic film shall have a maximum loss in weight of 0.25 grams in 500 revolutions when abraded according to ASTM D 4060.

(6) Skid Resistance:

The surface of the material shall provide a minimum resistance value of 45 BPN when tested according to ASTM E 303.

705-2.02 Preformed Pavement Markings - Type II (Temporary - Removable):

Type II preformed pavement markings shall be a non-metallic 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.

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, loss of skid resistance, 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 degrees F without the use of heat, solvents, grinding or sand blasting. Visible 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 inches 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):

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.

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, loss of skid resistance, roll back or other signs of poor adhesion throughout the useful life of the marking.

705-2.04 Preformed Thermoplastic Pavement Markings – Type IV (Permanent):

(A) General:

Preformed thermoplastic pavement markings shall be a resilient white, yellow, or other color thermoplastic material, composed of an ester-modified resin in conjunction with pigments, binders and glass beads that have been factory-produced as a finished product. The markings shall be resistant to the detrimental effects of motor fuels, lubricants, hydraulic fluids, and antifreeze. Preformed thermoplastic pavement markings shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting, or shrinkage or significant tearing, roll back, loss of skid resistance, or other signs of poor adhesion throughout the useful life of the marking.

The markings shall be capable of conforming to pavement contours, breaks and faults through the action of traffic at normal pavement temperatures. The marking shall have resealing characteristics, such that it is capable of fusing with itself or previously applied, worn thermoplastic pavement markings when heated with a common propane torch. The material shall not be brittle and must be sufficiently cohesive and flexible for one person to carry without danger of fracturing the material prior to application. Surface preparation primer shall also be applied if recommended by the manufacturer.

The material shall be supplied at a minimum thickness of 0.090 inches (90 mils). Arrows, symbols, legends, and short lines shall be capable of being affixed to bituminous and Portland cement concrete pavements by the use of the heat of a common propane torch. Any preheating requirements shall also be met by the use of the heat of a common propane torch and as recommended by the manufacturer.

Type IV preformed thermoplastic markings shall be suitable for use for one year after the date of manufacture when stored in accordance with the manufacturer's recommendation. Type IV marking materials supplied to the jobsite shall clearly display the date of manufacture, and shall be applied within one year of this date.

(B) Composition Requirements:

The preformed thermoplastic pavement marking material shall consist of the following components:

Component	Percent by Weight	
	White	Yellow
Binder (Min.)	18	18
Titanium dioxide (Min.)	10	-----
Yellow Lead-Free Pigment (Min.)	-----	1.5
Reflective glass inter-mix beads	30 – 45	30 – 45

(C) Physical Requirements:

(1) Color:

The pigments shall be selected and blended to provide a white or yellow preformed marking that conforms to standard highway colors, when tested according ASTM D 6628, throughout the expected life of the preformed marking.

(2) Bend Test:

The preformed thermoplastic shall have flexibility at 50 degrees F such that when a specimen, measuring six inches long by one inch wide, is bent through an arc of 90 degrees at a uniform rate in 10 seconds (9 degrees per second) over a one-inch mandrel, no cracking occurs in the test specimen. The specimen shall be conditioned prior to testing at 50 ± two degrees F for a minimum of four hours. At least two specimens tested shall meet the flexibility requirements at 50 degrees F for a passing result.

(3) Tensile Strength:

The preformed thermoplastic material shall have a minimum tensile strength of 150 pounds per square inch when tested in accordance with the requirements of ASTM D 638. The rate of pull of the test shall be 10 to 12 inches per minute. The test shall be conducted at a temperature between 70 and 80 degrees F. The elongation shall be no greater than 20 percent.

(4) Bond Test:

The material shall exhibit a bond strength to Portland cement concrete pavement equal to or exceeding 180 pounds per square inch when tested at 73 ± three degrees F in accordance with the ASTM D 4796.

(5) Abrasion Resistance:

The plastic film shall have a maximum loss in weight of 0.25 grams in 500 revolutions when abraded according to ASTM D 4060.

(6) Skid Resistance:

The surface of the material shall provide a minimum resistance value of 45 BPN when tested according to ASTM E 303.

(7) Impact Resistance:

When tested in accordance with ASTM D 256, Method A, a one-inch by one-inch by six-inch sample shall not break when an impact energy of at least 1.0 joule is applied. The test specimen shall be prepared in accordance with ASTM D 4960 and shall not be notched.

705-2.05 Retroreflectance:

All white and yellow pavement marking materials shall have the retroreflectance values as identified in Section DR 460.3.3 Pavement Marking of the Conformed Technical Provisions.

705-2.06 Glass Bead Properties:

(A) General Requirements:

When glass beads are used to achieve retroreflectivity, the beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering.

(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) Refractive Index:

The glass beads used with the preformed pavement marking material shall have a minimum refractive index of 1.50 when tested by a liquid immersion method (Becke Line Method or equivalent, as specified in ASTM C 1648) at a temperature of 25 +/- 5 degrees C.

(3) Gradation:

The gradation of the glass beads shall be such that performance requirements for the preformed pavement marking material shall be met.

(4) Heavy Metal Concentration:

Heavy metal concentration in glass beads shall be as specified in the following table, when tested by an independent laboratory, approved by the Engineer, using EPA Method 3052 and EPA Method 6010B. A Certificate of Analysis conforming to Subsection 106.05 shall be furnished to the Engineer prior to use.

Heavy Metal	**Concentration**
Arsenic	< 75 ppm
Antimony	< 75 ppm
Lead	< 100 ppm

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, for raised pavement markers and adhesive, shall be submitted at least 10 days prior to use.

The pavement marker samples shall be tested to determine conformance to the applicable plans 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 inches.

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 E	Yellow, red
Type G	Clear, one-way
Type H	Yellow, one-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 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, or red 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 three square inches.

Temporary reflective pavement markers will be tested for compressive strength and specific intensity. Temporary reflective pavement markers, or permanent reflective pavement markers used as temporary, will not be tested for abrasion resistance.

The strength by compressive loading shall be at least 2,000 pounds for both permanent and temporary reflective pavement markers.

The original specific intensity of each reflecting surface for both temporary and permanent reflective markers shall not be less than the following:

Reflectance:	**Specific Intensity: candelas/foot-candle**		
degrees incidence	**Clear**	**Yellow**	**Red**
0	3.0	1.8	0.75
20	1.2	0.72	0.30

Permanent reflective pavement markers shall be subject to an abrasion resistance test as follows:

Steel Wool Abrasion Procedure: Form a one-inch 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 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	**Color**
A	white
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 and six inches, except that the radius of the 1/2 inch 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: Inches	0.005 Minimum
Moh Hardness:	6 Minimum
Directional Reflectance: (White Only) Glazed Surface Body of Marker	 75 Minimum 70 Minimum
Yellowness Index: (White Only) Glazed Surface Body of Marker	 0.07 Maximum 0.12 Maximum
Color (Yellow Only): Purity: percent, range Dominant Wave Length: mu, range Total Luminous Reflectance (Y valve)	 75 - 96 579 - 585 0.41 Minimum
Compressive Strength: pounds	1,500 Minimum
Water Absorption: percent	2.0 Maximum
Autoclave	Glaze shall not spall, craze or peel

Reflectorized dagmars shall have encapsulated lens reflectors conforming to standard manufacturing practices.

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.

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-mile per hour wind load shall not deflect the post more than two inches 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. The tensile stress shall be determined in accordance with the "Standard Method of Test for Tensile Properties of Plastic," ASTM D 638 (Test Specimen Type 1). The rate of jaw separation shall be 20 inches per minute.

The post shall be conditioned for a minimum of two hours in an oven at 140 ± three degrees F. The conditioned post shall be capable of straightening itself within 30 seconds when bent 180 degrees at the midpoint for each of four bends. The stress test on each post shall be completed within two minutes of removal from oven.

The post shall be sufficiently rigid to resist wilting after conditioning a minimum of two hours at 180 ± three degrees F.

The post shall be conditioned a minimum of two hours at -5 ± three degrees F 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 miles per hour at temperatures of 40 degrees F 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.

The post shall also be capable of sustaining a wheel hit during testing at 55 miles 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 10 vehicle impacts at 55 miles 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 four inches 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 Developer'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 Developer.

SECTION 708 PERMANENT 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 plans, MUTCD, and associated ADOT Supplement.

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.

(B) Composition Requirements:

The pavement marking paint shall be a ready-mixed, one component, water-borne lead-free 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, lead, hexavalent chromium, toluene, chlorinated solvents, hydrolyzable chlorine derivatives, ethylene-based glycol ethers and their acetates, and not any carcinogen, as defined in 29 CFR 1910.1200. Lead content shall not exceed 0.06 percent of 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 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 as follows:

(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,	2.1	2.1

	White	Yellow
ASTM D 3960 according to 7.1.2.		
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:

$$\text{Yellowness Index} = \frac{\text{Amber} \quad \text{Blue}}{\text{Green}} x100$$

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 ^{o}C followed by four hours condensate exposure at 40 ^{o}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 ± one degrees F for a period of one week. Remove the paint from the oven and check the viscosity in Krebs Units at 77 ± one degrees 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 degrees F. The blender should have a tight fitting lid taped onto it to minimize volatile loss. When the paint reaches 150 degrees 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 ± one degrees F according to ASTM D 562. The viscosity measured 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 ± one degrees 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 wet film thickness in the field. The paint shall show the following properties at ambient temperatures of 50 to 100 degrees F with a paint spray temperature of 150 degrees F, maximum, and six to eight pounds of post-applied glass beads per gallon of paint. Beads shall conform 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) Road Service Rating:

Glass beads conforming to the requirements of Subsection 708-2.02 of these specifications (moisture proof type) will be applied after the paint has been applied, but during the same striping operation at a rate such that the initial bead retention on the test line is a minimum of six pounds of beads per gallon of wet paint.

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.

Certificates of Compliance shall be submitted.

(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	100
No. 50	15 - 35
No. 70	0 - 15
No. 100	0 - 5

(2) Roundness:

When tested by the method provided in ASTM D 1155 (Procedure B), 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 ^{o}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:

Place 100 grams in an oven at 110 ^{o}C for one hour.

Remove beads and place in a desiccator until the sample is cool.

Remove approximately 60 grams of beads from the desiccator and weigh the sample accurately.

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.

The total volume, minus 50, will give the volume of the beads.

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.

(6) Heavy Metal Concentration:

Heavy metal concentration in glass beads shall be as specified in the following table, when tested by an independent laboratory, using EPA Method 3052 and EPA Method 6010B. A Certificate of Analysis shall be furnished to the Independent Quality Firm prior to use.

Heavy Metal	Concentration
Arsenic	< 75 ppm
Antimony	< 75 ppm
Lead	< 100 ppm

(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.

708-3.02 Application:

Pavement markings shall be applied when the atmospheric temperature is below 50 degrees F when using water-borne paint, nor when it can be anticipated that the atmospheric temperature will drop below said 50 degrees F temperature during the drying period.

Tolerances for Placing Paint, Beads, and Primer:

The length of painted segment and gap shall not vary more than six inches in a 40-foot cycle.

The finished line shall be smooth, aesthetically acceptable and free from undue waviness.

Painted lines shall be four, eight, or 12 inches wide as shown on the plans with a tolerance of ± 1/8 inch and shall be placed at a minimum rate of 16 gallons per mile for a solid four-inch line and four gallons per mile for a broken four-inch line, based on a 10-foot stripe and a 30-foot gap (40-foot cycle aggregate).

Glass reflectorizing beads shall be applied on the wet paint at a minimum rate of eight pounds per gallon of paint.

Wet thickness shall not be less than 15 mils, unless otherwise shown on the plans.

SECTION 730 GENERAL REQUIREMENTS FOR TRAFFIC SIGNAL AND HIGHWAY LIGHTING SYSTEMS:

730-1 Description:

It is the purpose of this section to provide general information necessary for completion of the work on traffic signal and highway lighting systems in accordance with 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, and all auxiliary and external equipment housed in 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, bicycles 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) Magnetometer Vehicle Detector:

A detector capable of being actuated by the magnetic disturbance caused by the passage or presence of a vehicle.

(C) 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, 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 the pole.

730-2.13 Pedestrian Signal:

A traffic control signal for the exclusive purpose of directing pedestrian traffic at signalized locations.

730-2.14 Pretimed Controller Assembly:

A controller assembly for operating traffic signals in accordance with a predetermined fixed-time cycle.

730-2.15 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.

730-2.16 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.

730-2.17 Signal Indication:

The illumination of a signal section or other device, or of a combination of sections or other devices at the same time.

730-2.18 Signal Section:

A complete unit for providing a signal indication consisting of a housing, lens, reflector, lamp receptacle and lamp.

730-2.19 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.

730-2.20 Traffic-Actuated Controller Assembly:

A controller assembly for operating traffic signals in accordance with the varying demands of traffic as registered with the controller unit by detectors.

730-2.21 Vehicle:

Any motor vehicle normally licensed for highway use.

730-2.22 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 current standards of National Electrical Manufacturers Association (NEMA), National Electric Safety Code (NESC), Underwriters' Laboratory Inc. (UL), 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), the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), requirements of the plans, these specifications , and to any other codes, standards, or ordinances which may apply.

730-4 Equipment List and Drawings:

The Developer shall note that approval by the Engineer is required before ordering or installing any material that is to be used on the project.

The Developer shall submit six copies of a complete project material submittal for approval at the pre-construction conference which shall conform to these specifications. The project material submittal shall state all relevant information regarding materials and equipment to allow the Department to procure exact replacements of any or all items on the project. To be acceptable, the material submittal shall be complete and contain all items supplied on the project by the Developer. The Department reserves the right to reject an incomplete or unclear material submittal.

The materials on the submittal 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, schedules for other pertinent information. The materials from any catalog cuts shall be clearly indicated by the Developer. Any material designations used in the contract documents shall be so noted on the materials list. If requested by the Engineer, the Developer shall submit manufacturer shop drawings for review and approval and shall furnish Certificates of Compliance conforming to the requirements of Subsection 106.05.

There shall be no substitutions 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 Developer shall submit samples of the proposed materials for inspections, testing, and approval by the Department. The Department will not be liable for any electrical materials procured or any labor performed prior to approval.

When the plans include lighting, the Developer shall submit six copies of photometric data sheets indicating the IES distribution classification for each type of luminaire submitted for approval. In addition, the Developer 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 Project Specifications, the Developer shall provide computer printout grids of both luminance and illuminance values for the spacing, height, roadway width, and type of luminaire submitted.

730-5 Battery Backup System for Traffic Signals (TP Attachment 460-1)

730-5.1 General

This specification establishes the minimum requirements for a complete emergency battery back-up system for use at traffic signals utilizing light emitting diodes (LED) signals and pedestrian heads. The battery back-up system (BBS) must include, but not be limited to the following:

A. UPS with inverter, charger, tap switching transformer and internal power transfer switch;
B. Power Transfer Switch and Manual - bypass transfer switch unit;
C. Batteries;
D. Cabinet;
E. Mounting hardware; and
F. Wiring.

The BBS must provide reliable emergency power to a traffic signal in the event of a power failure or interruption.

730-5.2 Operation

730-5.2.1 General

The BBS must provide the following operational modes when operating on battery power:

A. Full operation of all traffic signal devices;
B. Flash operation; and
C. Combination of full and flash operation.

730.5.2.2 Run Time

The BBS must provide a minimum of 6.75 to 8.0 hours of full time operation with a 450 watt load. The battery size requirement is listed in section 7.0, Battery Type.

730.5.2.3 Compatibility

The BBS must be compatible with Model 332, 336, and 337 cabinets; the ITS cabinet; model 170 and 2070 controllers and any NEMA style cabinet and enclosures; the advanced transportation controller; and all cabinet components for full time operation.

730.5.2.4 Output Capacity

The BBS must provide a minimum of 1100W/1100VA at 25°C active output capacity with 80 percent minimum inverter efficiency with 30 percent minimum loading.

730.5.2.5 Output Voltage

When operating in backup mode, the BBS output must be 120VAC ± 5 percent, pure sine wave output, ≤ 3 percent THD, 60Hz ± 3.0 Hz.

730.5.2.6 DC System Voltage

The BBS DC system voltage shall be 48VDC nominal.

730.5.2.7 Transfer Time

The maximum transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, must be 7 milliseconds (ms). The same maximum allowable time must also apply when switching from the inverter line voltage to utility-line voltage. Transfers to and from battery operation must not interfere with the operation of the other equipment in the intersection.

730.5.2.8 Operating Temperature

The BBS and all components must operate without performance degradation over a temperature range of -37°C to +74°C with a maximum load of 70 percent of rated output of the BBS inverter.

730.5.2.9 Surge Protection

The BBS must have surge protection design to meet IEEE/ANSI C.62.41 Cat. A & B.

730.5.2.10 Reliability

The BBS system must have a mean-time-before-failure of 61128 hours at a temperature of -37 to +74 degrees C.

730.5.2.11 Power and Control Connections

The BBS must be easily installed, replaced, or removed by using easily removable cables for AC input, AC output, DC input, external transfer control/alarm and battery temperature sense.

730.5.2.12 AC Connection

The AC input and output must hard wired connections.

730.5.2.13 DC Connection

The DC connection must be a recessed one piece Anderson Style connector rated to handle the maximum DC current required by the inverter while running on batteries.

730.5.2.14 Temperature Probe Connections

The battery temperature sense inputs shall be panel-mounted Telco style connector.

730.5.2.15 Unit Failure

In the event of inverter/charger failure, battery failure or complete battery discharge, the automatic bypass transfer switch shall revert to normally closed (NC) (de-energized) state, where utility line power is connected to the cabinet.

730.5.2.16 Overload

The inverter must support an overload up to 110 percent for 3 minutes and then turn off the inverter output.

730.5.2.17 AC Feedback

The BBS must prevent a malfunction feedback to the cabinet or from feeding back to the utility service.

730.5.2.18 BBS Failure Mode

In the event of BBS failure (inverter/charger or battery) or complete battery discharge, the internal power transfer relay must revert to NC (de-energized) state and provide utility power to the intersection when utility line power is available to the cabinet.

730.5.2.19 Automatic Shutdown

The BBS must initiate an automatic shutdown when battery output reaches 42.5VDC.

730.5.2.20 Destructive Discharge or Overcharge

The BBS must be equipped with an integral system to prevent the battery from destructive discharge or overcharge.

730.5.3 Automatic Bypass Transfer Switch PTS

730.5.3.1 Rating

The BBS must include an automatic/manual transfer switch rated at 120VAC/40 amps.

730.5.3.2 Automatic PTS & Manual Bypass Switch

The automatic bypass transfer switch must be a combination automatic/manual bypass switch. Placing the bypass switch in the “bypass” mode must transfer the intersection load from the UPS output directly to commercial power. AC commercial power must still be available to the UPS input, allowing the UPS to keep the batteries charged. An inverter input breaker must be provided to shut off commercial power to the UPS input, allowing safely disconnecting and removing the inverter. With the inverter turned off, the batteries can be safely disconnected from the system.

730.5.3.3 Terminal Blocks

The automatic bypass transfer switch must have terminal blocks capable of accepting #14 AWG wiring for the AC input and output with #14 AWG from the automatic bypass transfer switch to inverter/charger module.

730.5.4 Functionality

730.5.4.1 Output Voltage Regulation Mode

The BBS must include auto voltage regulation functionality.

730.5.4.1.1 AC Input Voltage Range for Output Regulation

The buck/boost mode must have a minimum range of 96 - 144 VAC.

730.5.4.1.2 Transfer Set Points

There are to be user definable transfer set points for the buck boost mode.

730.5.4.1.3 Regulated Voltage

Whenever auto voltage regulation mode is selected the output of the system must be regulated between 90-150VAC. When the output of the system can no longer be maintained with this range, the BBS must transfer to backup mode.

730.5.4.2 Circuit Breakers

The BBS must be equipped with an AC Input circuit breaker that protects both the UPS and the loads connected to the output. Should the AC input breaker on the UPS trip, the PTS will Fail-Safe back to the Utility Power. The BBS AC Breaker turns ON/OFF VAC input and VAC output simultaneously.

The BBS must have a flush mounted battery circuit breaker installed on the front panel of the BBS inverter module.

730.5.4.3 Line Qualify Time

The BBS must have a user definable line qualify time. The user must be able to select a minimum of six possible settings. The settings must be 3, 10, and 30 seconds. The default line qualify time must be 30 seconds.

730.5.4.4 Battery Charger

The BBS must have an integral charger that is compatible with Gel and AGM battery topology. The charger must be an intelligent fluctuating charger with temperature compensation.

730.5.4.4.1 Battery Temperature Compensation

The integral intelligent charger must use temperature compensation. The charging system must compensate over a range of 2.5, 3.0, 4.0 or 5.0 mV/°C per cell, user adjustable when required.

730.5.4.4.2 Battery Temperature Sensor

A temperature probe which plugs into the front panel of the BBS must be used to monitor the internal temperature of the batteries. The temperature sensor must be 9 feet in length, temperature probe on hanger, bolted to positive Terminal of battery in a string.

730.5.4.4.3 Battery Temperature Charging

The batteries must not be charged whenever the battery temperature exceeds 50°C.

730.5.4.4.4 Recharge Time

The recharge time for the batteries from “protective low-cutoff” to 90 percent or more of full charge capacity must not exceed 12 hours. The BBS charger must be capable of providing 10 amps at 54VDC.

730.5.5 User Interfaces and Displays

730.5.5.1 Inverter/Charger Display

The BBS inverter/charger unit must include a backlit LCD display for viewing all status and configuration information. The screen must be easily viewable in both bright sunlight and in darkness.

730.5.5.1.1 Screen Size

The screen must be large enough to display the following information with the use of menu scrolling buttons to read required information. All active readings must be real time.

A. Operating mode (line, standby, batt, buck / boost)
B. Utility input voltage
C. BBS output voltage
D. Battery temperature
E. Input frequency
F. Output power
G. Battery voltage
H. Unit firmware version
I. Any alarms and faults

730.5.5.1.2 Keypad

The BBS inverter/charger unit must include a keypad for navigating system information.

730.5.5.1.3 Status LEDs

The BBS must have discrete status LED indications on the front of the inverter/charger.

730.5.5.1.4 Green Output LED

This LED must be "on" any time that the output of the BBS is in normal mode. When the BBS output is either in backup mode or auto voltage regulation modes the LED must flash "on" and "off".

730.5.5.1.5 Red Fault LED

This LED must be solid "on" any time that there are any faults in the system.

730.5.5.1.6 Red Flashing Alarm LED

This LED must flash "on" and "off" any time that there are any alarms in the system.

730.5.5.1.7 Event Log

The BBS must maintain an event log containing a minimum of 200 of the most recent events recorded by the BBS. These events must be down loadable via Notebook Computer with RS-232 or USB interface. The events log must be date and time stamped.

730.5.5.1.8 Events, Alarms and Faults

The BBS must display and log the following events, alarms and faults:

A. Operating mode;
B. Overload;
C. High and low temperatures;
D. Line frequency out of specifications;
E. No temperature probe;
F. Low battery;
G. Short circuit;
H. Output voltage high;
I. Output voltage low;
J. Battery voltage high;
K. Battery voltage low; and
L. Temperature high.

730.5.5.1.9 Counters

The BBS must keep track of the following:

A. The number of times that the unit was in backup mode.
B. The accumulated number of hours and minutes that the unit has operated in backup mode since the last reset.

730.5.5.1.10 Programmable Relay Contacts

The BBS must provide the user six programmable dry relay contacts. As a minimum, the programmable options must be on battery, low battery, timer, alarm, and fault.

730.5.5.2 Relay Contact Terminals

The relay contacts must be made available on the front panel of the BBS via 6, 3 position plug-in terminal blocks with screw down wiring connections.

730.5.5.2.1 Contacts

Each relay, C-1 through C-6 must have their own common and their own set of normally open (NO) and NC terminals. The terminals for each relay must be oriented as NO-C-NC on the terminal block.

730.5.5.2.2 Labeling

The contacts on the terminal block must be labeled 1-18, left to right. Additionally, each set of contact must be labeled with the NO-C-NC designation, as well as C1…C6 from left to right.

730.5.5.2.3 Rating

The relay contacts must be rated at a minimum of 1 amp at 240 VAC.

730.5.5.2.4 On Battery Relay Contact

The dry relay contacts that are configured for “on battery” must only energize when the Inverter is operating in backup mode.

730.5.5.2.5 Timer Relay Contacts

The BBS must include a timer that must energize the “timer” configured dry relay contact after the user configured time has elapsed. The timer is started when the BBS enters backup mode. The user must be able to configure the timer to the required time. The format must be in 15 minute intervals.

730.5.5.2.6 Low Battery Relay Contact

The BBS must have an adjustable low battery relay setting. This setting must be adjustable so that the user can set the point at which the low battery relay contact is energized.

730.5.6 Communications

730.5.6.1 Serial Interface

The BBS must be equipped with an industry standard RS-232 serial connection for user configuration and management. The serial port must be an EIA-232 (DB9-Female) connector.

730.5.6.2 User Configuration Menus

All BBS configuration and system menus must be accessible and programmable from the RS-232.

730.5.7 Batteries

730.5.7.1 Battery Type

The battery must be comprised of extreme temperature, float cycle, GEL valve regulated lead acid. Individual batteries must meet the following specifications:

A. Voltage rating: 12V
B. Amp-hour rating: 105 AH, at the 20 hour rate, to 1.75 Volts per cell, minimum battery rating. OEM pass through warranty.
C. Batteries must be easily replaced and commercially available off the shelf

730.5.7.2 Battery String

Batteries used for the BBS must consist of a 4 batteries configured for a 48 VDC battery buss system.

730.5.7.3 Operating Temperature

The battery system must consist of one or more strings of extreme temperature; float cycle GEL valve regulated lead acid batteries. Batteries must be certified to operate at extreme temperatures from –40°C to +60°C.

730.5.7.4 Construction

730.5.7.4.1 Terminals

The batteries must have maintenance-free threaded insert terminals eliminating annual torqueing. Battery terminals that require annual torqueing of each post connection must not permitted.

730.5.7.4.2 Ability to Function

An integral lifting handle should be provided on the batteries for ease of removal/installation.

730.5.8 Cabinet

730.5.8.1 General

730.5.8.1.1 BBS Service Cabinet Dimensions

The dimensions for the BBS cabinet must not exceed 55 inches in height, 35 inches in width and 17 inches in depth.

730.5.8.1.2 Inverter/Charger Mounting

The inverter/charger unit must be shelf or rack mounted on a standard EIA 19 inch rack.

730.5.8.1.3 Automatic Transfer Switch Mounting

The automatic transfer switch must be mounted.

730.5.8.1.4 Interconnect Wiring

All interconnect wiring must be provided and must be UL Style 1015 CSA TEW.

730.5.8.2 BBS Replacement

The BBS equipment and batteries must be easily replaced and must not require any special tools for installation.

730.5.8.3 Hot Swappable

The BBS inverter and batteries must be hot swappable. There must be no disruption to the traffic signal when removing the inverter or batteries for maintenance.

730.5.8.4 Quick Disconnects

All inverter and battery connections must be of the quick disconnect type for ease of maintenance.

730.5.8.5 Ancillary Installation Hardware

All necessary installation hardware (bolts, fasteners, washers, shelves, racks, etc.) must be included.

730.5.8.6 Cabinet Sizing

The external cabinet must be capable of housing batteries, inverter/charger power module, automatic transfer switch, control panels, wiring, wiring harnesses, and all other ancillary equipment.

730.5.8.7 Cabinet Types

The BBS can be installed either as:
(A) Free-standing base-mounted cabinet with optional 8 inch riser for easy cable entrance;
(B) Pole-mounted cabinet with optional pole mount bracket kit; or
(C) Side-mounted to a traffic controller cabinet with no mounting brackets required.
(D) Combination meter pedestal cabinet with Battery Back-up System housed in cabinet.

730.5.8.8 Rating

All external cabinets must be NEMA 3R rated. The enclosure must be made of 0.125 (5052-H32) aluminum.

730.5.8.9 Ventilation

The external service cabinet must be ventilated through the use of louvered vents, filter, and two thermostatically controlled fan. The filter must be the re-usable with louvered filter located on the bottom rear of back door. The battery compartment door will be louvered with screens. In addition, the back-side of battery compartment will be louvered with screens.

The BBS cabinet must come with all bolts, washers, nuts required to mount it to a controller cabinet.

730.5.8.10 Accessibility

All components, terminations, terminal blocks, relays, etc. must be fully accessible.

730.5.8.11 Shelves

Battery shelves must be located on the side of the enclosure. Air must be allowed to flow from the side access door of the cabinet .

730.5.8.12.1 Locking

Cabinet comes with padlock provision for the Customer Compartment and Side Battery Door. Padlock supplied by others. Battery heater mats to increase battery capacity in cold climates. Installation of standard ADOT apparatus and control for, but not limited to, Lighting Control, etc.

730.5.9 Maintenance

730.5.9.1 Probe Jacks

The BBS must provide voltmeter standard probe input-jacks (+) and (-) to read the exact battery voltage drop at the inverter input.

730.5.10 Warranty

730.5.10.1 Battery Backup System

The BBS system must include a five-year warranty on parts and labor on the entire BBS system, including batteries, to ADOT when utilizing the BBS Manufacturers own designed enclosure, meeting the above cabinet specifications.

If another enclosure is provided by the BBS manufacturer, the manufacturer must provide a three-year warranty on parts and labor on the BBS inverter module only.

730.5.10.2 Batteries

The BBS manufacturer must provide a 5 year unconditional full replacement warranty for every battery with the BBS under this specification. Under the warranty time period, the battery must provide a minimum of 70% of its original capacity.

730.5.11 Vendor Support

730.5.11.1 Technical Support

The BBS manufacturer must provide a toll-free technical support phone number. The toll-free phone number must be included in the BBS manual.

730.5.11.2 Documentation

Equipment manuals must be provided for each BBS cabinet. Equipment manuals must include installation, operation, programming, maintenance and troubleshooting.

730.5.12 Quality Assurance

730.5.12.1 Design and Production

Each BBS must be manufactured in accordance with a written manufacturer's Quality Assurance program. The QA program must include, as a minimum, specific design and production QA procedures.

730-6 Video Detection:

Video detection must comply with the following requirements.

A. System
1. Vehicle and bicycle presence detection, vehicle and bicycle counting, pedestrian presence detection, traffic data collection, and inverse direction detection
2. Number of detection zones
   a. 24 vehicle presence zones
   b. 8 bicycle presence regions
   c. 8 pedestrian zones
   d. 8 traffic data zones
   e. 8 inverse direction zones

B. Cameras must be forward looking infrared cameras.
1. Resolution: QVGA (336 x 256)
2. Frame rate: 30 frames per second
3. Compression: H.264, MPEG-4, or MJPEG

C. Housing
1. Material: Aluminum

D. Communication
1. Contact closures: 3 for ETH versions, direct or via optional ETH interface (PN 10-6075), 24 for BPL versions, 4 outputs via TI x-stream EDGE (PN 10-6055), up to 20 extra outputs via up to 5 4/Os xp expansion boards
2. Ethernet: For communication of output state events, configuration & monitoring (streaming video)
3. Input power: 12-42VDC, 12-30VAC
4. Current consumption: BPL: < 230 mA @ 24VDC (< 320mA @ 24VDC peak at startup), ETH: < 130 mA @ 24VDC (< 250mA @ 24VDC peak at startup)
5. Power consumption: BPL: < 5.5W (< 7.5W peak at startup), ETH: < 3.1W (< 6W peak at startup)

E. Environmental
1. Shock and vibration: NEMA TS2 specs
2. Materials: All weatherproof (UV-resistant)
3. Protection grades: Housing = IP68, Connectors = IP67
4. Temperature range: from -29 degrees to 165 degrees Fahrenheit
5. FCC: FCC part 15 Class A

730-7 Locations of Utilities:

The locations of utilities shown on the project plans are approximate. All involved utilities may not be shown on the plans.

The Developer'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 Developer 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.

SECTION 731 STRUCTURAL SUPPORTS AND FOUNDATIONS FOR TRAFFIC SIGNAL AND HIGHWAY LIGHTING:

731-1 Description:

The work under this section shall consist of furnishing all materials and constructing new supports and foundations for traffic signal and highway 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 conduit, elbows, anchor bolts and clearance pad.

731-2 Materials:

Excavation and backfill shall conform to the requirements of Subsection 203-5.03. Concrete shall conform to the requirements of 1006 and 601. Reinforcing steel and wire mesh shall conform to the requirements of 1003 and 605.

Concrete for all foundations shall be Class S and shall have a required 28-day compressive strength of 3,000 pounds per square inch.

731-2.01 Blank

731-2.02 Standard Steel Poles:

(A) General:

Standard steel poles for traffic signals and highway lighting shall include pole shafts and pole bases.

Material standards for traffic signal and lighting supports shall be in conformance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. All pole supports shall be designed to withstand 90-mile per hour winds except for the type K and R poles. The type K & R poles shall be designed to withstand 90-mile per hour winds. Metal parts of standard steel poles and hardware shall conform to the details shown on the plans and the following specifications. Welding shall conform to the requirements of Subsection 604-3.06.

(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. The type K and R poles shall be constructed from sheet steel that has a minimum yield stress, after fabrication, of 48,000 pounds per square inch. A taper rate of 0.14 inches in diameter per linear foot shall be required unless otherwise specified. Pole shafts shall be fabricated according to the thickness requirements shown on the plans.

Standard pipe pole shafts shall be fabricated from standard weight structural steel which conforms to the minimum strength requirements of ASTM A 53, Grade B, and a nominal diameter indicated on the Plans. Each section shall be fabricated from not more than two pieces of sheet steel. When two pieces are used, the longitudinal welded seams shall be directly opposite one another. When the sections are butt-welded, seams shall be directly opposite one another. When the sections are butt-welded together, the longitudinal welded seams on adjacent sections shall be placed to form continuous straight seams from base to top of pole. Pole shafts shall be straight, with a permissive variation not to exceed one inch measured at the midpoint.

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 shall not be allowed. Pole shafts that have a finish unacceptable to the Independent Quality Firm shall either be repaired or replaced.

Hand holes in the base of the poles shall conform to the details shown on the Standard Drawings. 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 per the Technical Provisions.

(C) Steel Pole Extensions and Luminaire Brackets:

Pole extensions and 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 luminaire brackets shall be fully galvanized in accordance with the requirements of ASTM A 123. Fabrication of the pole extensions and luminaire brackets shall be in accordance with the dimensions as specified in the plans.

(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 radius. Standard bases shall be galvanized in accordance 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 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 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, Luminaires 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 project plans.

(G) Anchor Bolts:

All anchor bolts shall be threaded at the top and shall conform to the plans.

Standard anchor bolts, washers, and nuts shall be fabricated from steel conforming to the strength requirements of ASTM A 36. 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 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 shall be submitted for high strength anchor bolts, washers and nuts.

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.

Wood poles shall be used for service or temporary traffic signal or roadway lighting installations when specified unless an alternative is approved by the Independent Quality Firm.

(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 one to two inches 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 occurs in the living tree, and is 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, 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" (one twist in 30 feet).

(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 Pines:

(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 planes)
Hollow butts or tops
Improper Framing
Nails or other metal not authorized by the Inspector
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 sapwood will be rejected. Additional cores may be taken to determine extent of the stain.

(b) Check:

Any check more than 1/8 inch wide and extending down from the top of the pole more than 12 inches and within 30 angular degrees from the axis of the face of the pole directly above the 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 two feet.

A check is considered to be continuous if it is not separated by at least 1/2 inch of wood. Maximum acceptable dimensions of checks are as follows:

Length of Pole	Maximum Width	Maximum Length
30 feet and shorter	1/4 inch	5 feet
35 and 40 feet	5/16 inch	5 feet
45 feet and longer	3/8 inch	8 feet

(c) Compression Wood:

Compression wood in the outer 1-1/2 inch 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
Pine	3 inches

(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 one-foot section shall not exceed the limits set up in the following table. Knots 1/2 inch or less in diameter shall be ignored in applying the limitations for the sum of diameters.

Length/Class of Pole	Diameter of Any Single Knot	Sum of Diameters of Knots in Any One-Foot Section
45 feet and shorter	2.5 inches	8 inches
50 feet and longer	3.0 inches	10 inches

Maximum single knot in any sworl shall be two inches 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 table above under the column heading "Sum of Diameters of Knots in Any One-Foot 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.

(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 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 average annual ring count shall be not less than six rings per inch average measured in the outer three inches 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 two inches 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.

(m) Spiral Grain:

Spiral grain is permitted provided it does not exceed 1/2 turn in 15 feet or one complete turn in any 30 feet 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 six feet 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 one inch for each 10 feet 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 six feet 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 in length shall be not more than three inches shorter or six inches longer than nominal length.

Poles 50 feet or more in length shall be not more than six inches shorter or 12 inches longer than nominal length.

The minimum lengths for the wood species shown are as follows:

Wood Species	Minimum Length of Pole
Douglas Fir	50 feet
Western Pine	45 feet
Southern Pine	30 feet

(2) Classification:

The pole circumference at the top and at a point six feet 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 from Butt

Length of Pole (Feet)	Groundline Distance from Butt (Feet)	(Inches) Western Pine	(Inches) Douglas Fir and Southern Pine (all types)
20	4	29.5	27.0
25	5	32.5	29.5
30	5.5	35.0	32.0
35	6	37.5	34.0
40	6	39.5	36.0
45	6.5	41.5	37.5
50	7	43.5	39.0
55	7.5	45.0	40.5
60	8	46.5	42.0

(F) Manufacturing Requirements:

(1) Bark Removal:

Poles shall be smoothly trimmed by machine; 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 wide and six inches 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 burn-branded legibly on the butt and on the face of the pole per AWPA Standard M6 at a point 12 feet ± two inches 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 two inches in fir or 2-1/2 inches in pine.

(3) Retention:

Douglas Fir - The treating process must produce not less than one inch penetration at any point on the pole. If the sapwood thickness exceeds one inch between the butt and standard ground line, 85 percent of the sapwood shall be treated. The assay zone shall be 1/4 to one inch.

Cellon or Dow Process - Retention shall be not less than 0.90 pounds per cubic foot 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.

Cellon or Dow Process - Retention shall be not less than 0.60 pounds per cubic foot in the 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 conforming to AWPA Standard C1.

Cut Back Poles - All poles that are shortened or trimmed shall be retreated within seven days conforming to AWPA Standard C1.

(I) Inspection:

Inspection shall be made upon delivery. The Developer shall provide the necessary assistance and facilities to enable safe and efficient inspection of the work. A Certificate of Compliance shall be furnished to the Independent Quality Firm upon delivery to the job site or other approved locations.

731-2.04 Mast Arms and Tie Rods:

Mast arms for standard steel poles that are not tapered shall be fabricated from steel pipe as specified in ASTM A 53. The arms shall conform to the dimensions shown on the Plans. The pipe shall be one piece and free from burrs.

Tapered mast arms shall be fabricated from sheet steel conforming to the requirements of ASTM A 36, except for the types K and R pole mast arms. The mast arms for the types K and R poles shall be constructed of sheet steel with a minimum yield stress of 48,000 pounds per square inch after fabrication. Mast arms shall be fabricated according to the thickness requirements shown on the plans. A taper rate of 0.14 inches change in diameter per linear foot 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 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.

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 Independent Quality Firm shall not be allowed. Mast arms and tie rods that have a finish unacceptable to the Independent Quality Firm shall either be repaired or replaced to the satisfaction of the Independent Quality Firm.

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, mast arm or pole drawing number, length, and gage number.

731-3 Construction Requirements:

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 Developer. After each excavation is completed, the Developer shall notify the Inspector, and under no circumstances shall any underground materials or equipment be covered with fill without the approval of the Independent Quality Firm.

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5. At the end of each working period, all excavations shall be barricaded or covered, or both, 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 these specifications.

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 flush with the existing or new curb and sidewalk or flush with the finished grade where there is no curb or sidewalk, except in sloped areas they shall be as shown on the project plans. The dimensions and locations of foundations shall be as specified on the project plans; however, the Inspector may direct that changes be made in locations due to obstructions or other existing conditions. The Developer shall verify top of foundation elevations with the Inspector prior to foundation construction.

Concrete shall be placed in holes which have been augered against undisturbed earth. If the material in the bottom of the hole is not firm and stable, it shall be compacted or treated. 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 augered, 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.

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 installation except for types J, K, Q and R pole foundations which shall set for seven days.

Before the concrete for cabinet foundations has set, depressions shall be made around the anchor bolts for adjustment of the cabinet leveling nuts.

731-3.02 Base Plates and Poles:

High strength bolts, nuts, and washers for slip-away bases shall be assembled as specified in the Project Plans and shall be torqued as required by the Project Plans. Anchor bolts, washers, and nuts required for relocating existing poles shall be furnished by the Developer.

Poles shall be drilled and tapped for mounting hardware as shown on the Project Plans. 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 luminaires installed.

Sidewalks, curbs, gutters, pavement, base material, lawns, plants, and any other improvements removed, broken, or damaged by the Developer's operations shall be replaced or reconstructed with materials in accordance with these specifications. The replaced or reconstructed improvements shall be left in a serviceable condition 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 project specifications.

Wood poles shall be placed in the ground to a depth of at least six feet. 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 six inches before compaction. Each layer shall be moistened and thoroughly compacted.

Existing poles shall be either relocated or used in place as specified in the project plans. The Developer 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 painted with a zinc galvanized paint.

If any poles are damaged by the Developer's operations, such repairs or replacements shall be made at no additional cost
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 Developer, the entire section between expansion joints shall be removed and the concrete reconstructed.

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 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 Inspector. Saw cuts shall be neat and true with no shattering or chipping of concrete adjacent to the outside of the removal area.

SECTION 732 ELECTRICAL UNDERGROUND MATERIAL:

732-1 Description:

The work under this section shall consist of furnishing and installing electrical conduit, conductors, and pull boxes for traffic signals and highway lighting including jacking, drilling, excavating, backfilling, and compacting 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 single 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, highway lighting and other electrical systems shall be UL listed and rated for 600-volt operation. The UL label shall be present on each reel, coil or container of wire or cable. When requested, the Developer shall submit 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 with THW grade thermoplastic compound 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 of coating. The insulation thickness shall conform to the requirements of the NEC. Conductor insulation shall be a solid color as specified in the conductor table unless otherwise specified. The color shall be continuous over the entire length of the conductor.

(A) Traffic Signal and Highway Lighting Conductors:

Conductors used for traffic signal and highway lighting systems shall conform to the requirements of the following table. The minimum conductor sizes shall be as shown in the following table unless otherwise specified.

CONDUCTOR TABLE

CIRCUIT	SIGNAL PHASE OR FUNCTION	INSULATION		CONDUCTOR		
		COLOR	TYPE	Minimum Thick. (MILS)	Minimum Gauge (AWG)	TYPE
Vehicle Signals	Red Interval Yellow Interval Green Interval	Red Yellow Green	THW THW THW	45 45 45	12 12 12	
Pedestrian Signals	Intl. Symbol Hand/Man	Red Green	THW THW	45 45	12 12	
Pedestrian Push-Button	Pedestrian Detection	Orange	THW	45	12	
Series Lighting	Series Loop	Black	THW 5 kv	150	8	S
Highway Lighting	Multiple Lighting	Black	THW	45	12	
Lighting in Pole	Pull box to Luminaire	Black	XHHW	30	12	S
Sign Lighting	Multiple Lighting	Black	THW	45	12	
Common	Common Lead	White	THW	45/60	12/8	
Spares	Unused Leads	Brown or Black	THW	45	12	
Detection	Detector Roadway Loops	Black Orange	THWN in PVC Tubing	15 31	14	S
Detection	Loop Detector Lead in Cable	Clear Black	PE Foil Shield Vinyl	32	14/16/18	STP
Detection	Magnetometer Lead in Cable	Red Black Green White	PE in PVC Jacket	18 18 18 18	18 18 18 18	S4C
	Service Service Common Bond	Black White Green or Bare	THW THW	AS AS AS	AS AS 8	
Legend: AS = As Specified; PE = Polyethylene; S = Stranded; STP = Stranded, twisted pair; S4C = Stranded, 4 Conductor						

(1) Roadway Loop Detector Wire:

Roadway loop detector wire shall be a factory assembled combination of PVC 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. Developer assembly of the wire in the flexible tubing will not be acceptable.

The PVC 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 with a nominal inner diameter of 0.186 inches. The tubing shall be orange in color, be highly resistant to chemicals and oils, and have a dielectric strength of 900 volts per centimeter.

(2) Wire Marking Tags:

Wire marking tags shall be made of flame retardant reinforced epoxy tape 5.5 mils in thickness and 1/4 inch minimum width. The tape shall be flexible, resistant to oil and water, and have a pressure sensitive acrylic adhesive backing. The adhesive shall be a high tack adhesive with good adhesion to clean neoprene, hypalon, nylon and PVC insulation materials. The film material shall conform to the flame retardant requirements of UL 510 and be rated at 150 °C. Appropriate numbers and letters shall be printed on wire tags for conductor identification.

(B) Cable:

(1) Shielded Cable:

Shielded cable used for loop detector lead-in cable and telephone coordination interconnect circuits shall be two-conductor, stranded, twisted pair, aluminum-polyester foil shield with 100 percent coverage, tinned copper with polyethylene insulation, vinyl jacketed, rated at 600 volts and 60 °C, and shall be in conformance with UL and the following table:

TABLE FOR SHIELDED CABLE		
AWG Size Number	14	16
Stranding	19 x 27	19 x 29
Insulation Thickness, inches	0.032	0.032
Jacket Thickness, inches	0.035	0.032
Outside Diameter, inches	0.340	0.274
Ground Wire AWG Number	16	18
Nominal Capacitance* (pF/ft)	24	24
Nominal Capacitance** (pF/ft)	47	47
* Capacitance between conductors.		
** Capacitance between one conductor and another conductor connected to the shield.		

(2) Instrumentation Cable:

Instrumentation cable normally used for magnetometer detectors shall be a number 20 AWG four-conductor, low-capacitance cable suitable for both conduit and direct burial.

The cable shall be round and be less than 0.25 inches in overall diameter. The jacket shall be a weatherproof, high density, heavy duty, abrasion resistant, polyethylene material with a minimum thickness of 0.032 inches.

The cable shall have an interior moisture penetration barrier to prevent capillary absorption of water and be suitable for a temperature range of -60 °C to +80 °C.

Each conductor shall have thermoplastic insulation with a minimum thickness of 0.018 inches. The conductor to conductor capacitance shall not be greater than 18 picofarads per foot for adjacent pairs and 15 picofarads per foot for diagonal pairs with all other conductors disconnected.

(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, surface coated, or adhered to surface.

732-2.02 Electrical Conduit and Warning Tape:

All conduit and fittings shall be listed by UL, and conform to NEC standards. Except as specified below, 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.

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 metal galvanized steel conduit bends shall be used for entering pull boxes that are spaced more than 150 feet apart.

Intermediate metal conduit may be used in place of rigid metal conduit except for service risers. Galvanized intermediate metal conduit shall conform to the requirements of UL 1242. Intermediate metal conduit and fittings shall be manufactured from steel and work hardened to provide high strength. The exterior wall shall be hot-dip galvanized. Threads shall be fully cut and galvanized after cutting. All threaded fittings shall be the same as fittings approved for metal conduit.

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 a PVC cover. Approved liquid-tight fittings shall be furnished and installed with the conduit.

Sampling and testing procedures shall conform to UL Standards. Samples of conduit shall be tested by UL standards and be approved for use by the Independent Quality Firm prior to installation on the project.

Conduit warning tape shall be a four-mil 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 Independent Quality Firm, pull boxes, covers, and extensions shall be furnished for testing.

Covers shall be marked as follows:

"A.D.O.T. ELECTRICAL HIGH VOLTAGE"

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 gage 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 shall fit between the box and the cover. 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 Developer.

732-3 Construction Requirements:

732-3.01 Installation of Electrical Conduit and Pull Boxes:

Conduit runs shown on the project plans may be changed to avoid underground obstructions.

The Developer may, at its option 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 will not be permitted. Changes in the location and size shown on the project plans shall be documented by the Developer and submitted to the Independent Quality Firm for as-builting the drawings.

The PVC conduit shall be cut square and trimmed to remove all rough edges. Conduit connections shall be of the solvent weld type. Purple primer conforming to the requirements of ASTM F 656 shall be applied to the joined surfaces prior to use of cement. The joint cement shall be the gray PVC cement conforming to the requirements of ASTM D 2564. 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 in which both ends of the conduit 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. Approved expansion fittings shall allow for a linear thermal expansion of up to six inches.

If a trench has to be left open overnight, a minimum of six inches 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 Inspector has not been made.

Backfill containing large rock, paving materials, cinders, large or sharply angular substance, or corrosive material, shall not be placed in an excavation where materials may damage raceways, cable, or other substructures or prevent adequate compaction of fill or contribute to corrosion of raceways, cables or other substructures.

Where necessary to prevent physical damage to the raceway or cable, protection shall be provided in the form of granular or selected material, suitable running boards, suitable sleeves, or other approved means.

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5.

All PVC conduit shall be stored and handled in an approved manner to minimize ultraviolet deterioration due to exposure to sunlight.

Conduits in protected areas such as behind curbs, in sidewalks, etc., that are not subject to any vehicular traffic shall be at a minimum depth of 18 inches. Conduits installed under roadways, driveways or any open areas where it is possible for vehicles to drive and conduits with conductors that have voltages over 250 volts, shall be at a minimum depth of 30 inches. When conduit in protected and open areas cannot be installed at the minimum depths, it shall be encased in concrete.

Where specified due to shallow trenching depths, the conduit shall be encased in a minimum of three inches of concrete. The conduit shall be supported with masonry block or brick on 10-foot centers, during encasement, so that the conduit will be completely encased.

Installation of conduit for underground primary service shall conform to the utility company requirements, local codes and the project specifications. Conduit installed in railroad right-of-way shall be to the depth specified by the railroad company.

Except for factory bends, conduit bends shall have a radius of not less than that specified in the NEC. Conduit shall be bent without crimping or flattening, using the longest radius practicable.

Existing underground conduit to be incorporated into a new system shall be cleaned and blown out with compressed air.

Conduit for future use shall have a number 8 AWG bare bond wire installed with at least two feet of pull wire doubled back into the conduit and capped.

A three-inch "Y" shall be cut into the face of the curb directly over conduit located under curbs.

The Developer shall place warning tape in all trenches in which new conduit is placed. All warning tape shall be buried at a depth of six to eight inches below the finished grade.

Conduit entering pull boxes shall terminate a minimum of three inches inside the box wall. The conduit shall be between two and four inches above the bottom of the pull box and shall be sloped to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall be located near the sides and ends 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.

Rigid metal conduit bends shall be used for entering pull boxes that are spaced more than 150 feet apart. The bends shall be 90 degrees and be of the same diameter as the connecting conduit. The bends shall be wrapped with an approved PVC tape.

Conduit ends shall be capped with conduit end cap fittings until wiring is started. When end caps are removed, PVC ends 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 steel conduit ends.

Conduit embedded in concrete structures shall be securely attached to the reinforcing steel at intervals of approximately 12 inches. Expansion fittings shall be installed where 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 clearance between the conduit and the inside wall of the sleeve. The sleeve shall be discontinuous at the expansion joints.

All existing conduits and conduit embedded in concrete structures shall be cleaned out with a mandrel and blown out with compressed air.

Conduit may be installed under existing pavement by jacking or drilling methods. Open trench excavation across an existing roadway shall not be permitted without the written permission. Jacking and drilling pits shall be kept two feet clear of the edge of the pavement. Pull boxes shall be installed in accordance with the details shown on the project plans and the plans. Pull boxes shall be installed flush with the finished grade and when in concrete shall have a 1/2-inch felt expansion joint installed around all sides of the pull box. Junction boxes placed in concrete structures shall be flush with the finished concrete surface.

732-3.02 Wiring Procedures:

(A) General:

Wiring shall conform to the regulations and codes listed in Subsection 730-3, and of the NEC, and shall be UL listed and bear the UL labels 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.

Conductors shall have a minimum of 36 inches of slack from the conduit end bell in the pull box.

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 kiloamperes 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 600 volts AC, splices shall be made utilizing approved spring-type wire 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 one inch. 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. Conductors shall be spliced only in pull boxes, terminal compartments, pedestals, or cabinets.

Splices for high-voltage series lighting conductors shall be made from an approved splice kit. The splices shall consist of either molded rubber plug-in connectors or epoxy resin mold type splice insulating kits and shall be rated at five kilovolts. 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 and telephone interconnect circuits shall be run continuous and unspliced to the controller cabinet. Unless otherwise shown on the plans, one lead-in cable shall be installed per loop detector except for six foot by six foot loop detectors.

Signal circuit conductors for each mast arm mounted signal assembly shall be continuous without splicing from the pull box, adjacent to the pole, to the terminal blocks in the mast arm assembly.

(C) Tagging:

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. The tags shall be furnished and installed by the Developer. Each tag shall be wrapped entirely around the conductor twice. Each signal wire shall be tagged as to phase, color indication, and function such as vehicle indication, pedestrian indication, or pedestrian push button (Phase 1 - 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.

(D) Testing:

(1) Signal Circuits:

Prior to control cabinet installation, the Developer shall apply 120 volts to signal circuits and verify equipment is operational. The Developer will connect field wiring inside the control cabinet.

(2) Roadway Lighting Circuits:

The Developer shall connect field wiring to the load center terminals. Lighting circuits shall be energized for 100 hours prior to final acceptance. Failures occurring during this test period shall be corrected.

Wires shall be tagged in control cabinets, load center cabinets, pull boxes, terminal compartments of signal mounting assemblies, or wherever splicing occurs.

732-3.03 Bonding and Grounding:

All metallic enclosures such as cabinets, pedestals, poles, 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 or a green insulated copper bond wire installed with suitable connections to form a continuous grounded system. In all traffic signal conduits, the copper bond wire shall have green insulation. The insulation shall be removed from the bond wire in pull boxes from the point at which the wire leaves the bell end of the conduit.

At each service disconnect, 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 5/8 inch in diameter and 10 feet in length. The rod shall be driven vertically into the ground to a minimum of nine feet 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 of number 4 AWG bare copper conductor coiled and placed at the bottom of the excavation 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 prior to final connection of the utility service. Pole foundation coil grounds shall be tested as determined by the Inspector 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 verified by the Inspector.

All tests shall be performed in the presence of the Inspector and test results shall be written down, dated, and given to the Independent Quality Firm 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 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 Developer 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 10 days prior to testing.

732-3.04 Service:

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.

Service risers shall be PVC-mold or galvanized steel as specified. Fastening of the service risers shall be done through the use of suitable straps and wood screws a minimum of 1-1/2 inches in length. Tape, nails or other means of attachment shall not be used.

Plywood backing boards, when required, shall be 3/4-inch, medium density, paper faced and of an appropriate size to mount all the necessary components. An approved primer and two finish coats of light gray paint, conforming to Section 1002 shall be applied to the plywood before the components are mounted. Special care shall be taken to insure that the edges are well sealed.

All safety switch and multi-breaker enclosures shall be provided with a padlock to prevent unauthorized persons from operating equipment of disconnects.

Meter sockets, when required, shall be approved by the serving utility company. They shall be furnished and installed by the Developer. The meter socket shall be located as shown on the project plans. Meter service inspection shall be approved by the Independent Quality Firm prior to service connection by the utility company.

If work is required on existing high voltage and series lighting circuits, the Developer shall obtain daily safety circuit clearance from the Inspector and the serving utility company prior to any work being done.

Signs painted “Danger-High Voltage” and “Arizona Department of Transportation” shall be installed permanently by the Developer on all Department electrical service structures. These signs will be furnished by the Department.

Fused cutouts on the voltage side of a series lighting service structure shall be pulled out and safety signs shall be furnished by the Developer 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.

SECTION 733 SIGNAL INDICATIONS AND MOUNTING ASSEMBLIES:

733-1 Description:

The work under this section shall consist of furnishing and installing or modifying traffic signal indication assemblies, pedestrian signal indications, flashing beacons, and mounting assemblies at the locations shown on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

733-2 Materials:

733-2.01 Signal Indications:

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.

All traffic signal indication housings, pedestrian, indication, housing backplates, visors, louvers, mounting assemblies, and push button stations, shall receive a minimum of two coats of dull black enamel. Painting shall be done by the manufacturer.

(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.

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 eight-inch or 12-inch lens size.

(1) Optical Equipment:

Each optical unit shall consist of a lens, a reflector or reflector assembly, a lamp holder, and a clear traffic signal lamp of the appropriate size and type as specified herein. The optical units shall conform to ITE Standards and ANSI Standard D 10.1.

(a) Lenses:

All traffic signal face lenses shall be glass unless otherwise specified on the plans.

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, of the best quality glass, free from imperfections, and provide high illumination transmission. Lenses shall conform to ITE Standards.

(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	User-Hours	Rated Wattage	Light Center Length
8 inch	A19	Green Yellow	610	8000	60	2-7/16 inch
8 inch	A19	Red	1040	8000	90	2-7/16 inch
12 inch	A 21	Green Yellow Red	1750	8000	135	3 inch
Pedestrian Indication	A 21	White Orange	1750	8000	135	3 inch

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 seven 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, 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:

The housing for each signal section shall be a 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 Plans. 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.

(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 insulation thickness and rated at 105 ^{o}C.

(3) Visors:

Each signal section shall have an 11-inch to 12-inch long tunnel-type visor which shall be fabricated from number 3003 H-16 aluminum alloy. Visor shall conform to ITE Standards and details of the plans.

(4) Backplates:

Louvered backplates shall be furnished and installed on all vehicular signal sections. Anodized aluminum sheet, 16 gage, shall be used. All 12 inch signal faces shall have five inch backplates installed. All eight inch signal faces shall have eight inch backplates installed.

(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 inches minimum thickness, and the vanes shall be 0.016 inches 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 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 lanes 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 1,200 feet 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 candelas on the optical axis and a maximum intensity of 30 candelas at 15 degrees horizontally from the axis. Each section shall be capable of having visibility programmed for a minimum 3,000 candelas at two 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, 6,000-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) Fiber Optic Turn Arrow Signal:

(1) General:

Each fiber optic signal unit shall conform to the provisions in Subsection 733-2.01(A) except the provisions for optical equipment.

The signal unit shall display alternate legends, consisting of either a green or yellow directional arrow.

The signal unit shall be clearly legible under any lighting conditions within a 20-degree cone of vision centered about the optical axis. Visors or hoods shall have a weatherproof housing and door and shall not be required for legibility.

The signal unit shall consist of a fiber optic module with individual output lenses, color filters for specified legend colors, required light sources and transformers.

A separate lamp shall be used for each display, and lamps shall be rated between 10.5 and 10.8 volts. The rated lamp life shall not be less than 8,000 hours.

Nineteen individual lenses, 5/8 inch in diameter, shall be fitted over the end of each fiber optic bundle to form the arrow legend. The same lenses shall be used for both displays. Fiber optics shall be glass fiber bundles assembled on a flat black matrix panel. Individual fiber optic bundles shall not be jacketed or encased. The signal shall supply approximately 50 percent more light to the lenses when displaying a green arrow in order to balance the intensity between colors. No color shall appear in the lenses when not illuminated regardless of sunlight intensity.

(3) Hardware:

The complete signal unit shall be mounted in a standard aluminum 12-inch round signal case. An aluminum front panel 12 inches in diameter and lens mounts shall be colored black to minimize legibility of arrow when not illuminated.

All fiber optics, transformers, and lamps shall be mounted on the door of the unit. Lamps shall be mounted horizontally to prevent their collecting water from condensation or possible gasket leaks. No moving parts are permitted.

All screws, washers, nuts and bolts shall be corrosion resistant. All components shall be readily accessible when the door is opened. Maintenance or replacement of components shall require only simple tools.

(4) Transformers:

A separate transformer having Class A insulation rated at 48.5 volt-amps shall be used for each color display to reduce the voltage to 10.5 volts AC.

(5) Temperatures:

The fiber optic signal assembly shall be capable of continuous operation over a temperature range of -35 to +165 degrees F.

733-2.02 Pedestrian Signals:

Neon 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 Developer as shown on the plans.

(A) Neon Pedestrian Signal Indications:

(1) General Requirements:

The maximum overall dimensions of the pedestrian unit including the visor shall be 18-1/2 inches wide, 18-3/4 inches high, and nine inches deep. The man/hand symbols shall be in a single housing containing both message symbols.

The pedestrian signals shall be energy efficient, with a maximum energy usage of 20 watts, at 120 volts.

(2) Case:

The case shall be a 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.

(3) Door Frame:

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.

(4) SolidState Message Module:

A molded support tray manufactured from black polycarbonate plastic shall protect the two neon tube light sources and the solid state controller.

The tube for the "Hand" symbol shall be 10 millimeters in diameter and be coated on the inside with Portland orange fluorescent material. The tubing for the "Walking Man" symbol shall be nine millimeters in diameter and be coated on the inside with lunar white fluorescent material. Both shall be formed and positioned for maximum intensity.

The message lens shall consist of a 1/8-inch minimum thickness clear U.V.-stabilized, refractor-type polycarbonate plastic with outer prisms and shall be heat, craze, and water resistant.

The two neon compartments shall be sealed into an integral assembly with a one-piece sponge gasket fitted around the perimeter to protect the enclosed neon tubing from handling and weather.

Solid State circuitry shall be assembled on circuit boards as necessary to energize to high voltage flyback transformers and the neon tubes.

Each controller circuit shall be sealed into an integral assembly with a one-piece sponge fitted around the perimeter to protect the enclosed neon tubing from handling and weather.

The entire unit including neon tubing and solid state controller shall have a factory warranty of five years against defects in workmanship or materials.

Each controller circuit shall be powered from 120-volt AC, 60-hertz and shall have a power factor of 90 percent minimum.

(5) Messages:

Messages shall be the Portland orange "Hand" and the white "Walking Man" illuminated by multiple configuration neon tubes encased in the plastic solid state message module. The symbols shall be a minimum of 12 inches in height and seven inches in width and shall be configured as shown in the MUTCD.

The inside face of the message lens shall be painted in all areas except where the desired symbols are formed. The first coating of paint shall be black to form a contrasting background. The second coating shall be white to reflect internal light in between symbols.

(6) Visors:

The visor shall be the crate type to eliminate sun phantom and shall be 1-1/2 inches deep.

The crate assembly shall contain a minimum of 21 zigzag-pattern horizontal louvers and 20 straight horizontal louvers. Every other formal louver shall be reversed to form one-inch diamond shaped cells. The material used for the visor shall be 0.030 inches thick and shall be 100 percent impregnated black polycarbonate plastic with a flat finish.

(B) 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 wide, 18-3/4 inches high, and 11-1/2 inches deep.

(2) Case and Door Frame:

The case and door frame for the incandescent pedestrian signals shall conform to the requirements of Subsection 733-2.02(A).

(3) Message Lenses:

Each message lens shall be one-piece and shall be made of 1/8-inch minimum thickness, ultraviolet-stabilized polycarbonate or 3/16-inch thick tempered glass. Either lens shall have a textured outside surface to eliminate message "hot spots".

(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 phantom.

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. The completed egg-crate portion shall be 1-1/2 inches deep.

The material for the crate visor shall be as specified in Subsection 733-2.02(A)(6).

(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.

733-2.03 Flashing Beacons:

Flashing beacons 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.

(A) Overhead Flashers:

The overhead flashing beacon shall consist of two signal sections mounted on a cantilever arm assembly. Each overhead assembly shall incorporate 12-inch signal sections with yellow lenses unless otherwise specified. The "Signal Ahead" sign to be mounted on the mast arm will be furnished by the Developer.

(B) Pole Flashers:

Each pole flasher shall consist of two signal sections. Each pole flasher assembly shall contain eight-inch signal sections with yellow lenses.

(C) Control Equipment Housing:

The control equipment housing shall be a Type I load center cabinet as shown in the plans unless otherwise specified.

733-2.04 Mounting Assemblies:

Mounting Assemblies shall consist of terminal compartments and assemblies of 1-1/2 inch nominal standard pipe and fittings. All members shall be so fabricated that they shall provide plumb, symmetrically arranged, and securely fabricated assemblies.

Terminal Compartments: A terminal compartment shall be assembled in the mounting brackets as shown in the Plans. The terminal compartment shall be manufactured of bronze, Type 356-T6 aluminum, 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 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-mil 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 three terminals	Phase B R-Y-G
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.

733-3 Construction Requirements:

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, 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 plumbizer when specified shall be placed on the mast arm, and a 3/8-inch by four-inch bolt shall be used to fasten both together.

Materials removed and not designated to be salvaged or incorporated into the work shall become the property of the Developer.

All traffic signal heads not in use shall be covered with burlap and shall be unmistakably out of service when observed by an approaching driver. Plastic coverings shall not be allowed.

SECTION 734 TRAFFIC CONTROLLER ASSEMBLY:

734-1 Description:

The work under this section shall consist of furnishing and installing traffic controller assemblies 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 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 controller assembly shall include the controller unit, all necessary auxiliary equipment, the controller cabinet, concrete foundation, conduit, elbows, anchor bolts and clearance pad.

The auxiliary equipment shall include all appurtenances such as flasher controls, loop detector amplifiers, power assemblies, signal load switches, conflict monitors, pre-emptors, controllers, coordinators, time switches, external logic, lighting controls, cabinet wiring and accessories as indicated on the plans.

The entire surface area of each circuit board shall be sealed to protect against moisture.

The following auxiliary equipment shall be furnished with all wired traffic controller assemblies when required:

Controller
Power Panel
Signal Load Switches
Signal Conflict Monitor
Detectors
Controller Flasher Assembly
Flash Switches
Surge Protector
Radio Interference Suppresser
Cabinet Ventilation Fan
Terminal Tie Points
Field Terminals

734-2.01 General Requirements:

The traffic controller assembly equipment shall conform to the requirements of the current edition of NEMA Publication TS-1.

(A) Documentation:

The Developer'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 Developer 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; and
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.

(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 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.

(C) Certificate of Compliance:

A Certificate of Compliance shall be submitted for each traffic controller assembly.

The Department reserves the right to perform tests on any equipment supplied by the Developer in the Department's testing facilities.

(D) Pre-Approval of Controller Equipment:

The Department will only accept equipment furnished by manufacturers or vendors with proof of liability insurance for controller units, conflict monitors, load switches, flashers, and flash relays, and which have been pre-approved by the Department.

All traffic signal controller units shall be tested by the Department's testing procedures and be pre-approved by the Department Pre-approved traffic signal controller units are listed below. Any controller unit and specified component not listed will not be accepted.

The Department reserves the right to re-test any pre-approved equipment supplied by the Developer in the Department's testing facilities.

The following includes all traffic signal controller units that have been tested and preapproved as specified by the Department as per the Arizona Department of Transportation Technical Provisions for Road and Bridge Construction.

The following controller equipment has been pre-approved by the Department as of January 2014:

(1) Type MPS Controllers: Special Programmable and System Applications (TS2, Type 2 - Downward Compatible TS1):

(b) Econolite Control Products Inc:

Colbalt with the following special programs:

	ADOT Basic Program Configuration
MPS-SI	Computer Supervised Unit
MPS-P	Pre-emption
MPS-T-C	Time Base and Traffic-Actuated Coordination
MPS-M	Arterial Master Controller

(2) NEMA Conflict Monitors:

(a) Eagle

3 Channel	LT-213
6 Channel	LT-216
12 Channel	LT-222

(b) Econolite

3 Channel	NCMU-3
6 Channel	NCMU-6
12 Channel	NCMU-12

(c) E.D.I.

3 Channel	NSM-3L
6 Channel	NSM-6L
12 Channel	NSM-12L
16 Channel	MMU-16LE
16 Channel	MMU2-16LE

(d) Solid State Devices

3 Channel	NM(NP)-3L
6 Channel	NM(NP)-6L
12 Channel	NM(NP)-12L
18 Channel	LCD-18P

(e) Transyt Corporation

3 Channel	Model 300
6 Channel	Model 600
12 Channel	Model 1200

(f) Traffic Control Technologies

3 Channel	LSM-3
6 Channel	LSM-6

12 Channel	LNM-12E
12 Channel	LMN-12E

(E) Department Testing of Control Equipment:

A completely wired controller assembly with wiring diagrams and instruction books shall be delivered for inspection and testing unless otherwise specified. The equipment shall be delivered to:

Arizona Department of Transportation
Traffic Operations Services
Traffic Signal Shop
2104 South 22nd Avenue
Phoenix, Arizona 85009

It shall be the responsibility of the Developer to correct or replace any equipment that fails Department testing. Such corrections or replacements shall be as directed by Independent Quality Firm.

(F) Department Testing Procedures:

The traffic controller assembly shop test procedure shall be as follows:

(1) The Developer shall deliver the equipment to the Traffic Signal Shop.

(2) The Department will take inventory of the delivered equipment.

(3) The Department 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 Department at the discretion of the Department.

(5) After any test failures, the Developer 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 Department may require the replacement of any component after that component's second failure under test.

(6) After the controller operation tests are approved, the Developer shall pick up the control cabinet and equipment, haul them to the job site, and install them as specified. After the Developer has mounted the control cabinet on the cabinet foundation,

(7) Developer personnel will connect all the field wiring inside the control cabinet and test the signal circuits.

(8) Scheduling the activation of traffic signals shall require a minimum of 10 working days notice to the Department's Electrical Inspection Unit at 2104 South 22nd Avenue, Phoenix, Arizona 85009, (602) 712-7312. No activations outside the Phoenix metropolitan area shall be scheduled either on Monday or Friday. The Developer shall be responsible to ensure that all the required work has been completed and that the traffic signals are ready to be activated on the pre-arranged date. If the Department determines that the traffic signal work is not complete and cannot be activated, then the Developer shall be responsible for costs incurred by the Department (personnel, equipment, lodging, per diem, salary etc.).

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 these project specifications.

(A) Solid State Digital Controllers:

The solid state digital controllers shall utilize modular construction, solid state circuitry, and digital timing techniques. Integrated or discrete semiconductor devices shall be used exclusively.

Controller logic shall have high noise immunity.

Solid state components shall be standard production types and shall be readily available.

Components shall be properly rated with respect to heat dissipating capacity and rated voltage.

The minimum rated life of all components shall be 10 years under 24-hour-a-day operation.

Components shall be clearly identifiable by markings on circuit boards or parts numbers on pictorial diagrams.

The digital timing techniques and repeatability shall be accordance with:

(1) Module Circuit Boards:

The controller shall contain plug-connected module boards. The solid state components shall be mounted on printed circuit module boards.

The module boards from the controller shall be easily removed without the use of special tools and shall be designed to permit replacement of all components without damage to the board or its circuits. Each individual printed circuit board shall be identified by a serial number or parts number clearly stamped or etched on the board.

The module circuit boards shall be arranged by functional groupings.

Each module board by functional design shall be electrically and mechanically interchangeable with other controllers of the same model, controller series, or frame type.

The module boards shall be fabricated from epoxy glass laminate NEMA grade G-10 or G-11, with a minimum weight of two ounces of copper per square foot. The copper track shall have adequate cross-section to carry the designed current capacity. All contact surfaces shall be non-corrosive construction. The entire surface area of each circuit board shall be sealed to protect against moisture.

Phase timing modules which time more than one phase shall be programmable to permit the selective disabling of unused phases.

Modules that have a 120-volt AC input shall be properly fused within the controller.

The interfaces and the power supply for the controller shall be designed to accommodate the maximum module configuration possible for the controller such that no additional future modifications are required.

Interchangeable connectors (except data buss type) shall be keyed to prevent their insertion into the wrong receptacle of the controller.

The controller's housing shall be an integral frame assembly constructed of non-ferrous metals. The housing shall conform to all NEMA requirements.

(2) Volatile Memory:

All volatile memory in controllers, time switches, and time base coordinators shall utilize a battery back-up supply to maintain memory as follows:

(a) Complete memory retention for 30 days if RAM board is removed from controller.

(b) Non-rechargeable Battery: The non-rechargeable battery shall be rated to maintain memory for not less than five years in continuous use and include a battery condition indicator.

(c) Rechargeable Battery: The rechargeable batteries shall be the type that can be operated, stored, or charged in any position and be capable of being recharged not less than 1,000 times. The rechargeable batteries shall have an automatic battery charger with a battery discharge indicator and shall operate within the NEMA environment standards.

(3) Indicators:

Indicators shall be the sub-miniature type and may be either incandescent lamps or solid state. Incandescent lamps shall be replaceable from the front of the panel.

All programming pins shall be the printed circuit receptacle, non-corrosive, turning fork type. The pin contactor shall fit any standard 0.055-inch to 0.73-inch board. The pin shall be rated for 600 volts and five amperes.

(B) Digital Pre-Timed Solid State Controllers:

The DPT controller shall designate a digital pre-timed controller compatible with NEMA standards, these specifications and the plans.

The Type DPT controller shall be designated with six-position alphanumeric code. The two numbers in the code shall have the following meanings:

DPT18_ - Capacity of up to 18 signal load circuits

DPT40_ - Capacity of up to 40 signal load circuits

The letters in the last position shall have the following meanings:

DPT__S - Computer Supervised Unit

DPT__P - Programmed for Pre-emption

DPT__T - Programmed for Time Base Coordination

DPT__H - Hard Wire Intertie

When the last position has more than one letter, the controller shall have all the functional features defined by each letter.

All the DPT controller units supplied shall be readily programmable for pre-emption and shall include the time base coordination module and programming.

(1) The DPT18 Pre-Timed Controller:

The DPT18 shall meet the following specifications and shall be designed for non-actuated operation of traffic signals having pre-determined cycle lengths, cycle lengths, interval durations, and interval sequences.

The controller shall have three independent cycles with three offsets and two splits per cycle. Cycle lengths shall be front panel adjustable with a front panel cycle-in-effect indicator. The cycle display shall show the local elapsed time, inputs, outputs, and timing values.

The controller shall have 10 signal intervals and 18 independently controlled on/off signal circuit outputs which may be independently programmed for flashing the signal output in a designated interval.

The controller unit for replacement for a type-F electromechanical controller shall be a retrofit back panel 22.5 inches high, 13.0625 inches wide, and 10.3125 deep. The back panel shall house NEMA-type flasher, load switches, and two-channel card rack amplifier. The flasher transfer relays shall be interfaced with a Cinch-Jones type eight-pin socket. The signal load shall be controlled by a 60-ampere tungsten mercury contactor.

(a) Indicators:

Indicators shall include digital read-outs to display all inputs, countdown timing intervals, cycle, split, local master and pre-emption.

(b) Controller Programming:

Program entries shall be front panel programmable without the use of tools or software.

(c) Pre-emption:

Pre-emption functions shall be programmable assignments to include entrance times, track clearance (passage and clearance times), minimum duration protection time, and exit. The programming shall also include detection mode, pedestrian indications operation, delay time, and flash operation.

(d) Vehicle Detection:

The back panel shall include card-rack mounted NEMA-type vehicle detector for two detector channels. Each channel shall input each actuated vehicle signal phase group.

(e) Pedestrian Detection:

The actuated signal phase groups shall have pedestrian actuated movements.

(f) Start-Up and Flash:

The start-up operation and flash operation intervals and timing shall be programmable in the unit.

(g) Control Cabinet for DPT18 T/H:

The control cabinet shall be the type specified on the plans.

The control cabinet shall include the following items: cabinet fan, light, convenience outlet, and police panel.

The following switches shall be included: main-on/off, controller auto on/controller on-flash/controller off-flash, signal lights on/off, and auto/manual.

The following switches shall be mounted inside the police panel: main switch, auto/flash switch, and auto/manual switch, and manual control cord.

(h) Conflict Monitor:

The conflict monitor shall be a cable-connected unit, external, shelf mounted, six channel, NEMA-wired to monitor all functions. All the equipment housed in the control cabinet shall be installed and removed from the front with ease.

(2) The DPT40 Pre-Timed Controller:

The DPT40 shall be designed for non-actuated operation of traffic signals with pre-determined cycle lengths, interval durations, and interval sequences. The controller unit shall have a minimum of three independent cycles. Each cycle shall have a minimum timing range of 0-255 seconds and interval timing of 0-25.5 seconds, in one-second and one-tenth-second increments. Each cycle length shall be front panel adjustable with a front panel cycle-in-effect indicator. A cycle read-out shall show the time of the local cycle that has elapsed.

Each cycle shall have three offsets and four splits. The four splits (signal interval plans) shall be selected by either a remote interconnect, time switch, or a local detector actuation. The controller unit shall have 31 signal intervals and 40 independently controlled on/off signal circuit outputs which may be independently programmed for flashing the signal output in a designated interval.

(a) Synchronization:

The pre-timed controller unit shall have a manual switch to synchronize itself with an intertie system input, or the controller unit shall be capable of providing a sync-pulse to an intertie system when programmed to be a master controller unit.

(b) Interconnected System:

The controller unit shall be capable of operating with an existing master controller unit with six of 10 functions. The controller unit inputs from a standard-type pre-timed interconnect shall be as follows:

Dial	2	One Input
	3	
Offset	1	
	2	
	3	
Split	1 *	
	2 *	
	3 *	
	4 *	
Flash		
Common		AC neutral
*Note: Splits 1, 2, 3, and 4 shall be used with a 10-function intertie system only.		

Dial 1 shall be in effect when neither the Dial 2 nor the Dial 3 lines are energized.

A master controller unit with direct control by a computer system shall have NEMA-logic level inputs.

(c) Conflict Monitor:

The conflict monitor shall be an external shelf-mounted, 12-channel or larger NEMA cable-connect unit wired to monitor all functions.

(d) Manual Control:

An auto-manual control switch and wiring terminals shall be furnished in the controller cabinet assembly for a momentary contact hand held switch. The auto-manual control switch shall be accessible with a standard police type key. The hand-held manual switch shall be weather-proof on a retractable cable.

Manual operation of the controller shall provide the same color sequence as was programmed for the automatic operation. The duration of all intervals, except the yellow vehicle interval and the red vehicle clearance interval, shall be controlled by operation of the manual switch. Duration of the yellow interval and red clearance interval shall be the minimum time specified to be programmed in the controller unit.

(e) Minimum Timing:

A guaranteed minimum back-up time for each interval, programmed in accordance with the signal plan non-volatile programmable read-only memory, shall be provided as specified on the plans.

(f) Manufacturer Programmed Functions:

The following functions shall be programmed by the manufacturer into the programmable read only memory in accordance with the signal plan specified on the project plans:

1) Start-up programs:

2) Each signal plan and sequence programs:

3) Back-up times:

4) Remote flash operation programs:

5) Cycle back-up times:

6) Offset back-up times:

7) Pre-emption plan and sequence programs:

8) Field programmable functions:

The following functions shall be programmable from the front panel by the operator in the field:

Timing Entry;
Cycle Lengths;
Offsets;
Interval Time;
Read-out of cycle, split, and interval;
Read-out of Timing in the PROM; and
Pre-Emption Interval Timing.

9) Function Switches:

The following function switches shall be provided:

Lock/Non-Lock - Recall for each detector
Local/Remote selection of cycle, offset, split and plan
Sync/Hold for non-interconnected operation

The programming of the timing entry, cycle, offsets, selectable functions, and phase timing intervals shall be set by entry switches, programming pins or by keyboard entry. Programming shall include digital solid state read-outs of keyboard programmed functions.

10) Input-Output Connectors:

The signal output connectors shall be compatible with the NEMA four-phase controllers. The controller unit shall use the standard NEMA connectors A and B per NEMA table 13-3, four-phase terminations, and the following tables:

CONNECTOR A			
Pin No.	Function	Pin No.	Function
A	Reserved	f	Det. 1
B	24-Volt DC	g	Det. 5
C	Voltage Monitor	h	Det. 9
D	Sig. Ckt. # 3	i	-
E	Sig. Ckt. # 6	j	Remote Flash
F	Sig. Ckt. # 10	k	Guar. Interval
G	Sig. Ckt. # 13	m	-
H	Sig. Ckt. # 12	n	Signal Plan 2 (Preempt 1)
J	Sig. Ckt. # 11	p	AC +
K	Det. 2	q	Master Sync (Out)
L	Det. 6	r	Spare
M	Det. 10	s	Sig. Ckt. # 1
N	Stop Time	t	Sig. Ckt. # 4
P	Coord. Sync (IN)	u	-
R	External Start	v	-
S	Manual (Interval Advance)	w	Overlap Advance
T	Indicator Lamp Control	x	Free
U	AC -	y	Cycle 2
V	Chassis Gnd	z	Split 4
W	Logic Gnd	AA	Signal Plan 3 (Preempt 2)
X	Flash Logic (1PPS)	BB	O'L Mode
Y	Spare	CC	Spare
Z	Sig. Ckt. # 2	DD	Sig. Ckt. # 7
a	Sig. Ckt. # 5	EE	-
b	Sig. Ckt. # 9	FF	Signal Plan
c	Sig. Ckt. # 8	GG	Split 2
d	-	HH	Cycle 3
e	Sig. Ckt. # 14		

CONNECTOR B			
Pin No.	Function	Pin No.	Function
A	Free Output	f	Spare
B	Flash Cont.	g	Spare
C	Spare	h	Det. 12
D	Sig. Ckt. # 15	i	Det. 11
E	Sig. Ckt. # 16	j	Cycle 4 (Optional Function)
F	Sig. Ckt. # 17	k	-
G	Sig. Ckt. # 24	m	-
H	Sig. Ckt. # 26	n	-

CONNECTOR B			
Pin No.	Function	Pin No.	Function
J	Sig. Ckt. # 27	p	Sig. Ckt. # 30
K	-	q	Sig. Ckt. # 31
L	Det. 4	r	-
M	Det. 8	s	Sig. Ckt. # 21
N	Det. 3	t	Spare
P	Det. 7	u	Sig. Ckt. # 40
R	Offset 3	v	-
S	Offset 2	w	Sig. Ckt. # 38
T	-	x	-
U	Offset 1	y	-
V	CMU Stop Time	z	-
W	Split 3	AA	Sig. Ckt. # 29
X	-	BB	Sig. Ckt. # 36
Y	Sig. Ckt. # 18	CC	Sig. Ckt. # 37
Z	Sig. Ckt. # 19	DD	Sig. Ckt. # 34
a	Sig. Ckt. # 20	EE	Sig. Ckt. # 39
b	Sig. Ckt. # 22	FF	Sig. Ckt. # 32
c	Sig. Ckt. # 23	GG	Sig. Ckt. # 35
d	Sig. Ckt. # 25	HH	Sig. Ckt. # 33
e	Sig. Ckt. # 28		

The following inputs shall be in accordance with NEMA:

Stop Timing	shall have the effect of halting the local percent counter.
Manual Enable	guaranteed interval inhibit.
Interval Advance (Manual)	shall step controller through each programmed interval sequentially. Shall operate on trailing edge of pulse. When asserted with stop timing shall provide manual control of all intervals.
Indicator Lamp Control	shall extinguish all front panel indicators.
External Start	shall force the controller to the specified starting interval. The normal cycle shall resume immediately upon release of this input.
Detectors, Chassis Ground, and Pre-Emption.	

The following outputs shall be in accordance with NEMA:

Signal Output Circuits:	
Interval 1 On	shall be active for the duration of interval 1.
Voltage Monitor	shall be active as long as the controller is providing proper operation.

+ 24 volts DC	
Logic Common	
Master Sync	shall be active at all times except during the master sync period.
Flash Logic	shall alternate between true-false logic levels at a one pulse per second repetition rate.

11) Pre-Emption:

When specified, a pre-emption program shall be provided in the controller software. The pre-emption program shall be initiated by a non-locking pre-emption call. The pre-emption mode shall have its own timing, including minimum timing and signal plan.

12) Electrical Characteristics:

The controller programs provided by the manufacturer shall be permanently stored in a non-volatile memory such that batteries shall not be required to maintain the minimum interval timing, interval sequences, start-on, offsets, cycle and splits, flash on/off, detectors, signal circuits flash, and pre-emption.

(C) Actuated Solid State Digital Controllers:

(1) General:

The actuated solid state digital controller shall be designed for the operation of traffic signals with fully actuated or semi-actuated timing of the traffic signals including operation with auxiliary equipment.

Each actuated controller shall be furnished with the required number of phases, phase sequence, phase timing features, and all other control functions that are specified herein, on the plans.

(2) DAN-Actuated Controller and Features:

Actuated controllers shall be designated on the plans with the following designations:

The DAN controller shall designate a digital actuated controller conforming to NEMA Standards, these specifications and the plans.

The number in the alphanumeric code type shall mean the following:

DAN-2 Two-phase controller

DAN-4 The controller shall be capable of operating four phases.

DAN-8 The controller shall be capable of operating eight phases.

(a) Phase Timing:

Each DAN controller unit phase timing or phase module shall include timing periods for each vehicle and pedestrian phase actuated with volume density timing, or non-actuated timing for semi-actuated phase operation. Each phase timing period shall be not less than the minimum required by NEMA.

(b) Controller Pre-Approval:

The DAN controller pre-approval shall be in accordance with current NEMA specifications and these specifications. No additional functions shall be in the DAN controller. Pre-approval tests and evaluations shall be performed by the Department and approved by the Independent Quality Firm.

(c) Overlap Phases:

Controllers with more than two phases shall be furnished with a NEMA 14-9 overlap program board and driver outputs. The NEMA-type overlaps shall be programmed by the NEMA program board assembly with hard wire jumpers easily accessible inside the controller, or programmed in the controller without the use of tools.

(d) Frame Sizes:

The controller unit frames shall be two-, four-, and eight-phase, not exceeding the NEMA-specified dimensions, except height which shall be 17 inches maximum. Equipment shall be interchangeable in the controller cabinet.

(e) Phase Sequence Operation:

Each phase and associated overlap phases of a single-ring controller shall be sequentially timed as indicated on the plans.

Dual-ring controllers shall be sequentially timed per ring and concurrently timed per non-conflicting phase. Dual-ring controllers shall be programmed for the dual entry mode of operation.

Dual-ring traffic signal controllers that are PROM programmable shall include three PROMS, one installed PROM, and include two spare phase sequence PROMS as follows:

PROM A - Eight-phase, quad left turn operation.

PROM B - Eight-phase, dual left turn ring one operation, sequential ring two operation.

PROM C - Eight-phase sequential operation.

The two spare PROMS shall be identified and packaged for future use.

(f) Controller Input-Output Functions and Connectors:

The controller shall provide all the NEMA input/output functions. The A, B, and C Connectors and their pin assignments shall be the same as shown in Table 13-3 of 1983 NEMA for two-, four-, and eight-phase controller units and their cables.

All A and B connectors and cables shall include specified four- and eight-phase functions, for future use.

Auxiliary connectors shall not be permitted on Type DAN controllers.

(g) Standard Functions:

Standard controller functions specified by NEMA, and as specified in these specifications shall be furnished.

The controller unit functions shall include NEMA TS-1, Sections 13 and 14.

The standard functions shall be the NEMA-specified features on a per phase, per ring, and per unit basis.

(h) Pre-Programmable Guaranteed Minimum Clearance Timing:

All controllers shall have a guaranteed minimum clearance timing program and shall be programmed as follows:

(1) Guaranteed yellow change interval: three seconds

(2) Guaranteed pedestrian clearance interval: five seconds
The controller shall have the capability to permit exclusive pedestrian phase when required.

(i) Pre-Programmable Backup Timing:

All controllers with a backup timing PROM capability shall be programmed for the type of phase movement for the minimum times as follows:

Any Vehicle and Pedestrian Phase Movement (Non-Actuated)	
Interval	Time in Seconds
Minimum Green	25
Walk (Solid)	7

Ped Clearance (Flashing)	10
Yellow Change	4
Red Clearance	2

Any Vehicle and Pedestrian Phase Movement (Actuated)	
Interval	Time in Seconds
Initial Green	10
Vehicle Extension (Passage)	3
MAX I	25
MAX II	30
Walk (Solid)	7
Red Clearance (Flashing)	10
Detector Memory	ON
Recall Mode	PED.

Any Vehicle Exclusive Turning Phase Movement	
Interval	Time in Seconds
Initial Green	8
Vehicle Extension (Passage)	2
MAX I	20
MAX II	25
Yellow Change	4
Red Clearance	2
Detector Memory	ON
Recall Mode	Vehicle

Any required change or additions by the manufacturer to these time values shall be cleared through the Independent Quality Firm before delivery of the controller assembly.

(3) The MPS Controller & Features:

The MPS controller shall designate a digital microprocessor controller that conforms to all the DAN controller specifications, and shall include special programmable applications as specified in these specifications, and the plans.

(a) MPS Controller Minimum Phase Requirements:

The MPS Controller shall be a four-phase or eight-phase dual ring operation or twelve-phase dual or three ring operation as required in the plans.

The type of MPS controller shall be designated by the special program applications required.

The last letters shall designate the following:

MPS-SI	Computer Supervised Unit - Interconnected
MPS-SD	Computer Supervised Unit - Dial Up
MPS-P	Programmed for Pre-Emption
MPS-T	Programmed for Time Base Coordination
MPS-C	Programmed for TM Coordination - Traffic Actuated Coordination
MPS-M	Arterial Master Controller - Interconnected
MPS-SF	Programmed for any additional Special Functions

The MPS controller shall include the following features:

(1) Each MPS controller shall include the programming and module for Time Base Coordination with a front panel "D" connector, or auxiliary connector for all non-NEMA functions.

(2) All non-NEMA input/output functions shall be contained in a system or "D" connector only.

(3) Each MPS controller shall include the printer interface and port. The printer interface shall permit printout of all controller, coordinator, and pre-emptor operator entered data.

(4) The "D" Connector shall be located on the front panel.

(5) The MPS controller main frame shall be readily compatible for MPS-P pre-emptor programming.

(b) MPS Controller Pre-Approval:

In addition to meeting the DAN controller pre-approval requirements, the Independent Quality Firm will require each MPS controller model and special program type to be tested and evaluated on a program-by-program basis before approval by the Independent Quality Firm. Each approval will be limited to each type of program required by the Department, not by manufacturer or model. The number of manufacturers pre-approved by the Department may be limited for each type of program the Department requires.

Existing Department approved controller programs shall be limited to the manufacturer's program version and model currently in operation for a specified geographic area.

Approval of a MPS arterial or interconnected supervised controller unit shall be limited to the Department operating computer management software and hardware.

(c) MPS Twelve-Phase Controller:

The twelve-phase controller shall meet all DAN controller specifications plus the following functions:

(1) All non-NEMA functions and phases shall be contained in a "D" connector or auxiliary connector on the front panel.

(2) The controller shall include twelve phases with both vehicle and pedestrian timing.

(3) The controller shall have allocation of phases to be operated in a special programmable concurrent phase or co-phase mode. Up to six phases may be used as co-phases. The co-phases shall be capable of being implemented to create additional rings. The co-phase timing parameters shall be entered from the front panel.

(4) The controller shall contain two additional overlaps to the four NEMA overlaps.

(5) The controller shall include Time Base Coordination and three pre-emption programs.

(6) The controller shall accept up to sixteen detector inputs.

(d) MPS - Coordination Programming Pre-Approval:

The MPS-S computer supervised controller and the MPS-M arterial master controller for systems shall be pre-approved. per the Department computer hardware and software requirements.

The MPS-C TM coordination and MPS-T time base coordination shall be pre-approved per the Department's system requirements. Each manufacturer's unit shall be readily interchangeable within the same model line.

(e) MPS-T Time Base Coordination Program:

(1) The MPS-T program for time base coordination shall be included in each MPS controller unit.

The MPS-T program shall consist of the hardware, software, and cabinet wiring to provide coordinated traffic flow without the use of interconnect cables between controller units in a dedicated geographic area. The

MPS-T program shall be supervised by its own clock, which will monitor the program's memory so as to implement routine time of day, day of week, and week of year programs; as well as automatic daylight savings selection.

(2) The MPS-T controller program shall include the following functions:

(a) Shall be capable of being system interfaced (intertie or dial-up) for a program monitoring and data down-loading and system data up-loading. The data down-loading and clock updating shall also be accomplished by a hand-held device.

(b) The coordination programming shall include the following phase timing options: The MPS-T Controller shall have a coordination system "D" connector. The system connector shall function as input/output port and auxiliary output connector. All outputs shall be NEMA compatible.

(c) The MPS-T Controller shall provide for all time base coordination, user program data input, and the status read-outs, including cycle countdown and program data display, on the front panel.

(f) MPS-T Controller Cabinet Wiring:

The following cabinet wiring functions shall be included with the MPS-T controller cabinet assembly:

(1) The cabinet shall be wired for call to non-actuated mode I for the highway and mode II for cross street, unless otherwise specified.

(2) The inside cabinet switch panel shall include a switch for coordination, and free run modes of the coordinator program. The remote free input shall be wired to a cabinet terminal tie point.

(3) Two auxiliary time of day (24 hour) outputs shall be wired in the cabinet to program special functions via the coordination system "D" connector.

(g) MPS- Pre-Emption Programming:

The MPS Controller shall include all the required hardware and CPU software so as to readily accept the addition of a MPS-P program.

The MPS-P pre-emptor programmed controller unit shall be pre-approved. as per the Department requirements for any geographic area or system. Each manufacturer's unit shall be readily interchangeable within the same model line.

The MPS-P pre-emptor program shall include all required hardware and programming with an input/output connector cable interface. The removal of the pre-emption module shall not interfere with the normal operation of the controller unit.

The MPS-P controller shall have the pre-emption user program data inputs and status read-outs, including pre-emption intervals and program data, displayed on the front panel.

The following is an outline for a MPS-P program scheme. Each MPS-P program shall be evaluated by this scheme.

1) Pre-emptor Intervals:

The pre-emptor shall control intervals by ring. Before the initiation of pre-emption, a delay input interval must be completed. If the delay is released before timing out, the pre-emptor will not initiate time.

During pre-emptor timing any higher priority pre-emption input will override the active pre-emptor mode.

2) Interval Programs:

The following interval functions and sequence per ring shall be programmed in the pre-emptor module.

Interval 1: The minimum guaranteed green interval.

The effective start time for this interval is when the phase that is timing enters green. Therefore, if the phase was in green longer than the interval programmed time prior to initiation of pre-emption, the pre-emptor will advance to interval 3.

Interval 2: The minimum guaranteed green-pedestrian clearance interval.

The effective start time for this interval is when the phase that is timing enters pedestrian clearance. Therefore, if the phase was in pedestrian clearance longer then the interval programmed time prior to initiation of pre-emption, the pre-emptor will advance to interval 3.

Interval 3: The minimum guaranteed phase yellow clearance interval.

The effective start time for this interval is when the phase that is timing enters yellow clearance. Therefore, if the phase was in yellow clearance longer than the interval programmed time prior to initiation of pre-emption, the pre-emptor will advance to interval 4.

This interval will only be in effect if pre-emption was initiated during green or yellow. Pre-emption will terminate the green or yellow phase.

Interval 4: The minimum guaranteed overlap yellow clearance interval.

Any overlap is assigned to one ring that is timing during entry into pre-emption. The overlap will terminate when that ring starts interval.

The effective start time for this interval is when overlaps go into yellow clearance. If the overlaps have been in yellow clearance longer than the interval programmed time prior to the initiation of pre-empt, the pre-emptor will advance to interval 5.

Interval 5: The minimum guaranteed overlap all-red clearance interval.

The effective start time for this interval is when the overlaps that are going to terminate and the phase that is timing are in red. This interval will stay in effect until all the overlaps that are going to terminate, and the phase that is timing has been in red for the programmed all-red time. The pre-emptor then will advance to interval 6.

If there is no track clearance phase assigned to a ring, that ring will advance to interval 9.

Interval 6: The track clearance green interval.

This interval will time the assigned track clearance green programmed time, and upon completion, the ring will advance to interval 7.

Interval 7: The track clearance yellow interval.

This interval will time the assigned track clearance yellow programmed time. When the timing is complete, the ring will advance to interval 8.

Interval 8: the track clearance all red interval.

This interval will time the assigned track clearance all red programmed time. When the timing is complete, the ring will advance to interval 9.

Interval 9: The hold/lock interval.

When both rings of the pre-emptor sequence have reached interval 9, the pre-emptor will be advanced to interval A.

Interval A: The duration passage interval.

This interval will time the completion of the programmed duration time. The duration time will start timing when the pre-emption sequence is started. Interval A will insure that the pre-emption sequence will not terminate until programmed time after initiation of pre-emption, regardless of the phases and intervals in effect during initiation of pre-emption or the timing of intervals preceding interval A.

The phase assigned for each ring shall operate as a hold phase. The options of "ped indications active" and "hold flash" take effect during this interval.

Interval B: The hold/passage interval.

The hold time will start timing when pre-emption interval A starts. Interval B will insure a minimum time in the passage movement before pre-emption will be permitted to terminate. The interval will terminate only when the programmed time is complete and the pre-emption input is non-active, after which the interval will be set to C.

The hold phases, "ped indications active" and "hold flash" shall be applied during interval B.

Interval C: The hold/passage yellow clearance interval.

At the completion of the hold/passage interval, the hold clearance yellow will time unless:

(1) There are no exit phases. The pre-emptor will be non-active, and exit as soon as interval B is complete.

(2) The pre-empt call returns active. The pre-emptor will go back to interval B.

When the hold/passage yellow clearance timing is complete, the interval will advance to interval D.

Interval D: The hold/clearance all-red clearance interval.

If the pre-emption call returns, the pre-emptor will go back to interval B.

When the hold/passage all red clearance timing is complete, the interval will advance to interval E.

Interval E: The exit lock interval for the pre-emptor.

When both pre-emption rings get to interval E, the pre-emptor will exit the pre-emption sequence.

3) Pre-emptor Flash:

The Type MPS controller pre-emption module flash can be initiated in the following ways:

(a) Hold Flash

(b) Power up with pre-emption

(c) External start with pre-emption

(d) Sum check bad

(e) Power up/external start with illegal phases

(f) Illegal controller software valve.

The pre-emptor flash control output shall be true (low) during pre-emptor flash.

The controller signal output drivers will flash red if they are not assigned as a hold phase. The output shall flash yellow if assigned as a hold phase.

The required preemption intervals shall be programmed for single track or dual track clearance as shown on the plans.

734-2.03 Control Cabinets:

(A) General:

The control cabinets covered in this section shall be used to house all traffic pre-timed and actuated signal controller assemblies and shall include intersection controller cabinets 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.

Cabinets shall be wired and tested by the controller manufacturer or a representative designated by the controller manufacturer. The cabinet wiring shall be covered by the controller manufacturer's warranty.

The following cabinet types shall be supplied when specified on the plans. The cabinets shall be constructed according to the Traffic Signal and Highway Lighting Standard Drawings:

Type IV Controller Cabinet

Type V Controller Cabinet

The controller cabinet housings 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 primer paint and painted with two coats of aluminum paint in accordance with Section 1002. Cabinets shall have continuous welded seams on all outside seams.

The steel fabricated cabinet housings shall be constructed with No. 14 copper bearing sheet steel.

The aluminum fabricated cabinet housings shall be constructed with No. 10 gage welded sheet aluminum. The cabinet finish shall be clean and not painted.

(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 controller cabinet door, except the Type I, shall have a two-position steel-bar type door stop.

The main doors of the Types IV, and V controller cabinets shall be secured by a three-point locking device.

(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 shall have a standard police-type lock. The police-type lock key shaft shall be a minimum of 1-3/4 inch 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.

The shelves shall not sag or restrict the free flow of air. The cabinets shall contain adjustable support brackets. For NEMA controllers the following shelf heights shall be furnished with the delivered cabinet:

(a) A minimum shelf height of 14 inches shall be provided for two-phase controllers.

(b) A minimum shelf height of 15 inches shall be provided for four-phase and eight-phase NEMA controllers, and pre-timed controllers.

(C) Cabinet Accessories:

The following accessories shall be provided with each controller cabinet as specified herein:

(1) Cabinet Light:

The Types IV and V controller cabinets shall contain a minimum 18-inch 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, refrigerator-type, normally closed, durable push-button type switch 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:

(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 be disconnected from the controller.

(c) Detector Call Test Switches (including Pre-Timed-Cabinets): A test switch shall be furnished to simulate a vehicle and pedestrian actuation. Each switch shall be a momentary contact push button. The metering controller shall have test switches for each detector input shown on the plans. 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, 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 separate two-position stop time toggle switch shall be provided to permit stop timing/automatic mode of the controller's stop time function. The two positions shall be labeled "stop time - auto". When required, other special function switches shall be furnished. Such switches shall be of the proper voltage and current rating to perform the function as specified. The following switches shall be mounted in the police panel:

(f) Main Switch: This shall be the main on/off switch to control the AC power to the signal controller assembly. The switch shall be properly sized for the amperage of the equipment.

(g) Auto/Flash Switch: shall be a toggle switch to transfer from automatic control to flashing operation. During the flash operation the AC power shall be maintained to the controller.

(h) 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.

(3) Convenience Outlet:

A 120-volt AC, 15-Amp. NEMA 5-15 G.F.I. convenience duplex outlet shall be mounted in each cabinet for energizing test equipment or tools. The outlet shall be fuse protected.

(D) Cabinet Ventilation Equipment:

Cabinet Fan and Filters:

Controller cabinets containing solid state electronic equipment shall be ventilated by means of a 120-volt AC, 60-hertz, tube-axial compact type fan. The fan's free delivery air flow shall be not less than 100 cubic feet per minute.

The fan housing shall be approximately four inches square by 1-1/2 inches 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 five-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 90 to 120 degrees F. The fan shall run until the cabinet temperature decreases to approximately 20 degrees F below the turn-on temperature setting. The fan shall be fused.

The cabinet fan assembly shall be mounted either inside the control cabinet or inside a rainproof housing on top of the control cabinet.

The cabinet shall have louvered air inlets in the lower portion of the main door. A standard furnace filter shall be mounted behind all the louvered air inlets.

The air outlets shall be screened on the exhaust side of the fan unit. The cabinet shall have a dust resistant air outlet baffle well secured and removable in the top of the cabinet.

Auxiliary cabinets containing solid state electronic equipment shall use fan units with a free delivery air flow of not less than 100 cubic feet per minute. The fan unit shall be approximately 3-1/2 inches 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-volt AC, two-wire, 60-hertz, single-phase service unless otherwise specified.

The power leg to the controller and the signal load circuits shall be protected by a single-pole, 120-volt AC, circuit breaker. The breaker shall have a 10,000 ampere 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.

The neutral service leg shall be connected to the AC neutral buss.

The 120-volt AC 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.

The lighting load shall be 240-volt AC 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 on 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 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 115-volt AC ± 10 percent, 60-hertz., 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.

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 three-minute intervals. The peak current rating shall be 20,000 amperes.

(5) Inductive Suppressors:

Each 120-volt AC 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.

(F) Cabinet Wiring Standards:

(1) Conductors:

All conductors used in controller cabinet wiring shall be No. 22 or larger, with a minimum of 19 copper strands. Conductors shall conform to Military Specification MIL-W-16878D, Type B or better. The insulation shall have a minimum thickness of 10 mils and shall be nylon-jacketed polyvinyl chloride or shall be irradiated cross-link polyvinyl chloride, polyhalocarbon, or polychlor-alkene.

(2) Lead-in Wires and Cable:

Lead-in wires, from the loop detector field terminals in the cabinet to the amplifier unit inside the cabinet, shall conform to one of the following:

A twisted pair of No. 22, or larger, conductors.

A cable containing two No. 22, or larger, conductors with each conductor insulated with either (1) a minimum of 10 mils of polyvinyl chloride and two mils of nylon, or (2) a minimum of 14 mils of polyethylene or polypropylene. The conductors shall be twisted pairs with three to six turns per foot. The cable shall be provided with a polyethylene or polyvinyl chloride outer jacket with a minimum thickness of 20 mils, or with a chrome vinyl outer jacket with a minimum thickness of 25 mils.

All conductors used in controller cabinet wiring shall conform to the following color code requirements:

The AC common conductors shall be identified by a continuous white or natural gray.

The chassis ground conductors shall be identified by a continuous green color with one or more yellow stripes.

The non-grounded conductors shall be identified by any color not specified above.

(3) Load Switch and Flasher Wiring:

Each of the load switch outputs (120-volt AC) and the flash transfer relay load base terminals shall be hard-wired with a minimum No. 14 copper conductor with a 90 ^{o}C rated jacket, or No. 16 copper conductor with a 105 ^{o}C rated jacket.

The 120-volt AC load switch and flash relay terminals shall be soldered to each base terminal.

(4) Signal Load Switch Buss:

The AC+ signal load switch buss shall be controlled by a signal-pole 120-volt AC mercury contactor or an auxiliary control relay. The minimum contactor size per switch buss shall be 30 amperes.

(5) Signal Load Panels:

All load switches, flashers, and flash transfer relays shall be mounted on a load bay panel or back panel assembly of the appropriate size.

Each load switch input from the controller shall be programmable on the back panel by use of removable jumpers to facilitate possible redesignation of output assignments due to future phasing requirements.

Detector amplifier modules may be mounted on the panel in lieu of a detector rack.

The signal load panel or back plane panel shall be easily removable from the cabinet for repair in the field.

All the control hardware and wiring shall be mounted and installed so as to permit the main back panel to be released and dropped for the service repairs in less than 10 minutes.

The load bay or back plane panel shall be wired to include all future signal phases and operations shown on the plans.

Printed circuit board type back panels shall only contain 0- to 24-volt DC circuits. No 120-volt AC circuits will be allowed.

(6) Pre-emption:

When specified, the controller cabinet shall include the cabinet wiring provisions for a pre-emptor controller unit and its cables.

(G) Meter Pedestal Cabinet:

Meter pedestal cabinets shall be furnished and installed in accordance with the project plans and specifications. The cabinet shall be UL listed.

The cabinet shall be 12 gage steel of tamperproof construction with piano-hinged doors and provisions for padlocks. The top and front covers of the cabinet shall be 16 gage steel.

The cabinet shall be treated on the inside and outside with one coat of primer paint and painted with two coats of aluminum paint, conforming to the requirements of Section 1002. The cabinet shall be completely wired with copper conductors to include the required circuit breakers and lighting contactors and shall be wired and equipped to handle electrical service loads as detailed on the project plans.

The service pull section shall be 4-1/2 inches deep and shall be located in back of the cabinet. An access opening in the cabinet shall be provided at the bottom of the service pull section.

Each cabinet shall have a detachable pad mount sleeve for easy installation in concrete which can be bolted to the base of the pedestal.

Electrical service shall be 120/240-volt 60-hertz, three-wire service.

(H) Cabinet-Mounted Service Enclosure:

The cabinet-mounted service enclosure shall be mounted on the back of control or load-center cabinets to provide a combination of metered and unmetered service for traffic signals and highway lighting, respectively. The service enclosure shall provide for both metered and unmetered load circuits. The enclosure shall be rated for 100-ampere continuous service and shall comply with the requirements of the serving utility company.

The cabinet-mounted service enclosure shall be fabricated from 14 gage zinc-coated steel with tamperproof construction. The enclosure shall be a NEMA 3R rainproof type with provisions for padlocks.

The enclosure shall have factory installed breakers, sockets and other components and shall be U.L. listed. The installed conductors shall be copper of the size and type to conform to the NEC and U.L. requirements.

The enclosure shall be finished with one coat of primer paint and two coats of aluminum paint conforming to the requirements of Section 1002.

(I) Cabinet Foundations:

Concrete for cabinet foundations shall be 3,000-pound per square inch Class S concrete.

734-2.04 Auxiliary Control Equipment:

The auxiliary equipment described in this section shall be supplied and installed as required inside the controller cabinet.

All auxiliary equipment shall conform to current published NEMA Standards pertaining to that device.

(A) Flasher Control Assembly:

The flasher control equipment shall consist of a complete electrical assembly which shall provide flashing traffic signals by enabling flash relays when the auto/flash switch or conflict monitor is activated. The relays shall be the flash load relay type as specified herein.

(B) Solid State Flashers:

The flasher unit shall be a solid state NEMA-type flasher. All flashers for signalized intersections, pole flashers, and overhead flashers, shall be the dual circuit type.

All the flashers shall be constructed of replaceable, molded relay modules. Each relay module shall have the specified ampere capacity and shall operate with zero point switching.

The flasher shall turn on within five degrees of the zero voltage point of the line sinusoid and shall turn off within five degrees of the zero current point of the line sinusoid. The flashing rate shall be 55 to 60 flashes per minute with a 50 percent duty cycle.

Solid state flashers shall be one of the following types:

Type 1 20 amperes per circuit, single circuit

Type 2 20 amperes per circuit, dual circuit

The flashers shall interconnect with a six-pin Cinch-Jones, S-406-SB socket. The flasher shall either have a support bracket or shall be mounted in a rack frame.

(C) Solid State Load Switches:

Load switches shall meet the requirements of NEMA for three-circuit load switches.

Each load switch shall contain three individually replaceable, solid state relay modules. Each relay module shall utilize optical isolation between the input and the output. The relay module shall have the following functions and terminal assignments:

Terminal	Function
1	120 volt AC Output
2	120 volt AC Line
3	+12 to 28 volts DC
4	Sequence Input (Ground)

Each panel of load switches shall either be rack mounted or shall have a switch support bracket extending across the entire length of the switch panel.

The load switch unit shall have three indicators to designate when the AC output circuits are activated. Each indicator shall monitor the outputs and shall be labeled top to bottom "R" Red, "Y" Yellow, and "G" Green, on the front panel of the load switch unit.

(D) Flash Load Relays:

Flash load relays shall be for the purpose of providing special circuitry or operational requirements. The relays shall be the double-pole, double-throw type.

Flash relays shall interconnect with a Cinch-Jones type eight-pin socket or an approved equal. 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 10-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 10 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 hertz between insulated parts and between current carrying parts and grounded or non-current carrying parts.

(E) 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-volts AC, 28-volts AC/DC, or 12-volts AC/DC as required. The contacts shall be single-pole 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.

(F) Conflict Monitors:

The conflict monitor shall conform to the current NEMA specifications.

Fully programmable monitors shall be programmed with soldered wire jumpers on a NEMA interchangeable programming card. Jumpered channels shall represent nonconflicting phases. Non-jumpered channels shall be in conflict with any other channel.

When a malfunctioning monitor is replaced in the field, the replacement monitor shall be field programmable without the use of tools.

The jumper numerical sequence shall be standard NEMA matrix.

The monitor shall have an active indicator for each channel.

(G) Detector Amplifiers:

(1) General:

The correct type and quantity of detector amplifiers shall be furnished as specified herein, as required on the plans. Unless otherwise specified, all detector amplifiers shall be rack mounted or mounted on a load bay panel with support brackets. Each rack position shall be labeled.

Each detector card shall be the edge connected type. The detector edge connector shall be a 44-pin double read-out contact. The connector shall have 0.128-inch diameter mounting holes on each end, MIL-M-14 insulation material, and MIL-C-21097 contacts.

The edge connector terminals, for the specified type of detector amplifier, shall be wired as specified herein. All of the detector channel inputs and outputs, including those channels specified for future use, shall be wired from the mounting rack to the tie points and the field terminals of the controller cabinet.

Each amplifier rack assembly shall include one power supply card per each set of four detector amplifier modules. The required number of power supply cards shall be furnished with each rack assembly which shall include the quantity of power supply cards for future phases shown on the plans and one spare edge connector.

The required quantity of amplifier modules, including those required for future phases shown on the plans, and one spare edge connector shall be furnished with each control cabinet assembly.

The amplifier rack positions shall be mechanically and electrically interchangeable such that amplifier modules of different manufacturers can be connected into any amplifier module positions. The rack spacing shall be for NEMA 2.31-inch wide front panels on all card rack units.

(2) Detector Amplifier Power Supply:

A rack-mounted 24-volt DC power supply shall be furnished with each controller cabinet assembly with more than two amplifier modules. Each detector amplifier module 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 Vehicle Detection Assembly			
Power Supply			
Pin No.	Function	Pin No.	Function

Standard Input and Output Functions for Vehicle Detection Assembly			
Power Supply			
Pin No.	Function	Pin No.	Function
A	Output Logic Ground	1	(Redundant Side)
B	Output 1 (+24-volt DC)	2	
C		3	
D		4	
E		5	
F		6	
H		7	
J		8	
K		9	
L	Chassis Ground	10	
M	115-volt AC (-)	11	
N	115-volt AC (+)	12	
P		13	
R		14	
S		15	
T		16	
U	Output 3 (+24-volt DC)	17	
V	Output 4 (+24-volt DC)	18	
W		19	
X		20	
Y		21	
Z		22	

(3) Loop Detector Amplifiers:

(a) General Requirements:

There shall be one amplifier channel per detector, except for the six- by six-foot detectors, unless otherwise specified.

The amplifier unit shall utilize digital solid state circuitry. The detection, frequency counting, and inductance measuring circuitry shall utilize crystal controlled MOS-LSI microelectronic circuits.

The loop detector amplifiers shall detect all licensed motor vehicles when using the loop configuration shown on the plans. The loop amplifiers shall be operational when using up to 1,000 feet of lead-in cable for a six by six-foot, three-turn, loop. Each loop detector amplifier shall detect vehicles at speeds of zero to 80 miles per hour using loop configurations ranging from: six by six feet - two-turn, six by 50 feet - one-turn, six by 70 feet - one-turn; up to six by 100 feet - one-turn loops. The smaller size six by six-foot loop sensors shall be capable of being connected to the amplifier in series and/or parallel as required.

(b) Loop Detector:

The loop detector amplifier unit shall contain two to four channels per unit.

The following types of loop detector card rack units shall be used to identify the number of detector channels and timing functions for each card:

LCR-2	Loop detector card unit with two channels.
LCR-2T	Loop detector card unit with two channels having timing functions.
LCR-4	Loop detector card unit with four channels.
LCR-4T	Loop detector card unit with four channels having functions.

No single channel amplifier shall be utilized. All loop detector card units shall be mechanically and electrically interchangeable with other card units of the same type and function from different manufacturers.

The loop modules and loop modules with timing function PIN numbers and functions shall be as designated in the following table:

Standard Input and Output Functions for Vehicle Detection Assembly			
Loop Module		2 or 4 Channel	
Pin No.	Function	Pin No.	Function
A	Logic Ground	1	Channel 1 Green
B	+ 24-volt DC 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	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	

Standard loop detector racks for amplifiers not requiring timing functions shall still be wired for possible future use of timing functions (pins 1, 2, 3, and 10). The wires from these pins shall be tied to spare terminal block tie points in the cabinet.

Polarization keys shall be located at four positions:

1. Between B/2 and C/3

2. Between M/H and N/12

3. Between E/5 and F/6

(c) Amplifier Requirements:

Each amplifier 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 three feet directly in front of the amplifier.

The amplifier shall operate in compliance with all the requirements herein specified when connected to an inductance loop plus lead-in, of from 50 to 500 microhenries with a loop Q parameter as low as 5.0 at the amplifier's operating frequency.

Each channel's call output shall be an optically isolated solid state type. Each amplifier channel shall conform to the following requirements:

(1) Amplifier Tuning: Each channel shall be manual or 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.

(2) Tracking: Each channel's circuits shall be designed so that changes due to environmental drift and applied power fluctuations shall not cause an actuation. Self-tracking 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 turning point regardless of initial circuit drift.

(3) 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 module shall have an off switch position for disabling unused channels.

(d) Special Timing Functions:

The following special timing functions shall be furnished only when specified on the plans. or these project specifications.

(1) Delay Timing Function: This timing function shall delay the call output up to 15 seconds after the vehicle enters the loop sensor. The timer shall be adjustable, from 0 to 15 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 seven seconds after the vehicle leaves the loop sensor. The timer shall be adjustable, from zero to seven seconds, in not more than 0.5-second increments.

When any of the above special functions are specified, then that special function shall be furnished on all channels of the same amplifier module.

(e) Amplifier Sensitivity:

Each of the amplifier channels shall have a minimum of three sensitivity settings per detection mode. The settings shall be selectable from the front panel. The highest sensitivity sheeting 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.

(f) Amplifier Response Time:

The amplifier 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 10 trials, the value of that average difference shall not exceed 10 milliseconds.

The response time of the detector channel for the highest sensitivity setting shall be less than 250 milliseconds for a 1.0 percent inductance change.

(g) Operating Frequency:

Each channel shall have a minimum of three operating frequencies. The frequency switch may be either on the front panel or on the circuit board. Frequency selection shall be possible without the use of tools.

(h) Detection Holding Time:

The detector channel, in the least sensitive position, shall maintain the presence detection of a vehicle for a minimum of four minutes while the vehicle is over the loop sensor 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 sensor and is causing an inductance change of 0.02 percent or greater.

(i) Temperature Changes:

The operation of the amplifier shall not be affected by environmental temperature changes at the rate of 1.5 degrees F per three minutes.

(j) Interference:

Each channel shall not cause crosstalk with any other channel either within the same amplifier or within any other amplifier that is mounted in the same cabinet assembly. An amplifier channel shall not detect vehicles, moving or stopped, at distances of three feet or more from the loop perimeter to which it is connected.

(k) Lightning Protection:

Each 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 protection shall enable the detector to withstand the discharge of a 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 chassis shall be grounded and the detector loop input pins shall have a 5.0-ohm dummy resistive load connected across them.

(l) Fail-safe Operation:

Each channel shall have a fail-safe design such that if the loop sensor circuit is open, the channel shall output a continuous vehicle call.

(m) Isolation Transformers:

Each loop sensor shall be coupled to the channel input by isolated transformers. The isolated input shall provide continued operation of the channel if the loop sensor in the street becomes grounded or has resistive leakage to ground.

(4) Magnetometer Detector Amplifier:

(a) General:

The magnetometer detector shall detect all licensed motor vehicles when using the probe configuration shown on the plans.

(b) Amplifier Requirements:

The amplifier shall be operational with up to 12 probes per channel, up to 2,000 feet of lead-in cable, and vehicular speeds up to 90 miles per hour. Each amplifier shall have two independent channels per card. The card shall be connectable in any detector rack position.

Solid state circuitry shall accurately measure changes in the earth's vertical magnetic field intensity caused by motor vehicles. The front panel shall have a calibration control for each channel to calibrate the amplifier for the local magnetic field strength.

Each amplifier 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.

Each channel call output shall be an optically isolated solid state NPN transistor with a normally open collector which shall be rated for a five-milliampere load and 0.7-volt drop maximum.

The collector shall be rated for 30-volts DC when in the off mode. Each magnetometer amplifier shall conform to the magnetometer table and the following requirements:

(c) Detection Modes:

Each channel shall permit the selection of either a presence mode or a pulse mode. Each channel shall be independent of the other channel of the amplifier. In the presence mode, the channel shall indicate the presence of a vehicle until the vehicle leaves the detection area. The indication shall then cease in 100 milliseconds. In the pulse mode, the channel shall output a single 30- to 50-millisecond pulse for each vehicle entering the detection area.

(d) Timing Functions:

Each channel shall have the following independently selectable functions. The functions shall be selectable from the front panel:

1) Inhibit Pulse Timing:

This timing function shall inhibit subsequent call outputs up to five seconds after each vehicle leaves the sensor area.

2) Extended Presence Timing:

This timing function shall carryover or extend the call output up to five seconds after each vehicle leaves the sensor area.

(e) Environmental:

The operation of the amplifier shall not be affected by nominal changes in the environment.

(f) Number of Probes:

Each amplifier channel shall operate with one to twelve sensor probes.

Standard Input and Output Functions for Vehicle Detection Assembly			
	Magnetometer Module		2-Channel
Pin No.	Function	Pin No.	Function
A	Logic Ground	1	No Connection
B	+ 24-volt DC IN	2	No Connection
C		3	No Connection
D	Probe Set 1 (White)	4	
E	Probe Set 1 (Black)	5	
F	Output 1 (+)	6	
H	Output 1 (-)	7	
J	Probe Set 1 (Red)	8	
K	Probe Set 1 (Green)	9	
L	Chassis Ground	10	No Connection
M		11	
N		12	
P	Probe Set 2 (White)	13	
T	Output 2 (-)	16	
U	Probe Set 2 (Red)	17	
V	Probe Set 2 (Green)	18	
W		19	
X		20	
Y		21	
Z		22	

A polarization key shall be located between pins R/4 and S/15.

(5) 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 Developer. The size of the relay will be 1.6 inches wide by two inches long. The terminal strip shall be provided and wired by the Developer.

The terminal strip shall be the Type 141 with terminals in multiples of four. The size shall be 1-1/8 inches wide by 1/2 inch deep. The terminal spacing shall be 7/16 inch. The screw size shall be 6-32.

(a) 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, the top 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.

(b) 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-volt (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.

734-2.05 External Logic Circuit Boards:

(A) General:

External logic that is required to supplement the controller or auxiliary control units shall be on solid state, plug-in cards. The logic cards shall be designed as specified herein.

The logic cards shall be the 22-pin, edge-connector or octal-base type. The pins shall be either single- or double-sided as required.

Each card shall be keyed to prevent the improper connection of the card. The printed circuit board shall meet the requirements of NEMA TS1-14.2.3.

Power supplied from the controller's power supply shall not exceed 350 milliamperes. If more than 350 milliamperes is required, then a separate external power supply must be utilized. Such an external power supply may be either shelf-mounted or rack-mounted.

The logic circuitry shall be properly interfaced and buffered from the controller and other controller assembly equipment.

All external logic timing functions shall be digital and shall be in the required timing range. Timing entries shall be front-panel programmed without the use of tools or software and shall be accessible without the removal of the enclosure's cover. The timing shall be set by thumbwheel switches, programming pins, or digital binary (DIP) switches. The timing accuracy shall conform to NEMA TS1-2.1.11 for digital timing.

(B) Digital Time Switch:

When specified, each controller cabinet shall include a solid state digital time switch of the type specified, wired for the function detailed in the project specifications.

The solid state digital time switch shall utilize solid state circuitry and digital timing techniques. Integrated or discrete semi-conductor devices shall be used exclusively. No electro-mechanical parts shall be employed except for the controlled circuit output relay.

The design life of all components under 24-hour-a-day operation in their electrical applications shall be not less than 10 years.

All components shall be clearly identifiable by markings on circuits boards or parts numbers on pictorial diagrams.

(1) Operational Requirements:

Each time switch shall control the required number of circuit outputs in a 24-hour period, for seven days with an omit control for any one or more of the seven days.

The time switch shall be powered by a 120-volt 60-hertz input in the temperature range between 30 and 165 degrees F. The 60-hertz line frequency shall be the time base for the clock.

(2) Time Clock Back-up:

The time switch shall have a battery back-up circuit which shall power the timer for not less than 12 continuous hours during the loss of electrical A.C. power. Battery back-up shall generate its own time base, and clock accuracy shall be within 0.02 percent. During battery back-up operation, all luminous displays and relays shall be disabled. During normal operation, the battery shall be trickle charged. The rechargeable battery system shall be an integral part of the time switch housing. The battery unit shall include an on-off control switch to permit it to be disconnected from the time switches.

(3) Programming:

Programmed time entries shall be front-panel programmed without the use of tools or software. The programming of the selectable functions and time operations shall be set by thumbwheel switches, programming pins, DIP switch, or front-panel keyboard entry.

All programming pins shall be the printed circuit receptacle, non-corrosive, turning-fork type. The pin contactor shall fit any standard 0.055-inch to 0.73-inch board. The pins shall be rated 600 volts RMS at five amperes.

The time operations shall be programmable to a one-minute increment.

(4) Displays:

The time switch shall have a digital time-of-day display; 24-hour or with A.M./P.M. indicator; in hours and minutes past midnight. There shall be a day-of-the-week-in-effect indicator.

A separate indicator shall indicate when an output circuit is active (on).

(5) Output Control Circuit:

Each output control circuit shall be a single-pole, double-throw independent relay output. The relay shall be rated not less than five amperes at 120 volts AC. The relay shall be energized when the clock program is on, and de-energized when the clock program is off.

(6) Power Supply:

The time switch shall have the 120-volt AC input fused to protect its internal circuitry. Line transients normally experienced in traffic signal controller environments shall not affect the clock accuracy herein specified. Line transient protection devices shall be provided to prevent these inaccuracies.

(7) Housing and Connector:

The entire time switch shall be completely enclosed in a dust resistant housing. The housing door shall enclose all the program switches, display and indicators.

The housing shall contain solderless lug-type terminals or a detached connector.

(8) Digital Time Switch Types:

The solid state digital time switches shall be designated in the project specifications or plans with the following five-position alphanumeric code. The code shall have the following meaning:

The type DTS clock shall mean the solid state digital time switch.

DTS-1-1	is a single program, single circuit.
DTS-1-3	is a single program, three-circuit.
DTS-3-3/4	is a three program, three or four-circuit as required.

The single program shall have seven on-off operations per unit and three on-off operations per circuit in a 24-hour period.

Each program shall be selectable for day omit (days 1 through 7).

The solid state time switches shall have an 11-pin octal connector. The cabinet shall have a female interface connector as shown in the following table:

Cabinet Solid State Time Switch Interface Connector	
Pin No.	Function
1	Common No. 1
2	Output No. 1 N.O.
3	Output No. 1 N.C.
4	Common No. 2
5	Output No. 2 N.O.
6	Output No. 2 N.C.
7	AC Common
8	Common No. 3
9	120-volt AC Input
10	Output No. 3 N.C.
11	Output No. 3 N.O.

734-3 Construction Requirements:

734-3.01 General Requirements:

All traffic controller assembly equipment shall be furnished and installed as shown on the plans, and in accordance with these specifications. Cabinet wiring, connecting cables, support bases, and shelves shall be provided to allow for future installation and use.

734-3.02 Test Requirements:

General:

All specified traffic controller assembly items shall meet the applicable environmental and testing standards of NEMA Publication TS-1. All traffic signal controller units shall be tested by the Department's testing procedures.

734-3.03 Wiring and Grounding Requirements:

(A) Cabinet Wiring:

All cabinet wiring shall be neatly arranged and made tight by the use of wiring harnesses, cable sheaths, cable wraps, or raceways. All wires in a harness shall be laced or bound together. Harnesses shall be routed to minimize crosstalk and electrical interference.

Cabling shall be routed to prevent conductors from being in contact with metal edges. Cabling shall be arranged so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

All pin assignments shall be wired to the controller cabinet terminal for future use.

The following time-base coordination wiring functions shall be provided when MPS coordination is specified to be furnished in the control cabinet.

(1) Fully actuated controller units shall be wired to operate in non-actuated mode during coordination period.

(2) The inside cabinet switch panel shall include a switch for coordination, and free run modes of operations. The remote free input shall be wired to a cabinet terminal tie point to permit control input from a remote input.

(3) An auxiliary time of day (24-hour) from the MPS "D" connector output shall be wired in the cabinet to program the Max 2 Function.

(B) Conflict Monitor Wiring:

The conflict monitor unit cable shall be wired to perform the following functions:

(1) To monitor conflicts of green, yellow and walk signal for each applicable phase.

(2) To monitor absence of red voltage. Any phase specified for future use shall have a removable jumper so as to permit future implementation of that phase without rewiring the controller cabinet.

(3) To monitor voltage +24-volt DC source of the controller unit and any auxiliary controller unit.

(4) To start-delay the controller unit per NEMA Standards.

(5) The conflict monitor cable shall have the cabinet interlock A and B wired to control cabinet tie points for future use.

(6) The monitor input for each signal circuit shall be terminated at the furthest field terminal point, so as to monitor both the automatic and flash modes of the controller cabinet.

(C) Cabinet Grounding:

All controller cabinets and auxiliary cabinets shall have the AC common, the logic ground, and the chassis ground isolated from each other as detailed in the current NEMA Standards.

(D) Field and Tiepoint Terminal/Wiring:

(1) 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 five inches from the base of the cabinet.

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 inch 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.

(2) 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-volt AC output). The field terminals shall include the following terminal positions:

(a) To railroad (120-volt AC)

(b) From railroad (not wired)

(c) "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.

Two sets of the final wiring diagrams and a second original shall be required with delivery with each control cabinet assembly. The second original shall be a legible reproducible linen cloth, mylar film, or polyester film.

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 nine inches wide by eight inches high by 1-1/4 inches deep, mounted inside.

734-3.05 Cabinet Foundations:

Before the concrete for cabinet foundations has set, depressions shall be made around the anchor bolts for adjustment of the cabinet leveling nuts. Cabinet foundations shall be four inches above ground level.

SECTION 735 DETECTORS:

735-1 Description:

The work under this section shall consist of furnishing and installing traffic signal loops, preformed loop detectors, complete or partial traffic data loop and weigh-in-motion (WIM) systems, 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 the 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, passage, speed, weight, and classification of vehicles.

Except as specified in Subsection 735-2.01 (F), all materials shall be furnished by the Developer. The Developer shall submit a complete list of all required project material for approval, as specified in Subsection 730-4 of the specifications.

(B) Loop Detectors:

The detector loop dimensions shall be as specified on the Plans.

Loop detector wire shall be 14 AWG HDPE polyethylene insulated conductors conforming to IMSA 51-7, as shown on the Plans.

(C) Lead-in Cable:

For Type SA and SB speed/classification detectors specified in Subsection 735-3.02(D), lead-in cable from the pull box to the cabinet shall conform to IMSA specification 50-2, except as modified on the Plans.

(D) Conduit:

Conduit shall be rigid nonmetallic PVC conforming to the requirements of Subsection 732-2.02 of the specifications. Conduit shall be large enough to contain the number of wires required, but not less than the diameters shown on the Plans.

(E) Cabinets:

Traffic monitoring site cabinets for Type SA and SB speed/classification and WIM detectors shall be pole-mounted Type MPD control cabinets as shown on the Plans, and as specified in Subsection 734-2.03 of the specifications, except that no pre-wiring for AC or DC electric, police panel, or provisions for fan or light shall be required.

Warranties shall comply with Subsection 106.13 of the specifications.

(F) Materials:

When required, the Developer will furnish detectors for speed/classification systems (piezoelectric sensors-Class 2) and weigh-in-motion systems (piezoelectric sensors–Class1, or quartz piezoelectric sensors) with pre-attached lead-in cables. For such installations, the Developer will also furnish the piezo grout sealant for the sensor portion of speed/classification and weigh-in-motion detectors. The Developer shall furnish all other sealants.

The Developer shall notify the Traffic Monitoring Team of the Multimodal Planning Division (MPD) at (602) 712-8598 a minimum of 15 working days prior to scheduled installation of the piezoelectric sensors. The required sensors and grout will be provided by the Developer.

735-2.02 Pedestrian Push-Button Detectors:

The pedestrian detector shall be a push-button switch mounted inside an approved push-button housing, as shown on the Plans.

Pedestrian push-button signs shall be made with porcelain enameled 20 gage sheet steel, 9 inches by 12 inches 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.

735-2.03 Blank

735-2.04 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) Two-Part Epoxy Filler Sealant:

Two-part epoxy joint filler sealant shall be a 100-percent solids, flexible, two-component, solvent free, epoxy resin/hardener system for use as a saw cut sealant in asphaltic concrete pavements and Portland cement concrete pavements.

Materials shall comply with the requirements of Subsection 1015-1 of the Specifications.

The epoxy system shall be specifically designed for the intended application according to the product literature provided by the manufacturer.

The epoxy system shall be of sufficient strength and hardness to withstand stress and abrasion from vehicular traffic, while remaining flexible enough to provide stress relief under thermal movement and protect the loop wire from moisture penetration. It shall also be moisture insensitive to allow effective application to damp pavements. No standing water is permitted on the surfaces to which the epoxy system is to be applied.

The epoxy system shall be designed to enable vehicular traffic to pass over properly filled saw cuts immediately after installation without tracking or stringing of the material.

Properly installed and cured epoxy systems shall exhibit resistance to the effects of weather, motor oils, gasoline, anti-freeze solution, brake fluid, deicing chemicals, and salt in such a manner that the performance of the vehicle detector loop wire is not adversely affected.

The epoxy system shall be designed for roadway installation when the surface temperature is a minimum of 40 degrees F and rising. The cured epoxy system shall be temperature stable and exhibit no degradation in performance throughout the ambient pavement temperature ranges experienced within the State of Arizona.

The components of the epoxy system shall have a minimum shelf life of 12 months in original unopened, undamaged containers, when stored in a cool dry environment, as recommended by the manufacturer.

The epoxy system shall meet the following requirements:

Property	Test Method	Requirements
Mixing Ratio; Part A to Part B	-	1 to 1 by volume
Viscosity, centipoises	ASTM D 2393-86	4000 to 8000
Pot Life, minutes	ASTM C 881	12 to 20
Cure Time, minutes	ASTM C 679	60 maximum, Tack Free
Hardness (Shore D)	ASTM D 2240	35 to 65
Tensile Elongation, %	ASTM D 638	50 minimum
Water Absorption, % (24 hrs)	ASTM D 570	1 maximum
3% Salt Water Absorption, % (24 hrs)	-	0.03 to 0.20
Oil Absorption, % (24 hrs)	ASTM D 471	0.01 to 0.02
Gasoline Absorption, % (24 hrs)	-	0.05 to 0.90

(B) One-Part Elastomeric Sealant:

One-part elastomeric sealant may be used to seal saw cuts in Portland cement 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 its installation.

The encapsulant shall, within its engineered 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 degrees F 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 the State of 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, prior to curing of the encapsulant, with a suitable non-flammable solvent. 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 and 140 degrees F.

The encapsulant shall have the following physical properties in its uncured and cured states.

Uncured (Wet) Encapsulant		
Property	**Requirement**	**Test Procedures**
Weight	10.1 ± 0.3 pounds/gallon	A. Weight/Gallon
Total Solids by Weight	75 – 85%	B. Determination of Non-Volatile Content
Viscosity	10,000 - 85,000 centipoise	C. Dynamic Viscosity
Drying Time	Touch: 24 hrs. maximum Complete: 30 hrs. max.	D. Tack-Free Time

Cured Encapsulant		
Property	**Requirement**	**Test Procedure**
Hardness (Indentation)	65 – 85	E. Rex hardness
Tensile Strength	500 psi minimum	F. Tensile & Elongation
Elongation	300% minimum	

(C) Hot Applied Rubberized Sealant:

Hot applied rubberized sealant may be used to seal saw cuts in asphaltic concrete and in lean concrete base. 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 pressure feed melter unit. Pour pot application is not acceptable. 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 for the loop detector sealant.

Test	Specification
Penetration: 125 oF, 50g, 5s	50 maximum
Penetration: 77 oF, 100g, 5s	10 – 25
Softening Point:	210 oF minimum
Ductility: 77 oF	15 cm minimum
Mandrel Bend: 0 oF, 90o Arc, 10s, 3/4 inch diameter	Pass 2 of 3
Recommended Pour Temp:	380 oF
Safe Heating Temp:	420 oF
Brookfield Viscosity: 400 oF	7,500 centipoise max.
Unit Weight:	8.5 pounds per gallon
Coverage; 1/2 by 1/2 inch crack	11.0 pounds per 100 feet

SECTION 736 HIGHWAY AND SIGN LIGHTING:

736-1 Description:

The work under this section shall consist of furnishing and installing or modifying highway lighting systems or sign illumination 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.

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 Highway Lighting Materials:

(A) LUMINAIRE (HIGH MAST) (LED):

General:

High mast LED luminaires supplied on this project shall be 480 volt luminaires with a 4,000K correlated color temperature and shall meet the requirements of this specification. All high mast luminaires shall be supplied with a shorting cap. The following high mast LED luminaire was used in the design of this project and meets the requirements of this specification. This luminaire, used in conjunction with the horizontal mount luminaires provides the required light levels.

Holophane HMAO LED II – HMLED2 12 3K AH G AW PSC P7

If the contractor proposes a different luminaire, it must meet the requirements of this specification and meet the required light levels when used in conjunction with approved horizontal mount LED luminaires.

Listing Requirements:

- The luminaire shall be listed by a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. The testing laboratory must be listed by OSHA in its scope of recognition for the applicable tests being conducted as required by this specification. A list of recognized testing labs for products sold in the United States may be found on the U.S. Department of Labor's web site:

  http://www.osha.gov/

- The luminaire shall be listed and labeled by a NRTL as being in compliance with UL 1598 and suitable for use in wet locations.

- The light source and drivers shall be RoHS compliant.
- The luminaire shall have an International Electrotechnical Commission (IEC) 529 Ingress Protection (IP) rating of IP 65 or greater.
- The luminaire shall be in compliance with Electro Magnetic Interference (EMI) requirements as defined by FCC 47 Sub Part 18.
- The luminaire shall be tested according to the most current version of Illuminating Engineering Society of North America (IESNA) LM-79.
- The luminaire shall have lumen maintenance measured in accordance with the most current version of IESNA LM-80.
- The luminaire shall have long term lumen maintenance documented according to the most current version of IESNA TM-21.
- The luminaire shall have LM-79, LM-80 and In-situ temperature testing conducted by U.S. Department of Energy Lighting Facts Program LED Lighting Facts approved testing laboratories:

  (http://www.lightingfacts.com/approvedlabs)

Luminaire Housing:

- The luminaire shall have an aluminum housing and shall be painted gray with corrosion resistant paint.
- All hardware on the exterior of the housing including cover and latch shall be stainless steel, zinc, or steel with zinc alloy electroplate and chromate top coat.
- The luminaire shall have readily accessible internal parts.
- The luminaire shall have a 4-bolt slip fitter type mounting on nominal 2 inch (2 3/8 OD) pipe (tenon) brackets.
- The mounting assembly shall permit any necessary adjustment to orient the luminaire with the roadway for proper light distribution.
- The maximum weight of the luminaire when fully assembled shall be 60 pounds or less.
- The luminaire shall have an effective projected area of no more than 1.6 square feet.

- The luminaire shall be compliant with American National Standard (ANSI) C136.31, 3G, Table 2 Roadway Lighting Equipment -Luminaire Vibration for both normal applications and bridge and overpass applications.

- The luminaire shall have area on the top of the housing to allow for a level to be used for proper orientation of the luminaire.

- The luminaire shall be provided with a seven pin photo-electric control receptacle (PECR) conforming to ANSI Standard C136.10 with a shorting cap. PECR shall be rotatable up to 359 degrees.

- The housing shall be designed to allow water shedding.

- A passive cooling method shall be employed to manage thermal output of LED light engine and power supply.

Electrical Requirements:

- The luminaire shall fully operate in an ambient temperature range -40º C to 45° C (-40º F to 113º F).

- The luminaire shall have an integral power supply (electronic driver) with a driver current no greater than 1500mA.

- The luminaire shall have a power supply (electronic driver) that will operate at 480 VAC (rms) ±10% at 60 hertz.

- The electronic driver shall have the following:

  - A power factor of .90 or greater at full load.
  - A total harmonic distortion of 20% or less at full load.
  - A rated life of 100,000 hours with a luminaire operated at an ambient temperature of 25° C (77°F).
  - Self-limited short circuit protected and over load protected.
  - Termination with quick disconnect wire harnesses for easy maintenance. Wire nut termination is not acceptable.
  - A terminal block for terminating pole wiring to the luminaire. The terminal block shall be a 3 station, tunnel lug terminal board that will accommodate #6 thru #18 AWG pole wire.
  - Electrical components that are protected per ANSI/IEEE Standard C62.41, for Class C applications. The transient suppressor is not required to be RoHS compliant.

LED Performance Requirements:

- The luminaire shall have a minimum luminaire efficacy of 100 lumens/watt.
- The luminaire shall meet the chromaticity requirements as follows:
    - The standard color for the LED luminaire shall be white. The colors shall conform to the following color region based on the 1931 CIE chromaticity diagram.
    - The luminaire shall have a Nominal Correlated Color Temperature (CCT) of 4000K +/-300K.
- The luminaire shall have a minimum Color Rendering Index (CRI) of 70.
- Chromaticity as stated above must be shown on the LM 79 test report.

Optical Requirements:

- The luminaire shall have an IESNA Uplight rating of zero.
- The luminaire shall have a light distribution pattern at the road surface that has an evenly dispersed appearance.
- The luminaire shall not have a perceptible light level flicker to the unaided eye over the voltage range as specified in the Electrical Requirements.
- The high mast luminaire shall provide the following light levels when used in conjunction with the approved LED horizontal mount luminaires that will be installed with this project. The photometric analysis shall use the ADOT standard lighting equipment shown in the Pole and Luminaire Schedule and the light pole locations designated on the project plans. The contractor shall provide the manufacturer with a complete set of project plans and cross sections so the photometric calculations can be achieved with accuracy.

Mainline and ramps:

- ♦ Minimum maintained average horizontal illuminance: 0.6 footcandles
- ♦ Minimum maintained horizontal illuminance: 0.2 footcandles
- ♦ Average to minimum uniformity ratio: 3:1 or better
- ♦ Average to minimum uniformity ration (System TI) 4:1 or better

- The light level calculations shall be performed in accordance with the procedures contained in IES RP-8-14 and must be documented using lighting support software utilizing a Light Loss Factor (LLF) as defined below:
  - Calculations shall be for maintained values (Light Loss Factor (LLF) < 0.8.) where: LLF = LLD X LDD.
  - Lamp Lumen Depreciation Factor (LLD) shall be the specified percentage of LED lumen maintenance at 50,000 hours at 40°C (104°F) from the TM-21 report.
  - Luminaire Dirt Depreciation (LDD) = 0.9.
- The TM-21 Report must show the drive current used for the submitted luminaire. The report may show a larger drive current to represent a worst case scenario.
- The product submittal shall be accompanied by IES TM-21 compliant test reports from a CALiPER qualified or NVLAP accredited testing laboratory for the specific model being submitted.

Minimum Required Submittals:

The following items are required for approval of luminaires that are not listed in the General section of this specification.

- Luminaire specification sheet.
- LED driver specification sheet.
- LM-79 luminaire photometric report.
- The vendor must submit LM-79 in-situ test data to confirm thermal operating temperatures of the luminaire.
- LM-80 lumen maintenance report.
- TM-21 calculations as defined in this specification.
- Backlight, Uplight, Glare (BUG) rating of the luminaire.
- Computer generated point by point photometric analysis.
- Written product warranty.
- Independent test lab IES photometric reports including IES electronic file.

- IES chromaticity data from an LED Lighting Facts approved testing laboratory.
- Instructions for installation and maintenance.

(B) LUMINAIRE (UNDERDECK) (LED):

Materials:

General:

Underdeck LED luminaires supplied on this project shall be 480 volt luminaires with a 4,000K correlated color temperature and shall meet the requirements of this specification. All underdeck luminaires shall be supplied with a shorting cap. The following underdeck LED luminaire was used in the design of this project and meets the requirements of this specification. This luminaire, used in conjunction with the high mast and horizontal mount luminaires, provides the required light levels.

Holophane TNLED 3 4K 1 AH WCR DBZA L DM

If the contractor proposes a different luminaire, it must meet the requirements of this specification and meet the required light levels when used in conjunction with approved high mast and horizontal mount LED luminaires.

Listing Requirements:

- The luminaire shall be listed by a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. The testing laboratory must be listed by OSHA in its scope of recognition for the applicable tests being conducted as required by this specification. A list of recognized testing labs for products sold in the United States may be found on the U.S. Department of Labor's web site:

  http://www.osha.gov/

- The luminaire shall be listed and labeled by a NRTL as being in compliance with UL 1598 and suitable for use in wet locations.
- The light source and drivers shall be RoHS compliant.
- The luminaire shall have an International Electrotechnical Commission (IEC) 529 Ingress Protection (IP) rating of IP 65 or greater.
- The luminaire shall be in compliance with Electro Magnetic Interference (EMI) requirements as defined by FCC 47 Sub Part 18.

- The luminaire shall be tested according to the most current version of Illuminating Engineering Society of North America (IESNA) LM-79.
- The luminaire shall have lumen maintenance measured in accordance with the most current version of IESNA LM-80.
- The luminaire shall have long term lumen maintenance documented according to the most current version of IESNA TM-21.
- The luminaire shall have LM-79, LM-80 and In-situ temperature testing conducted by U.S. Department of Energy Lighting Facts Program LED Lighting Facts approved testing laboratories:

  (http://www.lightingfacts.com/approvedlabs)

Luminaire Housing:

- The luminaire shall have an aluminum housing and shall be painted bronze with corrosion resistant paint.
- All hardware on the exterior of the housing including cover, latch and mounting brackets shall be stainless steel, zinc, or steel with zinc alloy electroplate and chromate top coat.
- The luminaire shall not require tools to open when properly mounted.
- The luminaire shall have readily accessible internal parts.
- The luminaire shall be compliant with American National Standard (ANSI) IEEE C136.31, 3G, Table 2 Roadway Lighting Equipment -Luminaire Vibration for both normal applications and bridge and overpass applications.
- The luminaire shall support future dimming and luminaire performance monitoring.
- A passive cooling method shall be employed to manage thermal output of LED light engine and power supply.

Electrical Requirements:

- The luminaire shall fully operate in an ambient temperature range -40º C to 45° C (-40º F to 113º F).
- The luminaire shall have an integral power supply (electronic driver) with a driver current no greater than 1500mA.

- The luminaire shall have a power supply (electronic driver) that will operate at 480 VAC (rms) ±10% at 60 hertz.

- The electronic driver shall have the following:

  - A power factor of .90 or greater at full load.
  - A total harmonic distortion of 20% or less at full load.
  - A rated life of 100,000 hours with a luminaire operated at an ambient temperature of 25° C (77°F).
  - Self-limited short circuit protected and over load protected.
  - Termination with quick disconnect wire harnesses for easy maintenance. Wire nut termination is not acceptable.
  - A terminal block for terminating wiring to the luminaire. The terminal block shall be a 3 station, tunnel lug terminal board that will accommodate #6 thru #18 AWG pole wire.
  - Electrical components that are protected per ANSI/IEEE Standard C62.41, for Class C applications. The transient suppressor is not required to be RoHS compliant.

<u>LED Performance Requirements:</u>

- The luminaire shall have a minimum luminaire efficacy of 70 lumens/watt.

- The luminaire shall meet the chromaticity requirements as follows:

  - The standard color for the LED luminaire shall be white. The colors shall conform to the following color region based on the 1931 CIE chromaticity diagram.

  - The luminaire shall have a Nominal Correlated Color Temperature (CCT) of 4000K +/-300K.

- The luminaire shall have a minimum Color Rendering Index (CRI) of 70.

- Chromaticity as stated above must be confirmed by an independent test lab or shown on the LM 79 test report.

<u>Optical Requirements:</u>

- Optical enclosure shall be prismatic glass.

- The luminaire shall have a light distribution pattern at the road surface that has an evenly dispersed appearance.

- The luminaire shall not have a perceptible light level flicker to the unaided eye over the voltage range as specified in the Electrical Requirements.

- The underdeck luminaire shall provide the following light levels on the I-19 mainline and ramps when used in conjunction with the approved LED high mast and horizontal mount luminaires that will be installed with this project. The photometric analysis shall use the ADOT standard lighting equipment shown in the Pole and Luminaire Schedule and the light pole locations designated on the project plans. The contractor shall provide the manufacturer with a complete set of project plans and cross sections so the photometric calculations can be achieved with accuracy.

    - Minimum maintained average horizontal illuminance: 0.6 footcandles

    - Minimum maintained horizontal illuminance: 0.2 footcandles

    - Average to minimum uniformity ratio: 4:1 or better

- The light level calculations shall be performed in accordance with the procedures contained in IES RP-8-14 and must be documented using lighting support software utilizing a Light Loss Factor (LLF) as defined below:

    - Calculations shall be for maintained values (Light Loss Factor (LLF) < 0.8.) where: LLF = LLD X LDD.

    - Lamp Lumen Depreciation Factor (LLD) shall be the specified percentage of LED lumen maintenance at 50,000 hours at 40°C (104°F) from the TM-21 report.

    - Luminaire Dirt Depreciation (LDD) = 0.9.

- The TM-21 Report must show the drive current used for the submitted luminaire. The report may show a larger drive current to represent a worst case scenario.

- The product submittal shall be accompanied by IES TM-21 compliant test reports from a CALiPER qualified or NVLAP accredited testing laboratory for the specific model being submitted.

Minimum Required Submittals:

The following items are required for approval of luminaires that are not listed in the General section of this specification.

- Luminaire specification sheet.

- LED driver specification sheet.

- LM-79 luminaire photometric report.

- The vendor must submit LM-79 in-situ test data to confirm thermal operating temperatures of the luminaire.
- LM-80 Lumen maintenance report.
- TM-21 calculations as defined in this specification.
- Computer generated point by point photometric analysis.
- Written product warranty.
- Independent test lab IES photometric reports including IES electronic file.
- IES chromaticity data from an LED Lighting Facts approved testing laboratory.
- Instructions for installation and maintenance.

(C) LUMINAIRE (HORIZONTAL MOUNT) (LED)

Materials:

General:

All horizontal mount LED luminaires supplied on this project shall be 480 volt fixtures with a 4,000K correlated color temperature, shall be supplied with a shorting cap and shall meet the requirements of this specification.

Listing Requirements:

- The luminaire shall be listed by a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. The testing laboratory must be listed by OSHA in its scope of recognition for the applicable tests being conducted as required by this specification. A list of recognized testing labs for products sold in the United States may be found on the U.S. Department of Labor's web site:

  http://www.osha.gov/

- The luminaire shall be listed and labeled by a NRTL as being in compliance with UL 1598 and suitable for use in wet locations.
- The light source and drivers shall be RoHS compliant.

- The luminaire shall have an International Electrotechnical Commission (IEC) 529 Ingress Protection (IP) rating of IP 65 or greater.

- The luminaire shall be in compliance with Electro Magnetic Interference (EMI) requirements as defined by FCC 47 Sub Part 18.

- The luminaire shall be tested according to the most current version of Illuminating Engineering Society of North America (IESNA) LM-79.

- The luminaire shall have lumen maintenance measured in accordance with the most current version of IESNA LM-80.

- The luminaire shall have long term lumen maintenance documented according to the most current version of IESNA TM-21.

- The luminaire shall have LM-79, LM-80 and In-situ temperature testing conducted by U.S. Department of Energy Lighting Facts Program LED Lighting Facts approved testing laboratories:

  (http://www.lightingfacts.com/approvedlabs)

Luminaire Housing:

- The luminaire shall have an aluminum housing and shall be painted gray with corrosion resistant paint.

- All hardware on the exterior of the housing including cover and latch shall be stainless steel, zinc, or steel with zinc alloy electroplate and chromate top coat.

- The luminaire shall not require tools to open when properly mounted.

- The luminaire shall have readily accessible internal parts.

- The luminaire shall have a 2-bolt or 4-bolt slip fitter type mounting on nominal 2 inch (2 3/8 OD) pipe (tenon) brackets.

- The slip fitter mount shall allow 4 inches of the pole bracket to be inserted in the luminaire mounting assembly.

- The mounting assembly shall permit any necessary adjustment to orient the luminaire with the roadway for proper light distribution.

- The luminaire shall be compliant with American National Standard (ANSI) IEEE C136.31, 3G, Table 2 Roadway Lighting Equipment -Luminaire Vibration for both normal applications and bridge and overpass applications.

- The luminaire shall have area on the top of the housing to allow for a level to be used for proper orientation of the luminaire.

- The luminaire shall be provided with a seven pin photo-electric control receptacle (PECR) conforming to ANSI Standard C136.10 with a shorting cap. PECR shall be rotatable up to 359 degrees. Housing shall provide 360 degree stop to prevent the internal twisting of PECR wire assemblies.

- The housing shall be designed to allow water shedding.

- A passive cooling method shall be employed to manage thermal output of LED light engine and power supply.

- The luminaire housing shall have a label with lettering a minimum height of one inch on the bottom side of the luminaire indicating the luminaire type. The label must be clearly legible when viewed from a distance of 45 feet.

Electrical Requirements:

- The luminaire shall fully operate in an ambient temperature range -40º C to 45° C (-40º F to 113º F).

- The luminaire shall have an integral power supply (electronic driver) with a driver current no greater than 1500mA.

- The luminaire shall have a power supply (electronic driver) that will operate at 480 VAC (rms) ±10% at 60 hertz.

- The electronic driver shall have the following:

  - A power factor of .90 or greater at full load.
  - A total harmonic distortion of 20% or less at full load.
  - A rated life of 100,000 hours with a luminaire operated at an ambient temperature of 25° C (77°F).
  - Self-limited short circuit protected and over load protected.
  - Termination with quick disconnect wire harnesses for easy maintenance. Wire nut termination is not acceptable.
  - A terminal block for terminating pole wiring to the luminaire. The terminal block shall be a 3 station, tunnel lug terminal board that will accommodate #6 thru #18 AWG pole wire.
  - Electrical components that are protected per ANSI/IEEE Standard C62.41, for Class C applications. The transient suppressor is not required to be RoHS compliant.

<u>LED Performance Requirements:</u>

- The luminaire shall have a minimum luminaire efficacy of 70 lumens/watt.
- The luminaire shall meet the chromaticity requirements as follows:
  - The standard color for the LED luminaire shall be white. The colors shall conform to the following color region based on the 1931 CIE chromaticity diagram.
  - The luminaire shall have a Nominal Correlated Color Temperature (CCT) of 4000K +/-300K.
- The luminaire shall have a minimum Color Rendering Index (CRI) of 70.
- Chromaticity as stated above must be shown on the LM 79 test report.

<u>Optical Requirements:</u>

- The luminaire shall have an IESNA Backlight, Uplight and Glare (BUG) rating as follows:
  - Backlight rating shall not exceed 3.
  - Uplight rating shall not exceed 0.
  - Glare rating shall not exceed 3.
- The luminaire shall have a light distribution pattern at the road surface that has an evenly dispersed appearance.
- The luminaire shall not have a perceptible light level flicker to the unaided eye over the voltage range as specified in the Electrical Requirements.
- The luminaire shall provide the following light levels using an approved LED high mast luminaire, ADOT standard lighting equipment shown in the Pole and Luminaire Schedule and the light pole locations designated on the project plans. The contractor shall provide the manufacturer with a complete set of project plans and cross sections so the photometric calculations can be achieved with accuracy.
  - Minimum maintained average horizontal illuminance:
    - Intermediate: 0.6-0.9 footcandles
    - Commercial: 0.6-1.1 footcandles

- Minimum maintained horizontal illuminance: 0.2 footcandles
- Average to minimum uniformity ratio: 3:1 or better
- Average to minimum uniformity ratio (System TI): 4:1 or better

- The light level calculations shall be performed in accordance with the procedures contained in IES RP-8-14 and must be documented using lighting support software utilizing a Light Loss Factor (LLF) as defined below:
  - Calculations shall be for maintained values (Light Loss Factor (LLF) < 0.8.) where: LLF = LLD X LDD.
  - Lamp Lumen Depreciation Factor (LLD) shall be the specified percentage of LED lumen maintenance at 50,000 hours at 40°C (104°F) from the TM-21 report.
  - Luminaire Dirt Depreciation (LDD) = 0.9.
- The TM-21 Report must show the drive current used for the submitted luminaire. The report may show a larger drive current to represent a worst case scenario.
- The Lumen Maintenance Life L70 from the TM-21 Report must not be below 70% at 70,000 hours at 25° C (77°F).
- The product submittal shall be accompanied by IES TM-21 compliant test reports from a CALiPER qualified or NVLAP accredited testing laboratory for the specific model being submitted.

Minimum Required Submittals:

The following items are required for approval of luminaires that are not listed in the General section of this specification.

- Luminaire specification sheet.
- LED driver specification sheet.
- LM-79 luminaire photometric report.
- The vendor must submit LM-79 in-situ test data to confirm thermal operating temperatures of the luminaire.
- LM-80 Lumen maintenance report.
- TM-21 calculations as defined in this specification.

- Backlight, Uplight, Glare (BUG) rating of the luminaire.
- Computer generated point by point photometric analysis.
- Written product warranty.
- Independent test lab IES photometric reports including IES electronic file.
- IES chromaticity data from an LED Lighting Facts approved testing laboratory.
- Instructions for installation and maintenance.

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, rigid metal conduit riser, cabinet housing, panel, breakers, contactor, selection switch, fuses, dry transformer, internal wiring and other incidentals in accordance with the project plans and these specifications.

The load center cabinet housings 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 primer paint and painted with two coats of aluminum paint in accordance with Section 1002. Cabinets shall have continuous welded seams on all 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-gage 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. Switches, breakers and other components shall have openings to operate from the front panel.

736-3 Construction Requirements:

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.

After the poles have been erected and plumbed, the vertical-mounted type luminaires shall be aimed as described on the instruction sheet and specified herein. The Developer shall provide and utilize a manufacturer-supplied aiming device to adjust the tilt angle of each luminaire. The device shall be adjusted to the numerical factors given for each luminaire in the tilt-angle column of the project plans. Operation of the aiming device shall be as described on the instruction sheet.

The Developer shall maintain full nighttime operation of the existing lighting system during the duration of the construction project.

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:

Pole-line hardware shall be utilized in the installation of poles, messenger cable, pole anchors, etc.

(B) Wood Poles:

Wood poles shall be 35 feet in length, Class 3, unless otherwise specified, and meet the requirements of Section 731 of the 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 six feet deep in the ground, be well tamped, and raked one foot 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 3/8-inch minimum, seven-strand, high-strength grade, galvanized steel messenger cable securely attached to the poles and anchors in an approved manner.

(D) Department Furnished Material: Blank

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 hereinbefore specified.

737-3 Construction:

737-3.01 Maintaining Existing Traffic Signals and Lighting Systems:

All existing traffic signal locations and lighting levels shall be maintained for the benefit of the traveling public during the progress of the work, except when shutdown is permitted to allow for alterations or final removal of the systems. 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 shutdowns shall be limited to the normal working hours. During periods of shutdown, flaggers shall be employed to manually direct traffic. At all other times, the traffic signal system shall remain operational.

All traffic signal heads not in use shall be covered with burlap and shall be unmistakably out of service when observed by an approaching driver. Plastic coverings shall not be allowed.

During construction, the maintenance, care and control of the existing traffic signal control cabinet will be the responsibility of the agency as described in the DBMA. All other maintenance of the existing traffic signal system shall be accomplished by the Developer.

The Developer shall maintain full nighttime operation of the existing lighting system for the duration of the construction project. The Developer shall designate a person who will be available for emergency maintenance calls after normal working hours. The Developer shall furnish this person's name and telephone number to the Inspector. The Developer shall have labor and the necessary equipment available on a 24-hour per day basis for such emergency maintenance.

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 back plate shall initially be 17 feet 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 be not less than 16 feet. The Developer shall check each day to insure that the minimum clearance is maintained and shall take corrective measures if necessary.

Cable rings on 24-inch 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 Developer shall maintain the electrical systems for the duration of the construction project. The Developer shall designate a person who will be available for emergency maintenance calls after normal working hours. The Developer shall furnish this person's name and telephone number to the Inspector. The Developer shall have labor and the necessary equipment available on a 24-hour per day basis for such emergency maintenance.

When required, the Developer shall remove and salvage all material associated with the temporary traffic signal. All salvaged material shall be the property of the Developer and shall be the responsibility of the Developer 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 Developer shall coordinate any requested salvaged equipment with the City of Phoenix. The work shall also include the removal and disposal of foundations. All equipment and materials to be salvaged shall be the property of the Developer. Salvageable material shall be dismantled and stockpiled, prior to project completion, or as shown on the plans.

Unless otherwise specified, it shall be the responsibility of the Developer 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 or as designated by the Inspector.

When salvaged equipment is to be reinstalled, the Developer 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 Inspector shall be replaced with new material.

Douglas J. LaMont
REGISTERED PROFESSIONAL ENGINEER (CIVIL) CERTIFICATE 24995 DOUGLAS J. LaMONT Date Signed 6/6/18 ARIZONA, U.S.A.
Expires 6/30/18

SECTION 738 GENERAL REQUIREMENTS FOR INTELLIGENT TRANSPORTATION SYSTEMS:

738-1 Description:

It is the purpose of this section to provide general information necessary for completion of the work on the elements of intelligent transportation systems (ITS) in accordance with the referenced Standard Drawings, details shown on the project plans and requirements of the specifications.

Intelligent transportation systems generally include components of freeway management system, rural dynamic message sign systems, roadway weather information systems, closed circuit television camera systems, electronic communications and network infrastructure dedicated to supporting these systems.

All intelligent transportation system components and appurtenances shall be complete, functional, have successfully passed any specified testing and training procedures, and in operating condition at the time of acceptance.

738-2.01 Abbreviations:

Whenever the following abbreviations are used in these specifications or in other contract documents, they are to be construed as the respective expressions represented:

CCTV	Closed circuit television
CPU	Central processing unit
dB	Decibels – a logarithmic ratio of input and output power or voltage
DIN	Metal rail in control cabinets, to which equipment is attached
DMS	Dynamic Message Sign
ITS	Intelligent Transportation Systems
GIS	Geographic Information System
HDPE	High Density Polyethylene
Hz	Hertz.
IEEE	Institute of Electrical and Electronics Engineers.
ISO	International Standards Organization

kVA	Kilo-volt-amperes
LED	Light-emitting diode
mA	Milli-amp, equivalent to 1/1,000 Amp
MTBF	Mean time between failures
mV	Milli-volt, equivalent to 1/1,000 of a volt
MOV	Metal oxide varistor
NTCIP	National Transportation Communications for ITS Protocol
NTSC	National Television Systems Committee
Ps	Pico-second, equivalent to 1 trillionth of a second
RAM	Random Access Memory
RMS	Root Mean Square
ROM	Read-Only Memory
SAT	System Acceptance Test
SCU	Sign Controller Unit
SMFO	Single-Mode Fiber-Optic
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SST	Subsystem Acceptance Test
ST	Standard type Optical Connector
TIA	Telecommunications Industry Association
TOC	Traffic Operations Center
VAC	Volts, Alternating Current
VDC	Volts, Direct Current
WIM	Weigh-In-Motion

738-2.02 Definitions:

The words defined in the following subsection shall for the purpose of these specifications have the meanings ascribed to them pertaining to intelligent transportation systems:

Firmware	Program, or set of instructions programmed on a hardware device
Node	Communications hub for termination of trunkline fiber optic cables, connected to communication equipment, typically housed inside a climate-controlled secure building, at a system interchange
Protocol	A specific set of rules, procedures or conventions relating to format and timing of data transmission between devices
Pan/tilt/zoom	Pan, Tilt and Zoom, typically used to refer to the controls of a CCTV camera
Trunkline	Conduit duct bank, typically parallel to a freeway, for the purpose of housing communications and power cables

738-3 Regulations and Codes:

All electrical equipment shall conform to the current standards of National Electrical Manufacturers Association (NEMA), National Electric Safety Code (NESC), Underwriters' Laboratory Inc. (UL), Telecommunications Industry Association (TIA), Institute of Electrical and Electronic Engineers (IEES), International Standards Organization (ISO) or the Electronic Industries Association (EIA), when applicable. All materials and workmanship shall conform to the requirements of the National Electric Code (NEC), the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), National Television Standards Committee (NTSC), requirements of the plans, and specifications, and to any other codes, standards, or ordinances which may 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.

738-4 Equipment List and Drawings:

Developer shall note that approval by the Engineer is required before ordering or installing any material that is to be used on the project.

Developer shall submit electronic files of complete project material submittal for approval at the preconstruction conference. The project material submittal shall contain a list of submittal items addressed in the submittal package, state all relevant information regarding materials and equipment to procure exact replacements of any or all items on the project. To be acceptable, the material submittal shall be complete and contain all items supplied on the project by Developer, with the exception of the DMS support structures. The DMS support structure submittal shall occur only after conducting the required field survey and showing survey data in the submittal, per Subsection 744-2.01. The Engineer reserves the right to reject an incomplete or unclear material submittal.

The materials on the submittal shall be identified by the contract project number, bid item numbers, catalog part numbers, catalog cuts, shop drawings for equipment, trade names, schedules for other pertinent information. The specific materials, models and variations within any catalog cuts shall be clearly indicated by Developer. Any material designations used in the contract documents shall be so noted on the materials list. Developer shall submit manufacturer shop drawings for review and approval and shall furnish Certificates of Compliance.

There shall be no substitutions 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. If requested by the Engineer, Developer shall submit samples of the proposed materials for inspections, testing, and approval by the Engineer. The Engineer will not be liable for any materials procured or any labor performed prior to approval.

Developer shall provide complete wiring diagrams and schematics for controller assemblies and auxiliary controller cabinets at the time of delivery for testing. An electronic copy and one set of 11” x 17” 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.

Developer's work schedule shall account for a sufficient period of time for the submittal approval process.

738-5 and 738-6 Blank:

738-7 Required Preactivity Meetings:

Developer shall schedule pre-activity meetings as described in approved QMP prior to the start date of specific construction activities. Developer shall present a detailed plan, schedule, cutover plan, if applicable, and approved traffic control plans if applicable for each construction activity at the pre-activity meetings.

At a minimum, pre-activity meetings shall take place for the following construction activities:

Horizontal Directional Drilling
Conduit & Pull Box Placement;
DMS Construction;
CCTV Construction;
Ramp Meter Construction;
Fiber Placement, Splicing and Testing;
Mainline Detection Construction;
Stand-Alone Testing;
Subsystem Testing; and,
System Acceptance Testing.

738-8 Field Inventory:

Field inventory shall be completed per Technical Provisions except as noted. The existing spare conduits to remain and/or incorporated into the design will be inspected prior to construction commencing in the area. All active Loop Detectors to remain will be tested at that time.

738-9 Access to Traffic Operations Center:

Developer access to the TOC will be permitted as approved by ADOT. The TOC will not be available for Developer access during State Holidays. A minimum 48 hour advanced notice to the ADOT is required for access.

SECTION 739 STRUCTURAL SUPPORTS AND FOUNDATIONS FOR ITS ELEMENTS:

739-1 Description:

The work under this section shall include but is not limited to, furnishing all materials, tools, equipment and labor necessary to install new DMS support structures including crosswalks, CCTV poles and foundations or modifying existing systems as shown on the project plans, and in accordance with the ITS Standard Drawings and the specifications.

Foundations shall include new CCTV pole foundations, DMS support structure foundations, shoulder and median installations, concrete barrier pedestals, removal and replacement of concrete median barrier, removing and installing new glare screens, maintaining existing median and shoulder lighting in close proximity to any new DMS foundation, conduit, elbows, anchor bolts, grounding wire, reinforcing steel, and any grading adjustments necessary to accommodate impacts to existing drainage patterns as a result of foundation placement, as shown in the ITS Standard Drawings, project plans, and specifications.

739-2 Materials:

Concrete shall conform to the requirements of 1006 and 601. Reinforcing steel and wire mesh shall conform to the requirements of 1003 and 605.

739-2.01 DMS Structural Supports:

All materials for the DMS support structure shall be in accordance with the requirements of the Section 606, Overhead Sign Structures, and the applicable Standard Details and details contained in the project plans. Reinforcing steel bars shall conform to the requirements of ASTM A615. Unless otherwise specified, steel bars meeting the requirements of ASTM A706 may be substituted for ASTM A615 steel bars. When ASTM A706 bars are used, tack welding of the reinforcement will not be permitted. Reinforcing steel wire shall conform to the requirements of ASTM A1064.

All materials for the sign structure foundations shall be in accordance with the requirements of Section 609 and 1006, the project plans, and the ADOT Structure Details. Concrete for all foundations shall be Class S and shall have a required 28-day compressive strength of 3,000 pounds per square inch.

739-2.02 CCTV Poles:

All materials and products shall comply with applicable ASTM and AASHTO specifications.

(A) Tapered Steel Poles:

(1) General:

Tapered steel poles for CCTV cameras shall include pole shafts, pole-top mounting plates, and base plates.

Material standards for CCTV camera poles shall be in conformance with the current edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Each pole shall be designed to accommodate a CCTV camera assembly, electrical hardware, mounting hardware, lowering device, cabinets, and enclosures as shown in ITS standard drawings and Project Plans

CCTV camera poles shall withstand a wind speed of 80-miles per hour, with a gust factor of 30 percent.

CCTV camera poles shall conform to the requirements of Sections 604 and 731.

CCTV camera pole foundations shall conform to the requirements of Section 609 and the ITS Standard Drawings.

The CCTV camera poles shall accommodate a pole-mounted field equipment cabinet with all required conduits and attachments as shown on the plans.

The CCTV camera poles shall provide a means of routing the required conductors inside the structure from the base of the structure. These conductors shall not be exposed between ground level and the base of the tilt/pan unit nor between the pole-mounted field equipment cabinet and ground level.

When raising/lowering devices are used, all cables and conductors shall be able to be stored within the pole and extend up and down within the pole, as the lowering device is used, without getting caught on other items within the pole shaft.

(2) Pole Shafts:

Pole heights shall be as shown on the project plans. CCTV camera poles shall be constructed of a uniformly tapered, one or two-piece round tubular pole, conforming to the ITS Standard Drawings.

The pole shaft shall conform to ASTM 595, Grade A, with a minimum yield strength of 55 kpsi, or ASTM A572 with a minimum yield strength of 55 kpsi.

Freeway CCTV camera poles, with all equipment mounted, shall have a maximum deflection in any direction of 1 inch at the top of the pole in a typical wind speed of 30-miles per hour. This deflection shall be measured at the top of the support structure At a point where tilt pan drive is attached.

Prior to pole fabrication, Developer shall submit detailed shop drawings, in accordance with the requirements of Subsection 738-4 for each type of support structure and foundation, that includes material specifications and structural calculations that show stresses and deflection, in accordance with, Sections 604 and 731 , and the ITS Standard Drawings and project plans. Developer shall submit drawings and design calculations that are stamped, sealed, and signed by a Civil or Structural Engineer registered in the State of Arizona.

(B) Standard Bases:

CCTV poles shall have standard bases, dimensioned as shown in the ITS Standard Drawings and project plans. Standard bases shall be fabricated from structural steel plates conforming to the minimum strength requirements of ASTM A36. Exposed surfaces shall be finished smooth and all exposed edges shall be neatly rounded to a 1/8 inch radius. Standard bases shall be galvanized, in accordance with the requirements of ASTM A123.

(C) Anchor Bolts:

Anchor bolts shall conform to the requirements of ASTM F1554 Grade 55. The upper 12 inches of the bolts shall be hot dip galvanized in accordance with ASTM A153. The strength of the nuts shall be equal to or exceed the proof load of the bolts.

(D) CCTV Pole Hand Hole:

The CCTV pole hand hole opening shall be reinforced with a minimum 2 inch wide hot rolled steel rim. The nominal outside dimension of the hand hole shall be 6 inches x 27 inches. The hand hole shall have a tapped hole for mounting the portable winch.

The hand hole shall be positioned on each CCTV pole such that the hand hole is not in conflict with the CCTV pole mounted cabinet and associated 1 inch mogul elbow. The hand hole shall also be positioned such that the CCTV camera is not directly above the user when operating the lowering tool.

(E) CCTV Camera Lowering Device:

The CCTV camera lowering device shall be equipped with a locking mechanism. This locking mechanism shall securely hold the movable portion of the CCTV camera lowering device and the CCTV camera system. The locking mechanism shall be operable from the base of the pole. When in the locked position, all weight shall be removed from the lowering cable.

The CCTV camera lowering system shall contain cable guides to prevent contact between the lowering/lifting cables and the CCTV camera electrical cables.

Each CCTV pole equipped with a lowering device shall include all required cable guides and supports to relieve strain from lowering/raising and CCTV camera cables, and to retain the pole top-mounted hardware.

The CCTV camera lowering device shall be compatible with the type and orientation of camera used, resulting in an upright orientation of camera image.

All electrical connectors shall be rain tight and suited for operation at 120 VAC with a current carrying capacity not less than 15 Amperes. The electrical connectors shall contain a minimum of 14 contacts including a ground. Data contacts shall be designed to handle

1V peak to peak NTSC video signals, RS-232 and RS-485 control signals, and Ethernet.

The CCTV camera lowering system shall be designed to securely support CCTV camera systems weighing up to 100 lbs.

All moving parts of the CCTV camera lowering device system shall be designed for a minimum of 10,000 lowering and lifting operations. All components shall be corrosion resistant, self-lubricating and sealed to achieve the required number of lowering/lifting cycles.

The cables from the lowering device to the CCTV camera assembly shall be outdoor rated, contain shielded communication conductors and five auxiliary conductors (stranded), 14 AWG or larger.

The interface and locking components shall be made of metal. All external components of the lowering device system shall be made of corrosion resistant materials, powder coated, galvanized, or otherwise protected from the environment.

The CCTV camera lowering device system shall incorporate a field adjustable counterweight system to minimize the amount of effort required to raise the CCTV camera. The CCTV camera lowering device shall not obscure the CCTV cameras range of vision.

(1) Lowering Device Tool:

The CCTV camera lowering device shall be operated by the use of a portable lowering tool. The tool shall consist of a lightweight metal frame and winch assembly operated by a variable speed electric drill motor or hand crank at the user’s option. The CCTV camera lowering system shall include clutches and brakes to prevent the free-fall of the CCTV camera and over tensioning of the lowering device cable.

One lowering tool shall be delivered to ADOT upon project completion. The lowering tool shall have the appropriate gearing to facilitate using a hand crank for lowering and raising of the CCTV camera system.

(2) CCTV Camera Junction Box:

The CCTV camera lowering device system shall include a junction box mounted at the top of the pole to facilitate the connection of CCTV camera power, video, and camera control. The junction box shall be water resistant and in accordance with NEMA 3R requirements.

(F) Training Requirements:

In the event Developer submits a CCTV camera lowering device system which is not currently in use by ADOT, Developer shall arrange for and provide a training course for the CCTV camera lowering device system components. The course shall be of adequate duration to cover the subject matter and shall have an instructor competent in the technical aspects of the CCTV camera lowering device system. The training course shall provide training to up to 12 engineering and maintenance personnel.

Developer shall submit a syllabus, training materials and a schedule for the CCTV camera lowering device training course to ADOT for review and approval 45 days prior to the proposed start of training. ADOT will notify Developer of acceptability within 30 days of submittal. Developer shall schedule the training no sooner than 14 days from receipt of the approved syllabus unless otherwise noted in the approval. Training materials shall include the course outline, material describing the course, and operations and maintenance manuals with any additional information needed to adequately describe the subject being taught. Training materials shall not be copyrighted.

739-3 Construction Requirements:
Excavation and backfill shall conform to the requirements of Subsection 203-5.03.

739-3.01 DMS Support Structures:

Construction requirements for the DMS support structure shall be in accordance with the requirements of the Section 606 of the specifications.

Bolts connecting the horizontal support structure tube to the end flanges, when shown on the ADOT Bridge Group Standard Detail as 3/5-inch ASTM A325 bolts torqued to a tension of 28K, shall be torqued to a minimum of 350 ft-lbs. Support structure submittals for new structures shall specifically identify the bolt torque values for the proposed structure.

739-3.02 and 739-3.03: Blank

739-3.04 DMS Structural Support Foundations:

Prior to excavation, Developer shall stake the exact location of each foundation to be installed, for field review and approval by the Independent Quality Firm. Pruning of plant material may be required to provide construction and maintenance access. The pruning shall be performed by trained and experienced landscape personnel. The pruning methods and locations shall be approved, prior to any pruning**.**

Foundations shall conform to the requirements of Sections 601 and 609.

The excavations required for the installation of foundations shall be performed in such a manner as to avoid any unnecessary damage to pavements, sidewalks, landscaping, irrigation systems, and other improvements. Whenever a part of a section or slab of existing concrete or sidewalk or curb is damaged by Developer, the entire section between expansion joints shall be removed and the concrete reconstructed.

Foundations shall not interfere with or significantly impact existing drainage. Locations of foundations may be field adjusted to mitigate drainage impacts, if not shown on the project plans. Mitigations may include location adjustment, and regrading near the foundation.

Excavations shall not be wider than necessary for the proper construction of the foundations. 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 or pedestrians and interference with drainage.

All surplus excavated material shall be removed and properly disposed of. After each excavation is completed, Developer shall notify the Independent Quality Firm for inspection, and under no circumstances shall any underground materials or equipment be covered with fill or concrete prior to inspection.

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5. At the end of each working period, all excavations shall be barricaded or covered, or both, to provide safe passage for pedestrian and vehicular traffic.

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. 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 augered, 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.

Anchor bolts and conduit stubs shall be placed and held in proper alignment, position, and height during the placing and vibrating of concrete. All foundations shall set for seven days prior to pole installation.

Each DMS support structure shall be bonded to form a continuous grounding system. Developer shall bond and ground each DMS support structure in accordance with Subsection 732-3.03.

739-3.05 CCTV Pole Foundations:

(A) Foundations:

The CCTV poles shall be mounted on concrete foundations with reinforcing steel as shown on the plans.

Prior to excavation, Developer shall stake the exact location of each foundation to be installed, for field review and approval by the Independent Quality Firm. Pruning of plant material may be required to provide a minimum 5 foot construction and maintenance access or for optimal viewing of the CCTV camera without vegetation impacting view. The pruning shall be performed by trained and experienced landscape personnel. The pruning methods and locations shall be approved by the Independent Quality Firm, prior to any pruning.

CCTV camera pole foundations shall be set flush with the existing or new curb and sidewalk or flush with the finished grade where there is no curb or sidewalk, except in sloped areas they shall be as shown on the project plans. The dimensions and locations of foundations shall be as specified on the project plans. However, the Independent Quality Firm may direct that changes be made in locations due to obstructions, to avoid utilities, or other existing conditions.

If the soil is not stable and a hole cannot be augered, forms in accordance with section 601 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.

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 a minimum of seven days prior to pole installation.

(B) Base Plates and Poles:

All steel poles shall be plumbed to the vertical with all camera equipment installed.

Holes shall be drilled and nippled at each site in accordance with the plans and ITS Standard Drawings. Touch-up of field drilled hole galvanizing damage shall be by hot-stick method.

The open space between the base plate and the foundation shall be grouted with a ¼-inch weep hole. The grout shall be non-shrink.

(C) Grounding Requirements:

Each CCTV pole shall be bonded to form a continuous grounding system. Developer shall bond and ground each CCTV pole in accordance with Subsection 732-3.03, and as shown in the ITS Standard Drawings**.**

SECTION 740 ELECTRICAL UNDERGROUND MATERIAL FOR ITS ELEMENTS:

740-1 Description:

The work under this section shall consist of furnishing and installing conduit, innerduct, conductors, fiber optic cables, splice closures, and pull boxes for ITS elements, including horizontal directional drilling, horizontal directional boring, excavating, backfilling, compacting, warning tape, detectable pull tape, connectors and fittings, locating existing conduit when new is to be intercepted with existing, and restoration of the surface to existing condition, including the replacement of concrete slabs, decomposed granite, irrigation and other landscaping items where appropriate, in accordance with the details shown on the plans and the requirements of these specifications.

740-2 Materials:

740-2.01 Electrical Conductors:

Electrical conductors shall conform to Section 732, unless otherwise specified. Conductor size and quantity shall be as shown in the ITS Standard Drawings unless otherwise specified.

Conductors used for ITS systems shall conform to the requirements of the following table. The minimum conductor sizes shall be as shown in the following table, unless otherwise specified.

CONDUCTOR TABLE						
		INSULATION		CONDUCTOR		
CIRCUIT	FUNCTION	COLOR	TYPE	Minimum Thick. (MILS)	Minimum Gauge (AWG)	TYPE
Ramp Meter Signals	Red #1 Red #2 Green #1 Green #2 Common Spare Spare	Red Blue Green Orange White Black White/Blk			#14	IMSA 19-1
Ramp Meter Flashers	Beacon Common Spare Spare	Red White Green Black			#14	IMSA 19-1
Common	Common Lead	White	THW	45/60	AS	AS

Spares	Unused Leads	Varies	Varies		AS	AS
Detection	Detector Roadway Loops, Saw Cut, ITS	Black, in Orange Tubing	PE in PVC or PE Tubing	*15* *31*	#14 Stranded	IMSA 51-7
Detection	Detector Roadway Loops, Pre-formed, ITS	Black, in Orange Tubing	TFFN in PVC or PP Tubing	*AS*	#16 Stranded	
Detection	ITS Loop *Detector* Lead-In Cable	Black/ Natural	PE Alum/ Mylar Tape Shield		#14	IMSA 50-2

CONDUCTOR TABLE						
		INSULATION		**CONDUCTOR**		
CIRCUIT	**FUNCTION**	**COLOR**	**TYPE**	**Minimum Thick. (MILS)**	**Minimum Gauge (AWG)**	**TYPE**
	Service Service Common Bond	Black White Green or Bare	THW THW THW	AS AS AS	AS AS AS	
Legend: AS = As Specified; PP = Polypropylene; STP = Stranded, twisted pair; S4C = Stranded, 4 Conductor						

(1) Saw cut Loop Detector Wire:

The wire shall be enclosed in factory extruded PVC or PE flexible tubing by the wire manufacturer. Developer assembly of the wire in the flexible tubing will not be acceptable.

The tubing shall be UL FR-1 rated at 105 degrees C and have moisture absorption of less than one percent. The wall thickness shall be 31 ± 3 mils with a nominal inner diameter of 0.186 inches. The tubing shall be orange in color, be highly resistant to chemicals and oils, and have a dielectric strength of 900 volts per centimeter.

(2) Loop Lead-In Cable:

Loop lead-in cable, from the pull box where the loop wires are spliced from the roadway, to the cabinet in which they terminate, shall be IMSA Specification 50-2, #14 AWG shielded cable, unless otherwise specified.

740-2.02 Fiber Optic Cable:

Developer shall furnish and install Single Mode Fiber Optic (SMFO) communication cables to provide a communications subsystem.

(A) Documentation:

Developer shall provide certification that the fiber optic cables furnished and installed are in conformance with the appropriate specifications. This certification shall be in two parts:

1. Developer shall secure a certification from the cable manufacturer that the cable is in conformance with the Rural Electrification Administration (REA) Bulletin PE-90 (where applicable) and the specifications.

2. Developer shall certify that the communication cable subsystem has been installed and spliced in accordance with the plans, cable and splice manufacturer's recommendations, standard industry practice and the project plans and specifications.

(B) Technical Requirements:

All fiber optic cable shall be SMFO cable that is of loose tube construction, filled with a water- blocking material, and constructed by a certified ISO 9001 or 9002 manufacturer. Fiber optic cable shall be dielectric and comply with the requirements of REA PE-90, except as modified by the following requirements:

Number of fibers:	Per project plans and Project Specifications
Cladding diameter:	125 ±1.0 μm
Core-to-cladding offset:	≤0.8 μm
Cladding non-circularity:	≤1.0 percent
Maximum attenuation:	≤0.35 dB/km at 1310 nm, ≤0.25 dB/km at 1550 nm
Microbend attenuation(1 turn, 1.25-inch dia.):	≤0.5 dB at 1550 nm
Microbend attenuation (100 turns, 3' dia.):	≤0.05 dB at 1310 nm
Mode-field diameter (matched cladding):	9.3 ±0.5 μm at 1310 nm; 10.5 ±1.0 μm at 1550 nm

Maximum chromatic dispersion:	≤3.2 ps/(nm x km) from 1285 nm to 1330 nm and <18 ps/(nm x km) at 1550 nm
Fiber polarization mode dispersion:	≤ 0.5 ps/(Sq root of km)
Fiber coating:	Dual layered, UV cured acrylate
Coating diameter:	245 µm ±10 µm
Minimum storage temperature range:	-40 to 158 °F
Minimum operating temperature range:	-40 to 158 °F

(1) Buffer Tubes:

Each buffer tube shall be filled with a dry water-blocking material that provides for an efficient and craft-friendly cable preparation.

Buffer tubes shall be stranded around a central member using the reverse oscillation or "S-Z", stranding process. Filler rods shall be used in the fiber optic cable to lend symmetry to the cable section.

(2) Central Strength Member:

The fiber optic cable shall have a central strength member designed to prevent buckling of the cable.

(3) Cable Core:

The fiber optic cable shall utilize a dry water-blocking material to block the migration of moisture in the cable interstices.

(4) Tensile Strength Members:

The fiber optic cable shall have tensile strength members designed to minimize cable elongation due to installation forces and temperature variation.

The fiber optic cable shall withstand a 600 lbf (pound-force) maximum installation tensile load and a long term installed maximum tensile load of 200 lbf.

(5) Cable Jacket:

The fiber optic cable jacket shall be constructed of a high or medium density polyethylene (HDPE or MDPE) jacket that has been applied directly over the tensile strength members and water-blocking material. The jacket shall have at least one ripcord designed for easy sheath removal.

The cable shall be wound on the reel in such a manner as to provide access to both ends of the cable to enable testing to be performed while the cable is on the reel.

(6) Environmental:

The cable shall be capable of withstanding total immersion in water with natural mineral and salt contents, and wasp/hornet spray without damage or decrease in function.

740-2.03 Fiber Optic Cable Splice Closure:

Fiber optic splice closures shall be either shell design or cylindrical, butt-end style, corrosion resistant, watertight, and meet the requirements of CR-771-CORE. Underground splice closures shall seal, bond, anchor, and provide efficient routing, storage, organization, and protection for fiber optic cable and splices.

The splice closure shall provide an internal configuration and end cap with a minimum of two express ports for entry and exit of backbone cable and a minimum of three additional ports for distribution and branch cables.

Splice closures shall be designed to accommodate heat-shrink fusion splice trays in sufficient quantities to perform the required number of splices. At a minimum, the splice closure shall accommodate 144 splices, unless otherwise specified. Each splice closure shall be supplied with adequate number of fusion splice trays.

Splice closures shall have a reliable dual seal design with both the cable jackets and core tubes sealed, without the use of water-blocking material. The splice closures shall be capable of being opened and completely resealed without loss of performance.

The splice closure minimum dimensions shall be at least 29 inches long by 11 inches wide, unless otherwise specified.

740-2.04 Marking Tags:

Cable marking tags shall conform to the requirements of Subsection 732-2.01 (A) (2), unless otherwise specified. Developer shall submit sample durable wire and cable marking tags for approval by the Independent Quality Firm. The tags shall have the capability of being moved along the cable during future alterations.

740-2.05 Conduit:

Polyvinyl Chloride (PVC) conduit, Rigid Metallic Conduit (RMC), and Flexible Metal Conduit shall conform to Subsection 732-2.02 of the Standard Specifications. Intermediate Metal Conduit (IMC) is not allowed for ITS applications.

Intermediate Metal Conduit (IMC) is not allowed for use in any ITS-related applications. PVC

Should Developer choose to substitute HDPE conduit in place of direct buried PVC conduit, the HDPE conduit must meet the specifications for HDPE conduit listed below, and Developer shall provide original data sheets or a Certification of Compliance letter from the HDPE conduit manufacturer to the Independent Quality Firm stating that the product meets the Project Specifications and obtain the written approval from the Independent Quality Firm prior to procuring and installing the HDPE conduit.

Unless otherwise shown on the Plans; bends, conduit fittings, expansion joints, sweeps and other conduit accessories not specifically mentioned shall be manufactured from a material similar to the connecting conduit.

Conduit elbows intended for new or future fiber optic cable installations shall have a minimum radius of 36-inches. All other conduit elbows shall be a minimum radius of 24-inches.

(A) HDPE Conduit:

HDPE conduit and fittings shall comply with ASTM D 2241 and ASTM-F2160-01. HDPE conduit shall have a minimum rating of SDR 11. It shall have a cell classification of PE334470C (for black conduit) and PE334470E (for colored conduit) in accordance with ASTM 3350: Standard Specification for Polyethylene Pipe and Fittings Materials.

The polyethylene base resin shall meet the density requirement and melt index properties described herein. The density shall not be less than 0.940 and not more than 0.955 g/CM^3 in accordance with ASTM D 1505: Standard Test Method for Density of Plastics by the Density-Gradient Technique. The range for the melt index shall be between 0.05 to 0.5g/10 minutes in accordance with ASTM D 1238: Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer. The HDPE conduit shall have a minimum Flexural Modulus, of 80,000 psi, in accordance with ASTM D 790 and a minimum tensile strength at yield of 3,000 psi, in accordance with ASTM D-638.

Additives to the base resin shall be included to provide heat stabilization, oxidation prevention and ultraviolet (UV) protection. It shall utilize carbon black in the range of 2 to 3 percent for long term protection against UV degradation. The minimum protection period shall be one year from date of manufacture in unprotected, outdoor storage in accordance with ASTM D 1603: Standard Test Method for Carbon Black in Olefin Plastics.

Developer shall provide the manufacturer's certification of analysis and compliance showing that HDPE conduit meets these specifications.

(B) Innerduct:

When called for in the project plans or Project Specifications, shall be corrugated, made of HDPE, and of the color specified in the project plans or Project Specifications. If color is not specified in the project documents, innerduct exterior color shall be orange, from the factory. Innerduct quantity, color and size shall be as called for in the project plans. The innerduct shall be furnished in one continuous length with no factory installed splices or couplings, and of lengths sufficient to complete each run between pull boxes without splicing.

(C) Conduit Warning Tape:

Conduit warning tape shall be a minimum four-mil composite reinforced thermoplastic, with a minimum width of 3 inches and minimum length of 5 feet. Warning tape shall be highly resistant to alkalis, acids, and other destructive agents found in the soil.

Warning 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” or “CAUTION – COMMUNICATION CABLE BURIED BELOW” in black letters on a red (electric) or orange (communications) background. Where both electric and communications lines are in a single trench, both tapes, as described above, shall be provided.

(D) Detectable Pull Tape:

Detectable pull tape shall be constructed of fiber and have an embedded #22 AWG conductor. The tape shall be low-stretch and moisture-resistant. The tape shall have nominal pull strength of 2,500 pounds. The tape shall include distance markings at intervals not to exceed two feet.

740-2.06 Pull Boxes:

All pull boxes and lids shall conform to the plans and specifications.

Pull box lids shall bear the words “ADOT ITS” unless otherwise specified.

Markings shall be clearly defined and shall be placed parallel to the long side of the cover. Letters shall be a minimum of 1 inch in height for No. 4, 5, 6 and 7 series pull boxes, recessed into the lid, and 4 inch in height, raised on lid surface, for No. 9 pull boxes.

All pull boxes shall have a locking mechanism.

Chipped, cracked, deformed or otherwise damaged pull boxes and lids will not be accepted.

(A) No. 7 ITS Pull Boxes:

No. 7 ITS pull boxes shall be precast, polymer concrete, fiberglass reinforced, pull boxes, with ASTM Tier 22 rating for both box and lid, and conforming to the ITS Standard Drawings. Steel pull box lids shall not to be used for No. 7 ITS Pull Boxes, unless the Project Specifications call for H20 traffic loading for lids and boxes. A certificate of compliance shall be supplied for structural capabilities and materials used in manufacture. Concrete pull boxes and lids shall not be used. Developer shall submit test results to certify that the pull box sidewalls and lids remain intact when subjected to the loading conditions specified.

No. 7 ITS pull boxes shall be 24 inches in depth, and consist of a single-piece box unit. Stacked units shall not be used unless otherwise specified.

(B) No. 9 Pull Boxes:

No. 9 and No. 9 “split” pull boxes shall be fabricated of concrete and provide conduit access ports on each of the four sides, as shown in the ITS Standard Drawings. Pull box lid wording shall be as indicated in the ITS Standard Drawings, unless otherwise specified.

The No. 9 pull box lid shall have a square, hinged lid that opens a full 180 degrees. Opening of the lid shall be spring assisted from both the open and closed positions via a torsion bar lift system. The lid shall lock down with at least one stainless steel security type penta-head bolt that shall be captive to the lid. The lid shall have provisions for an externally mounted padlock for extra security. The padlock shall mount in a cavity in the pull box cover so no part of the padlock is exposed.

Existing No. 9 pull boxes indicated on the project plans or Project Specifications to have existing round lid tops to be retrofit with spring torsion lids shall be furnished in the same width and depth dimensions as the existing boxes to which the retrofit lids are to be attached.

A certificate of compliance, in accordance with Subsection 106. shall be supplied for structural capabilities and materials used in manufacture of No. 9 pull boxes and No. 9 “split” pull boxes.

Each No. 9 pull box shall be furnished with galvanized and slotted C-channel struts embedded in the concrete walls of the pull box, with an 18-hole rack mounted to each slotted C-channel strut, and ½ inch spring nuts and bolts and a cable hook per rack, as shown on the plans or specifications.

(C) Retrofit Lids for No. 9 Pull Box:

New lid assemblies retrofitted onto existing No. 9 pull boxes shall match the width and length of the existing No. 9 pull box. Existing No. 9 pull boxes that do not have existing grounding shall have new a ground rod, grounding conductor and grounding lugs, furnished and installed.

(D) 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 in the referenced Standard Drawing or on the project plans.

A neoprene gasket with a thickness of 1/8 inch shall fit between the box and the cover. The cover shall be made to fit securely and shall be held in place with a minimum of four stainless steel machine screws.

740-3 Construction Requirements:

Electrical underground material for ITS elements shall be constructed in accordance with the requirements of Section 732, unless otherwise specified.

740-3.01 Electrical Conductors:

Wiring procedures for electrical and detection conductors and cables shall conform to the requirements of Subsection 732-3.02, unless otherwise specified.

All electrical conductors that are left un-terminated shall be coated by an approved waterproofing method.

(A) Bonding & Grounding:

Bonding and grounding shall conform to Subsection 732-3.03 and the requirements of the plans and specifications.

Metal enclosures such as cabinets, pedestals, poles, conduit and cable sheaths shall be bonded to form a continuously grounded system. Non-metal portions of the system such as PVC or HDPE conduit shall have a bare copper bond wire or a green insulated copper bond wire installed with suitable connections to form a continuously grounded system. In all ramp meter conduits, the copper bond wire shall have green insulation. The insulation shall be removed from the bond wire in pull boxes from the point at which the wire leaves the bell end of the conduit.

All metal lids, for new or retrofit No. 9 pull boxes, shall be grounded to a ground rod, driven into the sump of the box. Existing boxes that do not have existing ground rods, shall have new ground rods furnished and installed, included in the price of the pull box or pull box retrofit lid item.

(B) Existing Circuits:

Prior to the start of construction, Developer, in coordination with the Independent Quality Firm, shall inventory and verify the location, condition and operational status of all ITS-related circuits and devices within the project limits. Developer shall verify the status of other equipment with circuits that run through the project limits and provide the inventory and status to the Independent Quality Firm.

740-3.02 Fiber Optic Cable:

Installation of fiber optic cable shall be continuous and without splices between allowable splice points, as identified on the project plans. Additional splice locations proposed by Developer, not indicated on the project plans, are subject to approval of the Independent Quality Firm. Developer shall perform all final length measurements, and order cable accordingly.

(A) Cleaning Existing Conduit:

No more than one week prior to installation of fiber optic cable, all new and existing conduits in which fiber optic cable is to be installed shall be cleared/cleaned by pulling through a metal- disc mandrel with a diameter of 90 percent of the conduit inside diameter for PVC conduit, or a ball mandrel with a diameter of 80 percent of the conduit inside diameter for HDPE. The conduit may be brushed or swabbed, if deemed necessary, prior to pulling the mandrel through the conduit. Where cable is to be installed by Developer over existing cables that remain in place, conduit clearing/cleaning is not required.

(B) Installation Procedures:

Developer shall ensure that the cable is protected from dragging or scraping on sharp edges and excessive bending. Developer shall not cause the cable to violate the minimum bending radius for which the cable was designed, as specified by the cable manufacturer. In the event Developer violates the minimum bending radius, the entire length of cable from the previous splice point shall be removed from the project and a new cable shall be pulled.

Fiber optic cables shall be pulled through conduit with a device designed to provide a firm hold on the exterior covering and the central strength member of the cable. Cable shall not drag on the ground or pavement, rub the edges of the pull boxes and shall be guided into conduits to avoid contact with sharp edges.

Developer shall ensure that the tensile load on the cable does not exceed the manufacturer's allowed maximum tensile load. Developer may use a break-away tension limiter set below the recommended tensile limit of the cable being pulled and/or a system that provides a means of alerting the installer when the pulling tension approaches the tensile load limit.

During pulling, the cable shall be lubricated at each pull box. The lubricant used shall be compatible with the cable jacket, and meet the cable manufacturer. Liquid detergent shall not be used.

Developer shall use a pre-lubrication or continuous lubrication method. Lubricant quantity for each pull shall be as follows:

$$Q = 0.0008 \times D \times L$$

Where:

Q = is the quantity of lubricant in gallons
D = is the diameter of the conduit in-inches
L = is the length of the pull in feet

Developer shall supply documentation identifying the manufacturer's recommendation for maximum pulling tension and speeds, and these values shall not be exceeded. Developer shall have this documentation on site during each fiber optic cable installation pull. If Developer fails to continuously lubricate the cable, the work shall be stopped until a meeting is held between Developer and the Independent Quality Firm to discuss why the terms of this specification are not being met.

Use of equipment required to install cable, including equipment to limit pull-tension and speed will be considered to be included in the cost of these items. All installation equipment will remain the property of Developer.

(C) Occupied Existing Conduit:

Where fiber optic cables are to be installed in conduit with existing loop lead-in cables or other cables or conductors that shall remain, Developer shall not damage the existing or conductors. Where fiber optic cables are to be installed in a conduit that contains existing loop lead-in cables, Developer shall disconnect, remove, reinstall, and reconnect the existing loop lead-in cables as specified in Subsection 735-3.01 (D) and (E), to facilitate the installation of the new fiber optic cable. Developer shall be responsible for any damage to the existing loop lead-in cables caused by this operation.

New fiber optic cables or other cables or conductors shall not be pulled over existing fiber optic cables in any existing conduit or existing innerduct. When an existing fiber optic cable is present in an existing conduit, Developer shall disconnect, remove and re-pull it at the same time with the new fiber optic cable or other cables or conductors. The existing fiber optic cable shall then be reconnected in the same manner as it was in its original condition, including any fusion splicing or connectorization, unless otherwise specified.

Prior to disconnecting any existing conductors or cables, Developer shall submit a schedule with the timeframes of when the existing cables are to be disconnected.

(D) Cable Slack & Coiling:

In all locations where fiber optic cable enters an existing or new No. 9 pull box, cable slack shall be loosely looped into a circular shape, using the rack and hook system integral to the wall of the No. 9 pull box.

Each new fiber optic cable shall be attached to the rack and hook system with industry standard nylon cable ties. Cables should be looped independently of one another. Cable ties shall encompass the cable loops of one cable per cable tie, applying ties to each cable individually. Cable ties shall be tightened to prevent cable slippage, but not as to deform or damage the cable sheath.

No. 9 pull boxes with splice closures shall have 50 feet of cable slack provided for all cables entering the pull box, between the splice closure and the point where the cable enters/exits the pull box, allowing the attached splice closure to be removed up to 50 feet from the pull box, unless a greater distance is otherwise specified.

No. 9 pull boxes without splice closures shall provide a minimum of 100 feet of slack in each cable passing through the pull box, unless otherwise specified.

(E) Splicing:

Developer shall perform all required fusion splicing at the locations shown in the project plans. Splice closures shall be installed so the trunk cable entries are on the same side of the end cap so that if additional branch fiber optic cables are installed at a later date, the two existing seals shall remain undisturbed.

Where Developer is splicing to existing fiber optic cable, Developer shall take care not to disturb any existing splices. Existing splices that are damaged shall be repaired immediately by Developer.

Splicing of fiber optic cable shall be conducted only at communications hub buildings, specified pull boxes, and connector housing units as shown on the project plans and described in the Project Specifications.

All splices and connectors shall be prepared in accordance with the manufacturer's recommendations. Each splice between two new fiber optic cables shall introduce less than0.1 dB attenuation. For splices between one new and one existing, or reconnection of two existing fibers, the maximum allowable attenuation shall be 0.3 dB.

(F) Connectors:

Trunk line fiber optic cables, typically connecting between communications hubs and No. 9 pull boxes with splice closures, shall not be connectorized. Branch fiber optic cables, typically between a cabinet or device, and a splice closure on the trunk line cable, shall be connectorized, as indicated on the project plans and in the Project Specifications.

Developer shall install as many connectors as is necessary to meet the communications requirements shown on the plans. Where connectors are required, Developer shall first install a spider type fan-out kit to strengthen and protect all the fibers of the branch cable (regardless of how many connectors are required for the branch cable). The spider fan-out kit shall protect each fiber of the branch cable with a protective PVC jacket with a minimum length of 1 meter and a minimum diameter of 3 millimeters. The jacket shall contain a Teflon inner tube into which the fiber is inserted, and a dielectric strength member.

Each fiber connector shall introduce less than 0.5 dB attenuation. Connectors found to exceed 0.5 dB attenuation shall be replaced until this requirement is met.

(G) Test Requirements:

Fiber optic cable shall meet the following test requirements.

(1) Pre-Installation Testing:

Developer shall inspect all cable upon delivery and prior to installation. Cable that is found to have visual damage shall be tested using an OTDR, Optical Time-Domain Reflectometer, as described herein.

(2) Post-Installation Testing:

After installation and splicing of fiber optic cable, Developer shall perform the following tests:

***(a) Power Meter Test**:*

Developer shall conduct Power Meter Tests for each fiber to measure the installed fiber cable attenuation, demonstrate connectivity, and correct splicing. Developer shall perform Power Meter Tests on each fiber strand terminated with connectors utilized in circuits, in accordance with Method A.3 of TIA/EIA-526-7 – "Measurement of Optical Power Loss of Installed Single-mode Fiber Cable Plant", and submit test results for each fiber to the Independent Quality Firm.

Power meter tests shall be conducted after all cable has been installed, all splices have been made, all fiber optic pigtails have been installed, and all break-outs have been installed. Testing shall be conducted at the cable ends in one direction for all fiber strands using 1310 nm wave length. The testing shall include a test summary spreadsheet listing, at a minimum, the parameters for each buffer tube by cable.

***(b) OTDR Tests**:*

Developer shall conduct bi-directional tests using an OTDR in accordance with EIA/TIA-455-8 for each fiber. Developer shall demonstrate that the attenuation for each fiber, splice, and connector, individually and as a whole, comply with the requirements of the specifications. Developer shall test each fiber at 1310 nm and 1550 nm using a launch cable of a length recommended by the OTDR manufacturer. Developer shall submit OTDR traces for approval, and clearly annotate the location of each splice and identify the measured loss.

Developer shall test all fibers in all splice enclosures Developer works in, whether existing or new, including dark fibers.

Developer shall identify unacceptable losses, and make corrective actions. Failed splices shall be remade and re-tested for compliance. Developer shall replace cable in its entirety that is not compliant with these specifications.

Following completion of all testing, Developer shall compile and submit an organized set of electronic files reflecting the post-installation tests, in electronic form (PDF) on a USB thumb drive to the Independent Quality Firm. These files shall include a fiber test summary that includes, at a minimum, the parameters shown in the ITS Standard Drawings, the OTDR traces of each fiber strand, and the power meter test results.

(H) Cable & Conductor Labeling:

Developer shall submit permanent identification labels, and the method of attachment, for approval by Independent Quality Firm.

Labels shall be installed on each conductor/bundle of conductors and cable near the point where it enters/exits the pull box. A cable passing through a pull box, whether spliced or not, shall have two labels, one near each exit/entry point to the pull box. The two labels for the cable will be similar, but will always differ in the "destination". A typical trunkline No. 9 pull box with one branch circuit fiber optic cable would have three labels, two on the trunkline fiber optic cable (one on each side of the splice closure), and one on the branch fiber optic cable. All labels shall include, as applicable:

The word “CAUTION”

Cable type and number of strands/conductors, such as:

“SMFO144” (single mode fiber-optic, (SMFO 144 strands)
“AWG6” (American Wire Gauge, No. 6)
“IMSA 7” (IMSA 19-1 7-conducator cable, IMSA 50-2, etc.)
“DLC” (Detector Loop Cable)
“Loop 1U” (Identifying which lane served & up/downstream)
“CCTV”
“DMS “

Voltage:
“480 Volts”
“120 Volts”

Destination

The following table is the default labeling scheme for destinations, unless otherwise specified.

Cable Tagging: Destinations --- “TO:__________”

Type	**Use**	**Destination**	**Examples**
Fiber-optic	Trunk	Next: • Terminal point for segment • Node • Building	• “TO Val Vista” • “TO Node 12” • “TO TOC”
Fiber-optic	Branch	Trunkline & side of freeway	“TO EB Trunkline”
		Cabinet Number	“TO CAB 3118253”
Power	Load Center to Cabinet	Load Center Number	“TO LC 3118256”
		Transformer Number	“TO XFMR 118279”
		Cabinet Number	“TO CAB 3118253”

Where appropriate, cable labels may be bundled around multiple conductors/cables. For example, where power conductors are coming from one load center and going to four cabinets:

The conductors coming from the load center entrance to the pull box may be bundled with a label “TO LOAD CENTER ____”

The conductors heading to the four individual cabinets shall have one label per set of conductors heading to the four cabinets, thus four bundles, each labeled with the appropriate cabinet number "TO CAB _______"

A complete labeling record, in the form of a Record Drawing Cable Schedule, shall be provided to Independent Quality Firm with the final project documentation. The cabling record shall include the distance markings on all fiber optic cables at the ingress and egress points of each No. 9 pull box, at each splice closure, entry to each cabinet and all termination points.

(I) Installation Sequential Report:

After each fiber optic cable installation, Developer shall record the fiber cable "foot marking" at the entrance and exit point in each No. 9 pull box for each fiber cable in a Developer-furnished Fiber-Optic Cable Installation Sequential Report. Report shall take the form of a spreadsheet, and be submitted to the Independent Quality Firm in electronic form (thumb drive) prior to final acceptance.

740-3.03 Conduit:

Conduit installation shall conform to Subsection 732-3.01, with the exception of the following requirements and revisions.

(A) Conduit Routing and Underground Obstructions:

The Developer shall restore any damaged or contaminated vegetation and/or landscaping features, decomposed granite and irrigation facilities, walkways, utilities, other existing electrical items resulting from its construction activities.

Developer shall contact the Independent Quality Firm to arrange and coordinate work in the vicinity of any irrigation lines. Spaghetti lines to vegetation, and feeder hoses may not be Blue Staked, but shall be repaired or replaced if damaged during construction.

Conduit shall be placed in accordance with the lines, grades, details and dimensions shown on the project plans.

Conduit runs shown on the plans are depicted to indicate the intended path from point to point. Final conduit locations shall be documented and submitted to the Independent Quality Firm in the form of a record drawing.

(B) Conduit Size:

Changes in the size of the conduit shall be submitted to the Independent Quality Firm for approval prior to construction. All changes in conduit size shall be documented by Developer in the form of a record drawing.

(C) Conduit Bend Radius and Deflection:

Except for factory bends, conduit bends shall have a radius of not less than that specified in the NEC. Conduit shall be bent without crimping or flattening, using the longest radius practicable. Communications conduits shall not deflect more than one inch per foot (1:12) vertically or horizontally. This is equivalent to a minimum radius of 6 feet.

If the 1:12 rule cannot be achieved, standard factory-made elbows of 11 1/4, 22 1/2, 30 or 45 degrees, with a minimum radius of 24 inches shall be used. If 90-degree cumulative turns are required they shall be made of individual elbows with a minimum radius of 36 inches.

(D) Conduit Ends and Connections:

New runs of HDPE conduit shall be continuous from pull box to pull box. HDPE conduit shall not be joined to PVC conduit in the length of the run. At pull boxes and/or cabinets where new HDPE is required to transition into new or existing PVC elbows, Developer shall propose a coupling recommended by the manufacturer for approval.

When joining segments of HDPE conduit, Developer shall utilize non-corrosive, sit-tight, water-tight couplings. Heat fusion, electrofusion fittings and mechanical connections shall be permitted if the HDPE conduit and joining device manufactures recommendations are followed and the internal diameter of the HDPE conduit is not reduced. Extrusion welding and hot gas welding to join HDPE conduits is not permitted.

Upon completion of joining HDPE conduit sections and setting the pull boxes, Developer shall clean the HDPE conduit with compressed air. Developer shall demonstrate by pulling a cleaning mandrel or ball mandrel, correctly sized for the conduit (80 percent of the HDPE inside diameter), that the conduit was not deformed during installation. If the mandrel passes through the HDPE conduit Developer shall install the pull tape in accordance with Section732 of the Project Specifications. If the mandrel encounters a deformity in the HDPE conduit, Developer shall replace the entire segment of HDPE conduit between pull boxes with new HDPE conduit.

(E) Conduit Expansion Fittings:

Expansion fittings shall be installed in conduit runs which cross an expansion joint in a structure. Approved expansion fittings shall be as shown in the ITS Standard Drawings or project plans. Conduit encased in a structural member shall be installed in accordance with the National Electrical Code.

A minimum of three feet shall separate any expansion coupling on any conduit from the pipe sleeve the conduit enters. Expansion couplings shall be staggered to keep the conduit entering the pipe sleeve as straight as possible.

Where bonding is not continuous, expansion fittings shall be provided with a bonding jumper of #6 AWG conductor. Allow enough slack conductor to accommodate the range of expansion supported by the expansion coupling.

Where it is not possible to use expansion fittings, sleeves of sufficient size shall be installed to provide a minimum 1/2 inch clearance between the conduit and the inside wall of the sleeve. The sleeve shall be discontinuous at the expansion joints.

(F) Conduit Depth:

Conduits shall be at a minimum cover depth of 30 inches, or as indicated in the project plans. Backfill compaction shall be in accordance with Subsection 203-5.03 (B) (4).

When conduit cannot be installed at the required minimum depths, it shall be encased in Class B concrete, as defined in Section 1006.

(G) Conduit in Trenches:

Immediately after conduits are installed, they shall be sealed to prevent the intrusion of water, mud, gravel, vermin, etc. The conduits shall be sealed after mandrelling, pull tape, cable and/or fiber, installation. Taping the ends of the conduit is not allowed.

All unoccupied conduits on which work is performed shall be sealed with a water-tight, corrosion-proof, removable, reusable, and vermin resistant conduit plug or cap.

Occupied conduits on which work is performed shall be sealed with a conduit cap. The conduit cap shall be water-tight, corrosion-proof, removable, and vermin resistant.

All unoccupied innerduct on which work is performed extending beyond the end of the capped conduit shall be sealed with a water-tight, corrosion-proof, removable, reusable, and vermin resistant innerduct plug or cap. Prior to use, the innerduct plug or cap shall be submitted to the Independent Quality Firm for approval.

Occupied innerduct on which work is performed extending beyond the end of the capped conduit shall be sealed with an innerduct cap. The innerduct cap shall be water-tight, corrosion-proof, removable, and vermin resistant.

New innerducts installed as part of the project, and existing innerducts previously empty and slated for use as part of the project, shall have a plug pulled through to demonstrate that the innerduct integrity and continuity is appropriate for use.

New innerducts installed as part of the project, and existing innerducts previously empty and slated for use as part of the project, shall have a means to secure the end of the innerduct, in the pull boxes at both ends, from being pulled into the conduit, beyond the inside face of the pull box or end of conduit.

A three inch "Y" shall be cut into the face of the curb directly over conduit located under rolled or vertical curbs.

Developer shall place warning tape in all trenches in which new PVC or trenched HDPE conduit is placed. Warning tape is not required in conduit segments where trenchless methods are used for installation. All warning tape shall be buried at a depth of six to eight inches below the finished grade.

Excavation and backfill of excavated pits shall be in accordance with the requirements of Subsection 203-5.03 (A) and (B).

(H) Conduit by Trenchless Methods:

Any new conduit to be installed under existing pavement, curbs and gutters, sidewalks, established landscaping or existing decomposed granite not otherwise impacted by construction, and at any other additional locations specifically indicated on the project plans, shall be installed by Horizontal Directional Boring (HDB) or Horizontal Directional Drilling (HDD) methods. Use of either method is allowed.

Conduit installation in areas where trenching would typically be allowed may be completed by trenchless methods, only if preapproved by the Independent Quality Firm as a means of facilitating installation or mitigating potential damage to existing surface and subsurface elements.

Conduit installed by boring shall be HDPE. HDPE or PVC can be used with directional drilling. Coupling HDPE to PVC is not allowed at mid-runs. If HDPE is used with directional drilling, a #9 pull box will be required at the beginning and end of each run where transitions from HDPE to PVC occur.

When enlargement of an installation hole is necessary, the hole shall be at least 25 percent larger than the conduit to be installed. Pulling equipment such as grips, pulling eyes, and other attachment hardware external to the conduit will be permitted as long as a wooden dowel is placed inside the conduit to prevent it from collapsing at the point of attachment when pull tension is at its peak. A swivel shall be used with all pulling hardware when pulling back the conduit into the installation path. Drilling fluid shall be pumped down the hole to provide lubrication for the conduit as it is pulled in. The pulling tension for installing conduit into the installation path shall not exceed 75 percent of the conduit manufacturer’s tensile strength rating in order to prevent the conduit from “necking down” or deforming.

(I) Detectable Pull Tape:

Detectable pull tape shall be installed in all new conduits and innerducts. Detectable pull tape in conduits shall terminate at the end of the conduit with a minimum of 2 feet of coiled slack in the pull box. Detectable pull tape traveling through the conduit that terminates in a pull box shall have its wire ends connected together to allow for a continuous locating signal to be used for the entire conduit run..

(J) Conduits Embedded in Concrete Structures or attached to Concrete Structures:

Attaching or embedding conduit in any concrete structure shall be as shown in the plans or approved in advance by the Independent Quality Firm.

Conduit to be installed either within an open bridge cell or attached to structures shall be rigid metal conduit (RMC). Where required for aesthetic reasons RMC shall be painted to match the color of the existing bridge structure.

For bridges over 1,000 feet in length, or as indicated on the project plans, intermediate junction boxes shall be evenly spaced.

Intermediate pull boxes shall be placed at distances as shown on the project plans.

(K) Incorporation of Existing Conduit or Innerduct, Empty or Occupied:

Existing underground conduit to be incorporated into a new system shall be cleaned and blown out with compressed air.

Where cables are to be installed in conduit with existing cables or wires that will remain, Developer shall disconnect, remove, reinstall, and reconnect the existing cables and wires, to facilitate the installation of the new cable.

Prior to disconnecting any existing cables, Developer shall submit a schedule with the timeframes of when the existing cables are to be disconnected.

Developer shall be responsible for any damage to the existing cables or wires caused by this operation. Existing wires and cables shall be considered in good condition unless Developer demonstrates otherwise to ADOT.

No more than one week prior to installation of cable or conductors, all new and existing conduits in which cable or conductors are to be installed shall be cleared/cleaned by pulling through a metal-disc mandrel with a diameter of 90 percent of the conduit inside diameter for PVC conduit, or a ball mandrel with a diameter of 80 percent of the conduit inside diameter for HDPE. The conduit may be brushed or swabbed, if deemed necessary, prior to pulling the mandrel through the conduit.

Where indicated on the plans, Developer shall remove and dispose of existing cables and/or conductors in existing conduits. Prior to their removal, all cables and/or conductors to be removed shall be identified and marked at all intermediate pull boxes. These cables and/or conductors shall be cut at all intermediate pull boxes before being removed. Conduits to remain empty for future use shall have a detectable pull tape installed.

Where multiple cables, conductors, pull tape, and/or new innerducts are required to be installed in the same conduit, all the materials shall be installed at the same time.

(L) Utility Conduits and Conduits in Railroad Right-of-Way:

Installation of conduit for underground utility service shall conform to the utility company requirements, local codes and the specifications. Conduit installed in railroad right-of-way shall be to the depth specified by the railroad company, and coordinated through ADOT Utility and Railroads Section to obtain appropriate licenses and approvals.

(M) Conduit Entering Pull Boxes:

Conduit entering pull boxes shall be installed in accordance with the details shown on the project plans and the ITS Standard Drawings.

New HDPE conduits terminating in No. 9 pull boxes shall run directly into the conduit port hole of the pull box wall and be cut flush with the inside face of the pull box. The void between the outside edge of HDPE and inside edge of concrete port hole sealed with an approved sealant.

HDPE and RMC conduits proposed to terminate in a No. 7 ITS Pull Box shall have a coupling to convert to PVC prior to any elbows underground. Elbows, couplings and conduit entering into the pull box shall be schedule 40 PVC. All conduits shall have bell end fittings or approved bell end shape integral to the conduit.

Conduit ends shall be capped with conduit end cap or plug fittings until wiring or cabling is installed. When end caps or plugs are removed, all new conduit ends in pull boxes shall be provided with an approved conduit end bell, as shown in the ITS Standard Drawings. End bells shall be installed prior to the installation of the conductors or cables. Approved insulated grounding bushings shall be used on steel conduit ends.

(N) Innerduct:

Innerduct shall be pulled into new and/or existing conduit as shown on the plans. Innerduct shall be pulled with a minimum of dragging on the ground or pavement. Developer shall ensure that the tensile load on the innerduct does not exceed the allowed maximum by using a break-away technique and/or a pulley system with numeric readout which includes a means of alerting the installer when the pulling tension approaches the manufacturer's maximum pulling tension.

Developer shall ensure that the innerduct is protected from sharp edges and excessive bends. Developer shall not cause the innerduct to violate the minimum bending radius for which the innerduct was designed. Developer shall be responsible for all damages caused from violations and shall remove and install new innerduct.

During pulling, the innerduct shall be continuously lubricated as it enters the conduit. Prelubrication may be necessary. The lubricant used shall be compatible with the innerduct material. The manufacturer's recommended pulling speed and pulling tension shall not be exceeded.

Innerduct shall be anchored at pull boxes to keep innerduct from retracting into the conduits, beyond the exposed conduit end.

All newly-installed empty innerduct shall contain detectable pull tape from pull box to pull box. Each pull tape shall terminate at the end of the innerduct with a minimum of 2 feet of coiled slack in each pull box.

(O) Cathodic Protection:

Prior to any trenching, Developer shall verify the existence of any cathodic protection in all existing utilities and take all possible precautions to maintain existing cathodic protection.

(P) Conduit Reconditioning:

Conduit and innerduct reconditioning shall be completed prior to the start of work on any other items related to use of existing conduits and innerducts. Conduit and innerduct reconditioning shall be completed prior to the start of work on other items related to use of existing conduits and innerducts.

(Q) Conduit at Removed Pull Boxes:

Existing HDPE conduit, originally running horizontal to a HDPE to PVC coupling and into an existing pull box scheduled to be removed on the project plans, shall be spliced HDPE conduit to HDPE coupling, to HDPE conduit/coupling/conduit, resulting in an all-HDPE segment, with no PVC components remaining.

740-3.05 Pull Boxes:

(A) General:

Pull boxes shall be field located to avoid drainage swales, extreme slopes, maintenance vehicle pathways or repeating wheel loads.

Developer shall be responsible for restoring the surrounding surface conditions back to their original condition.

Existing pull boxes shown on the project plans to be removed or replaced shall be removed and disposed of, away from the project site, by Developer. All existing ITS pull box flexible delineators within the project limits, associated with any existing ITS boxes, including those that otherwise have no work associated with or in the existing ITS pull box, shall be removed and disposed of by Developer.

When a new pull box occupies the same location as an existing pull box, the existing bricks, stone sump and felt paper shall be replaced with new. In instances where an existing 12 inch depth pull box is replaced by a 24 inch depth pull box, Developer shall adjust the existing conduits, as necessary, to allow the conduit to enter the bottom of the box in conformance with the ITS Standard Drawings, the project plans and specifications.

When installing a No. 9 pull box, Developer shall only lift the pull box and covers using the lifting hardware installed for that purpose. The lid shall be oriented such that the lid hinge lies along the side of the pull box farthest from the roadway.

At the locations where Developer is required to install a “Split No. 9” pull box, Developer shall pour the concrete floor of the pull box after the pull box installation. The concrete shall be Class S with 3,000 psi minimum compressive strength with an integrated 8” diameter sump hole which will be used for drainage, and for a ground rod.

Split No. 9 pull boxes for ITS conduits co-located with lighting conduits, shall have the lighting conductors removed, conduit rerouted around the split No. 9 pull box, and lighting conductors reinstalled and terminated, matching existing. Lighting conductor splicing shall occur only in adjacent lighting pull boxes. No lighting conductors or conduits shall pass through a split No. 9 pull box.

The compaction around pull boxes shall not cause the sides to deflect or any part of the box or lid to crack or become dented. Developer shall replace any cracked, broken, chipped or damaged pull boxes or lids.

At locations requiring retrofit of No. 9 pull box lids, the existing top section of the No. 9 pull box shall be replaced with a new section containing a square spring-loaded lockable lid, conforming to the ITS Standard Drawings, and matching the size of the box to be retrofitted. New lid assemblies shall be furnished and installed with manufacturer recommended sealant material between the body of the remaining No. 9 pull box and lid assembly, installed in accordance with the manufacturer's instructions.

(B) Pull Box Reconditioning:

The field inventory completed by Developer shall include locating and documenting damaged pull boxes within the project limits. Pull box reconditioning shall be completed prior to the start of work affecting the use of any pull box slated to be reconditioned. Developer shall recondition the pull boxes as indicated on the project, in response to the type and extent of damage identified.

New No. 9 torsion assist vault covers shall be retrofitted on top of the existing No. 9 pull boxes. The top surface of the existing concrete walls shall be ground to create a smooth plain surface for the installation of the torsion assist covers. The cost of grinding the top surface of the No. 9 pull box wall shall be included in the cost of the removal of No. 9 pull box cover. The top surface of existing box shall be perfectly levelled prior to installing retrofitted cover.

SECTION 741 CONTROL CABINETS AND ASSEMBLIES:

741-1 Description:

The work under this section shall consist of furnishing and installing various control cabinets and related equipment. A control cabinet assembly shall consist of electrical and electronic equipment and components for controlling the operation of the ITS devices served by the cabinet.

741-2 Materials:

The control cabinet assembly shall include the cabinet, all internal equipment and devices, a controller unit for the specific device being controlled, and all necessary documentation.

Cabinets shall be field mounted on a concrete foundation or pole mounting hardware, including any conduit, conduit elbows, foundation anchor bolts and foundation maintenance pads.

Cabinet foundations shall conform to the requirements of the ITS Standard Drawings.

The entire surface area of each circuit board shall be sealed to protect against moisture.

Equipment material submittals shall conform to the requirements of Subsection 738-4.

741-2.01 Controllers:

(A) Model 2070 Controllers

Model 2070 controller units shall be furnished by the Developer unless otherwise specified.

The model 2070 controller shall be an Intelight 2070LC Controller, Model Number INT YCT-2070LC (S) with an Intelight 2070-1C CPU Module, Model Number INT YCT-1CTX-CPU (S).

The Intelight Maxtime Ramp Meter Software and license, Model Number INT YSW-RAMPMT shall be purchased and installed on each controller.

In addition, the Intelight Maxview Central System License, Model Number INT YSW-MV-LICENSE shall be purchased for each controller provided.

(B) Sign Controller Unit:

Sign Controller Unit (SCU) and associated software and control cabinet for DMS shall be installed per the plans and specifications.

741-2.02 Requirements for Cabinets:

All cabinets shall be furnished with the following items.

(A) General:

The cabinets shall be the type indicated on the project plans, and shall be ventilated NEMA 3 weather resistant double or single-door enclosures, depending on specified type. Overall appearance and dimensions shall be as shown in the ITS Standard Drawings or other reference, as indicated on the project plans or Project Specifications.

All bolts, nuts, washers, screws, hinges, and hinge pins shall be stainless steel, unless otherwise specified.

All cabinet equipment and accessories shall be mounted on the cage mounting rails as shown in the ITS Standard Drawings, unless otherwise specified.

Each cabinet shall be installed with Developer-furnished pressure-sensitive, permanent identification decals, as shown in the ITS Standard Drawings. The decals shall be 3-inch tall, Series C, Gothic letters and shall be top-grade, glass-beaded, reflective black letters on a silver or chrome background.

(B) Mechanical Requirements:

All cable connectors shall have cable hoods or shields and strain relief clamps.

All pin and socket connectors shall use identical contact insertion tools, contact extraction tools, and contact crimping tools. Pin diameter shall be 0.062 inches.

Each unit of equipment shall be enclosed in a sheet metal case with a protective finish. The case shall be designed to provide convenient access to the entire interior assembly and permit the removal of printed circuit boards or modules without the use of special tools.

Module and printed circuit assemblies shall incorporate plug-in techniques and be easily replaceable. A guide or track shall be provided for each module and assembly. All assemblies shall be mechanically secured so as to retain the assemblies in their proper position under conditions of shock and vibration which may reasonably be expected when the unit is mounted in a roadside cabinet.

Assemblies shall be provided with two guides for each plug-in printed circuit board. The guides shall extend to within 0.75 inch from the face of either the socket or connector. All connectors and printed circuit cards shall be keyed to prevent accidental insertion of the wrong connector or card.

The manufacturer’s model number, serial number, functional variation circuit issue or revision number, and date of shipment (month and year) shall appear in an easily visible location on each equipment unit and module supplied.

All units having the same model number shall be electrically and mechanically interchangeable.

(C) Cabinet Housing:

Cabinet housing shall be rain-proof with the top of the enclosure crowned, to prevent standing water. Cabinet housing shall have single front and rear doors, each equipped with a lock.

The enclosure, doors, two lifting eyes, gasket channels and all supports welded to the enclosure and doors shall be fabricated of 0.125 inch minimum thickness aluminum sheet. Bolted-on supports shall be either the same material and thickness as the enclosure, or shall be 0.105 inch thick (minimum) steel. The side panels and filter shell shall be fabricated of 0.080 inch minimum thickness aluminum sheet.

Each cabinet shall be provided with two lifting eyes. Each lifting eye opening shall have a minimum diameter of 0.75 inch. Each lifting eye shall be able to support a load of 1,000 pounds.

All exterior seams for the enclosure and doors shall be continuously welded and shall be smooth. All edges shall be filed to a radius of 0.03125 inch minimum. Exterior cabinet welds shall be accomplished by gas Tungsten arc Tungsten Inert Gas (TIG) process only. For the TIG process, the ER5356 (AIMg-5) 5% Magnesium, Aluminum alloy welding rod, conforming to AWS A5.10 requirements shall be used for welding on aluminum. Procedures, welders, and welding operators shall conform to the requirements and practices in AWS B3.0 and C5.6 for aluminum. Internal cabinet welds shall be done by either gas metal arc Metal Inert Gas MIG aka: Gas Metal Arc Welding (GMAW) or gas tungsten arc TIG process.

An anodic coating shall be applied to all aluminum surfaces after the surface has been cleaned and etched. The cleaning and etching procedure shall be to immerse in inhibited alkaline cleaner at 159.8 degrees Fahrenheit for five minutes (in a mix of 6 to 8 ounces per gallon to distilled water) then rinsed in cold water and etched in a sodium solution at 150.8 degrees Fahrenheit for five minutes (0.5 ounce sodium fluoride, plus five ounces of sodium hydroxide mix per gallon to distilled water). The surface shall then again be rinsed in cold water and then degreased in a 50 percent, by volume, nitric acid solution at 68 degrees Fahrenheit for two minutes. Finally, the surface shall be rinsed in cold water.

The anodic coating shall conform to MIL-A-8625F (Anodic Coatings for Aluminum and Aluminum Alloys) for Type II, Class I Coating except the outer housing surface coating shall have a 0.0007 inch minimum thickness and a 0.952 ounces per square inch minimum coating weight. The anodic coating shall be sealed in a 5 percent aqueous solution of nickel acetate (pH 5.0 to 6.5) for 15 minutes at 210.2 degrees Fahrenheit.

The enclosure door frames shall be double-flanged on all four sides, and shall have strikers to hold tension on and form a firm seal between the door gasket and the frame. The dimension between the door edge and the enclosure external surface when the door is closed and locked shall be 0.156 $\pm$ 0.08 inch.

Gaskets shall be provided on all door openings and shall be dust-tight. Gaskets shall be 0.25 inch minimum thickness, closed-cell neoprene or silicone, and shall be permanently bonded to the metal. If neoprene is used, the mating surface of the gasket shall be covered with a silicone lubricant to prevent sticking to the mating metal surface. A gasket top channel shall be provided to support the top gasket on the door to prevent gasket gravitational fatigue.

The cage bottom support mounting angles shall be provided on either side, level with the bottom edge of the door opening, for horizontal support and bolt attachment. Side cage supports shall be provided for the upper cage bolt attachments. Spacer brackets between the side cage supports and the cage shall be either 0.188 inch aluminum or 0.105 inch steel.

No bolts shall protrude through the cabinet top or walls.

The latching handles shall have provisions for padlocking in the closed position. Each handle shall be 0.75 inch minimum diameter stainless steel with a minimum 0.50 inch shank. The padlocking attachment shall be placed at 4 inches from the handle shank center to clear the lock and key. An additional 4 inch minimum gripping length shall be provided.

The latching mechanism shall be a 3-point draw-roller type. Rollers shall have a minimum diameter of 0.75 inch with nylon wheels and steel ball bearings. The push rods shall be turned edgewise at the outward supports and have a cross-section of 0.25 inch thick by 0.75 inch wide, minimum.

When the door is closed and latched, the door shall be locked. The lock and lock support shall be rigidly mounted on the door. In the locked position, the bolt throw shall extend a minimum of 0.25 inch into the latch-cam area. A seal shall be provided to prevent dust or water entry through the lock opening.

Locks shall be consistent and compatible with current ADOT ITS control cabinet maintenance keys. The key shall be removable only in the locked position. One key shall be furnished with each lock. All parts of the locking mechanism shall be stainless steel. Locks shall have rectangular spring-loaded bolts. Bolts shall have a 0.281 inch throw and shall be 0.75 inches wide by 0.75 inches thick (tolerance is +/- 0.035 inches).

The rear door shall be provided with louvered vents. The louvered vent depth shall be a maximum of 0.25 inch. A removable, reusable air filter shall be housed behind the door vents. The filter shall cover the vent opening area. A filter shell that fits over the filter and provides mechanical support for the filter shall be furnished. The shell shall be louvered to direct the incoming air downward. The shell sides and top shall be bent a minimum of 0.25 inch to contain the filter. The filter resident in its shell shall be held firmly in place with a bottom bracket and a spring loaded upper clamp. No incoming air shall bypass the filter. The bottom filter bracket shall be formed into a waterproof sump with drain holes to the outside of the housing. The filter shall be 16 inches wide x 12 inches high x 0.875 inch thick, and compatible with the cabinet the filter is serving.

The intake (including filter with shell) and exhaust areas shall pass a minimum of 100 cubic feet of air per minute.

The housing shall be equipped with two electric fans with ball or roller bearings and each with capacity of 100 cubic feet of free air flow per minute. Each fan shall be mounted within the housing and vented.

Each fan shall be thermostatically controlled and shall be manually adjustable to turn on between 32 and 140 degrees Fahrenheit, with a differential between automatic turn on and off of not more than 20 degrees Fahrenheit. It shall be possible to manually adjust the on/off temperature set point in 20 degree Fahrenheit increments. Each fan circuit shall be protected at 125 percent of the fan motor current rating.

Two-bolt per leave hinges shall be provided to bolt the enclosure to the door. The housing shall have 4 hinges. Each hinge shall be 3.5 inch minimum length and have a fixed pin. The pin ends shall be welded to the hinge and ground smooth. The pins and bolts shall be covered by the door edge and not accessible when the door is closed.

Front and rear doors shall be provided with catches to hold the doors open at both 90 degrees and 180 ± 10 degrees. The catch minimum diameter shall be either 0.375 inch for plated steel or aluminum rods or 0.25 inch for stainless steel. The catches shall hold the door open at 90 degrees in a 60 mph wind acting at an angle perpendicular to the plane of the door.

The cabinets shall contain a minimum of two LED light fixtures. The fixtures shall be mounted on the inside top of the cabinet near the front edge and rear edge of the roof so that the front or rear of the control equipment will be illuminated when the corresponding door is open.

A door-actuated, refrigerator-type, normally-closed, durable push-button type switch shall automatically turn the appropriate light fixture on and off when the front or rear door is opened and closed.

(D) Cage Support Assembly:

A standard EIA 19-inch rack cage shall be installed inside the housing for mounting of the controller unit and cabinet accessories.

The EIA rack portion of the cage shall consist of two pairs of continuous, adjustable equipment mounting angles. The angle nominal thickness shall be either 0.1345 inch plated steel or 0.105 stainless steel. The angles shall be tapped with holes having 10-32 threads with EIA universal spacing.

The angle shall comply with standard EIA RS-310-D and shall be supported at the top and bottom by either welded or bolted support angles to form a cage.

Clearance between angles for mounting assemblies shall be 17.75 inches.

Two steel supporting angles extending from the front to the back rails shall be supplied to support the controller unit. The angles shall be designed to support a minimum of 50 pounds each. The horizontal side of each angle shall be a minimum 3 inches wide. The angles shall be vertically adjustable.

As part of the controller support brackets, a 1.5 inch rack mounted drawer shall be provided within a 1.75 inch space. The rack mounted drawer shall have a hinged top cover. The drawer shall store documents and miscellaneous equipment up to 50 pounds in weight when extended out from the cage. When fully extended, the drawer shall lock in place and shall require manual release of spring pins on each of two sides to allow the drawer to be retracted into the cage.

The cage shall be bolted to the cabinet at four points on both top and bottom, using the housing cage supports and associated spacer brackets, and shall be centered within the cabinet.

(E) Side Panels:

Aluminum side panels shall be provided in the cabinet as shown in the ITS Standard Drawings. They shall be bolted to the support cage.

(F) Electrical Requirements:

All circuits shall be functionally operational with regard to the following parameters:

Power source frequency:	57 to 63 Hz
Applied Line Voltage:	90 to 135 VAC, single-phase
Ambient temperature:	-35 to +165 ºF
Humidity:	5 to 95 percent, non-condensing

All circuits, unless otherwise noted, shall commence operation at or below 90 VAC, as the applied voltage is increased at a rate of 2 ± 0.5 VAC per second.

All equipment shall be unaffected by transient voltages normally experienced in commercial power lines.

Power line surge protection shall be provided to enable the unit being tested to withstand (non-destructive) and operate normally following the discharge of a 25 microFarad capacitor charged to ± 2,000 Volts, applied directly across the incoming AC line at a rate of once every 10 seconds, for a maximum of 50 occurrences per test, with the unit under test operating at between 27 to 109 degrees Fahrenheit, and at 108 to 132 VAC.

The equipment shall withstand (non-destructive) and operate normally when one discharge pulse of ±300 Volts is synchronously added to its incoming AC power line and moved uniformly over the full wave across 360 degrees or stay at any point of Line Cycle once every second. Peak noise power shall be 5 kilowatts with a pulse rise time of 500 nanoseconds. The unit under test will be operated at between 27 to 109 degrees Fahrenheit, and at 108 to 132 VAC.

All equipment shall be capable of normal operation following opening and closing of contacts in series with the applied voltage at a rate of 30 openings and closings per minute for a period of 2 minutes in duration.

(G) Cabinet Wiring:

All conductors used in cabinet wiring shall terminate with properly sized non-insulated (if used for DC logic only) or clear insulated spring-spade type terminals except when soldered to a through-panel solder lug on the rear side of the terminal block or as specified otherwise. All crimp-style connectors shall be applied with a power tool that prevents opening of the handles until the crimp is completed.

Conductors between the service terminal AC- and Equipment Ground, and their associated bus, the equipment ground bus conductor to Power Distribution Assembly, and cage rail, AC- Bus to Power Distribution Assembly shall be No. 8 AWG or larger.

All conductors, unless otherwise specified, shall be No. 22 AWG or larger, with a minimum of 19 copper strands. Conductors shall conform to Military Specification MIL-W-16878D, Type B, or better. The insulation shall have a minimum thickness of 10 mils and shall be nylon jacketed polyvinyl chloride, except that conductors No.14 AWG and larger may have Type THHN insulation (without nylon jacket), and shall be stranded with minimum of 7 copper strands.

All conductors, except those that can be readily traced, shall be labeled. Labels attached to each end of the conductor shall identify the destination of the other end of the conductor.

All conductors shall conform to the following color-code requirements:

The grounded conductors of AC circuits shall be identified by a solid white or solid gray color;

The equipment grounding conductors shall be identified by a solid green color or by a continuous green color with one or more yellow stripes;

The DC logic ground conductors shall be identified by a continuous white color with a red stripe;

The ungrounded AC+ conductors shall be identified by a solid black or continuous black with colored stripe;

The logic ungrounded conductors shall be identified by any color not specified above.

All wiring harnesses shall be routed to minimize crosstalk and electrical interference.

The C1 connector wire harness shall be a minimum of 4 feet in length and shall have adequate length to allow the C1P connector to properly connect the controller unit to the cabinet while the unit is mounted in the cabinet and while the unit is sitting on the cabinet drawer.

Wiring containing AC shall be routed and bundled separately or shielded separately from all logic voltage control circuits.

Cabling shall be routed to prevent conductors from being in contact with metal edges.

Cabling shall be arranged so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

Within the cabinet, the DC logic ground shall be electrically isolated from both the AC neutral and the equipment ground by at least 500 Megohms when tested at 250 VDC.

The cabinet power supply DC ground shall be connected to the DC logic ground bus using a No. 14 AWG or larger stranded copper wire.

With the power line surge protector disconnected, the AC neutral and the equipment ground shall be electrically isolated by at least 500 Megohms when tested at 250 VDC.

(H) Circuit Breakers:

Circuit breakers shall be UL 489 approved. The trip and frame size shall be plainly marked on the breaker by the manufacturer, and the Amperes rating shall be marked and visible from the front of the breaker. All breakers shall be quick-make, quick-break on either manual or automatic operation. Contacts shall be silver alloy enclosed in an arc quenching chamber. Overload tripping shall not be influenced by an ambient temperature range of from 0.4 to 122 degrees Fahrenheit. Minimum interrupting capacity shall be 5,000 Amperes RMS when the breaker is secondary to a UL approved fuse or primary circuit breaker, and both breakers in concert provide the rated capacity. For circuit breakers 80 Amperes and above, the minimum interrupting capacity shall be 10,000 Amperes RMS.

Circuit breakers shall be trip-free type with medium trip delay characteristics. Multi-pole circuit breakers shall be the common-trip type.

(I) Fuses:

All fuses shall be 3AG Slow Blow type, and reside in a fuse holder. Fuse size rating shall be labeled on the chassis or beside the holder. Fuses shall be easily accessible and removable without the use of tools.

(J) Power Line Surge Protector:

A power line surge protector shall be furnished and installed as part of the cabinet. The power line surge protector shall consist of a hardware base and replaceable protection module with LED failure indicators, conforming to the following requirements:

Operating Voltage	120 VAC
Clamping Voltage	340 VAC
Operating Current	15 Amps
Peak Surge Current	32.5 kA/Phase, 45.5 kA/Total
Operating Frequency	47 – 63 Hz
EMI Attenuation	50 dB Typ
Modes of Protection	L-N, L-G, N-G
Status Indicators	Power On, MOVs Functional
Temperature range:	-40 to + 185 ºF
Maximum Dimensions:	3.125 inches wide x 7.125 inches long x 3.5 inches high

Typical radio interference noise suppression shall be 10 dB at 10kHz, 50 dB at 100kHz, and 90 dB at 1 MHz.

(K) Power Strip:

The cabinet shall be equipped with a non-surge protected power strip conforming to the following requirements:

Electrical Rating:	120 VAC/20 Amps
Power Cord:	3-Wire, 4 Feet Length (NEMA 5-15)
Receptacles:	4 Minimum (NEMA 5-15)
Maximum Dimensions:	2 inches wide x 13 inches long x 2 inches high

The power strip shall be mounted in the rear of the cabinet on the left side (looking from the rear), and plugged into REC2A on PDA4.

(L) Fiber Optic Network Interface:

Developer shall furnish and install a DIN rail shelf in all cabinets containing components connected to fiber optic cables. The shelf shall support the power supply, fiber switch, fiber splice module kit or other devices necessary to support fiber optic network communications to devices served by the cabinet.

Fiber splice module kit (Fiber Distribution Unit) shall be capable of accommodating 12 separate single-stranded single-mode fibers with ultra-polished SC connectors.

A Remote Power Management Strip shall be provided, with IP network accessibility through the web, Telnet and local RS-232 port. Strip shall provide a minimum of 6 NEMA 5-20R power outlets, and be capable of being horizontally mounted and connected to the cabinet's vertical rails.

741-2.03 Requirements for Cabinet Accessories:

(A) Model 222 Two-Channel Detector Card:

The Model 222 Two-Channel Detector Card shall provide two loop-type vehicle detector channels for detecting vehicles and actuating the Model 2070 controllers. Each detector card shall conform to the requirements of the plans and to the following requirements:

Each card shall draw no more than 100 mA from the + 24 ± 6 VDC cabinet power supply and shall be insensitive to 700 mV RMS ripple on the incoming + 24 VDC line.

The detector card front panel shall be provided with a handle to facilitate insertion and removal.

All control switches, gain controls, and channel indicators shall be mounted on the front panel.

Each card shall have an indicator to provide visual indication of detection for each channel.

Each card output shall be an opto-isolated, open collector, NPN transistor and shall sink up to 50 mA at 30 VDC. The output shall be compatible with the controller unit's inputs.

Detector cards of the same type shall be interchangeable.

Detector cards shall be in full compliance with the environmental requirements of the most current NEMA standard, and shall meet the function, electrical, and performance requirements described herein.

All component parts and test points shall be clearly identified by permanent marking of circuit references on the printed circuit board.

Sensitivity, frequency, and mode selection for each channel shall be accomplished by dip switches. The use of rotary thumbwheel switches for sensitivity selection and either thumbwheel switches or toggle switches for mode and frequency selection are acceptable.

Each detector card shall include two complete detector channels. An open-circuited, short-circuited, or intermittently functioning loop system connected to one channel shall have no adverse effect on the operation of the other channel. Each channel shall contain an automatic means to eliminate crosstalk (mutual coupling) between large, very closely spaced adjacent loops connected to the same unit and a manual means to reduce crosstalk between units.

Each channel of the detector card shall automatically self-tune to any loop system inductance from 20 to 500 microHenries within one second after application or interruption of voltage. Each channel shall function properly with a loop detector surge protector installed on its associated loop system. The detector channel shall track changes in loop/system electrical characteristics as might reasonably be expected to occur in undamaged loops without producing false indications or changes in sensitivity. Each channel shall re-tune instantly and detect properly on a loop system following a momentary open condition. In the case of a broken (open) loop, each channel shall provide a continuous output and indication of the fault. The open loop indication shall not be resettable as long as the open circuit exists, except that it shall be capable of being defeated when the channel “OFF” or reset position is selected or by a change of mode or sensitivity settings.

Each detector channel shall be provided with an automatic loop test to verify the loop system’s integrity. The test shall indicate a previous fault via the front panel indicator. With an intermittent open loop, the channel shall re-tune and resume detection upon reconnection of the loop system. The occurrence of the “open” loop condition shall be indicated by a unique display sequence on the affected channel’s output indicator. The sequence shall consist of three display flashes lasting 50 ms in duration and spaced 100 ms apart. The sequence shall repeat once every second while the open loop condition is present on the affected channel.

Each detector card shall contain a remote reset circuit which, when activated by an external ground level signal (greater than 15 microseconds), shall cause all presence detections to be reset.

Each loop input channel shall be galvanically isolated, through the use of separate isolation-transformers, from each other and the internal circuitry of the detector.

Each channel shall include a mode switch to select “PRESENCE,” “PULSE,” and “OFF”. OFF shall disable the output and indicator and shall disable the channel excitation circuit to assist in determining the offending channel when crosstalk is present.

Pulse mode shall provide a single 125 ± 25 ms output pulse in response to all types of licensed motor vehicles when traveling over a 6 foot x 6 foot rectangular loop at 10 mph and shall detect successive vehicles traveling over the same rectangular loop at speeds of 10 to 60 mph with a minimum one second headway. Pulse mode shall include a two second maximum re-phase time to allow detection of a licensed vehicle over unoccupied portions of the loop within two seconds after initiation of the output with a vehicle stopped on the loop system. Selection of pulse mode shall RESET (Clear) the presence indication on the associated channel.

When presence mode is selected, the detector channel shall output a pulse that is directly related to the duration that a vehicle is detected by the loop system. The time delay between a vehicle entering the loop detection zone or area and the occurrence of an output Vehicle Present condition shall be 4 ms or less and the time delay between the vehicle leaving a loop detection zone or area and the output turning OFF, Vehicle Absent condition shall be 20 ms or less. That is, for any negative inductance change Vehicle Present condition that exceeds the sensitivity threshold, the channel shall output a ground true logic level within 4 ms. When the inductance change is removed (Vehicle Absent condition), the output shall become an open circuit within 20 ms. The recovery time between output turn-off and the unit being ready to respond to presence of another vehicle shall be 100 ms or less.

For test purposes, a negative inductance change shall be maintained for a minimum of 100 ms and a maximum of 600 ms after it is applied. When the difference between the length of time that the inductance change is applied and the duration of the corresponding ground true output are averaged over 10 trials, the average difference (algebraic) shall not exceed 4 ms.

For test purposes, a negative inductance change shall be maintained for a duration between 100 and 600 ms.

To test for the Vehicle Presence condition: the delay time between when an inductance change is applied and the time it takes for the output to respond, averaged over 10 trials, shall not exceed 4 ms.

To test for the Vehicle Absence condition: the delay time between when an inductance change is removed and the time it takes for the output to respond, averaged over 10 trials, shall not exceed 4 ms.

To test the recovery time, the above two tests shall be repeated in sequence ten times with a delay of not more than 100 ms between the beginning of each two stage sequence. The test will be used to determine if the output accurately responds to and records rapidly repeating stimuli.

Each channel shall be provided with a Multi-position sensitivity selector switch. The switch shall allow the selection of a range of sensitivity settings including a setting to ensure detection of all types of licensed motor vehicles (including motorcycles) without detecting moving or stopped vehicles 36 inches or more from the loop for each of the following loop configurations:

Three-turn Loops: Single 6 foot x 6 foot loop;
(each with 50 feet, 500 feet, and 1,000 feet of lead-in cable)

In presence mode, the detector channel shall have a sensitivity setting that allows the detector channel to detect a motorcycle and hold the output for at least four minutes when the motorcycle is parked over one loop of a series/parallel connected loop system having four 6 foot x 6 foot loops with 1,000 feet of lead-in. The detector channel shall hold the output for at least 15 minutes when the test is repeated using a standard automobile on the same loop system configuration.

Presence indicator lights and character displays shall have a 45 degree cone of visibility from an axis perpendicular to the front panel. They shall be readily visible at a radius of up to 4 feet within the cone of visibility when they are subjected to

9,000 foot-candles of white light (equivalent to bright sunlight) at 45 degree to the front panel.

The contractor shall set the loop detector card to the following parameters:

Mainline Channels:

Mode: Short Presence

Frequency Level (levels 1, 2, 3, and 4 correspond to low, medium low, medium high, and high, respectively):

1U: 1	2U: 4	3U: 2	4U: 3	5U: 1	6U: 4	7U: 2	8U: 3
1D: 1	2D: 4	3D: 2	4D: 3	5D: 1	6D: 4	7D: 2	8D: 3

Increase or decrease sensitivity to provide the following detection strengths observed under normal traffic:
No vehicle: 0
High Vehicles (Semi-truck, 4x4): 4
Mid-sized Vehicles (car, SUV, small pick-up truck): 5
Low Vehicles (sports car): 6

Entrance Ramp Channels:

Mode: Long Presence

Frequency Level (levels 1, 2, 3, and 4 correspond to low, medium low, medium high, and high, respectively):

ELI: 1	ELQ: 4	ERO: 2
ELO: 1	ERI: 4	ERQ: 2

Sensitivity (set to provide the following call strengths observed under normal traffic):
No vehicle: 0
High Vehicles (Semi-truck, 4x4): 4
Mid-sized Vehicles (car, SUV, small pick-up truck): 5
Low Vehicles (sports car): 6

Loop detector surge protectors shall be provided in existing and new cabinets with new loop terminations. Loop detector surge protectors shall have three spade lugs for connection to a terminal strip, with 7/16-inch spacing, and conform to the following minimum performance requirements:

Peak Surge Current:
8 x 20 µsec Differential Mode: 400 A
8 x 20 µsec Common Mode: 1,000 A

Life Expectancy (Occurrences):

8 x 20 µsec (200A):	500
10 x 700 µsec (100A):	100

Response Time:	Less than 5 ns
Input Capacitance:	35 pF
Clamping Voltage (After Breakover):	150 V
Operating Temperature:	Up to 185 ºF

Internal surge protection, provided on loop detector input terminals, shall:

Enable the detector to withstand the discharge of a 10 microFarad capacitor charged to ± 1,000 Volts directly across the detector loop input pins with no loop load present.

Enable the detector to withstand the discharge of a 10 microFarad capacitor charged to ± 2,000 Volts directly across either the detector input pins or from loop input pins to equipment ground. The detector input pins shall have a dummy resistive load attached equal to 5.0 Ohms for demonstration purposes.

Optically-isolated solid state output devices shall be rated to hold off 50 VDC at 20 mA ON current with a maximum 1.4-Volt drop across the output terminals. Isolation shall be at least 1,000 VAC RMS.

Each unit shall mate and be fully functional with the input file via a 44 terminal, double row, edge connector having terminal spacing of 0.156 inch.

(B) Power Distribution Assembly No. 4:

The power distribution assembly No. 4 (PDA4) shall conform to the project plans, and perform the following functions:

Receive the 120 VAC power source and distribute it to the various cabinet functions through separate circuit breakers.

Provide, via the Model 206 power supply module, a + 24 VDC power source for the operation of various cabinet accessories.

Provide, via a Model 204 flasher unit, a means of flashing external signal indications. Provide a switch pack load bay with inputs from the controller and outputs to field circuits.

The PDA4 shall include four 15 Amp circuit breakers. The rating of each breaker shall be shown on the face of the breaker or handle. Breaker function (EQPT, CCTV, SIG GATES, REC) shall be labeled on the front panel as shown on the ITS Standard Drawings.

The PDA4 shall have three duplex receptacles. Each receptacle shall accept both standard two-prong non-grounded and standard three-prong grounded plugs.

Receptacle No. 1 (REC1) and receptacle No. 2 (REC2) shall have ground-fault circuit interruption, as defined in the NEC. Circuit interruption shall occur in the presence of 6 mA or more ground-fault current and shall not occur on less than 4 mA ground-fault current.

The 120 VAC supplies to the two outlets of receptacle No. 3 (REC3A and REC3B) shall be separate. The rear panel of the PDA shall be etched to label REC3A as “CONTROLLER” and REC3B as “AUX”.

Terminal blocks shall have 10-32 thread terminal screws.

The PDA4 shall provide for the mounting and connection of four Model 200 switch packs. The PDA4 shall have a maximum depth of 10.5-inches.

(C) Model 206 Power Supply Module:

The Model 206 Power Supply Module shall supply + 24 VDC to the input files and other devices in the cabinet. It shall be furnished as a part of the PDA4.

The power supply shall be of ferro-resonant design, having no active components, and conforming to the following requirements:

Line regulation shall be 2 percent from 90 to 135 VAC at 60 Hz, plus an additional
1.6 percent for each 1.0-percent of frequency deviation.

Load regulation shall be 5 percent from one Ampere to five Amperes, with a maximum temperature rise of 86 degrees Fahrenheit, above ambient.

Design voltage shall be + 24 ± 0.5 VDC at full load, 86 degrees Fahrenheit, 115 VAC incoming voltage.

Full load current shall be 5 Amperes, minimum.

Ripple noise shall be no greater than 2 Volts peak-to-peak and 500 mV RMS at full load.

Power source shall be 90 to 135 VAC.

Efficiency, at full load, shall be 80 percent, minimum. Circuit capacitors shall be rated for 40 Volts, minimum.

The front panel shall include AC and DC fuses, power ON light, and test points for monitoring the output voltages.

The assembly, including terminals, shall be protected to prevent accidental contact with energized parts.

The module chassis shall be vented. Its top and sides shall be open. When resident in the power distribution assembly, the module shall be held firmly in place by a stud screw, an assembly connector support panel, and a wing-nut.

Two 0.5 Ohm, 10 Watt (minimum) wire-wound power resistors, each with a 0.2 microHenry maximum inductance, shall be provided; one on the AC+ power line and one on the AC- line.

Three MOV surge arrestors rated for 20 Joules minimum, shall be supplied between AC+ and equipment ground, AC- and equipment ground, and between AC+ and AC-. A 0.68- microFarad capacitor shall be placed across AC+ and AC- between the two power resistors and the MOVs.

(D) Input File Racks:

Developer shall furnish and install input files racks for cabinets used for detection applications, as shown in the ITS Standard Drawings.

The input file racks shall provide card slots for the Model 222 detector cards and conform to the following requirements:

Each input file rack shall have a maximum depth of 8.5 inches and shall mate with and support up to 14 two-channel detector sensor or isolator cards.

The file shall provide a PCB 22/44S connector centered vertically for each two- channel card slot.

The input file shall be provided with marker strips to identify detectors in the file.

Terminal blocks shall be provided with a terminal screw size of 8-32 with locking star washers.

(E) Switch Packs & Flasher Units – General Requirements

The unit chassis shall be made of metal suitable to meet rigid support and environmental requirements.

The unit control circuitry and switches shall be readily accessible using either a screwdriver or wrench. Only one type of screw head end (Slotted or Phillips) shall be used.

The unit shall be constructed so no live voltage is exposed. A handle shall be attached to the front panel for insertion or removal from the unit mating connector.

The unit shall be constructed so its lower surface is no more than 2.06 inches below the centerline of the connector and no part shall extend more than 0.9 inches to the left or 1.1 inches to the right of the connector centerline.

Continuous edge guides shall be provided on the unit.

Each switch shall be capable of switching any current from 0.050 to 10.0 Amperes (AC) load with a power factor of 0.85 or higher.

Each switch shall be designed for a minimum of 300 Million operations while switching a tungsten load of 1,000 Watts at 158 degrees Fahrenheit. Switch isolation between DC input and AC output circuit shall be at least 10,000 Mega Ohms at 2,000 VDC.

Each switch shall turn ON within ± 5 degrees of the zero voltage point of the AC sinusoidal line, and shall turn OFF within ± 5 degrees of the zero current point of the alternating current sinusoidal line. After power restoration, the zero voltage turn ON may be within ± 10 degrees of the zero voltage point only during the first half cycle of line voltage during which an input signal is applied. Turn ON and OFF shall be within 8.33 ms following application or removal of the logic signal, respectively.

(F) Model 200 Switch Packs:

The Model 200 Switch Pack unit shall be a modular plug-in device containing three solid-state switches. Each switch shall open or close a connection between applied power and external load.

A Ground True Controller Unit Input (0 to 6 VDC) shall cause the switch to energize and a Ground False (16 VDC or more) shall cause it to de-energize. State transition shall occur between 6 and 16 VDC. The input shall not sink more than 20 milliamps or be subjected to more than 30 VDC. The input shall have reverse polarity protection.

With all switches on, the unit shall not draw more than 60 milliamps at +16 VDC or more from the +24 VDC cabinet supply.

Each switch shall have an OFF state dV/dt rating of 100 Volts/Microseconds, or better. Each switch shall be isolated so that line transients or switch failure shall not alter the controller unit.

The unit front panel shall have an indicator on the input to each switch. The indicator shall be labeled or color-coded “Red”-top switch, “Yellow”-middle switch, and “Green”-bottom switch. The middle switch indicator shall be vertically centered on the unit front panel with the other indicators positioned 1 inch above and below.

The resistance between the AC+ input terminal and the AC+ output terminal of each switch shall be a minimum of 15 KiloOhms when the switch is in the open state. When the switch is in off state, the output current through the load shall not exceed 10 milliAmps, peak.

(G) Model 204 Flasher Unit:

The Model 204 Flasher Unit shall be a modular plug-in device containing a flasher control circuit and two solid-state switches. The unit's function is to alternatively open and close connections between applied power and external load.

The unit shall generate its own internal DC power from the AC line.

The unit shall commence flashing operation when AC power is applied providing 50 to 60 flashes per minute, per switch, with a 50% duty cycle.

Each switch shall have an OFF state dV/dt rating of 200 Volts/Microseconds, or better.

An indicator showing the switch's output state shall be provided. The two indicators shall be centered with 1 inch minimum spacing.

Each circuit shall be designed to operate in an open-circuit condition without load for 10 years minimum.

A surge arrestor shall be provided between AC (pin 11) and Flasher Output (pins 7 & 8).

The arrestor shall meet the following requirements:

Recurrent Peak Voltage	212 Volts
Maximum Energy Rating	50 Joules
Average Power Dissipation	0.85 Watts

741-2.04 Detection & Ramp Meter Cabinet:

The Detection & Ramp Meter Cabinet shall be furnished and installed in accordance with the ITS Standard Drawings or as shown on the project plans and in the Project Specifications.

Each cabinet shall be provided with the following cabinet accessories as shown on the plans and in the Project Specifications.

Model 200 Switch Packs;
Model 204 Flasher Units;
Model 206 Power Supply Module;
Power Distribution Assembly (PDA) No. 4;
Input Files "I" and "J", and
Model 222 Two-Channel Detector Cards.

Additional equipment shall be furnished and installed in the cabinet when required on the project plans. Detection and Ramp Meter Cabinet shall be capable of operating without a conflict monitor. Locking star washers shall be included on each terminal block mounting screw. Each terminal of each double-sided terminal block shall contain two terminal screws with a removable shorting bar between the terminal screws. The shorting bar shall be suitable for No. 22 AWG through No. 14 AWG wire, and PV 18-6F-M lugs. A removable shorting bar shall be installed between the terminal screws. The terminal number assigned to each terminal shall be clearly and permanently indicated on a marking strip placed on or adjacent to the terminal block.

The main circuit breaker box shall contain the following:

120 VAC, 30 Ampere, socket-mounted, double-pole, single-throw heavy duty relay and socket to serve as the signal power interrupt relay;

30 Ampere single-pole breaker; and

Power surge protection device.

The circuit breaker box shall have nominal dimensions of 10 inches high x 8 inches wide x 4 inches deep. The main circuit breaker shall accommodate service wire as large as No. 2 AWG. The electrical service conductors shall be contained in a flexible conduit as described in the NEC. This conduit shall enclose the service from the entrance conduit to the circuit breaker box. It shall be long enough to be dressed neatly and attached to the side panel.

The flexible conduit shall be equipped with a coupling and a reducer, if necessary, to enable its attachment to the service entrance conduit. Conduit shall extend approximately 6 inches into the service entrance conduit.

741-2.05 CCTV Cabinet:

The CCTV Cabinet shall be furnished and installed in accordance with the ITS Standard Drawings or as shown on the project plans.

Cabinet shall be a ventilated NEMA 3 weather-resistant cabinet. Only one exhaust fan shall be provided.

Each cabinet shall be provided with the cabinet accessories as shown in the ITS Standard Drawings or as shown on the project plans.

Additional equipment, such as CCTV equipment surge protectors, shall be furnished and installed in the cabinet when required on the project plans.

The main circuit breaker box shall include the following:

30 Ampere main circuit breaker;
20 Ampere circuit breaker for the EQUIP receptacles;
20 Ampere circuit breaker for UTIL receptacles (GFCI);

The CCTV Cabinet shall contain one standard three-wire 20 Ampere duplex outlet, and one GFCI three-wire 20 Ampere duplex outlet.

Each receptacle shall be clearly and permanently marked on the face plate of the outlet. The following abbreviations shall be used:

Outlet 1/Receptacle 1:	EQUIP
Outlet 1/Receptacle 2:	EQUIP GFCI
Outlet 2/Receptacle 1:	GFCI GFCI
Outlet 2/Receptacle 2:	GFCI

741-2.06 Foundations:

The Detection and Ramp Meter Cabinet shall be mounted on a concrete foundation and shall conform to the requirements of Subsection 736-2.03, with modifications as shown on the ITS Standard Drawings, project plans.

Concrete for cabinet foundations shall be 3,000-pound per square inch Class S concrete.

Anchor bolts shall conform to the requirements of Section 606-2.05 and 1004-4. Anchor bolts shall be used, as shown in the ITS Standard Drawings, unless otherwise specified.

741-3 Construction Requirements:

741-3.01 Controllers:

(A) Model 2070 Controllers:

Model 2070 controller shall be furnished by Developer, Developer shall arrange to have the units delivered to ADOT for configuration and testing. The controller shall include all the necessary cards as required by ADOT for operation of the controller and to communicate with the ADOT TOC. Developer shall install the Intelight Maxtime Ramp Meter Software and ADOT will load any additional application firmware required to configure the controller for the respective application and will conduct testing.

Developer shall allow a minimum of 14 calendar days for ADOT to perform programming and testing of Model 2070 controller units. Developer shall pick-up the controllers after the testing and programming are completed, transport the controllers to the work site, and install them in the field cabinets. Developer shall coordinate the completion of Department testing, availability of controllers, pick-up and transport to the project site a minimum of 14 calendar days in advance.

Developer shall securely mount the controller units in the controller cabinets by firmly attaching all rack-mounted controllers to the 19-inch cabinet rack with screws.

(B) DMS Controller Unit:

Developer shall coordinate the location and schedule for delivery of new DMS sign controller units. The sign controller unit will be shipped by the sign manufacturer directly to Developer.

Developer shall securely mount the sign controller unit in the DMS control cabinet by firmly attaching all rack-mounted controllers to the 19-inch cabinet rack with screws.

741-3.02 Cabinet Installation:

(A) Electrical Equipment:

All equipment, housings, metal conduits, and cabinets shall be grounded and bonded in accordance with Subsection 732-3.03 and the NEC.

The cabinet shall be grounded with a No. 8 AWG solid copper wire.

Wire and cable terminations shall only be made at recessed-screw barrier type terminal blocks, unless otherwise specifically noted. No in-line or butt splices shall be made at any point in the work other than at such terminal blocks.

All field wires and power service cables shall be wired to the cabinets as shown in the ITS Standard Drawings or on the project plans.

(B) Cabinet Installation Procedures:

Developer shall transport cabinets to the project site and install them as shown on the project plans. Installation shall include:

Grounding the cabinet to the ground system, using bare, solid No. 8 AWG soft-drawn copper wire;

Grounding the transformer, if on the same foundation as the cabinet;

Connecting the cabinet to the power source;

Completing fiber optic splices and terminations within the cabinet, as required;

Furnishing and installing any necessary mounting hardware (pole-mount, if applicable to specific cabinet type and location).

Developer shall connect the cabinet and its accessories to the various field devices to be controlled, to form a fully functional system.

Developer shall furnish and install silicone caulking, or other approved sealant around the base of the cabinet to form a watertight and dust-proof seal.

(C) Cabinet Accessories:

Detector cards and switch packs shall be installed by Developer in the appropriate slots in the control cabinet.

Any spare detector cards and switch packs called for by the project documents, shall be left in the cabinet or turned over to ADOT.

(D) Fiber Optic Network Interface

On two-door cabinets, the DIN rail shelf shall be attached to the vertical rails serving the "back side" of the cabinet. The "front side" of the cabinet is considered to be the door side from which controller face and keyboard are viewed. On single-door cabinets, the location for mounting the DIN rail shelf will be as specified to meet specific site equipment space requirements.

The fiber switch shall be mounted vertically, in the middle of the DIN rail shelf. The power supply shall be mounted to the left of the fiber switch. The fiber splice module kit (fiber distribution unit) shall be mounted vertically on the DIN rail shelf, near the right end.

The remote power management strip shall be mounted horizontally, to the left and right side vertical rails, below the DIN rail shelf, leaving a single space gap between DIN shelf and power management strip.

741-3.03 Cabinet Testing Requirements:

(A) Factory Certification:

Developer shall supply certification of the quality control and final test conducted on each item with each shipment of cabinets and components. The certification shall indicate the name of the tester and shall be signed by the responsible party representing the manufacturer or supplier.

The certification procedure shall include the following:

Acceptance testing of all supplied components;
Physical and functional testing of all modules;
A minimum of 100-hour burn-in of all modules; and,
A minimum of 24 hour operation of all cabinets.

The certification procedure shall include manufacturer or supplier testing, performed on the controller cabinet, of every unit furnished, as applicable, including:

All Model 200 Switch Packs;
All Model 204 Flasher Units;
All Model 206 Power Supply Assemblies;
All Model 222 Two-Channel Detector Cards;
All Power Distribution Assemblies; and,
All Input and Output files.

(B) Stand-Alone Tests:

Using the form and procedure indicated in the ITS Standard Drawings. Developer shall demonstrate that each Detection and Ramp Meter and CCTV Cabinet Assembly operates properly when assembled and connected to all equipment it serves.

Developer shall perform the following loop calibration test for all mainline detector stations:

1. On the Model 2070 controller, set/verify that the loop Trap Distance is 18 feet.
2. Using a vehicle with a calibrated speedometer or a radar gun verifying the exact speed of the vehicle, drive the vehicle past the detector station at a constant maximum safe, and legal speed.
3. Record the speed registered on the Model 2070 controller.
4. Record the actual vehicle speed of the car off the radar gun, or the car speedometer.
5. Multiply the actual vehicle speed (mph) by 1.467 to obtain the speed in feet per second (ft/sec).
6. Perform the following calculation:

$$\frac{\text{Actual vehicle speed (ft/sec)}}{\text{Speed read off Model 2070 (ft/sec)}} \quad X \quad 18(\text{ft}) = \text{Actual Trap Distance (ft)}$$

7. Adjust the value in the Model 2070 controller data location for the Trap Distance to the actual trap distance calculated in Step 6, above.
8. Record the corrected Lane Trap Distance on data sheets for submittal to the Independent Quality Firm, as well as create and record a table of this data for the record drawing plans documentation.

(C) Subsystem Test (SST):

ADOT, with the support of Developer, shall conduct the subsystem test on the Detection and Ramp Meter Cabinets with communications system to verify that all communications circuits (Developer installed equipment as well as any connections to existing) have been properly configured and operate without failure and without adversely affecting the existing system.

Failure of an equipment component to pass the SST shall require the equipment to be repaired or replaced and the test repeated until the equipment successfully passes the test. Developer shall supply all test equipment required for the troubleshooting of the system.

(D) System Acceptance Test (SAT):

Upon successful completion of all subsystem testing, the SAT shall be started. The SAT shall consist of a 30-day period of operation without failure of all Developer-supplied equipment. ADOT shall be provided with access to all equipment during this period for purposes of verifying its operation.

The purpose of the SAT is to demonstrate that the total system, consisting of hardware, software, communications, materials and construction, is properly installed, is free from defects and identified problems, exhibits stable and reliable performance, and completely complies with all contract documents.

During the SAT, Developer shall ensure that all equipment is maintained in operable condition. Developer shall identify, isolate, diagnose and troubleshoot all system problems and inconsistencies. Developer, in conjunction with the Independent Quality Firm, shall formulate possible solutions and shall implement all corrections required in Developer supplied equipment.

Developer shall provide test equipment and labor needed to test, isolate and correct all equipment deficiencies found during the SAT. Key Developer technical personnel familiar with the design and construction of each system component shall be available on site within 48 hours of notification of a problem.

During the SAT, Developer shall maintain a test event log, in a spreadsheet format. This log shall contain at a minimum the following information: Date and time of failure, who reported the failure, description of the failure, troubleshooting performed, and date and time repair was completed. Developer shall submit an updated log to the Independent Quality Firm after each reported failure, and again after the repair has been completed. Developer shall submit for approval a draft version of the test event log layout as part of the initial project material submittal data

All system documentation errors, omissions and changes occurring prior to and during the SAT shall be corrected and resubmitted before system acceptance can be completed.

(1) SAT Failure Definitions

(a) Minor Failure

In the event of a minor failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with 24 hours added to the remaining test time of the system. The following constitute minor failures:

- Failure of Department-furnished equipment.
- Failure of an entire communications circuit for more than 15 minutes over any 24- hour period.
- Failure to communicate to any ramp meter controller.

(b) Major Failure

In the event of a major failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with the test clock reset to day zero. The following constitute major failures:

- Minor failures of Department-furnished equipment three times, if determined that failures were caused by faulty installation by Developer.
- Minor failure of an entire communication circuit two times.
- Minor failure of communication to an individual ramp meter controller three times.
- Failure to correct a problem that adversely impacts the safety of the traveling public, within four hours of notification.

741-3.04 Foundations:

Developer shall install all wire, cable, connectors, and other incidental materials necessary to connect all equipment to be incorporated in or connected to the work through the foundation, to the cabinet, to form a properly operating and fully functioning system. Developer shall meet requirements of Subsection 731-3.01**.**

If the cabinet is to be located on a slope steeper than 2:1, the placement of the foundation shall be offset from the pull box along the mainline conduit or other structure so that their locations do not lie on a line perpendicular line to the roadway.

Foundations shall be monolithic with the exposed surfaces formed and finished to present a neat, smooth appearance. The bottom of each foundation shall rest on undisturbed earth and the top shall be level. This shall include adjacent concrete maintenance pads**.**

Forms for the concrete shall be rigid and securely braced in place. Templates shall be used to properly position and hold in place necessary conduit, anchor bolts, and the ground rod. Immediately prior to pouring the concrete, both forms and the earth shall be thoroughly moistened. The concrete shall be allowed to cure at least 12 hours and shall be hardened sufficiently to prevent damage before the forms are removed. Developer shall backfill and build slope per the plans as well as restoring the landscape.

Developer shall install the new cabinet and the associated cabinet accessories to the new foundation to form a fully functional system. Caulking is required along the base of the cabinet.

(A) Cabinet Grounding:

All equipment, housings, metal conduit, and cabinets (all exposed metal, non-current carrying parts) shall be grounded and bonded in accordance with the NEC, Article 250. Grounding conductors, or bonding jumpers, shall be connected by exothermic welding, UL listed pressure connectors, UL listed clamps, or other approved UL listed means. Connection devices or fittings that depend solely on soldering shall not be used. Sheet metal screws shall not be used to connect grounding conductors to enclosures.

Developer shall meet the requirements of Subsection 732-3.03 of the Standard Specifications to bond the cabinet to ground.

All cabinet foundations shall have a copper clad steel ground rod with a diameter of at least 5/8-inch, in the foundation. The ground rod shall be installed so that it extends into the surrounding undisturbed earth for a minimum of 9 feet. The ground rod shall be driven into place through the sleeve in the foundation. The ground rod shall extend approximately 3- inches above the foundation. The ground rod shall be connected to the cabinet and the grounding system using ground clamps on the rod and an approved lug connector in the cabinet.

The cabinets' ground resistance shall be 25 Ohms or less.

If Developer prefers to use an electrolytic grounding system, it must meet the following specifications. The electrolytic grounding system must be 100-percent self-activating/sealed and maintenance free. The ground system shall hygroscopically extract moisture from the air to activate the electrolytic process; no additions of chemicals or water are permitted. The electrolytic ground shall not use any hazardous material to improve grounding performance. The electrolytic system must be UL listed with a minimum life expectancy of 30 years.

SECTION 742 ITS DETECTION:

742-1 Description:

The work under this section includes furnishing and installing new detection, pre-formed and/or saw cut detector loops, associated detector lead-in cables, loop slot sealant, loop splice kits, and loop detector surge protectors to form loop systems and shall connect the loop systems to loop detector channels in control cabinets at designated locations as shown on the project plans.

All work shall conform to Section 735, unless otherwise specified.

742-2 Materials:

Except as specified in Subsection 735-2.01(F), all materials shall be furnished by Developer. Developer shall submit a complete list of all required project material for approval.

(A) Documentation:

In addition to the requirements of Subsection 738-4, Developer shall furnish a schematic diagram for each existing or new control cabinet to which loop systems are to be connected. The schematic diagram shall show the approximate location of each detector loop connected to the cabinet, the designation of the associated loop lead-in cable, the lead-in cable conductor pair serving the loop, the cabinet terminals to which the loop is proposed to be connected, and the function that the loop performs.

Schematic diagram shall be submitted to the Independent Quality Firm for review and approval prior to terminating and connecting loop cables in any existing or new cabinets.

(B) Certificates of Compliance:

Developer shall furnish certified reports per the Technical Provisions that state that the wire or cable fully complies with the requirements of these specifications for each type of wire and cable being furnished. A statement shall be attached to the certified report indicating that the batches furnished were manufactured under the same conditions as the batches tested.

742-2.01 Loop Wire:

Unless otherwise indicated in the project plans and Project Specifications, loop wire and loop lead-in cable shall conform to the requirements of Subsection 740-2.01.

Loop detector wire shall be 14 AWG HDPE polyethylene insulated conductors conforming to IMSA 51-7, as shown on the Standard Drawings.

742-2.02 High Temperature Backer Rod:

High Temperature backer rod shall be a round foam material rated to withstand a minimum temperature of 400 degrees Fahrenheit. The diameter of the backer rod shall be sized according to the width of the saw cut as follows:

Saw Cut Width	Backer Rod Diameter
1/4"	3/8"
3/8"	1/2"
1/2"	5/8"
3/4"	7/8"
7/8"	1"
1	1 1/4"
1 1/8"	1 1/2"
1 5/8"	2"

742-2. 03 Loop Slot Sealant:

Developer shall furnish and install loop slot sealant, depending on the pavement surface to be sealed, conforming to the following requirements, to seal the loop slots and surface holes for the loop stub-out conduits. Developer shall provide the expiration date of the material used, in the equipment submittal and review process.

Saw cut sealants shall be a flexible encapsulant intended for sealing and protecting vehicle detector loop wires installed in saw cuts.

Expired sealants shall not be permitted. Developer shall provide the expiration date of the sealant with the material submittal

(A) Two-Part Epoxy Filler Sealant:

Two-part epoxy joint filler sealant shall be a 100-percent solids, flexible, two-component, solvent free, epoxy resin/hardener system for use as a saw cut sealant in asphaltic concrete pavements and Portland cement concrete pavements.

Materials shall comply with the requirements of Subsection 1015-1 of the Specifications.

The epoxy system shall be specifically designed for the intended application according to the product literature provided by the manufacturer.

The epoxy system shall be of sufficient strength and hardness to withstand stress and abrasion from vehicular traffic, while remaining flexible enough to provide stress relief under thermal movement and protect the loop wire from moisture penetration. It shall also be moisture insensitive to allow effective application to damp pavements. No standing water is permitted on the surfaces to which the epoxy system is to be applied.

The epoxy system shall be designed to enable vehicular traffic to pass over properly filled saw cuts immediately after installation without tracking or stringing of the material.

Properly installed and cured epoxy systems shall exhibit resistance to the effects of weather, motor oils, gasoline, anti-freeze solution, brake fluid, deicing chemicals, and salt in such a manner that the performance of the vehicle detector loop wire is not adversely affected.

The epoxy system shall be designed for roadway installation when the surface temperature is a minimum of 40 degrees F and rising. The cured epoxy system shall be temperature stable and exhibit no degradation in performance throughout the ambient pavement temperature ranges experienced within the State of Arizona.

The components of the epoxy system shall have a minimum shelf life of 12 months in original unopened, undamaged containers, when stored in a cool dry environment, as recommended by the manufacturer.

The epoxy system shall meet the following requirements:

Property	Test Method	Requirements
Mixing Ratio; Part A to Part B	-	1 to 1 by volume
Viscosity, centipoises	ASTM D 2393-86	4000 to 8000
Pot Life, minutes	ASTM C 881	12 to 20
Cure Time, minutes	ASTM C 679	60 maximum, Tack Free
Hardness (Shore D)	ASTM D 2240	35 to 65
Tensile Elongation, %	ASTM D 638	50 minimum
Water Absorption, % (24 hrs)	ASTM D 570	1 maximum
3% Salt Water Absorption, % (24 hrs)	-	0.03 to 0.20
Oil Absorption, % (24 hrs)	ASTM D 471	0.01 to 0.02
Gasoline Absorption, % (24 hrs)	-	0.05 to 0.90

(B) One-Part Elastomeric Sealant:

One-part elastomeric sealant may be used to seal saw cuts in Portland cement 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 its 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 form a surface skin allowing exposure to vehicular traffic within 30 minutes at 75 degrees F 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 the State of 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, prior to curing of the encapsulant, with a suitable non-flammable solvent. 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 and 140 degrees F.

The encapsulant shall have the following physical properties in its uncured and cured states.

Uncured (Wet) Encapsulant		
Property	**Requirement**	**Test Procedures**
Weight	10.1 ± 0.3 pounds/gallon	A. Weight/Gallon
Total Solids by Weight	75 – 85%	B. Determination of Non-Volatile Content
Viscosity	10,000 - 85,000 centipoise	C. Dynamic Viscosity
Drying Time	Touch: 24 hrs. maximum Complete: 30 hrs. max.	D. Tack-Free Time

Cured Encapsulant

Property	Requirement	Test Procedure
Hardness (Indentation)	65 – 85	E. Rex hardness
Tensile Strength	500 psi minimum	F. Tensile & Elongation
Elongation	300% minimum	

(C) Hot Applied Rubberized Sealant:

Hot applied rubberized sealant may be used to seal saw cuts in asphaltic concrete and in lean concrete base. 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 pressure feed melter unit. Pour pot application is not acceptable. 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 for the loop detector sealant.

Test	Specification
Penetration: 125 ^{o}F, 50g, 5s	50 maximum
Penetration: 77 ^{o}F, 100g, 5s	10 – 25
Softening Point:	210 ^{o}F minimum
Ductility: 77 ^{o}F	15 cm minimum
Mandrel Bend: 0 ^{o}F, 90^{o} Arc, 10s, 3/4 inch diameter	Pass 2 of 3
Recommended Pour Temp:	380 ^{o}F
Safe Heating Temp:	420 ^{o}F
Brookfield Viscosity: 400 ^{o}F	7,500 centipoise max.
Unit Weight:	8.5 pounds per gallon
Coverage; 1/2 by 1/2 inch crack	11.0 pounds per 100 feet

742-3 Construction Requirements:

742-3.01 General:

Loop construction of saw cut and pre-formed loops shall conform to the ITS Standard Drawings and project plans, including loop numbering nomenclature.

Developer shall furnish and install all necessary loop wire, lead-in cable, loop detector surge protectors, hold down materials, loop slot sealant, splice kits, saw slots, pre-formed loops (when applicable), stub-out conduit from saw slots to pull boxes, solder, wire nuts, spade lugs, tape, wire ties, water-proofing, incidental materials necessary to complete the installation and perform testing.

The installation of the detectors shall be such that the operation shall not be affected by temperature changes, water, ice, rain, snow, chemicals, or electromagnetic noise. Vehicle detectors shall be installed prior to any chip seal or friction course for asphaltic concrete pavements, and prior to any friction course for Portland cement concrete pavements.

(A) Saw Cut Loops:

Prior to installing the loop wire or lead-in cable, Developer shall cut the slots, drill the conduit holes, and complete the installation of associated conduit and pull boxes. Developer shall use clean water to prevent blowing dust while cutting the slots. Developer shall flush the slots, vacuum water out of the slots and from the roadway, and then blow the loop slots with oil free compressed air to dry them and free them from debris, taking necessary safety precautions to avoid flying debris from coming into contact with personnel or vehicles. The slots shall be thoroughly cleaned to allow sealant to adhere to the sides of the slot.

Developer shall take precautions to keep any materials from entering the storm drains.

Developer shall install the loop wire in the slots without damage to the insulation. Developer shall not splice the loop wire at any point, except to the lead-in cable in the pull box. Loop shall consist of one continuous piece of wire from the pull box, through the loop, and back to the pull box.

If the loop is installed in reinforced concrete, or is at least 2-inches below the roadway surface, Developer shall install four turns of the loop. The loop wire pair from the corner of the loop in the roadway to the pull box shall be twisted 3 times per foot. All required turns of loop wire shall be installed in the same slot.

Loop wires shall be a minimum of 1 ½ inch below the pavement surface in new pavements, and a minimum of 2 inches below the pavement surface in existing pavements, measured from pavement surface to top of top loop wire tube.

Developer shall solder splice the loop wire to its associated lead-in cable in the pull box, and shall provide a watertight seal for the splice. Solder used for splicing shall be resin core solder with 60 percent tin and 40 percent lead.

Developer shall seal the slots with loop slot sealant. Developer shall ensure that the slots are clean and dry with no residue remaining at the time of sealing. Developer shall seal the conduit entrance at the curb, or in the roadway, with loop slot sealant. During the sealing operation, the ambient air temperature shall be within the application range specified by the sealant manufacturer. The sealant shall be installed in accordance with the ITS Standard Drawings and in a manner that will fill the slot to its full depth and will totally encapsulate the wire or cable. Developer shall strike off and remove any excess sealant and remove it from the site.

Developer shall install the lead-in cable between the control cabinet and the pull box adjacent to the loops at the roadside. Developer shall leave 5 feet of coiled slack in the pull box. Each lead-in cable shall be unspliced between the loop splice pull box and cabinet. One lead-in cable shall be provided, per loop, unless otherwise specified. All installed lead- in cables that are not immediately terminated (within 1 day) to the cabinet field panels shall have the unterminated ends waterproofed using an appropriate method.

Developer shall furnish and install a label on each lead-in cable in the control cabinet and in the pull box where the loop is spliced to the lead-in cable. The legend of the label shall conform to the loop numbering nomenclature shown in the ITS Standard Drawings. The legend shall be legible, weatherproof and shall indicate the location and lane of the associated loops.

The spade lugs installed on the loop lead-in wire in cabinets shall be crimped and soldered. Developer shall connect the loop system to the associated loop detector channel in the control cabinet, in accordance with the wiring schematic and shall tune the channel to operate properly and reliably with the loop system.

(B) Pre-Formed Loops:

Pre-formed loops shall be installed in accordance with the ITS Standard Drawings, the project plans and these specifications.

All new preformed loops shall be labeled in accordance with the provisions stated above.

742-3.02 Test Requirement – Using Existing Loops:

(A) General:

Developer shall verify the functionality of the existing detector loops identified for reuse as part of the project on the plans, by testing each loop. Where loop lead-in identification labels do not comply with the standards of these specifications, Developer shall place new identification labels the existing lead-ins at the pull box where the loop wire is connected to the loop lead-in cable to the cabinet. Developer shall verify which lanes have operable loops and which do not. If the loop meets the test requirements, Developer shall reconnect the loop to its related lead-in cable and 2-channel detector card. Developer shall not damage existing detector loops or existing lead-in cables. Developer shall replace any loops and lead-in cables damaged by this operation.

All testing of existing loops shall be completed prior to the installation or replacement of loop lead-in cable.

(B) Initial Inventory and Testing:

Developer shall evaluate the condition of and test any existing loops to be used as part of the initial field inventory in Subsection 738-8. Developer shall submit completed loop testing forms and a list of loops where tests were not performed due to an existing damaged condition.

Testing of loops shall be conducted by cutting off existing splices to lead-in cables or cutting off existing waterproofed ends of loop wires, testing, and resplicing the ends of existing loop wires to existing lead-in cables or securing and waterproofing the ends of successfully tested loop wires for future termination to future installed lead-in cables. Loop wires shall not be tested by "skinning" or cutting the existing loop wire insulation and covering with electrical tape or applying waterproofing agents.

(1) Insulation Resistance to Ground Test:

The insulation resistance to ground for each detector loop shall be measured with a MegOhmeter (Megger) connected between the loop wire and the nearest reliable electrical ground, such as a meter, metal pole or fire hydrant, or to a metal rod driven 3 feet into the ground. The insulation to ground shall not measure less than 100 Megohms at 500 VDC.

(2) Series Resistance Test:

The series resistance of each 6' x 6' loop, measured by an Ohmmeter, shall be between 0.1 and 0.5 Ohms. The maximum resistance of the other loops shall not exceed 10 Ohms.

(3) Inductance Test:

The inductance of each loop will be measured with an inductance tester. The accepted inductance shall be in the range of 50 to 100 µH for a 3-turn 6' x 6' loop and 100 to 155 µH for a 4-turn 6' x 6' loop, and the test may add 22 microHenries per 100 feet of lead-in cable. Developer shall notify the Independent Quality Firm of any unacceptable readings.

(4) Existing Loop Passes Test:

If the existing detector loop meets the test requirements, Developer shall proceed to install the detector loop lead-in cable, splice the detector lead-in cable to the loop wire, terminate the detector lead-in cable in the proper equipment cabinet, and connect it with the associated detector channel.

(5) Existing Loop Fails Test or Non-Existent Loop:

If testing indicates that the existing detector loop is defective, Developer shall replace the detector loop. If a replacement saw cut loop is designated to replace the failed existing loop, Developer shall install a new loop of the same size, conforming to the ITS Standard Drawings or project plans and Project Specifications.

If a single loop of a pair of detector loops (trap) is defective, Developer shall replace both detector loops. Developer shall offset the new loops in front of, or behind, the existing loop pair, and not cut immediately over the exact same placement footprint. The new detector loops shall not be placed within 6 feet of an existing operational loop.

Developer shall verify that all designated lanes contain existing loop detectors, as shown on the project plans. Developer shall saw cut new loops, of the proper configuration, in any lanes determined not have existing loops.

742-3.03 Test Requirements – New Loops:

As part of the Stand-Alone test, Developer shall incrementally test the complete loop system in the presence of the Independent Quality Firm. If the loop system fails any of the following tests, Developer shall, replace any defective splices, wire or cable and resplice and relabel, if necessary, the loop wire and lead-in cable. The loop system shall then be re-tested until subject loop passes the tests successfully.

Tests described in Subsections 742-3.03 (A) and (B) apply to all new freeway mainline and ramp meter loops.

(A) After Loop Installation:

Developer shall perform the following tests on each loop in the pull box, in the presence of the Independent Quality Firm, both before the sealant has been poured and after the sealant has hardened.

(1) Insulation Resistance to Ground Test:

The insulation resistance to ground for each detector loop shall be measured with a MegOhmeter (Megger) connected between the loop wire and the nearest reliable electrical ground, such as a meter, metal pole or fire hydrant, or to a metal rod driven 3 feet into the ground. The insulation to ground shall not measure less than 100 Megohms at 500 VDC.

(2) Series Resistance Test:

The series resistance of each 6' x 6' loop, measured by an Ohmmeter, shall be between 0.1 and 0.5 Ohms. The maximum resistance of the other loops shall not exceed 10 Ohms.

(3) Inductance Test:

The inductance of each loop will be measured with an inductance tester. The accepted inductance shall be in the range of 50 to 100 µH for a 3-turn 6' x 6' loop and 100 to 155 µH for a 4-turn 6' x 6' loop, and the test may add 22 microHenries per 100 feet of lead-in cable. Developer shall notify the Independent Quality Firm of any unacceptable readings.

(B) After Lead-in Installation:

Tests shall be conducted in the equipment cabinet after all splices have been made but before final connection to the loop detector channel. The following tests shall be conducted for each detector loop:

(1) Test No. 1:

Utilizing a Megger, Developer shall verify that the insulation resistance from each lead-in conductor to ground is at least 10 Megohms.

(2) Test No. 2:

Utilizing a loop inductance meter, Developer shall verify that the inductance of the loop plus its lead-in cable is within the range of 50 to 490 microHenries.

(3) Tests No. 3 and No. 4:

Tests No. 1 and No. 2 shall be performed when the splice between the loop wire and the loop lead-in cable is dry. The same tests shall be performed a second time after Developer has submerged the splice in water for 1 minute, minimum.

(4) Test No. 5:

After all preceding tests have been passed, the loop system shall be connected to the loop detector channel and the unit observed under normal working conditions. Failure of the loop to provide a count of vehicles within 5-percent of the observed volume of traffic during a 15-minute period, or 100 vehicles passing over the loop, whichever comes first, shall constitute failure of the test.

The communication failure is measured as 95% for the detection and ramp meter cabinet.

SECTION 743 LOAD CENTERS AND TRANSFORMER CABINETS:

743-1 Description:

The work under this section shall consist of furnishing and installing load center assemblies and transformer cabinet assemblies, as shown in the ITS Standard Drawings and on the project plans..

Depending on application, the transformers within the transformer cabinet may be serving to step-up or step-down voltages.

Developer shall furnish and install a load center cabinet or transformer cabinet foundation for each load center or transformer cabinet assembly.

743-2 Materials:

(A) Load Centers:

Load centers shall conform to the requirements of Subsection 736-2.03, with modifications as shown on the ITS Standard Drawings, project plans, and Project Specifications.

The load center assembly shall consist of a NEMA 3 cabinet, foundation, applicable transformer, circuit breakers, internal wiring, and appropriate hardware. The Service Entrance Section and Meter Socket shall meet the requirements of the utility company providing service.

Concrete for foundations shall be Class S and shall have a required 28-day compressive strength of 3,000 pounds per square inch.

All transformers shall be new and shall conform to paragraphs 2.1.3 and 2.1.5 in Section 2 of the current NEMA TS-1 Standards and to other applicable standards of NEMA (i.e., NEMA ST 120), UL (i.e., UL-506), EIA, and ANSI. Developer shall comply with all applicable national, state, and local laws, ordinances, and codes.

(B) Transformer Cabinets:

The transformer cabinet assembly shall consist of a NEMA 3 cabinet, concrete foundation, applicable transformer, external cut-off breaker with lever, internal wiring, and applicable hardware.

Concrete for foundations shall be Class S and shall have a required 28-day compressive strength of 3,000 pounds per square inch.

All transformers shall be new and shall conform to paragraphs 2.1.3 and 2.1.5 in Section 2 of the current NEMA TS-1 Standards and to other applicable standards of NEMA (i.e., NEMA ST 120), UL (i.e., UL-506), EIA, and ANSI. Developer shall comply with all applicable national, state, and local laws, ordinances, and codes in effect at the time that the work is performed.

All transformers shall be single phase, dry type, totally enclosed, encapsulated distribution transformers, and operate on primary and secondary voltages as shown on the project plans and as specified in the Project Specifications.

All cabinets and transformers furnished on the project shall be new and of prime quality, and shall not have been used previously on other projects or in other locations. All items of the same type shall be identical and totally interchangeable.

743-2.01 Load Center Cabinets:

(A) General:

The cabinets shall be of the type indicated on the project plans, and shall be ventilated NEMA 3 double or single-door enclosures, depending on specified type. Overall appearance and dimensions shall be as shown in the ITS Standard Drawings or as indicated on the project plans or Project Specifications.

There shall be no shelves in the interior of the cabinet.

Type II load centers for rural DMS applications shall not have photoelectric cells or associated circuitry supporting photocell and photocell switch.

All electrical components in the load center assembly shall be UL listed.

(B) Cabinet Construction:

The cabinet and door shall be constructed from 5052-H32 sheet aluminum alloy with a thickness of 0.125-inches. Welds shall be neatly formed and free of cracks, blow holes, and other irregularities. Inside and outside edges of the cabinet shall be free of burrs. The cabinet shall be designed with a sloped top to prevent the accumulation of water on its top surface.

The doors shall have signs stating "Danger High Voltage".

The door opening(s) shall be double flanged on all four sides to increase strength around openings and keep dirt and liquids from entering the enclosure when the door is opened. A two-position door restraint on each door shall be provided, to hold the door open at 90 degrees in a 60 mph wind acting at an angle perpendicular to the plane of the door. The restraint shall hold the door open at 90 ±10 degrees and at 180 ±10 degrees. The door shall be furnished with a gasket that satisfies the physical properties as found in UL508 Table 21.1 and shall form a weather tight seal between the cabinet and door. The hinges shall be continuous and welded to the inside of the door and cabinet and bolted to the outside of the cabinet and door using twenty 0.125-inch stainless steel carriage bolts and nylon insert lock nuts (known as elastic stop nuts). The hinges shall be made of 0.093-inch thick aluminum and shall have a 3-inch open width with a 0.25-inch diameter stainless steel hinge pin. The hinge pin shall be capped top and bottom by weld to render it tamper proof.

The latching mechanism shall be a 3-point draw roller type. The center catch and push- rods shall be cadmium plated, Type II Class 1. Push-rods shall be turned edgewise at the outward supports and shall be 0.25-inch by 0.75-inch steel, minimum. Rollers shall have a minimum diameter of 0.75-inches and shall be made of nylon. The center catch shall be fabricated from 0.140-inch steel, minimum.

The stainless steel handle shall have a 0.75-inch diameter shank. The latching handle shall have a provision for padlocking in the closed position. The lock shall be consistent and compatible with current ADOT maintenance keys. The key shall be removable only in the locked position. One key shall be furnished with each lock. All parts of the locking mechanism shall be stainless steel. The locks shall have rectangular spring-loaded bolts.

(C) Cabinet Ventilation:

Cabinet ventilation shall be provided, with ventilation holes as shown in the ITS Standard Drawings, the project plans and Project Specifications. A cabinet exhaust fan meeting the requirements of Subsection 734-2.03 (D) shall be mounted on top.

(D) Transformer Mounting:

The transformer shall be mounted on a 12 gauge steel mounting plate or panel board attached to the back wall of the cabinet with six 3/8-inch diameter mounting studs welded to the back wall.

The transformer shall be located 4 inches from the top of this mounting plate or panel board.

(E) Cabinet Finish:

Cabinets shall not be painted.

(F) Cabinet Mounting:

The cabinets shall be designed for pad mounting, and attached using anchor bolts of size and placement shown in the ITS Standard Drawings or project plans.

(G) Circuit Breakers:

Load center cabinets shall have a dead front panel to isolate all live electrical circuitry The panel shall be fabricated from 14-gage sheet steel. The dead front panels shall be hinged on one side and securely fastened on the other with bolts. Switches, breakers and other components shall have openings to operate from the front panel.

743-2.02 Load Center Transformer:

The transformer overall dimensions, physical outlines, and mounting hole dimensions shall be as shown on the project plans. All transformers shall be single-phase, dry type units. The transformer primary and secondary voltages shall be as shown on the project plans

The Volt-Ampere rating shall be 15 or 25 kVA, as indicated on the project plans to support the application loads. The mass of the transformer shall not exceed 250 pounds and shall be wall mounted. The transformer shall be labeled either “step-up” or “step-down” and the incoming (primary winding) and outgoing (secondary winding) voltages shall be clearly identified on the exterior.

The transformer shall conform to paragraphs 2.1.3 and 2.1.5 in Section 2 of the current NEMA Standards Publication TS-1, and to other applicable standards of NEMA (i.e., NEMA ST 120), UL (i.e., UL-506), EIA, and ANSI. Developer shall comply with all national, state, and local laws, ordinances, and codes in effect at the time that the work is performed.

All cabinets and transformers furnished on the project shall be new and of prime quality, and shall not have been used previously on other projects, or in other locations. All items of the same type shall be identical and totally interchangeable.

(A) Cores:

Power transformer cores shall be fabricated with high grade materials. The core volume shall allow operation at 10 percent above rated primary voltage at no load, without exceeding a temperature rise of 207 degrees F. All core laminations shall be oxide or varnish coated, annealed, free of burrs, and properly assembled to reduce noise and ensure efficient operation of the transformer.

(B) Coils:

Coil conductors shall be continuous with terminations brazed or welded without auxiliary flux material. The entire core and coil assembly shall be impregnated with varnish and cured to seal out moisture. Coils shall be protected with an outer layer of glass tape or similar quality insulation. Coils shall incorporate an electrostatic shield located between primary and secondary windings.

(C) Sound Levels:

All power transformers shall be of low noise design. Sound levels shall not exceed the following.

Up to 9 kVA:	40 dB
10 to 50 kVA:	45 dB

743-2.03 Transformer Cabinet:

(A) General:

The enclosure shall be a single door ventilated cabinet. Overall appearance and dimensions shall be as shown in the ITS Standard Drawings unless otherwise specified.

(B) Cabinet Construction:

The cabinet and door shall be constructed from 5052-H32 sheet aluminum alloy with a thickness of 0.125 inches. External welds shall be made by using the Heliarc welding method, whereas internal welds shall be made by the wire welding method. Welds shall be neatly formed and free of cracks, blow holes and other irregularities. Inside and outside edges of the cabinet shall be free of burrs.

The cabinet shall be designed with a sloped top to prevent the accumulation of water on its top surface. The door shall have a "Danger High Voltage" sign attached.

The door opening shall be double flanged on all four sides. A two-position door restraint on each door shall be provided, to hold the door open at 90 degrees in a 60 mph wind acting at an angle perpendicular to the plane of the door. The restraint shall hold the door open at90 ± 10 degrees and at 180 ± 10 degrees. The cabinet door shall be a minimum of 80 percent of the front surface area and shall be hinged on the right side when facing the cabinet. The door shall be furnished with a gasket that satisfies the physical properties as found in UL 508 Table 21.1 and shall form a weather tight seal between the cabinet and door. The hinges shall be continuous and bolted to the outside of the cabinet and door using twenty 0.25-inch stainless steel carriage bolts and nylon insert lock nuts (known as elastic stop nuts). The hinges shall be made of 0.093-inch thick aluminum and shall have a3-inch open width with a 0.25-inch diameter stainless steel hinge pin. The hinge pin shall be capped top and bottom by weld to render it tamper proof.

The latching mechanism shall be a 3-point draw roller type. The center catch and push- rods shall be cadmium plated, Type II, Class 1. Push-rods shall be turned edgewise at the outward supports and shall be 0.25-inch by 0.75-inch steel, minimum. Rollers shall have a minimum diameter of 0.875 inches and shall be made of nylon. The center catch shall be fabricated from 0.140-inch steel, minimum.

The stainless steel handle shall have a 0.75-inch diameter shank. The latching handle shall have a provision for padlocking in the closed position. The lock shall be consistent and compatible with current ADOT maintenance keys. The key shall be removable only in the locked position. One key shall be furnished with each lock. All parts of the locking mechanism shall be stainless steel. The locks shall have rectangular spring-loaded bolts.

(C) Cabinet Ventilation:

Cabinet ventilation shall be provided by louvered vents in the front door with a removable pleated paper air filter. The filter shall cover the vents and shall be held firmly in place with bottom and top brackets and a spring-loaded upper clamp. Exhaust air shall be vented out between the top of the cabinet and the door. The exhaust area shall be screened with a material having a maximum hole diameter of 0.125 inches.

(D) Transformer Mounting:

The transformer shall be mounted on a 12 gauge steel plate or panel board attached with six 3/8-inch mounting studs welded to the back wall of the cabinet. The transformer shall be located 4 inches from the top of this pan and centered from side to side. The transformer shall be mounted using appropriately sized carriage or lag bolts and attached at the top and bottom.

(E) Cabinet Mounting:

Transformer cabinets shall be fastened to a concrete foundation, as shown in the ITS Standard Drawings, using anchor bolts of size and placement shown in the ITS Standard Drawings or project plans. Caulking shall be placed along the bottom of the enclosure to seal to foundation.

(F) Cabinet Finish and Dimensions:

The outside surface of the cabinet shall have a smooth, uniform, natural, unpainted aluminum finish. The dimensions and physical construction shall be as shown in the ITS Standard Drawings, unless otherwise specified.

743-2.04 Transformer Cabinets:

The transformer overall dimensions, physical outline, and mounting hole dimensions shall be as shown in the ITS Standard Drawings unless otherwise specified. All transformers shall be single-phase, dry type units. The transformer primary and secondary voltages shall be as specified on the project plans. The Volt-Ampere rating shall be 3, 7.5, 10, 15 or 25 kVA, as indicated on the project plans. The mass of the transformer shall not exceed 250 pounds and shall be wall mounted. 25 kVa transformers used in transformer cabinet applications, will not fit in the standard transformer cabinet and require a special transformer cabinet, as shown on the project plans.

(A) Cores:

Power transformer cores shall be fabricated with high grade materials. The core volume shall allow operation at 10 percent above rated primary voltage at no load, without exceeding a temperature rise of 207 degrees Fahrenheit. All core laminations shall be oxide or varnish coated, annealed, free of burrs, and properly assembled to reduce noise and ensure efficient operation of the transformer.

(B) Coils:

Coil conductors shall be continuous with terminations brazed or welded without auxiliary flux material. The entire core and coil assembly shall be impregnated with varnish and cured to seal out moisture. Coils shall be protected with an outer layer of glass tape or similar quality insulation. Coils shall incorporate an electrostatic shield located between primary and secondary windings.

(C) Sound Levels:

All transformers shall be of low noise design. Sound levels shall not exceed the following:

Up to 9 kVA:	40 dB
10 to 50 kVA:	45 dB

(D) Standards:

Transformers shall be constructed and rated in accordance with applicable UL, CSA, NEMA, ANSI, IEEE and OSHA standards and shall meet NEC requirements.

743-3 Construction Requirements:

743-3.01 Load Centers:

Existing load centers, to be reused, shall remain in service for items and devices served in the existing condition.

Developer shall contact and coordinate with the utility company at project initiation to clearly define service locations, requirements specific to that utility, verify acceptance and approval of the type and style of load center proposed, and determine service addresses, if not shown on the plans.

Developer shall coordinate with the utility, bear the cost of any permits, fees, and connection costs assessed by the utility, and monthly electrical charges until final acceptance of the project.

The load center assembly shall be furnished and installed at the locations shown on the project plans.

The load center assembly foundation shall be constructed as shown in the ITS Standard Drawings and project plans. Developer shall meet the requirements of Subsection 731-3.01.

Developer shall meet the requirements of Subsection 732-3.03 to bond the cabinet to ground.

Developer shall furnish and install silicone caulking, or other approved sealant around the base of the cabinet to form a watertight and dust-proof seal.

Load centers shall be installed with Developer-furnished pressure-sensitive, permanent identification decals, as shown in the ITS Standard Drawings. The decals shall be 3-

inch tall, Series C, Gothic letters and shall be top-grade, glass-beaded, reflective black letters on a silver or chrome background.

(A) Test Requirements:

Developer shall verify that the transformer loadside voltage is within 3 percent of the rated voltage, stepped up/down under loaded and unloaded conditions.

743-3.02 Transformer Cabinets:

The transformer cabinet assembly shall be furnished and installed at the locations shown on the project plans.

The transformer cabinet assembly foundation shall be constructed as shown in the ITS Standard Drawings or project plans. Foundation shall meet requirements of Subsection 731-3.01.

Developer shall meet the requirements of Subsection 732-3.03 to bond the cabinet to ground. A separate 5/8 inch by 10 foot long copper clad ground rod shall be furnished and installed as part of the transformer cabinet assembly item.

Developer shall furnish and install silicone caulking, or other approved sealant around the base of the cabinet to form a watertight and dust-proof seal.

(A) Test Requirements:

Developer shall verify that the transformer loadside voltage is within 3 percent of the rated voltage, stepped up/down under loaded and unloaded conditions.

SECTION 744 DYNAMIC MESSAGE SIGN INSTALLATION:

744-1 Description:

The work under this section shall consist of installing Dynamic Message Signs (DMS) and control cabinets, complete with sign controller unit (SCU) on sign support structures and foundations. DMS support frameworks and catwalks, when shown on the project plans, shall be furnished and installed under this section.

744-2 Materials:

744-2.01 Documentation:

In addition to the requirements of Subsection 738-4, Developer shall submit structural shop drawings for each DMS installation to the Engineer for review and approval. The shop drawings shall detail the method of connection of the DMS to the support structure; a list of materials; the length of support members; flexible conduit routing; catwalk design, dimensions, and connections; handrail; grating; electrical and communications connections; and other features required for successful erection, installation, and operation of the DMS.

Developer shall obtain approval of these drawings within 60 days of the Preconstruction Conference and prior to fabrication of new sign support structures upon which DMS is to be mounted.

Developer's submittals shall show the existing lane configuration; shoulder widths; the location of the DMS centered over the roadway, or as otherwise specified; and the catwalk limits in relation to the shoulder widths.

To determine the specific mounting and cable routing requirements, Developer must coordinate with the DMS supplier; have a thorough understanding of the applicable Bridge Group Standard Drawings; and perform a field survey of the final location and elevation of the DMS and structural supports, showing surveyed elevations on the shop drawings.

In the event that field modifications to previously approved structural submittals related to DMS installation are required, Developer shall furnish new shop drawings for modified mountings and/or structural and electrical components made during installation.

744-2.02 SCU Cabinet and Foundation:

Concrete for SCU cabinet foundations shall be Class S, and shall have a required 28-day compressive strength of 3,000 pounds per square inch.

All wiring and grounding shall conform to the applicable requirements of Section 732-2 and the regulations and codes specified in Section 732-3.03.

744-2.03 Cabling between DMS and SCU Cabinet:

All interconnecting control and power cables between the SCU cabinet and final location of the DMS on the support structure shall be furnished by the DMS supplier, and coordinated through the Developer.

Developer shall determine the required cable length from the DMS to SCU cabinet. Cable lengths shall be communicated by Developer to the DMS sign supplier for cable fabrication. This information shall be communicated at least 12 weeks prior to the delivery date of the sign units to Developer.

744-3 Construction Requirements:

744-3.01 Delivery and Storage:

Developer shall be responsible for accepting the delivery of, storage, and safe keeping of the DMS, cabinet, SCU and all associated components. Developer shall coordinate with the DMS supplier to designated a delivery point for the DMS and related components.

Developer shall schedule installation on a just-in-time basis (to ensure the presence of the DMS supplier's technician) and install the DMS equipment on the sign structure at locations shown on the project plans. Developer shall notify and coordinate with the DMS supplier of the scheduled installation date a minimum of 45 days prior to installation, and shall keep the DMS supplier apprised of any Independent Quality Firm approved revisions to the schedule that affects the date of DMS installation.

The DMS supplier will have a representative arrive at the project site to terminate the cabling between the DMS and SCU cabinet in the DMS housing and in the SCU cabinet. Developer shall incur all of the supplier's costs caused by Developer's non-adherence with the schedule (storage, personnel time, air fare, hotels, meals, etc). Developer shall not install the DMS without the presence of the on-site DMS supplier's technician unless prior approval is received from both the supplier and the Independent Quality Firm, authorizing the installation, or specific portions of the installation, without the technician being present.

Independent Quality Firm shall thoroughly inspect all of the delivered items and equipment before the delivery truck departs, and note, in writing, any damage on the bill of lading. In the event that damage is found, or it is discovered components are missing, the Developer shall be notified immediately, and will contact the DMS supplier to arrange mitigations. Developer shall coordinate with the Independent Quality Firm, in advance of the delivery date, and to allow the Independent Quality Firm to be present at the location and time of delivery.

Storage must provide security from damage, theft, fire, weather and other causes of loss or damage. Any material arriving in a cardboard box or container shall be stored indoors.

The sign, and associated components, shall be loaded, transported, and unloaded from the storage site to the project site by Developer.

744-3.02 Installation:

Developer shall install the DMS sign on the sign structure per manufacturer requirements. Spreader beam shall be used with the lift eyes to lift the DMS sign for installation on the sign structure.

Developer shall install SCU control cabinet on the foundation furnished and constructed by Developer, as indicated in the project plans and Project Specifications.

Developer shall furnish and install UV-rated flexible metal conduits from the DMS structure to the DMS case.

Developer shall furnish and install one No. 8 AWG Green Bond conductor between the DMS sign housing and SCU cabinet. The one No. 8 AWG Green Bond conductor shall conform to Subsection 732-2.01, and shall be terminated on both ends by Developer.

Developer shall submit and obtain approval from Independent Quality Firm, for the specific date, time and traffic control strategy to be implemented for the installation of the DMS, if the DMS is to be mounted over the highway.

Developer shall coordinate all traffic control, police or DPS participation and any required media announcements and notifications with the ADOT Traffic Operations Center operators, in advance of the date of installation and activation.

Developer shall install DMS cabling between the DMS sign housing and SCU cabinet. Cabling shall be installed in accordance with DMS supplier's site representative's recommendations. Termination of communication cabling in the sign housing and in the SCU cabinet shall be the responsibility of the sign supplier. All power terminations within the sign housing and control cabinet shall be by Developer.

Developer shall provide all necessary traffic control required for the DMS installation and a bucket truck for use by DMS supplier's on-site technician to make connections at the DMS sign housing, and during the stand-alone test, subsystem testing, and through completion of the system acceptance test.

If an urban DMS is not in operation for more than 14 calendar days after the date of installation, a temporary 36-inch by 36-inch static sign shall be mounted on each DMS structural support vertical member with a Developer furnished steel strap or band. The temporary signs shall face traffic with the message "SIGN UNDER TEST" until final acceptance, at which time Developer shall remove the sign and mounting hardware. Sign mounting hardware shall become the property of Developer. Mounting of the temporary static sign by drilling into the support structure is not allowed.

744-3.03 DMS Communications:

Developer shall install communications equipment, as indicated in the project plans and these Specifications.

Developer shall integrate the DMS controller unit and the DMS with the communications system, as indicated on the project plans and these Specifications.

The Developer shall furnish and install Ethernet Network Switches, Patch and Splice Modules, Remote Management Power Strips, and cabinet foundations conforming to Section 736.2.

The Developer shall mount the Ethernet network switch and power supply, and the patch and splice module on the DIN rail shelf provided with the cabinet and integrate equipment, including the sign controller, with the Department's communications system.

744-3.04 Testing Requirements:

(1) Stand-Alone Test (SAT):

The stand-alone test will be performed by the supplier's on-site technician.

Developer shall work with the DMS supplier's on-site technician to debug and mitigate or repair any problems in the overall DMS system operation, including providing necessary lift or bucket trucks and traffic control, if required.

(2) Subsystem Test (SST):

ADOT, with the support of Developer, shall conduct the subsystem test on the DMS and communications system to verify that all communications circuits (Developer installed equipment as well as any connections to existing) have been properly configured and operate without failure and without adversely affecting the existing system.

Failure of an equipment component to pass the SST shall require the equipment to be repaired or replaced and the test repeated until the equipment successfully passes the test. If necessary, Developer shall supply all test equipment required for the troubleshooting of the system, based on the test results.

(3) System Acceptance Test (SAT):

Upon successful completion of all subsystem testing, the SAT shall be started. The SAT shall consist of a 30-day period of operation without failure of all Developer-supplied equipment. The Independent Quality Firm shall be provided with access to all equipment during this period for purposes of verifying its operation.

The purpose of the SAT is to demonstrate that the total system, consisting of hardware, software, communications, materials and construction, is properly installed, is free from defects and identified problems, exhibits stable and reliable performance, and completely complies with all contract documents.

During the SAT, Developer shall ensure that all equipment is maintained in operable condition. Developer shall identify, isolate, diagnose and troubleshoot all system problems and inconsistencies. Developer, in conjunction with the Independent Quality Firm , shall formulate possible solutions and shall implement all corrections required in Developer supplied equipment.

Developer shall provide test equipment and labor needed to test, isolate and correct all equipment deficiencies found during the SAT. Key Developer technical personnel familiar with the design and construction of each system component shall be available on site within 48 hours of notification of a problem.

During the SAT, Developer shall maintain a test event log. This log shall contain, at a minimum, the following information: Date and time of failure, who reported the failure, description of the failure, troubleshooting performed, and date and time repair was completed. Developer shall submit an updated log to the Independent Quality Firm after each reported failure, and again after the repair has been completed. Developer shall submit for approval a draft version of the test event log as part of the submittal data.

All system documentation errors, omissions and changes occurring prior to and during the SAT shall be corrected and resubmitted before system acceptance can be completed.

(A) SAT Failure Definitions

(1) Minor Failure

In the event of a minor failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with 24 hours added to the remaining test time of the system. The following constitute minor failures:

- Failure of Department-furnished equipment.
- Failure of communications to an individual confidence camera or traffic camera mounted on a rural DMS for more than 15 minutes over any 24-hour period.
- Failure of an entire communications circuit for more than 15 minutes over any 24- hour period.
- Failure to communicate to any DMS.

(2) Major Failure

In the event of a major failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with the test clock reset to day zero. The following constitute major failures:

- Minor failures of Department-furnished equipment three times, if determined that failures were caused by faulty installation of Developer.
- Minor failure of an entire communication circuit two times.
- Minor failure of communication to an individual SCU three times.
- Failure to correct a problem that adversely impacts the safety of the traveling public, within four hours of notification.

SECTION 745 CCTV CAMERAS:

745-1 Description:

The work under this section shall consist of furnishing, installing, and testing Closed Circuit Television (CCTV) cameras, and associated equipment including cabling, connectors, mounting hardware, and accessories required to provide a complete and fully functioning CCTV system integrated with software and equipment used by ADOT.

745-2 Materials:

CCTV Cameras shall operate to specification when service voltage varies between 90 and 135 VAC and/or input frequency varies ±5%. CCTV device voltages may be POE, POE+, 12-48V DC/AC or 120V. Power consumption shall not exceed 1000 Watts for CCTV camera equipment at a single site. CCTV Cameras shall be compliant with the FCC Rules, Part 15, Subpart J, for Class A devices. CCTV Cameras shall be able to withstand 80 mph winds with 30% gust factors. Equipment in the control cabinet shall operate to specifications in NEMA TS2 temperature ranges, humidity between 0% and 100%, and when exposed to sand, dust, and fungus per Mil-E-5400T or IP66 of IEC 60529. The maximum weight of pole mounted equipment shall be less than 30 pounds. The Developer shall provide technical details of the camera communications protocol to allow ADOT to interface its existing CCTV Management System. Materials shall be new and not refurbished. The Certificate of Compliance shall include that the CCTV, replacement parts, and software support is not planned to be discontinued within 5 years of the installation date.

The CCTV camera shall meet the following specifications:

Camera

Form:	Bullet
Resolution:	HD 720P/30 or greater for HD models
Resolution:	SD 480i/30 for NON-HD models
Image Sensor:	CCD or CMOS
Minimum low light Sensitivity:	0.002 Lux =0.000185 fc or better at lowest f stop
Auto Color and Night Modes:	Selectable

Lens

Zoom:	Motorized
Magnification:	18x or greater
Iris:	auto/manual
Field of View:	50 to 4 degrees
Shutter Operation:	1/30 to 1/10,000/sec

IP Video

Compression:	H.264 and MJPEG (with 2 individually

	configurable stream profiles)
Supported streams:	RTSP/RTP, RTSP Interleaved, HTTP Tunneling, RTP Multicast, MJPEG Push using HTTP, MJPEG pull using HTTP, MPEG2 Transport Stream (M2TS)
Adjustable Data Rates:	Fixed or Auto Adjust
Video latency:	<250ms

Network

Web Server Interface:	Yes
Open connectivity:	OnVif version 2.0 or greater, NTCIP
Protocols:	IPv4, HTTP, DNS, NTP, RTSP, RTP, TCP, UDP, IGMPv2, RTCP, ICMP, DHCP, ARP

Positioner

Pan/Tilt Range:	360° Continuous Pan, -30° to +30°
Accuracy:	0.25° or better
Presets:	8 minimum
Inverted Mounting Capable:	Yes

Environmental

Temperature:	-30 C to +70 C
Protection:	IP66 or better
Certifications:	FCC

The ADOT has determined that following products meet these specifications:

Cohu	3960 HD 720-30x HD35-7000
WTI Sidewinder	SW720-H.264-HD30
Bosch	MIC-7130-PW4

Developer may propose other products, which will be considered by ADOT. The Developer shall provide sufficient evidence that another product meets these specifications including providing samples of the proposed product for inspection and testing by ADOT if requested by the Engineer.

745-3 Construction Requirements:

745-3.01 General

Developer shall mount CCTV Camera to CCTV lowering device in accordance with requirements of CCTV camera manufacturer, lowering device manufacturer, and project plans.

Conductors and cables shall be routed inside CCTV pole. No cables or conductors shall be exposed, including at the base of the tilt/pan drive and at the entrance to the CCTV cabinet.

Developer shall program the camera with camera ID information, and preset positions. Developer shall coordinate with the Independent Quality Firm to obtain information for programming of the CCTV cameras.

745-3.02 Test Requirements

CCTV camera components will be subject to testing and monitoring to determine conformance with the specifications and to ensure proper operation of the equipment and system.

Developer shall submit and obtain approval from the Independent Quality Firm, for the schedule and traffic control strategy to be implemented for CCTV testing. Developer shall provide all traffic control necessary for CCTV testing.

Developer shall coordinate traffic control, law enforcement participation and required media announcements and notifications with ADOT's Traffic Operations Center operators, in advance of the date of CCTV testing affecting traffic.

(A) Stand-Alone Test:

Developer shall test the following stand-alone (non-network) functional operations of the CCTV system:

- Control of focus, optical zoom, digital zoom, iris, pan, and tilt
- Response to automatic preset positioning commands
- Display of Camera ID information
- Presence and quality of video signal during bright sunlight and night conditions
- Lowering device functions properly

For testing purposes, "bright sunlight" conditions shall be defined as occurring between 10:00 AM and 2:00 PM, on a cloudless day. "Night" conditions shall be defined as occurring between one hour after sundown and one hour before sunrise with the moon no more than one-quarter full.

Developer shall use *CCTV Test Form* obtained from ADOT and submit a complete and organized set of forms in electronic PDF format to the Independent Quality Firm.

(B) Subsystem Test (SST):

ADOT, with the support of Developer, shall conduct subsystem test on CCTV and communications system to verify that communications circuits (Developer installed equipment as well as connections to existing) have been properly configured and operate without failure and without adversely affecting the existing system.

Failure of a component to pass SST shall require equipment to be repaired or replaced at no cost to ADOT and test repeated until the equipment successfully passes the test. If necessary, Developer shall supply test equipment required for the troubleshooting of system, based on test results.

CCTV SST test shall verify following:

- Transmission of high quality video images to the TOC
- Transmission of control signals to camera
- Positioning of camera from the TOC control panels
- Response to automatic preset positioning commands from the TOC
- Priority and partitioning of commands
- Generation of text, date, and time on monitors

If video is substandard, Developer shall perform video resolution and signal-to-noise ratio testing as required by the Independent Quality Firm, in which case Developer shall submit a test procedure for approval, prior to testing.

(C) System Acceptance Test (SAT):

Upon successful completion of the subsystem test, SAT shall be started. SAT shall consist of a 30-day period of operation without failure of Developer-supplied equipment. The Independent Quality Firm shall be provided with access to equipment during this period for purposes of verifying its operation.

The purpose of SAT is to demonstrate that the total system, consisting of hardware, software, communications, materials and construction, is properly installed, is free from defects and identified problems, exhibits stable and reliable performance, and completely complies with contract documents.

During SAT, Developer shall ensure that equipment is maintained in operable condition. Developer shall identify, isolate, diagnose and troubleshoot system problems and inconsistencies. Developer, in conjunction with the Independent Quality Firm, shall formulate possible solutions and shall implement corrections required in Developer supplied equipment.

Developer shall provide traffic control, bucket truck, test equipment, and labor needed to test, isolate and correct equipment deficiencies found during the SAT. Key Developer technical personnel familiar with the design and construction of each system component shall be available on site within 48 hours of notification of a problem.

During the SAT, Developer shall record test failures on the *System Acceptance Test Failure Log* included in these specifications and immediately submit the form to the Independent

Quality Firm. After the repair has been completed, an updated form shall be submitted to the Independent Quality Firm. Documentation errors, omissions, and changes occurring prior to and during the SAT shall be corrected and resubmitted before SAT is completed.

System documentation errors, omissions and changes occurring prior to and during SAT shall be corrected and resubmitted before system acceptance can be completed.

(1) SAT Minor Failure

In the event of a minor failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with 24 hours added to the remaining test time of the system. The following constitute minor failures:

- Failure of ADOT-furnished equipment.
- Failure of an entire communications circuit for more than 15 minutes over a 24-hour period.
- Failure to receive acceptable CCTV video image at TOC or loss of CCTV control.

(2) SAT Major Failure

In the event of a major failure during the SAT, the test clock shall stop until the system is repaired. At tcompletion of repair, testing shall recommence with test clock reset to day zero. The following constitute major failures:

- Third failure of ADOT-furnished equipment, if determined that failures were caused by faulty installation by Developer.
- Second failure an entire communications circuit for more than 15 minutes within a 24-hour period.
- Third failure to receive acceptable CCTV video image at TOC or loss of CCTV control of an individual CCTV.
- Failure to correct an issue adversely impacting public safety within 4 hours of being notified by the Independent Quality Firm.

SECTION 746 RAMP METER SIGNALS:

746-1 Description:

The work under this section shall consist of furnishing and installing ramp meter pole flasher assemblies with signs, foundations, and mounting hardware, ramp meter signals and support assemblies, including foundations, at required locations in conformance with the ITS Standard Drawings and as shown on the project plans and Project Specifications.

746-2 Materials:

746-2.01 Documentation:

Developer shall comply with requirements of Section 608 and 1007 for signs, and shall submit sign layouts for approval, in accordance with the provisions of Subsection 738-4 prior to fabricating and installing signs. Certification of the reflectivity requirements of Section 1007 and Subsection 106.05 shall be furnished.

746-2.02 Signal Equipment:

Poles, breakaway bases, pole foundations, LED signal faces, signal mountings, visors, and back plates shall conform to the Traffic Signals & Lighting Standard Drawings, Sections 730 through Section 733 of the specifications, unless otherwise specified otherwise.

746-2.03 Tattle-Tale Light:

Each Type E signal face for a ramp metering application shall include a tattle tale-light consisting of a minimum of nine LED's (650-660 nm, one candela minimum) with bayonet UV shield. A tattle-tale light shall be permanently affixed to the highest elevation ramp meter signal head assembly housing.

Each LED shall emit a red indication. Chromaticity shall remain constant from 32 to 140 degrees Fahrenheit. The bayonet UV shield shall be 2-1/2-inch minimum depth. The pixel cluster shall be 2-inch to 3-inch in diameter. The tattle-tale light shall be affixed to the ramp meter signal head by means of a water-tight female type flexible, steel cord connector. The steel cord connector shall be attached to the exterior of the signal head, pass through the signal head and be secured on the interior.

The 100,000 hour (mean time between failure (MTBF)) component life span, fully encapsulated LED cluster shall be activated at precisely the same time the red signal indication of the Type E signal face is activated. Developer shall directly wire this connection to the red terminal within the ramp meter signal head. The LED's shall be visible at 300 feet within 20-degrees from perpendicular to the back plate. Wiring shall include such grommets and wire loops as necessary to prevent water intrusion into either the LED cluster or the signal head.

Developer shall provide a certificate from the manufacturer certifying chromaticity, power and LED life.

746-2.04 Pole Foundation:

Concrete for all foundations shall be Class S and shall have a required 28-day compressive strength of 3,000 pounds per square inch.

746-3 Construction Requirements:

Developer shall furnish and install signs, sign mounting hardware, sign posts, poles, break- away bases, pole foundations, signal faces with associated signal mounting hardware, flashing amber beacons, and mounting hardware as shown in the ITS Standard Drawings, on the project plans and in the Project Specifications.

The tattle-tale light shall be mounted to the housing of the upper ramp meter signal head. The tattle-tale light shall be mounted using a water-tight female type flexible, steel cord connector. The steel cord connector shall be attached to the exterior of the signal head, pass through the signal head and be secured on the interior. The Developer shall directly wire the tattle-tale light connection to the red light terminal within the ramp meter signal head. Wiring shall include such grommets and wire loops as necessary to prevent water intrusion into either the LED cluster or the signal head.

Electrical connections shall be in conformance with Subsection 740-2.01.

Developer shall furnish and install tattle-tale light, and all necessary mounting hardware.

Ramp meter signal faces and advance pole flasher assembly signal faces shall be covered with burlap and shall be unmistakably out of service when observed by an approaching driver. Plastic coverings shall not be allowed.

746-3.01 Testing Requirements:

(1) Stand-Alone Test (SAT):

ADOT will conduct operational testing of the ramp meters. Developer shall be readily available during the testing period.

SECTION 747 RECORD DRAWING DOCUMENTATION:

747-1 Description:

The work under this section shall consist of maintaining a comprehensive set of record drawing documentation, as it relates to the installation of new or modifications to existing ITS facilities.

747-2 Construction Requirements:

747-2.01 Project Documentation:

(A) In-Progress Project Documentation:

In-progress record drawing documentation of the work shall be kept current (no longer than 14 days behind the actual work period) through substantial completion of the project. This in-progress documentation shall be provided by Developer to the Independent Quality Firm prior to initiation of any required System Acceptance Tests (SAT).

In-progress record drawing documentation includes:

Construction Plans;
Operator's Manuals;
Maintenance Procedures/Manuals;
Equipment Assembly Drawings;
Cabinet and Rack Wiring Diagrams;
Electrical Schematics, Wiring and Logic Diagrams;
System Connection Diagrams;
Fiber Optic Splices/Assignments;
Splice Closure Diagrams;
Software Documentation;
Communications and Operating Protocols;
Manufacturer-Issued Manuals;
Detailed Shop Drawings;
Certifications;
Warrantees;
Instruction Sheets; and,
Parts Lists.

Documentation shall include manufacturer's equipment documentation for all Developer furnished items. Acceptable factory manuals must contain technical, diagnostic, and maintenance (preventive and troubleshooting) information. Advertising brochures and catalog cuts are not acceptable.

747-1.02 Final Documentation:

(1) Configuration Information:

Prior to the start of the project System Acceptance Test, Developer shall provide all final configuration information for Developer installed equipment. Developer shall submit two bound paper copies and one electronic copy of their configuration information, in the form of a computer spreadsheet, compatible with ADOT computer system and existing software. This electronic information shall be provided on a CD-ROM. The information shall include all configuration parameters for each device location, make and model number, serial number, date of installation, vendor, vendor contact information, and warrantee expiration date.

(2) Documentation:

All project documentation shall be subject to the approval of ADOT prior to acceptance.

Developer shall collect the record drawing coordinates using a GPS device with accuracy within 6.0 inches, using L1 L2 carrier and L1 code. Developer shall provide the electronic files of the GPS survey to the ADOT Transportation Technology Group in both a raw (non-post-processed) file format and post-processed .shp file format compatible for import into GIS software, unless otherwise specified.

Developer shall collect a minimum of 60 seconds of point logging information per field device to improve accuracy. Data is required for the following ITS features:

- New pull boxes
- Pull boxes containing new cables installed as part of this project
- New poles installed as part of this project
- Load center and cabinets installed as part of this project.
- DMS and ramp metering equipment installed as part of this project

Project final record drawing documentation shall consist of the following documents as a minimum (each of the following documents shall be submitted to ADOT prior to the completion of the project):

(a) Construction Record drawings:

Developer shall modify the construction plan sheets to reflect any variations in equipment locations or requirements shown on the plan sheets.

Whether or not modifications are made, Developer shall indicate the GPS coordinates for each field element inventoried during Developer's inspection of the existing ITS infrastructure. The construction record drawings shall also include station numbers, and offsets to each field device, referenced to back of curb, edge of pavement or other fixed landmark (barrier, guard rail, bridge wall, etc.).

Developer shall submit the GPS survey data to ADOT atleast 45 days prior to the start of the SAT. Developer shall provide atleast 45 days to review and process the GPS survey data.

The following attributes for each device shall be documented by Developer as part of the record drawing documentation process:

ITS Cabinets:
- Station & Offset
- Coordinates at left corner of front door
- Cabinet Identification Number
- MU decal numbers
- Control Application (DMS, Mainline Detection, Ramp Meter, CCTV, etc.)
- Route
- Direction

Load Center Cabinets:
- Station & Offset
- Coordinates at left corner of front door
- Cabinet Identification Number
- MU decal numbers
- Name of Serving Utility
- Route
- Direction

Dynamic Message Signs:
- Station & Offset
- Coordinates of DMS foundation on right shoulder in direction of traffic flow
- DMS Manufacturer
- Final height over roadway, at lowest point of clearance
- Route
- Direction

Ramp Meter Signal Heads and Advance Warning Flashers:
- Station & Offset
- Coordinates of pole foundation
- Pole Type
- Route
- Direction

Ramp Meter Queue Loops:
- Station of leading edge of loop
- Loop Size
- Route
- Direction
- Edge of roadway to center of loop.

Mainline Detection:
- Station of leading edge of loop

- Loop Size
- Route
- Direction
- Edge of roadway to center of loop.

CCTV Poles:
- Station & Offset
- Coordinates of pole foundation
- Route
- Direction

Pull boxes:
- Station & Offset
- Plan Sheet Number
- Pull box ID from Plan sheet (if applicable to project)
- Pull box Size (No. 7, No. 7 with extension, No. 7 ITS, No. 9, etc.)
- Conduit Qty/Sizes
- Route
- Direction

All new and existing ITS-related pull boxes where electrical conductors, fiber optic cables or new pull tape are existing or have been installed (or in the case of mainline No. 7 pull boxes, of any depth, existing pull boxes where new fiber cable was installed in conduits that otherwise bypass the box), and foundations shall indicate station number and offset from edge of roadway. The distance from pull box to pull box (along ITS and Lighting conduit runs containing cable), and/or from pull box to foundation shall be dimensioned.

Conduit:
- New and existing conduit inventoried and/or used in the project shall be dimensioned from edge of roadway, starting and ending point station number, and length indicated.
- Conduits should be dimensioned from pull box showing length and direction.

Fiber Cable:
- All fiber cable distance markings at the ingress and egress of No. 9 pull boxes and equipment cabinets shall be recorded in a table that references the pull boxes.
- Sequential distance markings of all cables entering and exiting each splice closure.

Any changes to any diagram or detail in the Project Plans (i.e. Communication Block Diagram, fiber splice details, etc.) shall be documented in the record drawings.

Conductor, Cable and Conductor, Pull Box and Pole schedules shall reflect any changes made, such as cable or pull box size changes, pole size/type, phase number, number of conductors, size of conductors, circuit number, size/type of signal head or mounting, sign changes, etc.

The final document submitted by Developer shall be a complete set of all plan sheets, including sheets added by Addendum or Change Order. Developer shall furnish two sets of drawings on electronic media in ADOT standard format with two 11 inch x 17 inch printed copies.

(b) Operator's Manuals:

A manual containing a general description and detailed operating and installation instructions shall be provided for each type or model of ITS equipment. One copy of each unit shall be provided for each model of equipment.

(c) Maintenance Procedures Manuals:

A manual containing detailed preventive and corrective maintenance procedures shall be provided for each type or model of ITS equipment. Step-by-step field and bench trouble- shooting procedures shall be included, as shall normative waveforms and test voltages as applicable. A detailed parts list shall be included. For each part, its circuit or pictorial identification shall be shown, as shall all necessary rating information and a manufacturer and associated model or part number. The list shall include cross-references to part numbers of other manufacturers who make the same replacement part. One copy of each unit's manual shall be provided for each model of equipment.

(d) Equipment Assembly Drawings:

A drawing showing the physical location and identification of each ITS component shall be provided for each different electronic unit and each different subassembly of each unit. These drawings may be included in the maintenance procedure manuals or they may be provided as electronic files in PDF format with two printed copies. The electronic files and two printed copies shall be provided for each distinct unit and subassembly model. Location information shall be shown on the construction record drawings**.**

(e) Cabinet and Rack Wiring Diagrams:

In addition to the diagram stored in the field cabinet, a wiring diagram shall be provided for each type of cabinet, equipment rack, and junction box containing wire terminals identified by location. The wiring diagram shall depict actual, installed conditions. If the diagrams are in manual form, six manuals shall be provided for each distinct cabinet and equipment rack. Drawings shall be furnished on electronic media in PDF format with two printed copies. Separate drawings and copies shall be provided for each distinct type of cabinet, rack, and junction box. If the same diagram serves more than one location, it shall be labeled with all appropriate locations and a copy provided for each location. If a set of drawings is provided, each depicting more than one location, a separate drawing on electronic media in PDF format with two printed copies shall be included that shows a cross-index by location and drawing.

Developer shall provide one cabinet wiring diagram and fiber optic splice diagram for each control cabinet, labeled with the location name and cabinet number, provided in a weatherproof holder mounted within each control cabinet.

(f) System Connection Diagrams:

Connection diagrams for the entire ITS system, including block diagrams, terminal numbers, IP addresses, and conductor color codes for the work performed by Developer, shall be cross-referenced to correlate with plan's wiring diagrams and shall be attached thereto. The diagram shall include field conduits, boxes, detectors, etc. Developer shall furnish the drawing on electronic media in PDF format with an additional two printed copies of each drawing.

(g) Fiber Optic Splices and Splice Closures:

Developer shall prepare documentation identifying the location and fiber color codes for each field splice performed by Developer. In addition to storing a drawing in each field cabinet, a fiber assignment drawing shall be provided to the Independent Quality Firm for each splice closure throughout the project. A drawing on electronic media in PDF format with an additional two printed copies of each drawing shall be furnished.

(3) Documentation Formats:

Except for standard bound manuals, all standard letter size documentation shall be bound in logical groupings in loose-leaf 3-ring binders. Each bound grouping of documentation shall be permanently and appropriately labeled. No documentation shall be smaller than standard letter size.

All documentation, including that documentation which exceeds standard letter size, shall be furnished on electronic media in ADOT standard format with an additional two printed copies. Developer shall provide a separate drawing of the cabinet wiring diagram for each control cabinet, labeled with the location name and number, even though some of the cabinets may be wired identically. All drawings shall be standard half size (unless otherwise approved by the Independent Quality Firm in each instance). Drawings larger than standard letter size but smaller than standard half size shall be placed in the lower right-hand corner of a standard half size sheet.

One print of each schematic diagram, cabinet wiring diagram, and fiber optic splice diagrams applicable to each control cabinet and equipment rack and the equipment in them shall be provided in a weatherproof holder mounted within each cabinet or rack for easy access. One weatherproof print of each wiring diagram applicable to each junction box shall be provided in each junction box. The cost of these prints, the weatherproof holder, and their installation shall be included in to the cost of the units in which they are installed.

Developer shall furnish all software manuals, flowcharts, printed tables, charts, and program listings in standard letter size 3-ring binders. All software source code shall be furnished in duplicate on CD or DVD ROM compatible with ADOT's computer system.

For purposes of record drawing documentation, fiber optic cable connection and splicing documentation shall be treated in the same manner as that for electrical wires and cables.

SECTION 748 FIELD HARDENED ETHERNET SWITCH:

748-1 Description:

Developer shall furnish and install Field Hardened Ethernet Switches at designated locations as shown on the plans and these Project Specifications.

748-2 Materials:

Provide all Field Hardened Ethernet Switches of the same manufacturer. All equipment shall be new and in strict accordance with the details shown on the plans and in the specifications. All Field Hardened Ethernet Switches shall be fully compatible with the existing ADOT Network Management System (NMS) server. Developer shall demonstrate, to the Inspector, the compatibility of the Field Hardened Ethernet Switch before the material submittal can be approved by the Independent Quality Firm.

Provide a high-performance and field hardened Field Hardened Ethernet Switch supporting standard Open System Interconnection (OSI) Layer 2 functionality. Provide a Field Hardened Ethernet Switch that supports direct connectivity to existing networks configured in ring and mesh fault tolerant topologies enabling applications to operate reliably and with low latency.

Include all equipment licenses, where required, for any software or hardware in the system.

Comply with the following standards for all Field Hardened Ethernet Switches furnished, assembled, fabricated, or installed under this item:

- IEEE 802.1d- Spanning Tree Protocol
- IEEE 802.1d- MAC Bridges
- IEEE 802.1p -Class of Service
- IEEE 802.1q- VLAN Tagging
- IEEE 802.1w- Rapid Spanning Tree Protocol
- IEEE 802.1x- Port Based Network Access Control
- IEEE 802.3- 10BaseT
- IEEE 802.3u -100BaseTX, 100BaseFX
- IEEE 802.3x- Flow Control
- IEEE 802.3z-1000BaseLX
- IEEE 802.3ab- 1000BaseTX
- IEEE 802.3ab- Link Aggregation
- IEEE 802.3af-Power Over Ethernet
- RFC768- UDP
- RFC783 — TFTP
- RFC791 —IP
- RFC792- ICMP
- RFC793 — TCP

- RFC826 – ARP
- FRC854 – Telnet
- RFC894 – IP over Ethernet
- RFC1112 -IGMP v1
- RFC1519- CIDR
- RFC1541- DHCP (client)
- RFC2030- SNTP
- RFC2068- HTTP
- RFC2236 – IGMP v2
- RFC2284 – EAP
- RFC2475- Differentiated Services
- RFC2865 – Radius
- RFC3414- SNMPv3-USM
- RFC3415- SNMPv3-VACM

Provide all Gigabit Ethernet Switches with a physical design that conforms to the following requirements:

- Shall be configurable in point-to-point, daisy-chain, ring, and mesh topologies for connectivity into new and existing fiber optic and copper based Ethernet networks.
- Designed with an operating system that allows individual ports to be configured for port mirroring, speed, duplex, auto-negotiation, and flow control. The operating system shall also provide for broadcast storm frame filtering with user defined thresholds.
- Designed with an operating system that allows for the collection of statistics on a per port basis and provides for full support of Remote Monitoring (RMON) statistics, history, alarms, and event groups.
- Shall be capable of providing port security to prevent unknown devices from gaining access to the network. Unauthorized attempts to access the network shall result in the port being shut down for a definable period of time along with Simple Network Management Protocol (SNMP) trap and alarm generation.
- Shall have an operating environmental range of -40 to +165 degrees F with no fans. Provide the following functionality and features:

(A) Port Performance:

- Provide Gigabit Ethernet Single mode Fiber ports that operate at 1000 Mbps.
- Provide Gigabit Ethernet RJ-45 copper ports with auto-negotiate operation at 10 Mbps, 100 Mbps and 1000 Mbps.
- Provide external optical attenuators as necessary to support interconnectivity with close range devices upstream or downstream.

(B) Packet-Processing:

- Processing type: store and forward
- Frame buffer memory: 2 Mbit
- Switching Latency: 8 us

- Priority Queues: 4
- Virtual Local Area Networks (VLAN): 64
- Internet Group Management Protocol (IGMP) multicast groups: 256
- Switching bandwidth: 1.8 Gbps

(C) Gigabit Ethernet Network Connections:

- Two duplex SC connector ports for single mode fiber with long haul optics to meet the project requirements.
- Eight RJ-45 connector ports for copper.

(D) Network Management Software:

The Network Management Software shall be server based software with the following capabilities:

- Graphic Visualization: Display network layout in hyperbolic tree structure with management functions, overview and tracking.
- Dynamic Discovery: Ability to discover and track all wireless, roaming or fixed devices in real time.
- Real Time Monitoring: Constant monitoring of all connected devices for potential status.

(E) Power Requirements:

- 120 VAC ± 10 percent, 60 ±3Hz

(F) Mechanical:

- Enclosure: Shall be constructed from a minimum 20 gauge high strength galvanized steel case with metal mounting plates, suitable for stand-alone, shelf, rack, or din mounting. Enclosure shall be permanently and clearly identified with name, model number, serial number, and any other pertinent information required to facilitate equipment maintenance.
- Power over Ethernet: Atleast 2 ports

748-3.01 General Requirements:

(A) Documentation:

Developer shall provide certification that the Field hardened Ethernet Switches furnished and installed are in conformance with the manufacturer standard and these specifications.

(B) Warranty:

The Field hardened Ethernet Switch shall be warranted by Developer against all defects in material and workmanship in accordance with Subsection 106.13 as amended by these Project Specifications with the following additional requirement:

The warranty for the Gigabit Ethernet Switch shall include the following; that in the event of a malfunction during the warranty period, the defective unit, card, module, subassembly, or auxiliary device shall be replaced with a working unit within three working days for use while the warranted unit is being repaired.

748-4 Construction Requirements:

Minimum requirements for Developer or designated subcontractor involved in the installation and testing of the Field hardened Ethernet Switch equipment are:

- Three years' experience in the installation, testing and maintenance of Ethernet equipment.
- Two installations where an Ethernet switches were deployed and the network has remained in continuously satisfactory operation for at least two years. Developer shall submit as proof, photographs or other support documents, and the names and contact information of the operating personnel who can be contacted regarding the networks operation.

Necessary documentation of subcontractor qualifications must be approved by Independent Quality Firm prior to purchasing the field hardened Gigabit Ethernet Switch.

Installations of equipment shall be for ease of maintenance, with all component parts being readily accessible for inspection and maintenance.

Ensure that all external screws, nuts and locking washers are stainless steel. The use of self-tapping screws shall not be permitted.

Developer shall meet all applicable codes and standards requirements for all external wiring to the Field hardened Ethernet Switches. All wires and cables shall be neatly installed and secured per common practices and standards. Developer shall provide service loop at all connection points.

Developer shall provide and install one duplex single mode SC to SC Fiber patch cable for each Fast Ethernet fiber port installed in the Field hardened Ethernet Switch.

Developer shall provide and install one Category 5e patch cord for each Fast Ethernet copper port install in the Gigabit Ethernet Switch.

Developer shall coordinate with ADOT for all switch configuration information, (i.e. IP addresses, VLANs etc.), host names and other configuration settings thirty (30) days prior to installing the Field hardened Ethernet Switches.

Service loops shall be provided at connection points or components installed where they are readily accessible for inspection and maintenance.

Developer shall label the Ethernet Switches.

(A) Testing Requirements:

The Gigabit Ethernet Switch shall meet the following tests:

- **Pre-Installation Testing:**

Developer shall inspect the Gigabit Ethernet Switch upon delivery for any visual damage, inventory contents, and ensure proper functionality.

- **Subsystem Testing:**

Developer shall ensure the Gigabit Ethernet Switches, are correctly installed, configured, and are properly functioning as networked subsystem.

- **System Acceptance Testing (SAT):**

As part of the SAT Developer shall demonstrate that all Gigabit Ethernet Switches functioning and are operational for the duration of the SAT.

(B) Training Requirements:

In the event Developer submits a Field Hardened Ethernet Switch which is not currently in use by ADOT, Developer shall arrange for and provide a training course for the Field hardened Ethernet Switch equipment components. The course shall be of adequate duration to cover the subject matter and shall have an instructor competent in the technical aspects of the Field Hardened Ethernet Switch equipment. The training course shall provide training to up to 12 ADOT Engineering and Maintenance personnel.

Developer shall submit a syllabus, training materials and a schedule for the Field Hardened Ethernet Switch equipment training course to ADOT for review and approval 45 days prior to the proposed start of training. ADOT will notify Developer of acceptability within 30 days of submittal. Developer shall schedule the training no sooner than 14 days from receipt of the approved syllabus unless otherwise noted in the approval.

Training materials shall include the course outline, material describing the course, and operations and maintenance manuals with any additional information needed to adequately describe the subject being taught. Training materials shall not be copyrighted.

SECTION 749 SINGLE NODE COMMUNICATION ASSEMBLY EQUIPMENT:

749-1 Description:

Developer shall furnish, install, and test, backbone communications equipment in each Node that consists of Layer 3 10-Gigabit Ethernet Backbone switches, fiber optic termination patch panels and associated patch cords, Gigabit Single Mode Small Form Pluggable Optics modules, 10 Gigabit 1550 nm pluggable XFP/SFP+ Optics modules, and the line cards to support the optics modules as shown in the plans.

749-2 Materials:

(1) Technical Requirements:

(A) Layer 3 10-Gigabit Ethernet Backbone Switches:

Provide high-performance 10-Gigabit (Brocade ICX 6610-24F-E, 8 10-GbE ports and 24 1-GbE ports) Ethernet Backbone Switches (2 switches in each Node) with stacking performance and supporting standard Open System Interconnection (OSI) Layer 3 functionality that is compatible with ADOT's current Layer 3 switch network and Network Management System (NMS) server. Provide Ethernet Backbone Switch supporting direct connectivity to existing and new networks configured in ring and mesh fault tolerant topologies enabling applications to operate reliably and with low latency.

Include all equipment licenses, where required, for software or hardware in the system.

(B) SFP and XFP Modules:

The 25 km Gigabit Single Mode Small Form Pluggable Optics modules and the line card to support the optics modules shall be compatible with the Layer 3, 10-Gigabit Ethernet Backbone switches furnished and installed in Node.

The 40 km 10-Gigabit 1550 nm pluggable XFP optic (LC) modules and the line card to support the optics modules shall be compatible with the Layer 3, 10-Gigabit Ethernet Backbone switch furnished and installed in Node.

Developer shall contact ADOT TTG staff to obtain IP addresses for all Ethernet based equipment.

(C) Fiber optic Pre-terminated panels:

At each Node, 144 fiber termination panels shall be installed with ST type single mode fiber connectors per plans. The panels shall have supporting infrastructure to support splicing of the incoming fiber cable to the pre-terminated pigtails.

(1) Mechanical:

The fiber optic panels shall mount in a standard 19-inch rack and shall occupy no more than 4 RU of vertical space for every 144 terminations.

(D) Cabling:

Developer shall supply all required electrical and optical cabling to interconnect all modules of the node communications equipment. Developer shall also furnish duplex single-mode fiber optic jumper cables to be used at Node. These cables shall be factory terminated with ST connectors on the termination panel end and LC connectors at the 25 km Gigabit Single Mode Small Form Pluggable Optics modules and 40 km 10 Gigabit 1550 nm pluggable XFP optic (LC) modules end.

749-3 Construction Requirements:

Developer shall configure all Developer furnished network equipment in accordance with an ADOT approved IP Addressing plan. Developer shall coordinate with ADOT on switch configuration information, (i.e. IP addresses, VLANs etc.) 45 days prior to installing Ethernet Switches.

(A) Node Installation:

Developer shall furnish and install the Layer 3 switches, compatible line cards to support the 10 Gigabit modules, 1 Gigabit modules, Fiber Termination Panels, duplex jumper cables as shown in the plans for a fully functional Node Assembly System. Developer shal install compatible line cards in existing Node 16 to support the 10 Gigabit connection from Node 19.

Developer shall interconnect the equipment per the manufacturer’s instructions using the electrical and optical cables furnished by Developer.

(B) Cabling:

All cables shall be neatly routed and bundled in cable trays. Strain relief shall be utilized where necessary. Each and every cable shall be labeled on each end of the cable near the connector with an Independent Quality Firm approved label and labeling method.

(C) Subsystem Test (SST):

The purpose of the Subsystem Test Procedure is to verify that Developer-furnished and installed equipment (CCTV, DMS, and Communications) is fully functional and operating per the specifications requirements for a period of 72 hours of time without failure. ADOT shall program the new cameras into the Chameleon database. The SST for new cameras shall begin at this time.

The SST shall verify that for a 72-hour period the new cameras function without any failures of the node communications system. The main purpose of this test is to verify that when the final condition is complete, no existing FMS equipment will be adversely affected.

During the 72-hour subsystem test all camera video output will be verified acceptable to ADOT. This will be a subjective test that the passing of which is solely up to the discretion of ADOT. Camera control shall also be tested per the CCTV test procedure supplied by ADOT. If the communication to any controller fails more than 1 percent of the time in any 15 minute period, the test has failed. If any controller or camera (video or PTZ) fails during this test, Developer shall troubleshoot the system and the test rerun for the full 72-hour period.

(D) System Acceptance Test (SAT):

After successful completion of the SST, the detector circuits will be moved to the operational server and the SAT may commence.

The 30-day SAT shall be run using the ADOT supplied test procedure.

749-4 Training Requirements:

In the event Developer submits Node equipment which is not currently in use by ADOT, Developer shall arrange for and provide a training course for the equipment components. The course shall be of adequate duration to cover the subject matter and shall have an instructor competent in the technical aspects of the equipment installed in Node. The training course shall provide training to up to 12 Engineering and Maintenance personnel.

Developer shall submit a syllabus, training materials and a schedule for the Node equipment training course to ADOT for review and approval 45 days prior to the proposed start of training. ADOT will notify Developer of acceptability within 30 days of submittal. Developer shall schedule the training no sooner than 14 days from receipt of the approved syllabus unless otherwise noted in the approval.

Training materials shall include the course outline, material describing the course, and operations and maintenance manuals with any additional information needed to adequately describe the subject being taught. Training materials shall not be copyrighted.

SECTION 750 NODE BUILDING:

750-1 Description:

Developer shall furnish and install a node building, and assemblies as described in these Project Specifications and shown in the plans. The term "Node" refers to node buildings and its electronics.

The node building shall be a prefabricated, concrete structure installed at the site indicated on the Project Plans. The node shall be designed in accordance with the following codes:

- 2009 International Building Code
- 2009 International Mechanical Code
- 2009 International Energy Conservation Code
- 2008 National Electrical Code

The node building shall house backbone communication equipment and serves as the concentration point for field communications prior to being transported on the communications backbone to the TOC.

Design node building to:

- Provide physical and environmental protection to the electrical and electronic equipment inside.
- Provide physical provisions for installing of electronic equipment (i.e., contain racks in which electronics are installed).
- Provide physical provisions for installing and routing signal interconnect cables, SMFO cable, IP transmission equipment, and all other ITS equipment (i.e., provide conduit and cable troughs as necessary to facilitate equipment installation and interconnection).
- Provide a compatible environment for equipment and maintenance personnel, considering a maximum ambient outdoor temperature of 50 degrees C (i.e., provide Air Conditioning).
- Provide basic equipment and human safety through proper grounding and power conditioning.
- Include all safety provisions required by the NEC, ANSI, NFPA, Local Code, and associated standards.
- Provide remote monitoring of the equipment's security, environment, and power status to support management of the network.

750-2 Materials:

The node buildings shall provide adequate work space and ergonomics to support equipment maintenance activities. Provide the following subsystems:

- Indoor and Outdoor Lighting.
- Accessible Utility Outlets for Test Equipment.
- Standard EIA Racks with Quick Releasing, Slide-Out, Locking, and Tilting Electronic Rack Drawers.
- Power Distribution Panel with Bolt-On Circuit Breakers to serve Installed Electronic Equipment, Receptacles, Lighting, and Air Conditioning.
- Level 2 Surge Protection for Incoming Power.
- Common Grounding System for Electrical and Electronic Equipment.
- Physical Security for Maintenance Personnel Working within the Node.
- Rack-Mounted Uninterrupted Power Supply.
- (2) Air Conditioning Units with Redundant Controls.
- Wall-Mounted Drop down Technician Table.
- Door Handle Security with Key and Key FOB Entry.

(A) Documentation:

Final documentation shall conform to DBMA as amended by these Project Specifications. Developer shall provide as-installed record drawings related to rack placement, power distribution, and final building construction. Developer shall provide commercial manuals on:

- UPS
- Air Conditioned Unit (ACU)
- Surge Protection Device
- Circuit Breaker Panel board

Documentation is considered to be part of the node building.

UPS equipment shall not be considered delivered until the equipment has been operationally tested after installation and all documentation is delivered. Software required for operation and maintenance of the UPS shall be included with instructions on usage and a usage license. Furnish four copies of operation and maintenance manuals that include detailed routine maintenance requirements, troubleshooting procedures, interface drawings, and parts lists for each piece of equipment furnished.

(1) Submittals:

Developer shall provide a list of all Developer furnished material and equipment as it relates to the node building prior to fabrication. The list must include the name of the manufacturer, size, model, and all other identification numbers along with detailed equipment and building specification sheets.

Provide all Manufacturers' Documentation for all Developer furnished items. These items include the following at a minimum: factory issued manuals, software, detailed shop drawings, wiring diagrams, certifications, warrantees, instruction sheets, and parts lists. Acceptable factory manuals must contain technical, diagnostic, and maintenance (preventive and troubleshooting) information. Advertising brochures and catalog cuts will not be accepted.

Provide all final configuration information for Developer installed equipment. Submit two bound paper copies and one electronic copy in the form of a Microsoft© Excel© spreadsheet saved to a CDROM. Include all configuration parameters for each device. Include device location, make and model number, serial number, date of installation, Vendor, and vendor contact information, and warrantee expiration date. Developer shall provide the following submittals for approval as related to the node building:

- Cut sheets of the equipment.
- Power and air conditioning load analysis.
- Rack arrangement and compatibility with floor load capacity.
- Power distribution and grounding diagrams and schematics.
- Final node building structural drawings.

(B) Node Building:

Provide the following for the node building installation as specified.

(1) Design Criteria:

Arizona State Requirements:

Design Code:	Building Code	2009 IBC
	Electrical Code	2008 NEC
	Mechanical Code	2009 IMC
	Concrete Structural Code	ACI 318-08

Building Code Design Data:

Occupancy Class	S2
Construction Type	V(B)
Occupant Load	I
Occupancy Category	III

Wind Design Data:

Basic Wind Speed	100 mph
Importance Factor	1.15
Exposure Category	C

Earthquake Design Data:

I_E	1.25
S_S	2.5
S_1	0.85
S_{DS}	1.67

S_{D1}	0.85
Site Class	D
Design Category	E
Seismic Force Resisting System	Special Shear Wall
C_S	0.25
R	5
Analysis Procedure	Equivalent Lateral Force

Roof Snow Load:

P_f	65 psf
P_g	70 psf
C_e	1.0
I_s	1.1
C_l	1.2

Concrete Material Specifications:

Concrete	F'c = 4,000 psi @ 28 days
Concrete Density	100 pcf
Rebar	ASTM A-615 Grade 60
Mesh	ASTM A-496 and A-497
Steel	ASTM A36 or A992
Steel Bolt	ASTM A325
Welding	E-70XX Electrodes

Interior Finish Specifications:

Wall/Ceiling	30 mil FRP on 1/2" moistureboard
Wall Flame Spread	ASTM E84 Class C
Structural Floor	Bare Concrete
Raised Floor	Anti-Static tile on removale floor panel

(2) Location and Foundation Requirements:

The building location shall comply with all applicable local codes and ordinances, and shall be as shown on the plans.

The building is to be located a minimum of one-third the height (40 ft maximum) away from downslopes greater than 3:1, and one-half the height (15 ft maximum) away from upslopes greater than 3:1.

Do not locate the building over subsurface utilities, tanks, or similar objects.

A geotechnical engineer should evaluate the effect of a high water table or any other unusual soil conditions.

The soil around the building shall be sloped away 1/8 inch per foot minimum for a minimum of 5 feet.

The building shall be placed on a foundation and anchored as shown on the drawings.

(3) Concrete and Steel:

All concrete work shall conform to ACI 318 building code requirements for reinforced concrete and shall have a minimum 28-day compressive test strength of 4000 psi.

Reinforcing steel bars shall be Grade 60 and compliant with ASTM A615. All steel fabrication and installation shall be done in accordance with the *American Institute of Steel Construction Manual and Specifications.*

Welding shall be coated with a corrosion inhibiting chemical. All steel shall be hot dip galvanized per ASTM A123 specifications after fabrication. All bolts shall be galvanized per ASTM A325 specifications for high strength bolts. All exposed hardware shall not corrode in an air and water environment with a high salt content.

(4) Node Building Dimensions:

The minimum inside dimensions of the node, after installation of the insulation and raised floor system, shall be as per the plans. The building shall contain one entrance door of standard dimensions suitable to install equipment racks with a sloping walkway and steps to enter the node building.

(5) Prefabricated Floor, Walls, and Roof:

The node building shall be constructed of factory-assembled, panelized concrete with the following minimum specifications:

- Concrete: Portland cement Type I or II with a 28-day compressive strength of 4000 psi.
- Concrete floor, walls, and roof panels shall be factory-assembled by weld or bolt connections. Welds shall conform to American Welding Society Code; if bolted, assembly shall use high-strength bolts, plates, and cast-in threaded sockets.
- Roof shall be supported by walls on four sides and pitched to the rear of the building to provide drainage.

(6) Raised Floor System:

Floor construction shall consist of a structural steel tube perimeter frame with W-section beams placed in such a manner as to support equipment rack installation (i.e., per Developer's floor plan).

The perimeter frame shall be bolted together and hot dip galvanized. The beams shall support a minimum floor loading of 250 psf or as required by equipment cabinet floor loading. The W-section beam floor shall provide for removable floor panels that cover all wiring to and from the equipment racks. The bottom side of the floor shall be protected by a totally sealed, galvanized, belly pan insulated with 3-3/8 inches of board insulation and topped with two layers of structural plywood to accommodate the required floor load. The plywood shall be APA Structural I, finished and sanded on both sides. The two plywood sheets shall be glued together with an exterior glue of an approved quality. All plywood sheets shall be rigidly fastened at all edges and support points with a metal bracket securing the top and bottom layer of the plywood.

All plywood joints shall be supported rigidly. A 5/32 inch, mottled-vinyl, composite tile floor covering shall be glued to the plywood after the plywood has been floated and sanded to provide a smooth and level surface. The floor covering shall be chemical-resistant and anti-static electricity discharging. The floor tile shall coordinate with both interior and exterior colors.

(7) Waterproofing, Sealants, Insulation, and Painting:

The node building wall exterior shall be waterproofed with a penetrating chemical sealer. All exterior connections below grade shall be waterproofed and protected against corrosion with an approved bituminous sealant. All node building joints shall be sealed inside and outside with a high grade polyurethane sealant impervious to weather and temperature changes.

The ceiling, walls, and door shall be foam-insulated with walls and ceiling rated no less than R-20. The roof shall have a liquid roof membrane that reduces heat transfer and prevents water absorption. Exterior walls shall be painted Desert Tan - Textured. The door finish shall be painted beige and the roof finish shall be Solar Magic Elastomeric Coating.

(8) Node Building lighting:

The node building interior shall have a flat insulated ceiling including a minimum of 3 surface-mount linear strip luminaires with diffusers. Luminaires shall be equipped with a diffuser, integral driver, and LED emitters that deliver 4000 lumens. Select luminaires for a nominal 4000K CCT. Luminaires shall be controlled by a single wall-mounted switch located for easy access from the entrance. Exact location of the ceiling mounted fixtures shall be determined by Developer based on his final equipment installation. Fixture placement shall be based on best visibility for maintenance operations. In addition, the luminaire located closest to the door shall be equipped with a self-contained, rechargeable batteries that delivers a minimum of 1500 lumens for 60 minutes after loss of primary power. The emergency lighting shall automatically activate upon loss of power. Battery life of the emergency light shall be a minimum of eight years based on normal power outages.

Building exterior shall be equipped with an LED wall-mount luminaire surface-mounted adjacent to the node door. Exterior luminaire shall deliver 1500 lumens and be equipped with a photocell control and motion detector to activate upon physical approach to the node building door.

(9) Node Building Door:

The door shall be constructed of 18 gauge galvanized steel with a 16 gauge frame, full flush, 1.5-hour fire-rated, windowless, and painted to match exterior and interior. The door's height and width shall be designed compatible with the measured size of the equipment rack to be installed inside the node. Minimum dimensions shall be 84 inches in height and 36 inches in width. The hinges and other exterior hardware shall be stainless steel or other acceptable corrosion-proof material. The hinges shall use flush-type, non-rising pins with concealed set screws for security against vandalism. The door shall include a neoprene gasket which, when closed, effectively prevents the entrance of air, blowing sand, dust, and water. A weather strip shall be provided at the bottom of the door. A gradually sloping ramp shall be provided for installing equipment. The slope shall be compatible with rolling equipment carts to support installation of equipment.

The door lock shall be of a non-corrosive material. The door shall contain a heavy duty electric door strike and a keyed handle lock. An oversized steel plate shall be installed on the outside of the node building door to cover the gap between the door and the frame preventing access to the electric door strike and door latch. The mounting hardware for the steel plate shall not be accessible from outside of the node building. The electric door strike shall be integrated with the node Access Control System. The door shall be capable of being opened from the outside two ways; using the door handle key and a key FOB. The door shall be capable of being opened from the inside without the use of a door handle key or key FOB.

(10) Node Building Maintenance Accommodations:

The node building shall be designed, laid out, and air conditioned for occupancy by two maintenance technicians. Node rack design, location, and equipment installation shall consider the access needs and convenience of maintenance personnel, including but not limited to the following:

- Access to utility outlets for test equipment.
- Resetting the power distribution strip's circuit breakers.

The UPS control/status communication panel shall include front panel indicators and controls to support operation, maintenance, and testing of the unit. The UPS shall include an ethernet communication port supporting diagnostics via interconnection with a maintenance notebook computer. MTBF estimates shall be furnished for each major part of the UPS.

(a) Access Control System:

The Access Control System (ACS) provides secure access to the node building by requiring a key FOB or door handle key in order to open the node building door. The ACS also creates a time/date stamp log entry every time a key FOB is used to release the electric door strike.

The ACS shall meet the following requirements:

The ACS hardware and software installed in the node buildings shall be compatible with and integrated into the existing HONEYWELL ACS used at the ADOT Traffic Operations Center (TOC) which consists of the following items:

- Model PR0221C
- Model PR022EN
- Model PR022R2
- Model PR022ENC3
- Model OMN140 Proximity
- SENTROL 107BC
- BOSCH DS1501
- Intelligent Control Module Ethernet interface board Dual Reader Board Enclosure and power supply FOB reader

Provide proximity type key FOB access system to the node building door with compatible electrically controlled electric door strike.

The proximity FOB reader shall be weather proof and mounted to the exterior of the node building using tamper proof hardware.

All software required for remote operation, programming, and upload/download operation shall be provided. Software provided shall be compatible with a PC running Windows software.

The electric door strike shall revert to a locked position in the event of a power loss or malfunction. The electric door strike shall not require more than seven watts of power to activate.

The door handle on the inside of the node building door shall allow persons inside the node building to exit when the electric door strike is engaged in the locked position without requiring the use of a key FOB or door handle key.

The FOB key system shall accommodate a minimum of 1000 access FOBs each with a unique ID identifying the FOB to the controller and shall log all entries into the node building identifying date, time, and FOB key that activated the door release. Developer shall supply 50 access key FOBs with unique ID numbers as part of the documentation for the ACS.

The system shall have sufficient non-volatile memory to store a minimum of 500 log entries.

The controller shall have remote programming and log retrieval capability using the Ethernet backbone network.

(11) Node Building Electrical:

The node building electrical requirements shall meet the following specifications:

(a) Wiring:

Developer shall provide all electrical wiring, power distribution, grounding, and power quality provision required to install, operate, and test the equipment from the utility feed site to the power inputs of all equipment and electrical/electronic apparatus housed at the node. All power cabling shall comply with current NEC requirements. Grounding commonality with commercial utility power shall be provided. Grounding shall comply with current NEC and IEEE 1100, "Recommended Practice for Powering and Grounding Sensitive Electronic Equipment."

(b) Power Distribution:

Power distribution provided by Developer shall include but not be limited to:

- From the ADOT power panel located nearby to the pad-mount transformer serving the node shelter.
- From the pad-mount transformer to the distribution panel board located inside the node building thru the node building main disconnect switch.
- From the main distribution panel board via circuit breakers to each rack mounted UPS and other node power circuits.
- From each rack mounted UPS power outputs to each node equipment rack Switched Power Distribution Strip(s) (SPDS).

(c) Load Center Power Interface:

Developer shall provide, install, and test a 480:120/240 VAC transformer and 120/240 VAC, single phase, 60 Hz, three wire configuration to the node's main distribution panel board from the nearby ADOT distribution panel through the pad-mounted transformer. Two unground conductors, one neutral, and one grounded conductor shall be run through conduit from the pad mounted transformer adjacent to the node building through the building wall into the main distribution panel. Two underground conductors and one grounding conductor shall be run through conduit from the nearby ADOT Load Center to the pad mounted transformer adjacent to the node building.

The interface shall include an exterior mounted electrical fusible disconnect. The conductors shall be sized so as not to drop more than 5 percent of the main supply voltage under full load, but not smaller than #4 AWG.

Developer shall coordinate the interface with the nearby load center power interface with SRP.

(d) Power Distribution Panel Boards:

The panel boards shall be located on an inside wall of the node building. All breakers shall be sized to accommodate Developer-selected equipment.

Panel board Interior:

The panel board shall be rated for 120/240 VAC and a continuous main current rating of 125 Amperes. Provide lug-only main. Panel bus and circuit breakers shall be fully-rated for 10,000 AIC.

Provide one continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors suitable for bolt-on branch circuit breakers. The bussing shall be fully rated. Panel board bus current ratings shall be determined by heat-rise tests conducted in accordance with UL 67. The bus shall be copper.

Panel shall be equipped with segregated grounding and insulated neutral terminal strips.

Interior trim shall be of dead-front construction to shield user from energized parts. Provide pre-formed closeout plates for each unused circuit breaker space.

Nameplates shall contain system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, UL listed label and short circuit current rating shall be displayed on the interior or in a booklet format.

Interiors shall be field convertible for top or bottom incoming feed.

Branch Circuit Breakers:

Circuit breakers shall be UL listed with amperage ratings, interrupting ratings, and number of poles as indicated on the Project Plans.

Molded case branch circuit breakers shall have bolt-on type bus connectors.

Circuit breakers shall have an toggle mechanism that will provide quick- make, quick-break contact action and trip-free characteristic. Circuit breakers shall have thermal and magnetic trip elements in each pole. Two-pole circuit breakers shall have common tripping of all poles.

The breaker handle shall reside in a position between ON and OFF as a visual trip indicator.

The exposed faceplates of all branch circuit breakers shall be flush with one another. Lugs shall be UL listed to accept solid or stranded copper and aluminum conductors.

Panel Board Enclosures:

The panel board enclosure shall be rated NEMA Type 1. Enclosures shall be constructed in accordance with UL 50 requirements. Enclosures shall be painted with ANSI 49 gray enamel electrodeposited over cleaned phosphatized steel.

All doors shall be equipped with a tumbler-type vault lock and two additional trunk-type latches. All lock assemblies shall be keyed alike. Two keys shall be provided with each lock. A clear plastic directory card holder shall be mounted on the inside of door.

Panel Board Installation:

Install panel boards in accordance with manufacturer's written instructions, NEMA PB 1.1, and NEC standards.

Anchor panel boards to structure and make branch circuit connections.

Inspect complete installation for physical damage, proper alignment, anchorage, and rounding.

Maintain proper phasing for multi-wire branch circuits.

Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications.

Switched Power Distribution Strip (SPDS):

The SPDS is a switched multi-receptacle power strip used by the High Temperature Switch to remove power from the equipment racks in the event of a high ambient temperature condition inside the node building.

The SPDS shall be connected to the Over Temperature Switch and shall remove AC power from the equipment rack when the Over Temperature Switch detects an ambient node temperature that is higher than the safe operating temperature of the equipment installed in the node building. Developer shall install a sufficient quantity of SPDS to provide power to all the equipment installed in the equipment rack(s) while maintaining a minimum of one spare receptacle per SPDS and maintaining a maximum load of 16 amps on any individual SPDS circuit.

The SPDS shall meet the following minimum requirements:

- Outputs rated for 120VAC, 20 Amp, 60Hz
- 19 inch Rack mounted requiring not more than one RU of vertical rack space
- Minimum of eight NEMA 5-20R receptacles per SPDS Over Temperature Switch:

The Over Temperature Switch monitors the ambient temperature inside the node building and shuts down power to the equipment racks via SPDS when the temperature exceeds a preset limit and turns the power back on when the node building temperature returns to normal. The over temperature switch shall be connected to the communications backbone network via the 10 gigabit Ethernet backbone switch in the node building. The Over Temperature switch shall be compatible with and integrated with the existing American Power Conversion (APC) NetBotz 500 equipment in the TOC.

The Over Temperature Switch shall meet the following requirements:

- Temperature measurement range - 25 degrees F to 150 degrees F
- 19 inch rack mounted
- Programmable turn on and off temperature settings
- Remote temperature sensing probe
- Connection to SPDS using industry standard connectors and cables
- Illuminated Status indicators
- Remote monitoring of Over Temperature Switch operation and remote monitoring of all connected sensors and SPDS via Web browser and/or a client console application running on a Windows based PC

The Over Temperature Switch shall be supplied with the most recent version of APC Corporation's InfraStruXure Central system management and configuration software with a 25 device license (minimum). The Developer shall install and configure the software on an ADOT furnished PC in the TOC.

(e) Surge Protection Device (SPD):

Developer shall furnish, install, and connect a SPD suitable for protection of service voltages of 240/120 VAC, single phase, three wire. By definition, the term SPD describes the equipment necessary for the protection of all AC electrical circuits from the effects of lightning induced voltages, utility substation switching transients, and internally generated switching transients resulting from inductive and capacitive load switching.

Provide SPD that conforms to Level 2, UL 1449 (3rd edition) and ANSI/IEEE C62.41, Category B. SPD enclosure shall conform to NEMA 4X.

Install SPD adjacent to the node building service entrance switch. Connect SPD to each phase and neutral on the safety switch secondary with no smaller than #2 AWG XHHW conductor.

Install SPD in accordance with the manufacturer's printed instructions to maintain warranty. No testing shall be required.

(f) Uninterruptible Power Supply (UPS):

Developer shall supply the node building with rack mounted uninterruptible power supply (UPS) with integral battery backup. Developer shall be responsible for the furnishing, construction, installation, integration, and testing of the UPS and battery backup equipment for the node building.

An exterior warning placard adjacent to the door shall provide a warning regarding the lead acid batteries contained within the UPS. Developer shall submit proposed wording to the Independent Quality Firm for approval prior to fabricating the placard.

The UPS shall include ancillary devices including integral batteries, cabling, electrical feeders, recharging devices, monitoring circuits, power panels, breakers and automatic power switchover devices to provide uninterruptible conditioned power.

Developer shall install UPS and battery backup equipment to provide conditioned, continuous, intelligent power failure protection for a wide range of equipment used in the node building.

One rack mount UPS shall be provided for each rack installed in the node building.

UPS and Batteries

The UPS and battery backup equipment shall meet the required amperage capacity, discharge time, and recharge requirement necessary to sustain operations of the Node Building rack mounted equipment.

The batteries shall consist of a maintenance free gel type battery, which require no addition of water or electrolyte, or other electrolyte maintenance.

The batteries shall have a flame-retardant polypropylene case and cover.

The batteries shall have a thermally welded case-to-cover bond to eliminate leakage. The batteries shall have a minimum 5-year life expectancy.

The batteries shall provide sufficient capacity to supply power to the associated equipment at maximum power draw for a minimum of four hours without recharge, upon loss of commercial AC power.

The UPS/battery charger shall provide sufficient capacity to fully recharge the discharged batteries within 24 hours after restoration of AC power.

The UPS shall provide intelligent charging (taper or step-rate taper charging) so that long term connection to the associated batteries does not result in overcharge and damage to the batteries.

The power supply shall charge the battery rapidly until within 0.5 Volts of full charge, and then change to a reduced rate of charge to protect the battery.

After fully charging the batteries, the charge current shall be no more than the capacity divided by 200.

Developer shall install a new UPS system with cabinetized (no external batteries). The new system batteries shall be proven to be capable of providing four minutes of uninterrupted power for a 1425W/1440VA load.

The UPS system shall meet or exceed the following requirements:

- Input voltage: 120 single-phase, 60Hz
- Output voltage: 120 single-phase, 60 Hz
- Output Power Capacity: 1425 Watts/1440VA
- Four minute battery backup at full load
- Mounted in an EIA-3100 19-inch rack
- Require not more than two RU of vertical rack space
- RS-232 communications diagnostic and configuration port
- Computer room rated performance
- Cabinetized batteries
- On-line efficiency: 90 percent minimum

Automatic Bypass Switch

An automatic bypass switch shall be furnished and installed to allow servicing of the UPS without removal of power from the load and to switch power from the UPS conditioned power to the utility supplied power in the event of a failure of the UPS.

One automatic bypass switch is required to be installed in the node building and connected to the 10-Gigabit Ethernet Backbone Switch, utility power feed, and the UPS servicing the switch. The UPS power feed shall be the primary power source and the secondary source shall be the utility power feed.

The automatic bypass switch shall meet the following minimum requirements:

- Input voltage: 120 single-phase, 60 Hz
- Output voltage: 120 single-phase, 60Hz
- Output Power Capacity: 1425 Watts/1440VA
- Mounted in an EIA-310 19 inch rack
- Require not more than one RU of vertical rack space
- Switch over to the secondary power source when the voltage of the primary power source is outside the range of 100 to 130 VRMS

Switching between primary and secondary voltage sources shall not take longer than 3ms after the detection of the out of range voltage condition

Installation of all specific UPS system components shall meet the requirements of the individual systems with which they interface.

The Developer is responsible for all permits, paperwork, licenses, etc. Required to coordinate and arrange the necessary utility installation.

All installations shall be in full compliance with the latest rev1s1on of National Fire Protection Association (NFPA)-70 and National Electric Code.

All installations shall be performed in accordance with the latest federal, state, county, and local seismic requirements for the Phoenix, Arizona region.

(g) Grounding and Bonding:

The grounding design for all node equipment shall accomplish at a minimum the following:

Personnel and equipment protection from electrical hazards, including lightning, in compliance with the NEC.

A common grounding system for all electrical and electronic equipment. Prevent voltage potentials in the grounded power conductors of node equipment. Provide a single point grounding system for all equipment, enclosures, racks, drawers, assemblies, and subassemblies (i.e., chassis/rack) at each node site.

Prevent static charge accumulation that could promote electromagnetic interference or constitute a shock hazard to personnel.

Protection against electromagnetic waves of a frequency and field strength that could interfere with the normal operations of communications equipment and high speed logic operating at frequencies up to 2.5 GHz.

Provide a fault current-to-ground path.

Safety considerations shall require the chassis or enclosures for electrical equipment to be grounded to minimize shock hazards to personnel. Proper grounding methods shall be implemented to minimize any noise voltage generated by currents from two or more circuits flowing through a common ground impedance and to avoid creating ground loops susceptible to magnetic fields and differences in ground potential.

All equipment provided shall conform to the requirements of Bellcore TR- NWT-001089

(Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunications Equipment). Similarly, Bellcore TP 77355 and IEEE 1100 apply. Developer shall provide and implement all node grounding necessary, both internally and externally, to accommodate the associated power and lightning protection systems.

(i) Node Building Air Conditioning:

The node building shall be equipped with redundant air conditioning units (ACU). Each ACU shall have an energy efficiency SEER rating of 11 or greater and shall be sized to provide cooling to the electronic equipment installed in the node. Developer shall size the ACU based on the heat load of the equipment installed in the node, plus at least 100 percent for future node loads. In addition to the heat load of the node equipment, Developer shall also include in the heat load analysis any heat dissipated by utility lighting, test equipment, ACU, UPS battery charging, heat dissipated by up to three maintenance personnel, and any other potential heat generators. In the heat analyses, Developer shall consider utility power use and facility manning to be intermittent for durations of up to 12 hours. The ACU shall be sized to adequately cool the facilities with only one ACU in operation while:

- Maintaining the interior temperature of the node between 50 degrees F and 86 degrees F independent of ambient outside temperature. No heating unit shall be required.
- Recovering from a five-minute period with the node doors open to normal ambient room temperature in no longer than five minutes.

Developer shall supply the ACUs with an automatic controller. Should one ACU fail, the redundant ACU shall be automatically activated by the controller. The air conditioning controller shall provide lead – lag operation (i.e., swap/reassign the primary and redundant ACU functions). The air conditioning controller shall ensure that only one ACU to be activated.

Thermostatic control shall be adjustable over a minimum range of 65 to 85 degrees F. Design temperatures for sizing ACUs shall be:

- Lead Thermostat Setpoint: 72 degrees F
- Lag Thermostat Setpoint: 75 degrees F

Not including heat dissipation of the UPS, heat load shall be 300 watts per rack.

(j) Node Building Equipment Racks:

Developer shall provide all node equipment racks and accessories. All electronic equipment, cross-connects and patch panels, and any permanently installed test equipment shall be installed in electronic equipment racks compliant with EIA-310-D 19-inch racks. Each of the racks shall include the following:

- Switched Power Distribution Strip(s) for equipment AC power.
- Quad convenience outlet fed from the main distribution panel.
- Provisions for installing cables without interference with installed electronic chassis.
- Standard chassis mounting provisions.

The racks shall not have sharp edges or corners. All racks shall be of a similar design and physical dimension and from the same manufacturer. Rack width shall be as required to accommodate 19-inches panel and chassis mount equipment and shall be at least 6 feet in height. Developer shall supply three equipment racks in the node building under this project; however, the node building shall be designed for and wired for an additional rack for future equipment mounting. In no case shall Developer compromise ergonomics of the equipment installation by using fewer racks than are required to properly accommodate the equipment selection.

Drawers for Electronic Chassis Installation:

Electronic drawers and chassis shall be mounted in racks using drawer slides that are locking and tilting. A 2:1 safety margin shall be used.

Electronic equipment (i.e., optical patch panels and electrical control panels) that do not have enough depth to support slides and are lightweight (less than 10 lbs) may be hardmounted to the rails of the rack provided that: at least four attachments are used (i.e., two per side) to ensure secure equipment mounting within the cabinet and the front panel is capable of supporting the equipment weight when directly connected to the rack rails.

Quick release, locking-type fasteners are to be used where possible.

Small electronic devices not suitable for rack mounting shall be mounted in a manufacturer provided electronic drawer. Where a drawer is not available, Developer shall mount equipment on a pull-out (on slides) drawer.

Power Distribution Strips:

Each rack shall be installed with a 120 VAC quad convenience outlet. Each quad convenience outlet shall have its branch feeder circuit conductors protected by a 20- amp, single-pole circuit breaker rated for 120 VAC service. Each equipment rack shall have one or more Switched Power Distribution Strip (SPDS) (i.e., quantity as required per rack population) for rack equipment power distribution. Each strip shall be mounted horizontally on the bottom of the rack or vertically along either side of the rack. Interconnection of rack mounted FMS equipment to the power strips shall be such that enough cable slack is included to allow full extension of the equipment chassis drawer during maintenance operations. The SPDS shall have their branch circuit feeder conductors interconnected to the UPS. All cabinets shall include an electrical ground strip. IEEE 1100 "Recommended

Practice for Powering and Grounding Sensitive Electronic Equipment" shall be met; IEEE 241 "Recommended Practice for Electrical Power Systems in Commercial Buildings" shall be used as a guideline. Developer shall also comply with the requirements of the current release of the NEC.

Cable Routing:

All cables shall be distributed to associated interconnect drawers from the opposite side of the racks as that used for power cable distribution. Cables between racks shall be run from one rack to the bottom of the rack, through the sub-floor, and to the next rack.

In no case shall a cable be connected between racks in such a manner as to interfere with the normal operations or maintenance of either an electronic chassis drawer or a panel. All cabling shall be vertical along the side of the rack inside vertical cable management channels and then extended horizontally to the associated chassis connector through horizontal cable management channels. Cable ties and strain relief shall be used to assure a neat and maintainable cable installation.

Vertical Cable Management Channels:

Vertical Cable Management Channels shall meet the following requirements:

- Mounted on the side of a 19inch EIA-31OD standard rack
- Plastic fingers to protect and route cables
- Nominal depth of four inches
- Nominal height of 72 inches
- Nominal width of 3-1/2 inches

Horizontal Cable Management Channels:

Horizontal Cable Management Channels shall meet the following requirements:

- Rack mounted in a 19inch EIA-3100 standard rack
- Require not more than two RU of vertical rack space
- Plastic fingers to protect and route cables
- Pass through holes
- Hinged cover
- Nominal depth of 12inches

(12) Wall Mount Technician Table:

The node building shall be furnished with a wall mounted drop down technician table. The technician table shall be securely mounted to the inside node building wall and shall not be in conflict with any equipment when fully extended.

The Technician table shall conform to the following requirements:

- Nominal dimensions of 48 inches long by 30 inches wide (extending from node building wall).
- Table made from 22 gauge polished stainless steel.
- Brackets attached to node building wall with quick-release tab for folding.
- Less than 2 inch protrusion from node building wall when table is collapsed.
- Safety locking brackets with quick release, 85 lb. capacity.

750-5 Construction Requirements:

(A) General Requirements:

Developer shall prepare the ground, provide the foundation, and construct/assemble the node building. The node building shall be constructed as shown on the Project Plans and in accordance with these Project Specifications. Developer shall install conduit, lighting, air conditioning, power distribution, and racks in accordance with the Project Plans and specifications.

Prior to working in node building, Developer shall coordinate node building access with ADOT at least 72-hours prior to entry. This pre-work notification is required for each entry into the node building.

(B) Testing Requirements:

It is the policy of the Department to require performance testing of all materials and equipment not previously tested and approved. Subsection 105. as amended by these Project Specifications shall apply. Developer shall test all power distribution, power control, air conditioning and alarms.

(1) Stand-Alone Tests:

As part of the node building stand-alone tests, Developer shall verify proper construction and operation of the following units or systems;

- Electrical power distribution and grounding
- All circuits annotated
- Thermostatic control of air conditioners
- Redundant air conditioner operation
- Over temperature equipment power shut-down
- Emergency lighting
- Access control system
- UPS operation
- CCTV Camera and monitoring equipment

Developer shall also be required to perform a walk through inspection with the Independent Quality Firm to verify that the building is constructed as per the Project Plans and Project specifications, (i.e. Correct lighting fixtures, removable floor panels with edge protection, proper grading for drainage, security door hinges).

(2) Subsystem Test (SST):

As part of the node building SST, Developer shall verify proper operation of the access control system from the TOG.

(C) Installation Requirements:

(1) Human Safety:

All node equipment shall comply with all commercial safety standards for electronic equipment and shall not contain any sharp edges. Power input requirements (i.e., voltage and current) shall be marked clearly on all node equipment. All power interconnections shall be protected against inadvertent contact by maintenance personnel. The power-on control switch of all node equipment shall be easily accessible by a maintenance technician. No cabinet shall include any exposed voltage above 24 Volts or exposed current above 100 mA. Protective covers shall be provided where required to prevent inadvertent power terminal contact by equipment technicians. Safety markings shall be included for any protective covers over high voltage and high current terminals. Handling instructions shall be clearly marked on all the sizable node equipment.

National Electrical Safety Code applies, as does Bellcore TR-NWT-001089 for electrical safety. Requirements of OSHA CFR-29, 1910.335 shall be met as applicable to equipment, as does UL 1950 for shock and fire hazards.

(2) System Safety:

All equipment shall comply with FCC requirements for 47 CFR, electromagnetic compatibility, Part 18 for Class A equipment. Operating node equipment in an electronic equipment cabinet with other data processing and communications equipment complying with FCC requirements shall not cause interference with other equipment. Similarly, Bellcore TR-NWT-001089 electromagnetic requirements shall be met. The node shall include protection against surges in its communications and power interfaces in accordance with IEEE Standard C62.36. Shorting or opening an interface shall not cause permanent damage to an interface circuit. Lightning protection for all copper signal circuits shall be provided. Interface circuits shall be designed and installed to automatically recover from open or shorted conditions. Connector keying shall be used where damage to a component could occur if connected improperly. Where connector keying is not possible, color coding is required. Resetting circuit breakers shall be used for power protection. All connectors and cables shall be clearly marked. Similarly, all indicators and controls shall be clearly and accurately marked as to function. Circuits shall be designed and installed so that the failure of any single circuit does not propagate and cause failure of other node equipment circuits.

Power input requirements (i.e., voltage and current) shall be marked on the UPS case. All power interconnections shall be protected against inadvertent contact by maintenance personnel. Operating the UPS in an electronic equipment environment with other data processing and communications equipment complying with FCC requirements shall not cause interference with other equipment. All UPS on/off power switches shall be easily accessible by a maintenance technician.

(3) Fiber Optic Cable Interconnect:

Developer shall terminate conduit supporting fiber cable ingress to the node in the floor of the node. All such conduit shall be sealed to prevent water seepage into the node. Duct tape is not acceptable as a conduit sealant. The conduit shall be placed to provide easy access to the cabinet containing the fiber termination drawer. Slack fiber cable shall be provided under the false flooring.

(4) Node Building Ground:

Developer shall furnish and install a power grounding sub-system in accordance with the Project Specifications. Grounding electrodes and grounding electrode conductors shall be provided and installed (i.e., bonded) per the NEC.

(5) Metallic Lines:

All metallic power and signal lines penetrating the node shall be installed with industry standard surge protection device.

(6) ACU Installation:

The ACU system and its installation shall comply with the requirements of the NEC. The ACU shall be mounted for easy removal from the inside of the node. A rain shield for the ACU shall be provided on the node exterior. Condensation drains for the ACU shall be redundant and shall be routed away from the node, assuring that no water condenses inside the node. Both ACUs shall be enclosed by a wire mesh cage attached to the node building to prevent vandalism, theft, and entry to the facility. The mesh cage shall be sized to assure critical and ample air flow to the ACU's. Installation, preventive maintenance (i.e., filter change), and corrective maintenance shall be from the interior of the node. Care of maintenance, as well as node security, shall be considered in the ACU installation. The cage shall be mounted in a manner that makes it not possible to detach the ACU security wire mesh cage from the node exterior.

(7) Foundation Requirements:

Developer shall prepare the site for node installation by appropriate grading. The node building foundation sub-base shall consist of Class 2 AB as defined in section 303 and shall be tested by Arizona Test Method 212. A five foot wide, 4 inch deep, sidewalk shall be provide on all sides of the building. The sidewalk shall be surrounded by a minimum of seven feet wide and six inches deep of crushed stone at the surface to prevent soil erosion beneath the foundation

Developer shall complete the foundation, select fill, and complete other site preparation requirements as necessary to ensure the integrity of the foundation and prevent settling. The concrete node foundation shall be constructed over the prepared site. The foundation shall be a steel reinforced (Grade 60) concrete slab not less than 8 inches thick. The foundation surface area dimensions shall be compatible with installation compatibility required for prefabricated wall units. The foundation shall be made to accommodate all interconnecting conduit requiring node penetration. The foundation of the new node building shall be located as shown on the contract plans with a finished floor elevation approximately the same as the adjacent existing node building. The foundation shall be class A finish.

(8) Electrical:

(a) Wire and Cable:

All wiring shall comply with the NEC. All conductor sizes are based on copper. Wire and cable routing shown on the Project Plans is approximate. Where wire and cable routing is not shown, and destination only is indicated, Developer shall propose a routing and length required. All wire shall be new. Insulation shall be rated 600V unless stated otherwise in other parts of these specifications and Project Plans. All conductors must be suitable for the application intended. Comply with the following:

- Conductors terminated with a crimp type device must be stranded. Stranded conductors shall be terminated with a crimp device and shall not be wrapped around terminal screws.
- Use type XHHW-2 insulation for feeders and branch circuits. Provide protection for exposed cables where subject to damage. Neatly train and lace wiring inside junction boxes, equipment, and panel boards. All wire and cable shall be installed in conduit (with obvious exceptions such as the interior cabinet wiring, etc.). Conductor minimum size for outlet power and lighting circuits is 12 AWG.
- Splice only in pull boxes. Use plastic cable ties to support cable as needed. Use solder less spring type pressure connectors with insulating covers for wire splices and taps, #10 AWG and smaller. Use mechanical or compression connectors for wire splices and taps, No. 8 AWG and larger. Thoroughly clean wire before installing lugs and connectors. At all splices and terminations, leave sufficient slack to cut splices out and completely re-splice.

(b) Conduit:

Conduit size shall be in compliance with NEC requirements and be a minimum of 3/4” inch. Routing shown on the Project Plans is approximate and Developer shall develop conduit routing plan to be approved by the Independent Quality Firm. All conduit runs shall be in compliance with the NEC. Verify location and pathway of conduit runs before installation. Conductors shall be run in either flexible or rigid conduit under the false floor to junction boxes and then routed to equipment. All conduits and boxes shall be fastened to the building structure.

SECTION 751 WEIGH-IN-MOTION SYSTEM:

751-1 Description:

Developer shall furnish and install Weigh-In-Motion system (WIM) in accordance with these Project Specifications and as shown in the plans. The term "Weigh-In-Motion System" refers to the weigh-in-motion loop detector system and its electronics.

The WIM shall be installed at the site indicated on the Project Plans. The WIM shall be designed in accordance with the ADOT standard drawings as noted on the Project Plans.

751-2 Materials:

751-2.01 Detectors:

(A) General:

Detectors shall conform to the minimum acceptable design and operating requirements of these specifications for detecting the presence, passage, speed, weight, and classification of vehicles.

All materials shall be furnished by Developer. Developer shall submit a complete list of all required project material for approval, as specified in Subsection 730-4 of the specifications.

(B) Loop Detectors:

The detector loop dimensions shall be as specified on the Plans. Loop detector wire shall be 14 AWG HDPE polyethylene insulated conductors conforming to IMSA 51-7, as shown on the Plans.

(C) Lead-in Cable:

The lead-in cable from the pull box to the cabinet shall be 14 AWG and conform to IMSA specification 50-2 with the exception that the cable can include up to 4 twisted pairs, not just one.

(D) Conduit:

Conduit shall be rigid nonmetallic PVC conforming to the requirements of Subsection 732-2.02 of the specifications. Conduit shall be large enough to contain the number of wires required, but not less than the diameters shown on the Plans.

(E) Cabinets:

WIM Type MPD control cabinets shall be pole-mounted as shown on the Plans, and as specified in Subsection 734-2.03 of the specifications, except that no pre-wiring for AC or DC electric, police panel, or provisions for fan or light shall be required. Developer shall provide the functional WIM system at each site and shall include all components including battery backup system, solar panels and data collectors (controllers) to support data collection to support data of atleast 10 loop detectors, and 20 piezoelectric sensors.

The data collector shall be connected to Fiber Ethernet Switch and integrate into ADOT Freeway Management System with 12 SMFO branch cable connected to the trunkline fiber as shown in the plans.

Warranties shall comply with Subsection 106.13 of the specifications.

(F) Materials:

Developer shall furnish detectors for speed/classification systems (piezoelectric sensors-Class 2 WIM) with pre-attached lead-in cables, piezo grout sealant for the sensor portion of WIM detectors. Developer shall furnish all other sealants.

Developer shall notify the Traffic Monitoring Team of the Multimodal Planning Division (MPD) at (602) 712-8598 a minimum of 15 working days prior to scheduled installation of the piezoelectric sensors.

751-2.03 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) Two-Part Epoxy Filler Sealant:

Two-part epoxy joint filler sealant shall be a 100-percent solids, flexible, two-component, solvent free, epoxy resin/hardener system for use as a saw cut sealant in asphaltic concrete pavements and Portland cement concrete pavements.

Materials shall comply with the requirements of Subsection 1015-1 of the Specifications.

The epoxy system shall be specifically designed for the intended application according to the product literature provided by the manufacturer.

The epoxy system shall be of sufficient strength and hardness to withstand stress and abrasion from vehicular traffic, while remaining flexible enough to provide stress relief under thermal movement and protect the loop wire from moisture penetration. It shall also be moisture insensitive to allow effective application to damp pavements. No standing water is permitted on the surfaces to which the epoxy system is to be applied.

The epoxy system shall be designed to enable vehicular traffic to pass over properly filled saw cuts immediately after installation without tracking or stringing of the material.

Properly installed and cured epoxy systems shall exhibit resistance to the effects of weather, motor oils, gasoline, anti-freeze solution, brake fluid, deicing chemicals, and salt in such a manner that the performance of the vehicle detector loop wire is not adversely affected.

The epoxy system shall be designed for roadway installation when the surface temperature is a minimum of 40 degrees F and rising. The cured epoxy system shall be temperature stable and exhibit no degradation in performance throughout the ambient pavement temperature ranges experienced within the State of Arizona.

The components of the epoxy system shall have a minimum shelf life of 12 months in original unopened, undamaged containers, when stored in a cool dry environment, as recommended by the manufacturer.

The epoxy system shall meet the following requirements:

Property	Test Method	Requirements
Mixing Ratio; Part A to Part B	-	1 to 1 by volume
Viscosity, centipoises	ASTM D 2393-86	4000 to 8000
Pot Life, minutes	ASTM C 881	12 to 20
Cure Time, minutes	ASTM C 679	60 maximum, Tack Free
Hardness (Shore D)	ASTM D 2240	35 to 65
Tensile Elongation, %	ASTM D 638	50 minimum
Water Absorption, % (24 hrs)	ASTM D 570	1 maximum
3% Salt Water Absorption, % (24 hrs)	-	0.03 to 0.20
Oil Absorption, % (24 hrs)	ASTM D 471	0.01 to 0.02
Gasoline Absorption, % (24 hrs)	-	0.05 to 0.90

(B) One-Part Elastomeric Sealant:

One-part elastomeric sealant may be used to seal saw cuts in Portland cement 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 its installation.

The encapsulant shall, within its engineered 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 form a surface skin allowing exposure to vehicular traffic within 30 minutes at 75 degrees F 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 the State of 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, prior to curing of the encapsulant, with a suitable non-flammable solvent. 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 and 140 degrees F.

The encapsulant shall have the following physical properties in its uncured and cured states.

Uncured (Wet) Encapsulant		
Property	**Requirement**	**Test Procedures**
Weight	10.1 ± 0.3 pounds/gallon	A. Weight/Gallon
Total Solids by Weight	75 – 85%	B. Determination of Non-Volatile Content
Viscosity	10,000 - 85,000 centipoise	C. Dynamic Viscosity
Drying Time	Touch: 24 hrs. maximum Complete: 30 hrs. max.	D. Tack-Free Time

Cured Encapsulant		
Property	**Requirement**	**Test Procedure**
Hardness (Indentation)	65 – 85	E. Rex hardness
Tensile Strength	500 psi minimum	F. Tensile & Elongation

Elongation	300% minimum	

(C) **Hot Applied Rubberized Sealant:**

Hot applied rubberized sealant may be used to seal saw cuts in asphaltic concrete and in lean concrete base. 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 pressure feed melter unit. Pour pot application is not acceptable. 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 for the loop detector sealant.

Test	Specification
Penetration: 125 oF, 50g, 5s	50 maximum
Penetration: 77 oF, 100g, 5s	10 – 25
Softening Point:	210 oF minimum
Ductility: 77 oF	15 cm minimum
Mandrel Bend: 0 oF, 90o Arc, 10s, 3/4 inch diameter	Pass 2 of 3
Recommended Pour Temp:	380 oF
Safe Heating Temp:	420 oF
Brookfield Viscosity: 400 oF	7,500 centipoise max.
Unit Weight:	8.5 pounds per gallon
Coverage; 1/2 by 1/2 inch crack	11.0 pounds per 100 feet

751-3 Construction Requirements:

751-3.01 Detector Installation:

(A) **General:**

Detectors shall be installed as shown on the project plans. The installation of the detectors shall be such that the operation shall not be affected by temperature changes, water, ice, rain, snow, chemicals, or electromagnetic noise.

(B) **Saw Cut Sealants:**

Saw cuts shall be sealed as specified in the Plans, with the following exceptions:

- Two-part epoxy filler sealant shall be used instead of pre-mixed emulsified crack filler sealant, and
- Developer furnished piezo grout shall be used to seal the piezo sensor portion of speed/classification and WIM detectors.

Before the sealant sets up, the surplus sealant shall be removed from the road surface without the use of solvents. Sand blotter shall be applied.

(C) Splices:

Except for piezoelectric or quartz piezoelectric sensors, detector sensor conductors shall run continuous and unspliced to the adjacent pull box. Lead-in cables from the controller cabinet shall be spliced to the detector sensor conductors in the pull box. Splicing of the lead-in cables between the controller cabinet and pull box will not be allowed.

Piezoelectric sensor lead-in cables used in WIM detectors shall run continuous and unspliced through the pull box to the controller cabinet. Splicing of the lead-in cables will not be allowed.

Wire splices in the pull box shall be soldered using resin-core solder with 60 percent tin and 40 percent lead. The splices shall be sealed as specified in the Plans. A weather proof bond shall form with a dielectric strength of 500 volts per 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 control cabinet.

(D) Detector Loop Field Tests:

Detector loop field tests shall be in accordance with the Plans.

Any loop that fails to meet the specified requirements or cannot be tuned to the project requirements and shall be replaced.

For the traffic data detectors specified in Subsection 751-3.02, Developer shall also FAX the complete test results to ADOT's Multimodal Planning Division (MPD) at (602) 252-8313, Attention: Traffic Monitoring Team, within two weeks of completion of the second test. As an alternate, Developer may email the test results to the Independent Quality Firm at MPDtrafficmonitoringteam@azdot.gov, also within two weeks of completion of the second test. In either case, Developer shall also mail two copies of all such required information to ADOT MPD at 1324 S. 22nd Ave., Mail Drop 070R, Phoenix, AZ 85009, Attention: Data Collection. The test results shall identify the project number and detector location.

For pull boxes used with data detector systems, Developer shall provide GPS latitude and longitude coordinates, ± five feet, for each installed pull box. Such GPS information shall be transmitted along with the test data required above for all pull boxes installed with each tested data detector loop system.

751-3.02 Traffic Data Detectors:

(A) General:

WIM detector systems shall be installed in accordance with the Plans and as specified herein.

Developer shall use a 3/4-inch wide saw blade to cut the channel for piezoelectric sensors in pavement. Multiple passes using a thinner blade will not be acceptable.

Pull boxes shall be as shown on the Plans.

As specified above in Subsection 751-3.01(D), Developer shall provide GPS latitude and longitude coordinates, ± five feet, for all pull boxes installed with each traffic data detector loop system.

(B) Installation of Piezoelectric Sensors:

Developer shall install the piezoelectric sensors, and piezo grout, as specified herein and shown on the plans. Independent Quality Firm must be present during all elements of the piezoelectric sensor installation (to the point where the pre-attached lead-in cable begins), including layout, groove saw-cutting, sensor placement, and application of piezo grout. Developer shall notify the Independent Quality Firm at least 15 working days prior to its scheduled installation of any piezoelectric sensors.

Lead-in runs of cable from all piezoelectric sensors to the controller cabinet shall be continuous; splices will not be acceptable.

(C) WIM Detectors:

A complete new WIM system shall include all loops, pull boxes, control cabinet, A-pole, pole foundation, the necessary conduits under the roadway and from pull boxes to control cabinets, and Developer-furnished sensors (piezoelectric as shown on the plans) with attached lead-in cables, all as shown on the Plans.

Developer shall provide trenches and install conduits from the edge of pavement to the pull box and from the pull box to the control cabinet. Wiring, conduit, and pull box installation shall be in accordance with Subsections 732-3.01 and 732-3.02 of the specifications.

Installation of Developer-furnished piezoelectric sensors shall be in accordance with Subsection 751-3.02(B).

The cabinet(s) shall be grounded in accordance with the requirements of Subsections 732-3.03 and 734-3.03 of the specifications. Developer shall keep the ground wire from the cabinet ground bus bar to the ground rod assembly or array as short as possible.

The total number of sensors for each complete new WIM system specified above shall be the number of sensors required for all traffic lanes in both travel directions at a specified location.

SECTION 752 – THERMAL CAMERA SYSTEM:

752-1 Description:

Developer shall furnish and install thermal camera systems in accordance with these project specifications. The thermal camera systems consists of thermal cameras, TI x-stream EDGE BPL Interface cards, 4/OS xp expansion cards, ethernet interface cards, ethernet cables, electrical conductors, circuit breakers, time extend relays, DC isolators, power supply, etc. and labor necessary to provide a complete and fully operational thermal camera system.

752-2 Materials:

Thermal Cameras, TI X-Stream EDGE BPL Interface cards, 4/OS expansion cards, Ethernet interface cards, communications connections, and power supply shall comply with the project specifications, Section 730-6 Video Detection.

Developer shall confirm with the manufacture that the camera focal lenses (Type 325, Type 335, Type 345, or other type) will provide ideal operation of detection zones at the proposed locations prior to ordering.

Conductors for powering the NEMA 3R Enclosure and internal contents shall be stranded 7C#12 AWG or 3C#12 AWG. See plans for details.

Conductors for powering the BPL cameras shall be IMSA 50-2, #12 AWG stranded, see plans for details.

The developer shall furnish all other materials necessary to complete the thermal camera detection system installation.

752-3 Construction Requirements:

(A) General

The systems shall be installed as described in the thermal camera manufacturer quick installation guide for Ethernet and BPL cameras at locations shown on the plan.

Minimum installation height of the thermal cameras on Type H Poles and on Type U Light Poles shall be 40 feet and shall be confirmed with the thermal camera vendor to achieve optimum viewing angles. Cameras shall be attached using hose clamps, not steel bands.

TI x-stream EDGE BPL Interface card, 4/OS xp expansion cards, Ethernet interface cards, circuit breakers, time extend relay, DC isolators, DIN Rail, and power supply shall be installed at cabinet and enclosure locations as shown on the plans.

Device power shall not come from GFCI receptacles.

The contractor shall coordinate all work that may affect traffic signal operation, including new thermal detection and traffic signal phasing with ADOT Systems Maintenance. The Contractor shall coordinate with ADOT Systems 30 days prior to develop a work plan. ADOT Systems Maintenance may choose to have an ADOT traffic signal technician present for turn-on of signals with new detection, and will choose who will create the detection zones.

All Thermal Cameras shall comply with the following tests:

(B) Stand-Alone Tests:

The developer shall test the following stand-alone (non-network) functional operations of the system:

- Display of Camera ID information.
- Presence and quality of video signal during bright sunlight and night conditions.
- Camera shall be installed at the proper view angle to optimize the detection zones in order to adequately detect wrong way drivers. This shall be coordinated with the camera manufacturer.

For testing purposes, “bright sunlight” conditions shall be defined as occurring between 10:00 AM and 2:00 PM, on a cloudless day. “Night” conditions shall be defined as occurring between one hour after sundown and one hour before sunrise with the moon no more than one-quarter full.

The developer shall prepare ITS test forms indicating the above tests for each camera and submit a complete and organized set of forms in electronic PDF format to ADOT.

(C) Subsystem Test (SST):

Prior to starting SST, developer shall coordinate with ADOT and integrate the cameras in ADOT’s Thermal Camera Central Management System.

The developer shall conduct the subsystem test on the thermal cameras and wrong way flashing system to verify that communications circuits have been properly configured and operate without failure and without adversely affecting the existing system. The SST shall start on a Monday, Tuesday, or Wednesday and be conducted for three consecutive working days.

developer shall perform 20 successful consecutive trials where wrong way flashing signs activate/deactivate once detected. Test trials should be implemented under light traffic conditions to simulate wrong way driving scenarios. developer shall coordinate with ADOT TOC operators to schedule testing trials of the wrong way flashing signs.

The developer shall repair or replace components that fail the SST at no cost to the

Department and the test shall be restarted on a Monday, Tuesday, or Wednesday and be conducted for three consecutive working days. The developer shall supply test equipment requested by the Department for troubleshooting the system.

The SST test shall verify the following:

- Transmission of high quality video images to the TOC
- Generation of text, date, and time on monitors

(D) System Acceptance Test (SAT):

Upon successful completion of the subsystem test, the SAT shall be started. The SAT shall consist of a 30-day period of operation by the Department without failure of all developer supplied equipment. GPS data shall be submitted and approved prior to beginning the SAT.

The purpose of the SAT is to demonstrate that the total system, consisting of hardware, software, communications, materials and construction, is properly installed, is free from defects and identified problems, exhibits stable and reliable performance, and completely complies with contract documents.

The SAT shall not start without providing the required FMS documentation and delivering red lines to the Independent Quality Firm. SAT may start after approving power meter tests and OTDR tests after completion of all the fiber splicing and commissioning of thermal camera system.

During the SAT, the developer shall ensure that equipment is maintained in operable condition. The Independent Quality Firm shall be provided access to equipment during this period for purposes of verifying its operation. The developer shall identify, isolate, diagnose and troubleshoot system problems and inconsistencies. The developer shall formulate possible solutions and shall implement corrections required.

The developer shall provide traffic control, bucket truck, test equipment, and labor needed to test, isolate and correct equipment deficiencies found during the SAT. Key developer technical personnel familiar with the design and construction of each system component shall be available on site within 48 hours of notification of a problem.

During the SAT, the developer shall prepare test failure log forms and immediately submit the form to the Independent Quality Firm. After the repair has been completed, an updated form shall be submitted to the Independent Quality Firm. Documentation errors, omissions, and changes occurring prior to, and during, the SAT shall be corrected and resubmitted before the SAT is completed.

System documentation errors, omissions and changes occurring prior to and during the SAT shall be corrected and resubmitted before system acceptance can be completed.

(1) SAT Minor Failure

In the event of a minor failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with 24 hours added to the remaining test time of the system. The following constitute minor failures:

- Failure to receive acceptable thermal camera video image at TOC

(2) SAT Major Failure

In the event of a major failure during the SAT, the test clock shall stop until the system is repaired. At the completion of the repair, the testing shall recommence with the test clock reset to day zero. The following constitute major failures:

- Third failure of equipment.
- Third failure to receive acceptable thermal camera video image at TOC.
- Failure to correct an issue adversely impacting public safety within 4 hours of being notified by the Independent Quality Firm or ADOT.

SECTION ITEM 753 - ILLUMINATED WRONG WAY SIGN ASSEMBLY:

753-1 Description:

Developer shall furnish and install illuminated wrong way sign assembly including the internally illuminated sign with flashing LED border, Type A-Pole, pole foundation, sign mounting hardware, electronic components, materials, tools, and labor necessary to provide a complete and fully operational system.

753-2 Materials:

The assembly shall include one 36” x 48” R5-1a “Wrong Way” internally illuminated wrong way sign with a minimum of 70 red LEDs which illuminate the border of the sign. The dimension shall be from the visibly illuminated portion of the sign panel. The structural frame of the sign is not included in these dimensions. The LED’s on the border shall flash at a rate of approximately 60 flashes per minute. The LEDs internally illuminating sign panel shall turn on without flashing when the sign is activated. The sign assembly shall be activated, for a user-adjustable duration up to 10 minutes, based off a short pulse contact closure from the thermal camera output. The sign will only be activated when a wrong way vehicle is detected by the system. Electronic components for the sign including relays, transformers, and flasher may be installed in the traffic signal cabinet or within the internally illuminated sign housing.

Components shall be able to withstand and operate at temperature extremes of -22 degrees F to +140 degrees F.

All exterior surfaces of the internally illuminated sign shall be powder-coat painted in accordance with Military Standard MIL-C-24712. Finish will meet the requirements of ASTM D3359, ASTM D3363, and ASTM D552. The internally illuminated sign enclosure shall have a weatherproof design that ensures water does not reach internal components, and shall be able to do so in its design, without the use of silicone. The sign shall have a 3mm or 4mm acrylic front panel that is UV, weather, abrasion and impact resistant. The acrylic panel shall be cyro-acrylite. The front panel shall be replaceable so that maintaining agencies have the option to supply their own sheeting for the sign faces. The sign shall have retroreflective strips on the back side of the sign and on the pole, facing the right way drivers exiting the ramp. The sign structure shall be able to withstand 150 mph wind loads in conformance with the requirements of the AASHTO publication, "Standard Specifications for Structural Supports of Highway Signs, Luminaries and Traffic Signals," 4th Edition 2001. Signs shall be tested and certified for the following environmental conditions: Exclusion of Water Test, Strain Relief Test, Temperature Test, Dielectric Voltage-Withstand Test.

The entire surface of the sign panel shall be evenly illuminated with a minimum average brightness reading at the letters of 580 Lux and a variation of no more than 15% for any reading from the average (minimum of 50 readings). Each background reading measured shall not vary by more than 10% (minimum of 50 readings) from the average of the background brightness readings. The light transmission factor of the sign panel shall provide a letter to background ratio of a minimum of 4:1.

The light source for the sign shall be LEDs (light emitting diodes). The LEDs shall evenly illuminate a light panel that is the same dimensions of the sign face. The LEDs shall have a minimum rated lumen maintenance of 70% at 60,000 hours (an L70 of 60,000 hours).

LED single output switching power supply shall be a fully-encapsulated, constant- current design built to withstand 300VAC surge input for 5 seconds, with inherent short circuit/over current/over voltage protection. The Power Supply shall be a UL 1310 Class 2 power unit, and will be housed in a fully isolated plastic case to prevent water intrusion. The sign's LED single output switching power supply shall be rated for a 1450 mA rated current, a DC voltage range of 9-34V, a power rating of 59.5W, a voltage tolerance of +/- 5.0%, an AC current of 0.7A/230VAC, and voltage range of 127- 370VDC with 87% operating efficiency rating, plus a working temperature of -30 to +70 degrees Celsius. Safety standards shall meet the following criteria: UL1310 Class 2, CAN/CSA C22.2 No. 223-M91 (for LPC-60-1750 only), IP67 approved; design refer to TUV EN60950-1, EN61347-2-13.

The sign manufacturer shall have a demonstrable Quality Assurance Program in place, with proof of regular re-certification by an independent auditing agency. Reports shall be made available upon request.

The sign shall be listed and approved to UL 48 Standards by a Nationally Recognized Testing Laboratory. The outside of the sign shall be marked with a certification mark for Electric Signs UL 48.

The sign shall have anti-graffiti film applied meeting these specifications and the requirements of the sign sheeting manufacturer.

Sign shall have a warranty for a minimum of five years.

The sign support hardware shall be certified by the hardware manufacture that it is structurally adequate and compatible to support the sign assembly considering wind and other loads in these specifications.

753-3 Construction Requirements:

The illuminated wrong way sign assembly shall be installed with the bottom of the internally illuminated wrong way sign three feet above the roadway elevation.

Grounding for the sign housing and posts shall be provided by a 25 foot coil of #4 AWG bare copper conductor, or a 14 inch square copper ground plate, installed before the concrete pole foundation is poured and shall be covered with 6 inches of fill. The ground shall be connected to the sign assembly providing ground to the pole and sign housing.

All mounting hardware shall be provided by the developer.

Device power shall not come from GFCI receptacles. Conductors shall be sized to support the power requirements of the sign.

SECTION 754 - NEMA TYPE 3R ENCLOSURE:

754-1 Description:

The developer shall furnish and install NEMA Type 3R enclosures, fiber termination units, and all materials, tools, and necessary labor, to be installed at the locations designated on the project plans, in accordance with the details shown on the plans, and the requirements of the specifications.

754-2 Materials:

The developer shall meet the requirements of the project plans, specifications, and the requirements for NEMA Type 3R enclosures. The enclosure shall include an internal air filter over any louvers for large dust particles.

The NEMA Type 3R enclosures shall include the necessary hardware for strapping the enclosure to the designated poles as indicated on the plans. The enclosures shall also come equipped with a standard DIN rail that will accommodate all of the equipment that needs to be housed within the enclosure. Din Rail shall be 10 inch maximum length to fit the side panel of the designated cabinets. The DIN rail shall be preassembled and include the necessary number of 15 amp circuit breakers and relays for providing power to the illuminated wrong way signs and flashing LED bars, and the 48 VDC, 2 amp minimum power supply to power the TI x-stream EDGE card. The DIN rail shall be positioned such that there is adequate space above and below the equipment for making all of the proper wiring connections within the enclosure. The enclosure shall be lockable with a keyed lock or padlock supplied by the contractor. Locks shall be keyed alike, contact ADOT systems maintenance for key requirements.

The developer shall supply a 120VAC to 24 VDC converter, 100 watt minimum, to be installed on the DIN rail mounting within the NEMA 3R enclosure. Power supply shall be rated at least two times the equipment power draw. This AC to DC converter will provide power to the Ethernet interface cards and media converter within the enclosure.

The developer shall provide appropriate grounding of the enclosure per National Electric Code.

754-3 Construction Requirements:

NEMA Type 3R enclosures shall be mounted to the designated pole a minimum of four feet above the ground surface, such that the enclosure is accessible by maintenance personnel standing on natural ground. The enclosure shall be centered on the pole and the door shall be positioned such that anyone accessing the enclosure does not have their back to traffic.

The developer shall securely mount the fiber termination units in the NEMA 3R enclosures and install fiber patch cords between the fiber termination units and the media converters. The developer shall provide a minimum of six connectors, up to two to be plugged into the media converters, and four as spares.

Device power shall not come from GFCI receptacles.

SECTION 755 – SINGLE & MULTI PORT MEDIA CONVERTER:

755-1 Description:

The developer shall furnish and install single port and multi-port media converters, all materials, tools, and necessary labor, to be installed at the locations designated on the project plans and in accordance the requirements of the specifications.

755-2 Materials:

Media converters shall be unmanaged industrial Ethernet switches that convert Ethernet media to single mode fiber optic media. The media converters shall meet the following minimum specifications:

The media converters shall be Industrial ETHERNET Rail Switches, with store and forward switching modes, along with Ethernet and Fast-Ethernet (10/100 Mbit/s) capability.

Port type and quantity:

Single camera locations:
1 x 100BASE-FX, SM cable, SC sockets
1 x 10/100BASE-TX, TP cable, RJ45 sockets, auto-crossing, auto negotiation, auto-polarity

2 camera locations:
2 x 100BASE-FX, SM cable, SC sockets
Minimum 2 x 10/100BASE-TX, TP cable, RJ45 sockets, auto-crossing, auto negotiation, auto-polarity

Power supply: 1 plug-in terminal block, 3-pin, no signal contact

Network size – length of cable:

Twisted pair (TP) 0 - 100 m
Single mode fiber (SM) 9/125 µm 0 – 32.5 km, 16 dB link budget at 1310 nm, A = 0.4 dB/km, 3 dB reserve, D = 3.5 ps/(nm x km)

Power requirements:

Operating voltage 9.6 V DC - 32 V DC
Current consumption at 24 V DC Max - 130 mA
Power consumption Max - 3.0 W 10.2 Btu (IT)/h at 24 V DC

Service: Diagnostics LEDs (power, link status, data, data rate)

Ambient conditions:

Operating temperature -40 ºC to +70 ºC Storage/transport temperature -40 ºC to +70 ºC Relative humidity (non-condensing) 10% to 95% MTBF 101.5 years; MIL-HDBK 217F: Gb 25 ºC

Mechanical construction:

Mounting DIN Rail 35 mm Weight 105 g Protection class IP 30

Mechanical stability:

IEC 60068-2-27 shock 15 g, 11 ms duration, 18 shocks
IEC 60068-2-6 vibration 3.5 mm, 3 Hz - 9 Hz, 10 cycles, 1 octave/min.; 1g, 9 Hz - 150 Hz, 10 cycles, 1 octave/min

EMC interference immunity:

EN 61000-4-2 electrostatic discharge (ESD) 6 kV contact discharge, 8 kV air discharge
EN 61000-4-3 electromagnetic field 10 V/m (80 - 1000 MHz)
EN 61000-4-4 fast transients (burst) 2 kV power line, 4 kV data line
EN 61000-4-5 surge voltage Power line: 2 kV (line/earth), 1 kV (line/line), 1 kV data line
EN 61000-4-6 conducted immunity 10 V (150 kHz - 80 kHz)

EMC emitted immunity:

FCC CFR47 Part 15 FCC CFR47 Part 15 Class A
EN 55022 EN 55022 Class A

Approvals: Safety of industrial control equipment cUL 508

The power source for the media converter shall be provided by a dedicated power supply or by a power supply within the designated cabinet where the media converter is installed, which is shared by multiple devices. Power supplies shall meet the requirements of the specifications. If a single power supply powers multiple devices, the power supply shall have capacity rated of 2 times the power of all devices it serves.

755-3 Construction Requirements:

The media converters shall be installed in the NEMA Type 3R enclosures mounted to DIN rail shelf. Media converters will also be installed in traffic signal cabinets to convert the signal from the fiber optic cable back to Ethernet 5e where indicated on the plans.

Device power shall not come from GFCI receptacles.

Loop Detectors

Stand Alone Test Procedure

LOOP TESTS

ITEM # ____________________ DATE ____________________
SUB-ITEM # ____________________ CONTRACTOR ____________________
NEW ______ EXISTING ________ INSPECTOR ____________________

STA. ____________________

1U (6' X 6')	2U (6' X 6')	3U (6' X 6')	4U (6' X 6')	5U (6' X 6')	6U (6' X 6')
________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ
________ Ω	________ Ω	________ Ω	________ Ω	________ Ω	________ Ω
________ µH	________ µH	________ µH	________ µH	________ µH	________ µH

1D (6' X 6')	2U (6' X 6')	3U (6' X 6')	4U (6' X 6')	5U (6' X 6')	6U (6' X 6')
________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ
________ Ω	________ Ω	________ Ω	________ Ω	________ Ω	________ Ω
________ µH	________ µH	________ µH	________ µH	________ µH	________ µH

STA. ____________________

1U (6' X 6')	2U (6' X 6')	3U (6' X 6')	4U (6' X 6')	5U (6' X 6')	6U (6' X 6')
________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ
________ Ω	________ Ω	________ Ω	________ Ω	________ Ω	________ Ω
________ µH	________ µH	________ µH	________ µH	________ µH	________ µH

1D (6' X 6')	2U (6' X 6')	3U (6' X 6')	4U (6' X 6')	5U (6' X 6')	6U (6' X 6')
________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ	________ MΩ
________ Ω	________ Ω	________ Ω	________ Ω	________ Ω	________ Ω
________ µH	________ µH	________ µH	________ µH	________ µH	________ µH

STA. ____________________

ELO (6' X 6')	ERO (6' X 6')	ELQ (6' X 6')	ERQ (6' X 6'')
________ MΩ	________ MΩ	________ MΩ	________ MΩ
________ Ω	________ Ω	________ Ω	________ Ω
________ µH	________ µH	________ µH	________ µH

ELI (6' X 6')	ERI (6' X 6')
________ MΩ	________ MΩ
________ Ω	________ Ω
________ µH	________ µH

ELI (6' X 6')	ERI (6' X 6")
________ MΩ	________ MΩ
________ Ω	________ Ω
________ µH	________ µH

TEST 1: INSULATION RESISTANCE TO GROUND
NOT LESS THAN 100 MEGOHMS AT 500 VDC

TEST 2: SERIES RESISTANCE
6' X 6' - 0.1 OHMS TO 0.8 OHMS

TEST 3: INDUCTANCE	LOOP SIZE	# OF TURNS	RANGE OF INDUCTANCE
	6' X 6'	4	100 TO 155 MICROHENRIES
	6' X 6"	5	160 TO 210 MICROHENRIES

CONTRACTOR SIGNATURE ____________________ INSPECTOR SIGNATURE ____________________

Control Cabinet Type 341A

Stand Alone Test Procedure

LOOP TESTS (WITH LEAD-IN)

ITEM # ____ DATE ________
SUB-ITEM # CONTRACTOR ______________________________
NEW _____EXISTING_______ INSPECTOR ____________
___

STA. ________

1U (6’ X 6’)	2U (6’ X 6’)	3U (6’ X 6’)	4U (6’ X 6’)	5U (6’ X 6’)	6U (6’ X 6’)
MΩ	MΩ	MΩ	MΩ	MΩ	MΩ
µH	µH	µH	µH	µH	µH
/	/	/	/	/	/

1D (6’ X 6’)	2U (6’ X 6’)	3U (6’ X 6’)	4U (6’ X 6’)	5U (6’ X 6’)	6U (6’ X 6’)
MΩ	MΩ	MΩ	MΩ	MΩ	MΩ
µH	µH	µH	µH	µH	µH
/	/	/	/	/	/

STA. ____

1U (6’ X 6’)	2U (6’ X 6’)	3U (6’ X 6’)	4U (6’ X 6’)	5U (6’ X 6’)	6U (6’ X 6’)
MΩ	MΩ	MΩ	MΩ	MΩ	MΩ
µH	µH	µH	µH	µH	µH
/	/	/	/	/	/

1D (6’ X 6’)	2U (6’ X 6’)	3U (6’ X 6’)	4U (6’ X 6’)	5U (6’ X 6’)	6U (6’ X 6’)
MΩ	MΩ	MΩ	MΩ	MΩ	MΩ
µH	µH	µH	µH	µH	µH
/	/	/	/	/	/

STA. ____

ELO (6’ X 6’)	ERO (6’ X 6’)	ELQ (6’ X 6)	ERQ (6’ X 6’)
MΩ	MΩ	MΩ	MΩ
µH	µH	µH	µH
/	/	/	/

ELI (6’ X 6’)	ERI (6’ X 6”)
MΩ	MΩ
µH	µH
/	/

ELI (6’ X 6’)	ERI (6’ X 6”)
MΩ	MΩ
µH	µH
/	/

TEST1 & 3: INSULATION RESISTANCE FROM LEAD-IN CONDUCTOR TO GROUND
MINIMUM OF 10 MEGOHMS

TEST 2 & 4: INDUCTANCE OF LOOP PLUS LEAD-IN CONDUCTOR
RANGE OF 50 TO 490 MICROHENRIES

TEST 5: SEE 341 CABINET STAND-ALONE LOOP TEST RESULTS

1	3	MΩ
2	4	µH
/		

TESTS 1 & 2: ARE DONE DRY
TESTS 3 & 4: ARE DONE WET

CONTRACTOR SIGNATURE____________________INSPECTOR SIGNATURE_____________________

PURPOSE OF TEST

The purpose of this Stand Alone Test Procedure is to describe the testing methods to verify that the 341 Cabinet, transformer, and associated equipment is fully functional and operating properly. All testing is conducted at each individual cabinet in an off-line environment.

TEST PROCESS

Using the following form and procedure indicated within these specifications, and as directed by the Engineer, the contractor shall demonstrate that: each Detection and Ramp Meter and CCTV cabinet assembly operates properly, when assembled and connected to all equipment it serves.

The contractor shall perform the following loop calibration test for all mainline detector stations:

1. On the Model 2070 controller, set/verify that the loop Trap Distance is 18 feet.
2. Using a vehicle with a calibrated speedometer approved by the Engineer, or a radar gun verifying the exact speed of the vehicle, drive the vehicle past the detector station at a constant maximum safe, and legal speed.
3. Record the speed registered on the Model 2070 controller.
4. Record the actual vehicle speed of the car off the radar gun, or the car speedometer, as directed by the Engineer.
5. Multiply the actual vehicle speed (mph) by 1.467 to obtain the speed in feet per second (ft/sec).
6. Perform the following calculation:

   $$\frac{\text{Actual vehicle speed (ft/sec)}}{\text{Speed off Model 2070 (ft/sec)}} \times 18 \text{ (ft)} = \text{Actual Trap Distance (ft)}$$

7. Adjust the value in the Model 2070 controller data location for the Trap Distance to the actual trap distance calculated in Step 6, above.
8. Record the corrected Lane Trap Distance on data sheets for submittal to the Engineer, as well as create and record a table of this data for the as-built plans documentation.

TEST EQUIPMENT:

- One set of cabinet keys.
- Multimeter with test leads.
- Applicable Forms Attachments A - D
- Safetran 416C Test Prom Module 2
- Test Vehicle

MANPOWER:

- Two Technicians (for all testing except Attachment D)
- One additional technician for each cabinet being speed tested.

EXPECTED MINIMUM TEST DURATION:

4 Hours

CONDITIONS:

The 341 cabinet is properly installed and in good condition. The cabinet electrical service is energized. All detection (loops, PADS, wireless sensors) is installed in the cabinet and properly terminated. The ramp meter signal heads have been bagged with an opaque material to avoid motorist confusion.

TESTING METHODOLOGY:

Brief descriptions of the columns in the testing documents are listed below.

TEST # - The order in which the tests should be performed.

TEST PROCEDURE – The manner in which the particular tests should be performed.

EXPECTED RESULT –Expected or desired result for each test. Any test performed that does not meet or exceed these criteria is a failure. The testing shall stop and the cabinet flagged for repair. Upon correction of the deficiency a new round of testing, including new documentation shall be completed.

PASS / FAIL – This is where all testing results are recorded. When a test is properly performed and it meets or exceeds the expected result, **P** shall be circled. When a test is properly performed and it does not meet the expected result then **F** shall be circled, the equipment tagged with the problem, and FAILED written on the front cover of the testing documentation.

If a test procedure step does not apply to the cabinet under test, **N/A** shall be written in the comment section.

CABINET NO.: ______________________________ **Test Date:** _____________________

CONTROLLER ADDRESS / CIRCUIT: _______________ / ____________

1. **Cabinet checks and verifications.**

This test form covers the 341A, detector and ramp metering cabinets.

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
1	Verify cabinet exterior is in good condition with no visible damage. Verify that the cabinet is firmly anchored in position.	Cabinet is free of dents, scratches, or other defects. Cabinet is firmly anchored to the foundation.	**P** or **F**	
2	Open front cabinet door fully and secure in the open position with the cabinet doorstop. Verify the doorstop arm is in good condition and keeps the door in place securely.	Cabinet door lock operates properly. Cabinet door opens freely and secures in position with the doorstop.	**P** or **F**	
3	Open the back cabinet fully and secure in the open position with the cabinet doorstop. Verify the doorstop arm is in good condition and keeps the door in place securely.	Cabinet door lock operates properly. Cabinet door opens freely and secures in position with the doorstop.	**P** or **F**	
4	Verify that cabinet interior is in good condition, lights and fans are intact and secure, and main breaker off.	The interior in good condition with lights and fans intact.	**P** or **F**	
5	Verify cabinet is at the proper location as shown on the plans and that the proper quantity and equipment (controller, PADS, etc) is installed.	The cabinet location and contents matches what is shown in the plans.	**P** or **F**	
6	Open transformer cabinet and test output voltage of transformer. Close and lock cabinet door.	Between 115 and 125 VAC	**P** or **F**	
7	Turn on the main circuit breaker	Fans and lights come on. If fans do not come on, set thermostat temperature lower until fans operate.	**P** or **F**	

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
8	Switch all breakers to the on position. Verify light in the upper right on side marked “Main AC + power On” is lit.	The light should be on.	**P** or **F**	
9	Check for AC power at all outlets.	Between 115 and 125 VAC.	**P** or **F**	
10	Depress the door actuator push button switches (front and rear).	Cabinet lights extinguish.	**P** or **F**	
11	Verify outlet strip is installed, plugged in and turned on. Test voltage at all receptacles..	Between 115 and 125 VAC at all receptacles.	**P** or **F**	
12	Locate the ground fault interrupt (GFI) receptacle in the front panel of the PDA. Press the “Test Reset” button. Push the “Reset” button.	Power is lost when Test Reset is pressed and is restored when Reset is pressed.	**P** or **F**	

2. Model 222 Loop Detector Configuration and Testing (Volume and Speed)

This section deals with the set-up, configuration, and testing of the loop system.

A. Volume Testing

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
13	Verify all loops tests and loop with lead in tests (Special Provisions Bid Item 7350030, Section 3.0 (D) have been performed successfully.		**P** or **F**	
14	Compare number of Model 222 cards with the road configuration. Record # of Mainline Lanes: _________	One amplifier card per lane (mainline) in Input File I, and three amplifier cards in Input File J (RM cabinets only).	**P** or **F**	

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
15	Set the Model 222 Cards to the following base settings and adjust as necessary for proper operation: Nominal Sensitivity: **Medium** Frequency (select one): **Lo, Med Lo, Med Hi, Hi** (Note that adjacent cards should NOT have identical frequencies selected.) Mode Of Operation: **Presence**		N/A	
16	Perform loop volume accuracy test per instructions on **Detector Accuracy Verification Form**, Attachment A	All the loops have been tested successfully and the results have been recorded.	**P** or **F**	

B. Speed Calibration and Testing

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
17	Calibrate and test loop detectors per the Loop Calibration and Speed Testing Form – Attachment B		**P** or **F**	

3. Ramp Meter Functions Testing

The next portion of the testing will test the 2070 Controller's operation of the signal heads, flashers, and watchdog timer. This testing will be performed using the "Test Prom Module #2.

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
18	Switch the Model 2070 controller power off and replace the 416C memory module with the ADOT supplied Test Prom Module.		N/A	

TEST #	TEST PROCEDURE	EXPECTED RESULT	PASS / FAIL	COMMENTS (if failed)
19	On the key pad type the following: **090330E** **02E** **102E**	Red signal lamp illuminates Red LED illuminates on Model 200 switchpack #1	**P** or **F** **P** or **F**	
20	Remove the fuse for the 24-volt DC on the front of the PDA.	Fail light on Model 208 illuminates and signal lamps extinguish	**P** or **F**	
21	Reinsert the 24 Volt DC fuse in the PDA and reset the 208 Monitor card.	Fail light on Model 208 extinguishes and signal heads re-illuminate	**P** or **F**	
22	On the key pad type the following: **090330E** **02E** **103E**	Green signal lamp illuminates Green LED illuminates on Model 200 switchpack #1	**P** or **F** **P** or **F**	
23	On the key pad type the following: **090330E** **02E** **104E**	Other Red signal lamp illuminates Red LED illuminates on Model 200 switchpack #2	**P** or **F** **P** or **F**	
24	On the key pad type the following: **090330E** **02E** **105E**	Other Green signal lamp illuminates Green LED illuminates on Model 200 switchpack #1	**P** or **F** **P** or **F**	
25	On the 2070 Controller key pad press: **090330E** **02E** **106E**	Beacons alternate off and on LEDs on Model 204 alternate off and on	**P** or **F** **P** or **F**	
26	Switch the Model 2070 controller power off and reinstall the original 416C module that came with the 2070 Controller.			

4. Cabinet Labeling & Detailing Checklist

Final checks that must be made to ensure the site is complete. A box is provided to mark when these tasks are complete.

	TASK	COMPLETE
1	Reset controller RAM to ensure all errors cleared (Note that this procedure deletes everything in RAM, therefore this must be done prior to entering any ramp metering parameters): Set Stop Timing Switch to **ON** Turn controller power switch to **OFF** Depress any keypad key and **Hold**, while turning controller power switch **ON** Set Stop Timing Switch to **OFF** and release key on keypad.	
2	Enter correct Controller Address in loc **C 0 0** (See Plans for correct controller ID)	
3	If RM cabinet, Enter **2** in loc **C 0 1** (Dual Lane RM configuration)	
4	Enter correct Circuit ID in **C 0 2** (See Plans for correct circuit ID)	
5	Enter correct Node ID in loc **C 0 3** (See Plans, note that Node ID is Node number minus 1))	
6	Re-enter Loop trap distances (if necessary).	
7	Set fan thermostat to 90° F.	
8	Set second fan thermostat to 110° F.	
9	Check that all signal wire field cables are labeled.	
10	Check that all loop lead-in cables are labeled.	
11	Verify that all cables are neatly routed and cable tie ends are cut off.	
12	Verify that no tools or debris is left in the cabinet.	
13	Check that the outside of the cabinet is labeled with the station location and the maintenance ID.	

Cabinet No.: ____________________________

Controller Ckt/ID: ____________/_______________

Test performed by (signature)	____________________________________
Print Name	____________________________________
Date of Test	____________________________________
ADOT Representative (signature)	____________________________________
Print Name	____________________________________
Date of Test	____________________________________

LOOP DETECTOR ACCURACY VERIFICATION FORM

CABINET ________________ **DATE** ____________________

TESTERS ________________ / ________________________

Test Procedure:

1. Each detection zone must be tested individually.
2. From the base display enter **D 1 0** to monitor Lane 1U. The vehicle count will appear in the last three digits of the display.
3. The 2070 display will increment each time a vehicle is detected. Note that every minute the display resets, therefore the display must be monitored constantly.
4. With both people in position and stopwatches at the ready, begin counting vehicles that pass over the detection zone being tested and record each minutes of volume date in the table below.
4. After 15 minutes or 100 vehicles, write down the total number of vehicles from the 2070 and manual counts during the test period.
5. Enter **A** to increment to the next memory location and repeat for all mainline lanes. (**D 1 1** Lane 1D, **D 1 2** Lane 2U, etc.)
6. Repeat test for ramp loops: **D 2 0** left lane input, **D 2 1** left lane output, **D 2 2** left lane queue, **D 2 3** right lane input, **D 2 4** right lane output, **D 2 5** right lane queue
5. Tally up total volumes and compute detector accuracy using following formula:

$$\frac{\text{Manual Count - (Manual Count - 2070 Count)}}{\text{Manual Count}} \text{ x 100 = \% Accuracy}$$

Passing is ≥ 95% Accuracy

	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		Total	
Zone	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man
1U																																
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6U																																
6D																																
	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		Total	

LOOP DETECTOR ACCURACY VERIFICATION FORM

Zone	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man	2070	Man
ELI																																
ELO																																
ELQ																																
ERI																																
ERO																																
ELQ																																

RESULTS:								
	Lane 1U: ______%	P	F		Lane 1 D: ______%	P	F
	Lane 2 U: ______%	P	F		Lane 2 D: ______%	P	F
	Lane 3 U: ______%	P	F		Lane 3 D: ______%	P	F
	Lane 4 U: ______%	P	F		Lane 4 D: ______%	P	F
	Lane 5 U: ______%	P	F		Lane 5 D: ______%	P	F
	Lane 6 U: ______%	P	F		Lane 6 D: ______%	P	F
	ELI: ______%	P	F		ELO: ______%	P	F
	ELQ: ______%	P	F				
	ERI: ______%	P	F		ERO: ______%	P	F
	ERQ: ______%	P	F				

LOOP SPEED CALIBRATION AND TESTING FORM

CABINET _______________ **DATE** ________________

TESTERS __________________ / ______________________

Test Procedure:

1. Verify/Set loop trap distance to 18.0' for all lanes (Note display resolution is 1/10 feet):
   - **F 3 B** = Lane 1 (shoulder lane), **F 3 C** = lane 2, **F 3 D** = Lane 3, **F 3 E** = Lane 4, **F 3 F** = Lane 5, **F 4 0** = Lane 6
2. From the controller base display enter **C 0 E 3 9 E B** (Changes contents of location C 0 to 39 and returns to base display)
3. Enter **F 9 E 1 E B** (Changes contents of location F9 to 1 and returns to base display)
4. Enter **E 2 1** to display speed for Lane 1 (shoulder lane). The speed is displayed in the last three characters in ft/sec. Use the **A** key to increment (depress twice) the display to the next lane. E 2 3 = Lane 2, E 2 5 = Lane 3, etc.
5. Drive vehicle at a known rate of speed over detection zone and record speed on form below.
6. Perform the following calculation to determine "actual" loop trap distance:

$$\frac{\text{Actual vehicle speed (mph)}}{\text{Speed off Mode 2070 (ft/sec)} \times 0.682} \times 18 \text{ (ft)} = \text{Computed Trap Length (ft)}$$

7. Change value in controller to Computed Trap Length and record values in table below. Repeat test to ensure correct speed recorded.
8. If speed error is ≤ ±5%, lane has passed and move on to next lane.

	PRELIMINARY TEST				RETEST (if needed)			
LANE	**Test Vehicle Speed (mph)**	**Model 2070 Speed x 0.682**	**% Error**	**Computed Trap Length (ft)**	**Test Vehicle Speed x 0.682**	**Model 2070 Speed**	**% Error**	**P/F**
1								
2								
3								
4								
5								
6								

CCTV
343 or 341 CCTV Cabinet

Stand Alone Test Procedure

Connect 202

for

I-10 ITS Segment D-3

75^{th} Ave to 43^{rd} Ave

202L MA 054 H882701C

NH-202-D(200)S

June 20, 2017

I. INTRODUCTION:

The purpose of this Stand Alone Test Procedure is to verify that the Contractor-furnished and installed CCTV camera, along with the 343/341 control cabinet and associated equipment is fully functional and operating per the specification requirements prior to connection to the communications equipment. Testing is conducted at each individual CCTV installation in an off-line environment.

A test data sheet is supplied at the end of this document. A copy of this sheet should be made for each CCTV/343 or CCTV 341 Cabinet under test.

II. TEST EQUIPMENT REQUIRED:

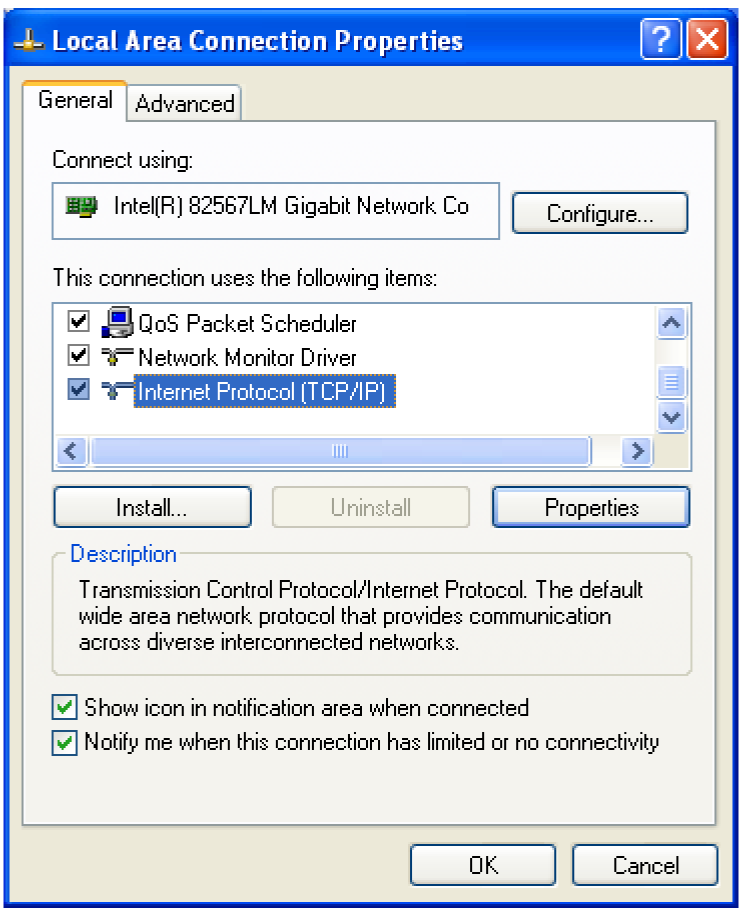
- Multimeter with test leads
- Laptop computer
- Category 5 patch cord

III. 343 CABINET TEST PROCEDURE:

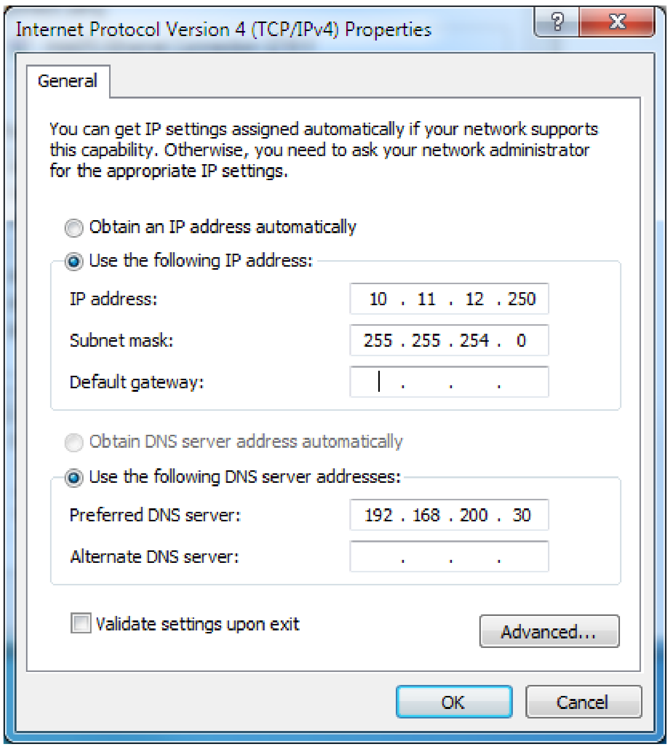
1. Open the 343/341 front and rear doors, verify both fluorescent lights illuminate.
2. Manually depress the refrigerator style contact switches and verify the lights go out.
3. Active Gear tests:
    a. Using the multimeter verify 120 ±10 VAC output at each electrical outlet.
    b. Verify the output voltage of the layer 2 Ethernet switch power supply is 24VAC and those connections are tight.
    c. Verify the surge arrestor is grounded
4. Adjust the fan thermostat to its lowest temperature threshold and verify the cabinet cooling fan comes on. Reset thermostat to 100°F.

IV. CCTV TEST SETUP:

With the laptop computer running, plug one end of a Cat 5 patch cord into LAN port of the Bosch POE supply and the other end into the Ethernet port of the laptop. On the laptop go to control panel, network connections, Local Area Connection, right click and select properties. From the general tab, select internet protocol (TCP/IP) and click properties.

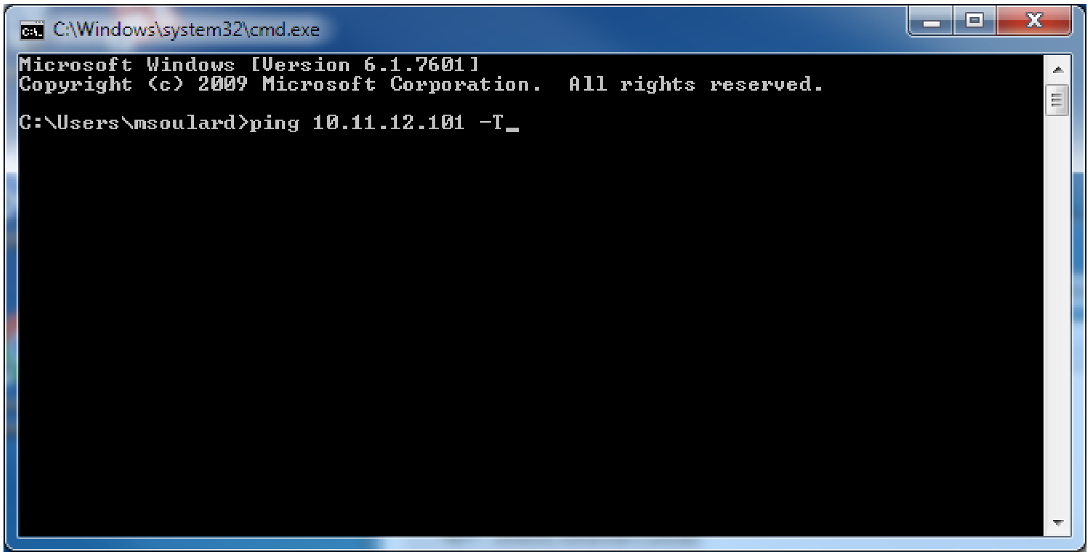


From the general tab select the button labeled, Use the following IP address. Edit the IP address of your PC to the following, 10.11.12.250. Edit your Subnet Mask to that listed in the example below. Then click the OK button and wait 15 seconds for the settings to become active.

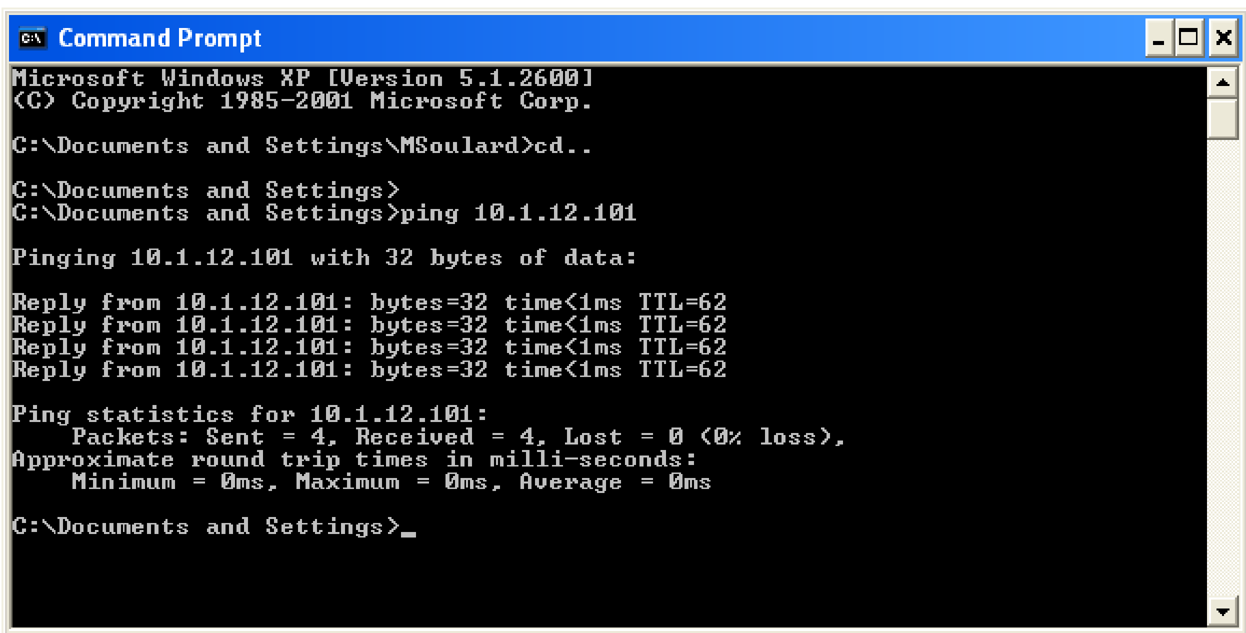


From the windows start menu select command prompt. If command prompt is not listed select run, type cmd and press the enter key. From command prompt type the following

Ping(space)(Bosch IP camera address)



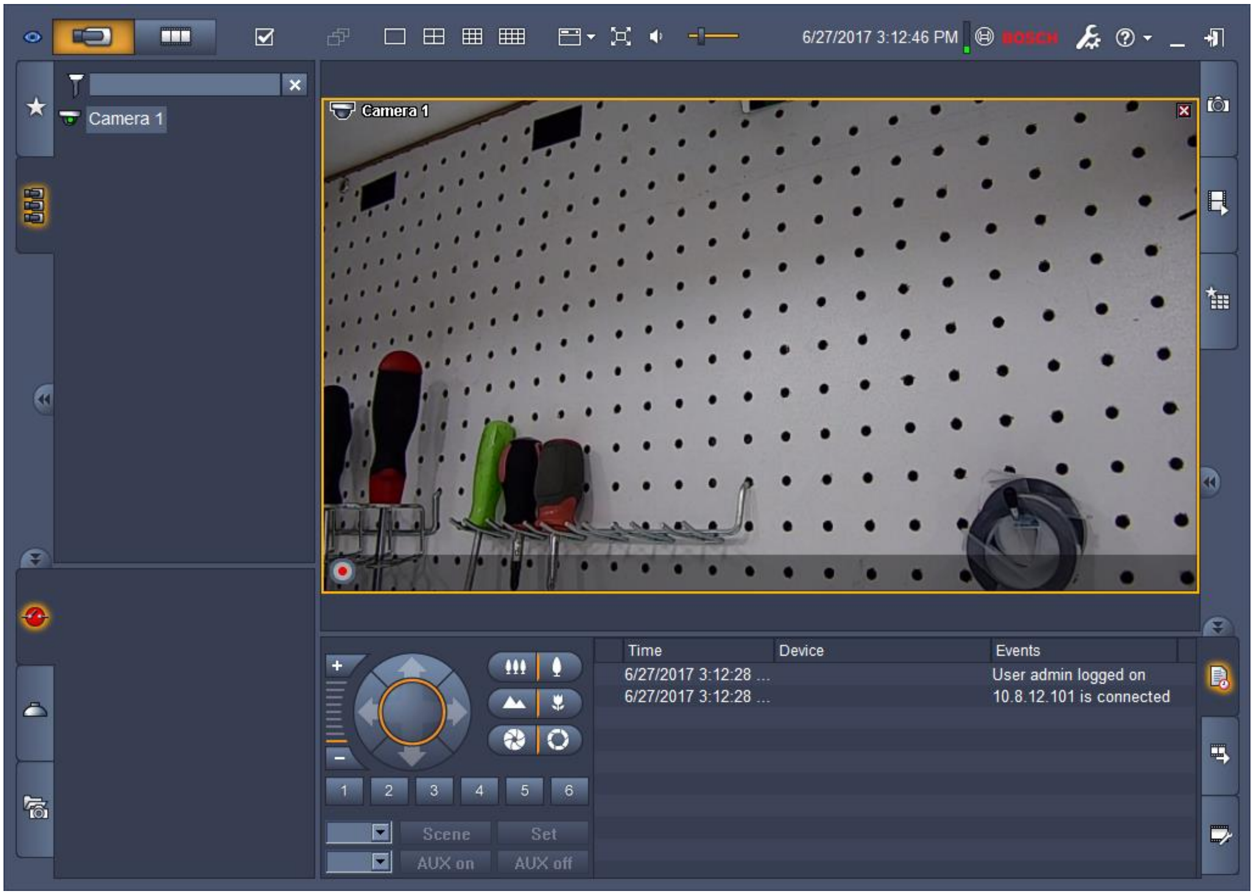
Press enter



As long as you receive replies from the encoder you are clear to proceed with the test.

IV. CCTV TEST PROCEDURE:

From the start menu launch Bosch Camera Viewer. Type the IP address of the encoder into the Connect to bar. Enter admin in the user name position. Hit enter.



Utilize the camera control screen to perform the test functionality.

VIDEO QUALITY TEST:

5. Verify during all following tests that the CCTV picture is of a high quality and acceptable to the ADOT Inspector.

PAN/TILT TEST:

6. Press the curser to the top of the PTZ button. Verify the CCTV tilts UP.
7. Press the curser to the bottom of the PTZ button. Verify the CCTV tilts DOWN
8. Press the curser to the right side of the PTZ button. Verify the CCTV pans RIGHT.
9. Press the curser to the left side of the PTZ button. Verify the CCTV pans LEFT.

IRIS CONTROL TEST:

10. Press the curser to the **OPEN** button. Verify the picture BRIGHTENS.
11. Press the curser to the **CLOSE** button. Verify the picture DARKENS.

Note: This test puts the iris in the manual mode. To put the iris back into automatic mode, click on the Auto Iris button.

FOCUS/ZOOM LENS TEST:

12. Using the PTZ control, point the CCTV at an object relatively far from the camera. Press the curser to the Zoom + button. Verify the image ZOOMS IN, optically at first and then digitally. When optically zooming, the image will get larger with no reduction in image

resolution, when the digital zoom begins, the image will continue to enlarge but the resolution of the image will decrease with each digital step.

13. Press the curser to the Focus + or – button as required to the image in and out of focus. Then press the Auto Focus button. Verify the image comes into FOCUS.
14. Using the PTZ control, point the CCTV at an object relatively close to the camera. Press the Zoom + key. Verify the image ZOOMS IN and stays in focus.
15. Press the stylus to the **FAR** (or **NEAR**) soft key as required to focus the image. Verify the image comes into FOCUS.

SCENE/PRESET TEST

16. Enter a 1 in the scene space and press set
17. Pan to a different position and enter a 2 in the scene position and press set.
18. Press the scene 1 button. The camera should slew to scene 1.
19. Press the scene 2 button. The camera should slew to scene 2.

AZIMUTH DISPLAY TEST:

20. Using the PTZ control, rotate the camera to point to the north.
21. Click/Tap the stylus to the PGM soft key, the programming menu appears.
22. Select Other mode and then select Azimuth Display.
23. Follow on-screen prompts to set the current camera position as north and enable the azimuth display. Verify N is displayed on the video.
24. Using the PTZ control, pan the camera 360° and verify the azimuth display changes with camera position.

NON VOLATILE MEMORY TEST:

25. Cycle the CCTV power off and back on with the main circuit breaker.
26. Using the PTZ control, pan the camera to eliminate the power—up on screen display and verify the correct azimuth is displayed on the monitor.
27. Click/Tap the stylus to the PGM soft key, the programming menu appears.
28. Select Other mode and then select Azimuth Display.
29. Disable display of Azimuth display.
30. Exit out of programming menu.

NIGHT TIME TEST (performed after sundown):

31. Verify that the video reverts to a Black and White image. Note it may be necessary to point the camera towards a darkened area. Verify the quality of the low—light Black and White image is acceptable.

CCTV TEST DATA SHEET

CCTV IP Address: ____ Test Date: ____________

CCTV Cabinet No./Location: ___________ / __________________

Note: The line numbers correspond to test procedure step numbers.

CC CABINET TEST:

1. Both Fluorescent Lights Illuminate: Pass: _______ Fail:________
2. Both Fluorescent Lights Extinguish: Pass: _______ Fail:________
3. Active Gear Tests:
   a. 120VAC at electrical outlets Pass: _______ Fail:________
   b. Surge arrestor grounded: Pass: _______ Fail:________
4. Cooling Fan comes On: Pass: _______ Fail:________

CCTV TEST:

Video Quality Test:

5. Video Performance: Pass: _______ Fail:________

Pan/Tilt Test:

6. Camera Tilts Up: Pass: _______ Fail:________
7. Camera Tilts Down: Pass: _______ Fail:________
8. Camera Pans Right: Pass: _______ Fail:________
9. Camera Pans Left: Pass: _______ Fail:________

Iris Control Test:

10. Picture Brightens: Pass: _______ Fail:________
11. Picture Darkens: Pass: _______ Fail:________

Focus/Zoom Test:

12. Lens Zooms In Optically and Digitally: Pass: _______ Fail:________
13. Camera Focuses Far: Pass: _______ Fail:________
14. Lens Zooms Out: Pass: _______ Fail:________
15. Camera Focuses Near:

Azimuth Display Test:

16. N is displayed on video: Pass: _______ Fail:________
17. Azimuth changes with camera position: Pass: _______ Fail:________

Non-Volatile Memory Test:

18. Azimuth still displayed on video: Pass: _______ Fail:________

Night Time Test:

19. Video Performance (Black/White Image): Pass: _______ Fail:________

Scene/Preset Test:

1. Camera Pans to Scene/Preset Chosen: Pass:_______ Fail:_______

Field Hardened Ethernet Switch (Layer 2)

Stand Alone Test Procedure

Connect 202

for

I-10 ITS Segment D-3

75th Ave to 43rd Ave

202L MA 054 H882701C

NH-202-D(200)S

June 20, 2017

I. INTRODUCTION:

The purpose of this Stand Alone Test Procedure is to verify that the Contractor-furnished and installed Ethernet Switch is fully functional and operating per the specification requirements prior to connection to the communications equipment. Testing is conducted at each individual Ethernet Switch with in the project in an online environment.

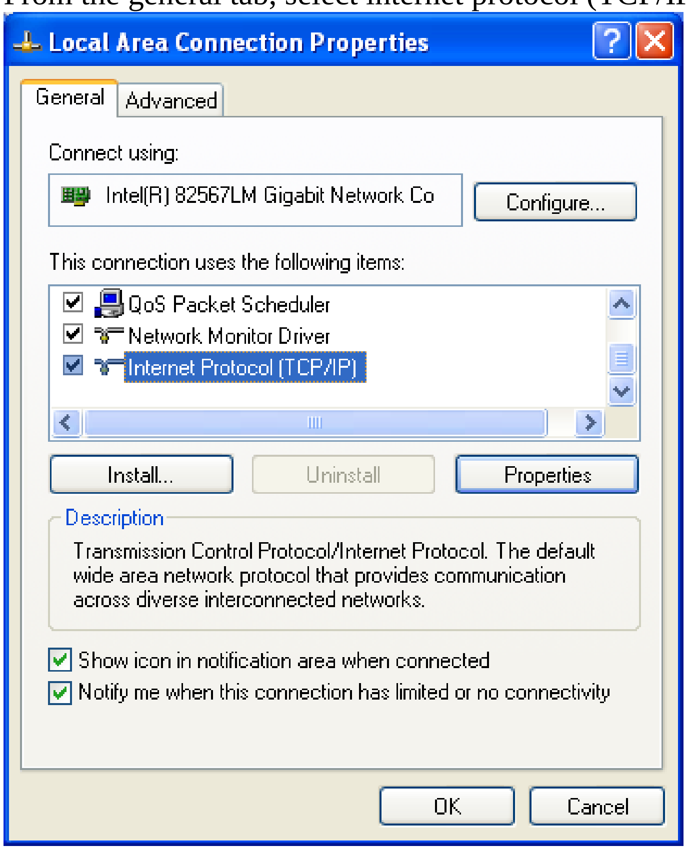
A test data sheet is supplied at the end of this document. A copy of this sheet should be made for each Ethernet Switch under test.

II. TEST EQUIPMENT REQUIRED:

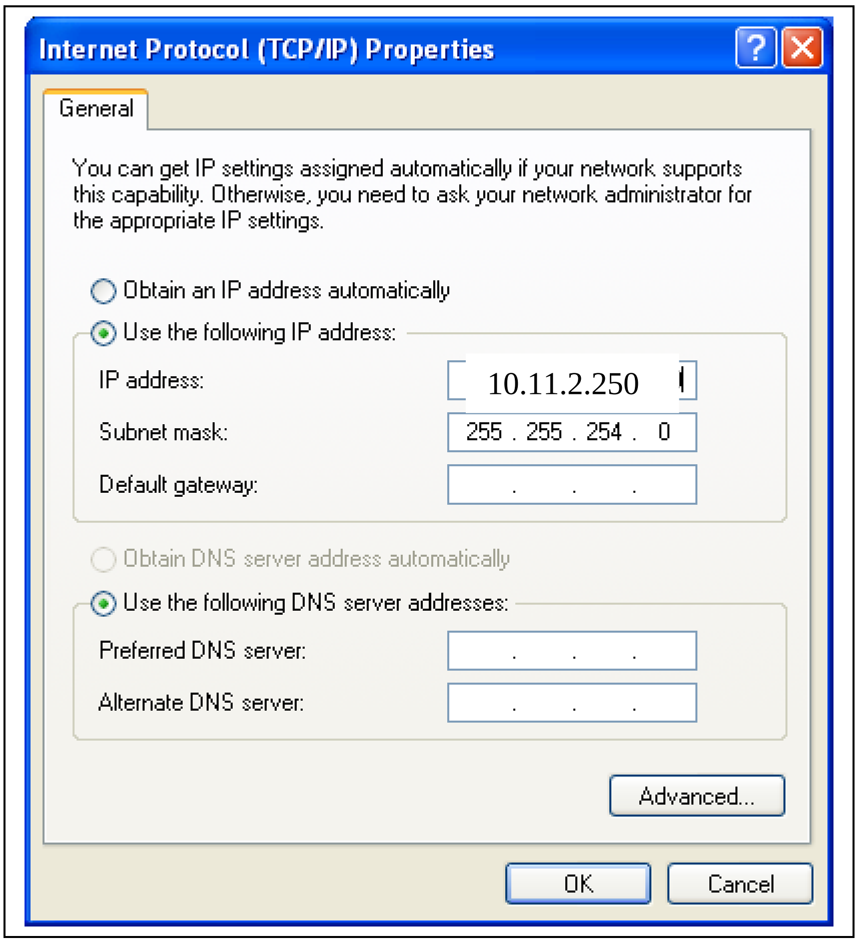
- Laptop computer
- Category 5 patch cord

III. ETHERNET SWITCH TEST SETUP:

With the laptop computer running, plug one end of a Cat 5 patch cord into Ethernet port 1 of the Ethernet Switch and the other end into the Ethernet port of the laptop. On the laptop go to control panel, network connections, Local Area Connection, right click and select properties. From the general tab, select internet protocol (TCP/IP) and click properties.

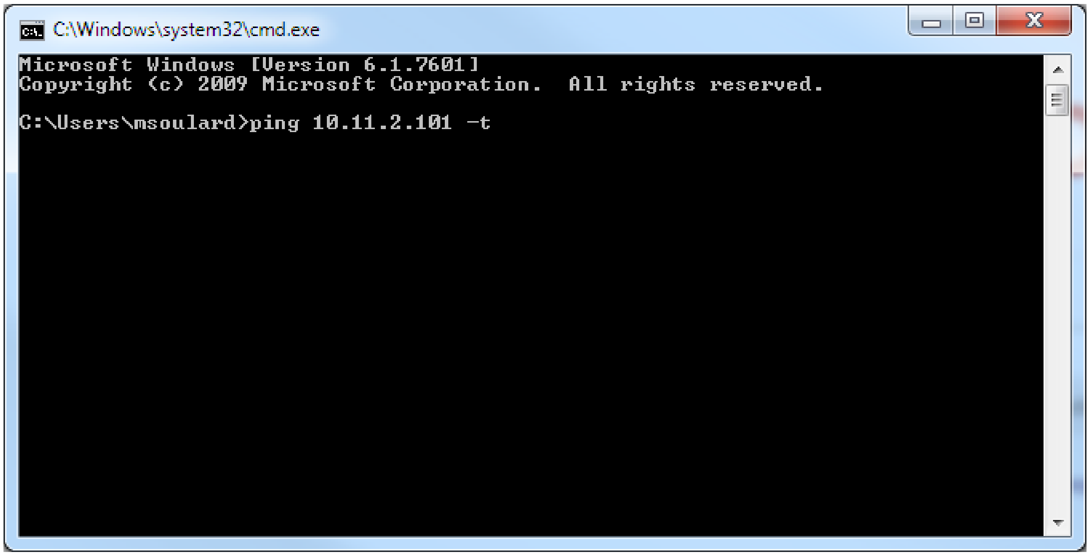


From the general tab select the button labeled, Use the following IP address. Edit the IP address to the following, 10.11.2.250. Edit your Subnet Mask to that listed in the example below. Then click the OK button and wait 15 seconds for the settings to become active.

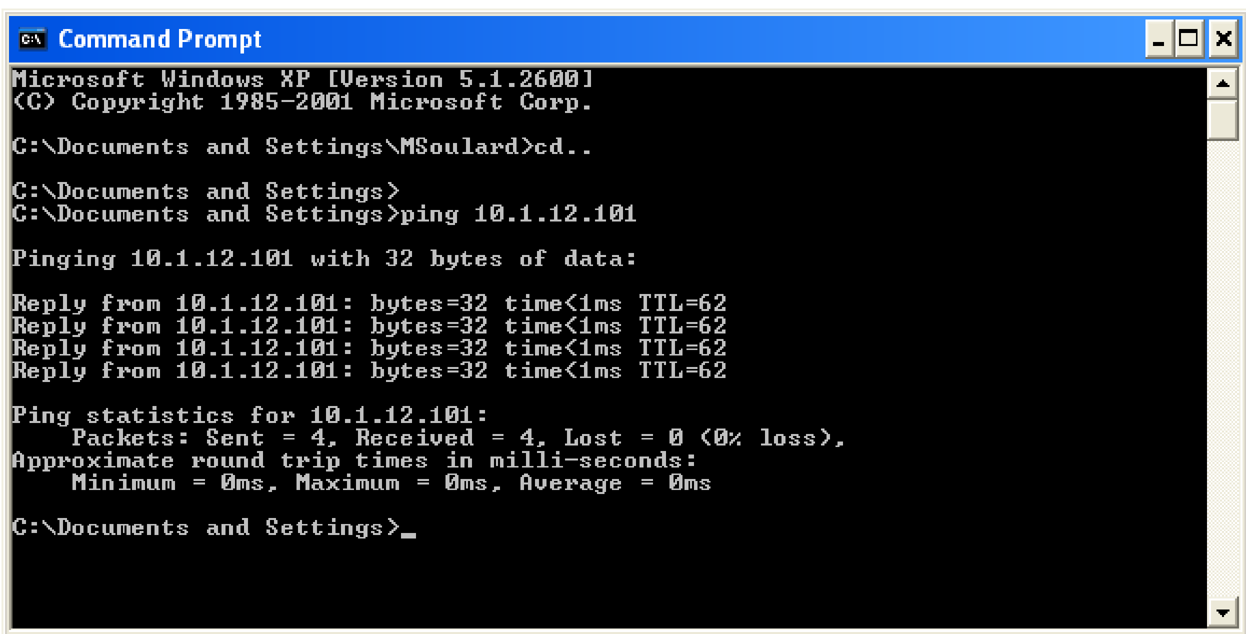


From the windows start menu select command prompt. If command prompt is not listed select run, type cmd and press the enter key. From command prompt type the following

Ping(space)(Ethernet Switch IP address)



Press enter



As long as you receive replies from the Ethernet Switch you are clear to proceed with the test.

IV. ETHERNET SWITCH TEST PROCEDURE:

1. Verify that power is applied to the Ethernet Switch and that ports with equipment connected have illuminated link lights.

2. With your laptop IP set to 10.11.2.250, ping switch installed in the cabinet.. Verify that you receive 4 successful ping responses of less than 50 milliseconds.

3. Ping layer 3 switch at 10.11.2.1. Verify that you receive 4 sucessful ping responses of less than 50 milliseconds.

4. Verify the Switch is mounted in accordance with manufaturers approved mounting methods which in this case the switch is designed to be mounted to DIN Rail. Verify the switch is mounted to DIN Rail

5. Verify that switch power and grounding connections are made securely.

6. Using a web browser navigate to the IP address of the local switch and verify that the following VLANS are installed on the ports listed.

Port 1 VLAN 1102	Port 2 VLAN 1112
Port 3 VLAN 1102	Port 4 VLAN 1114
Port 5 VLAN 1131	Port 6 VLAN 1141
Port 7 VLAN 1102	Port 8 VLAN 1118

ETHERNET SWITCH TEST DATA SHEET

Ethernet Switch IP Address: 10.11.2.X ____Test Date:

Subnet Mask:255.255.255.0 ____________ Ports in use: Port

Default Gateway IP:10.11.2.1

Cabinet No./Location: __________ /__________ ______________

Note: The line numbers correspond to test procedure step numbers.

ETHERNET SWITCH TEST:

Power and Port Status Indicator Test:

1. Active Ports LED Indicators Illuminated: Pass: _______ Fail:________

Local Switch Ping Test:

2. Receive 4 Reponses ≤ 50ms: Pass: _______ Fail:________

Layer 3 Switch Ping Test:

3. Receive 4 Reponses ≤ 50ms: Pass: _______ Fail:________

Mounting methods:

4. Is switch mounted securely (Din Rail in this case) Pass: _______ Fail:________

Power Connections:

5. Are power connections secure Pass: _______ Fail:________

VLANs Settings

6. Are the VLANS set for each Port on switch Pass:________ Fail:_________

Comments:____
____

Contractor Representative: C202P Representative:

_____________________________ _____________________________
Signature Signature

Subsystem Test Procedure (SST)

Connect 202

for

I-10 ITS Segment D-3

75^{th} Ave to 43^{rd} Ave

202L MA 054 H882701C

NH-202-D(200)S

June 20, 2017

I. INTRODUCTION:

The purpose of this Sub System Test Procedure is to verify that for a 72 hour period the CCTV, DMS, and communications systems operate in accordance with the contract documents. Testing is conducted in the node by the contractor with ADOT supervision.

A test data sheet is supplied at the end of this document. A copy of this sheet should be made for each device under test.

II. TEST EQUIPMENT REQUIRED:

- Laptop computer
- Category 5 patch cord

III. LAPTOP SETUP:

Laptop is not needed for the CCTV test. Following the CCTV Test, place your laptop in the Ethernet Switch IP subnet and conduct communications testing. No laptop setup is required for DMS testing as it is conducted from an ADOT workstation running DMS Cameleon.

IV. SUBSYSTEM TEST PROCEDURE:

1. From within the node building plug into an Ethernet port with your laptop. Place your laptop ethernet port in the CCTV subnet for that node. Open Bosch Camera viewer program and select each camera one at a time.

    a. Verify that Live video appears

    b. Verify that the video image movement is smooth and free of jitter

    c. Verify the camera responds to automatic presets

    d. Verify that text appears on screen such as camera name, date and time

    See appendix A to record results.

2. From your laptop in the node building, ping all node 11 FMS devices listed in Appendix B and receive 4 successful replies of ≤ to 50 ms. Tests of with 4 sucessful replies of ≤ 50 ms are sucessful. See appendix B to record results.

3. The contractor will work with an ADOT representative to place test messages on each of the project DMS signs. If the operaters can place messages, receive successful feedback that the messages posted and were able to be blanked, the test is successful. Utilize project cameras to verify that the messages post and clear correctly. See appendix F to record results.

Appendix A

	75th Ave						67th Ave						59th Ave						51st Ave						43rd Ave					
	Day 1		Day 2		Day 3		Day 1		Day 2		Day 3		Day 1		Day 2		Day 3		Day 1		Day 2		Day 3		Day 1		Day 2		Day 3	
Does live video appear on screen?	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F
Do objects move smoothly through the image?	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F
Does the camera respond to preset positioning commands?	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F
Does generated text appear on screen?	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F

Appendix B

Ethernet Switch IP Table

Ping Test Results			
	DAY 1	DAY 2	DAY 3
Ethernet Switch			
10.11.2.75	P / F	P / F	P / F
10.11.2.76	P / F	P / F	P / F
10.11.2.77	P / F	P / F	P / F
10.11.12.103	P / F	P / F	P / F
10.11.12.104	P / F	P / F	P / F
10.11.18.12	P / F	P / F	P / F
10.3.2.52	P / F	P / F	P / F
10.3..2.71	P / F	P / F	P / F
10.3.2.72	P / F	P / F	P / F
10.3.2.73	P / F	P / F	P / F
10.3.12.115	P / F	P / F	P / F
10.3.12.116	P / F	P / F	P / F
10.3.12.117	P / F	P / F	P / F
10.3.18.11	P / F	P / F	P / F

Appendix C

Note: Work with ADOT personnel to place test messages on the 2 DMS Signs. Verify that the messages are displayed correctly on the signs. Remove messages from the signs. Verify that the signs return to blank. Record the results below.

	DMS WB 59th Ave			DMS EB 67th Ave		
	DAY 1	DAY 2	DAY 3	DAY 1	DAY 2	DAY 3
Place Message on Sign	P / F	P / F	P / F	P / F	P / F	P / F
Remove Message From Sign	P / F	P / F	P / F	P / F	P / F	P / F

FMS

SUBSYSTEM TEST PROCEDURES

TABLE OF CONTENTS

I. INTRODUCTION:

The purpose of this Subsystem Test (SST) Procedure is to verify that contractor-furnished and installed equipment (vehicle detection, communications) is fully functional and operating per the specification requirements for a 72-hour period of time without failure. Note that the CCTV equipment is only required to be tested two times during the SST, once in daylight and again at nighttime; and DMS equipment will only be tested for as long is required to verify proper operation of the signs and communication circuit redundancy.

The Design-Builder shall work with the DMS supplier's on-site technician to debug and mitigate or repair any problems in the overall DMS system operation, including providing necessary lif tor bucket trucks and traffic control, if required.

The SST is broken down into three main groups:

- CCTV Group
- Model 2070 Controller Group
- DMS Group

The CCTV Group SST shall verify the following:

- Transmission of high quality video images to the TOC;
- Transmission of control signals to camera;
- Positioning of each camera from the TOC control panels;
- Response to automatic preset positioning commands from the TOC;
- Priority and partitioning of commands; and,
- Generation of text, date, and time on monitors

via laptop computers with Pelco control software.

If the video is substandard, the contractor shall be required to perform video resolution and signal-to-noise ratio testing on however many cameras the Engineer requires, in which case the contractor shall submit a test procedure for approval, prior to the testing.

The Model 2070 Controller Group SST will be performed by the Design-Builder with close ADOT support. The testing will last 72 hours and shall verify Model 2070 communications performance as well as verifying individual lane detection is functional by connecting the communication circuits to a spare FMS server and running test software. During the testing, the Design-Builder shall force communications on the primary and secondary communications paths (between the TOC and the nodes) to prove both fiber paths are operational, along with injecting simulated faults in the field to verify proper operation of the redundant circuits.

The DMS Group SST will verify DMS performance by connecting the communication circuits to laptop computers containing vendor control software (to simulate central control). During the testing, the Design-Builder shall inject simulated faults in the field to verify proper operation of the redundant circuit.

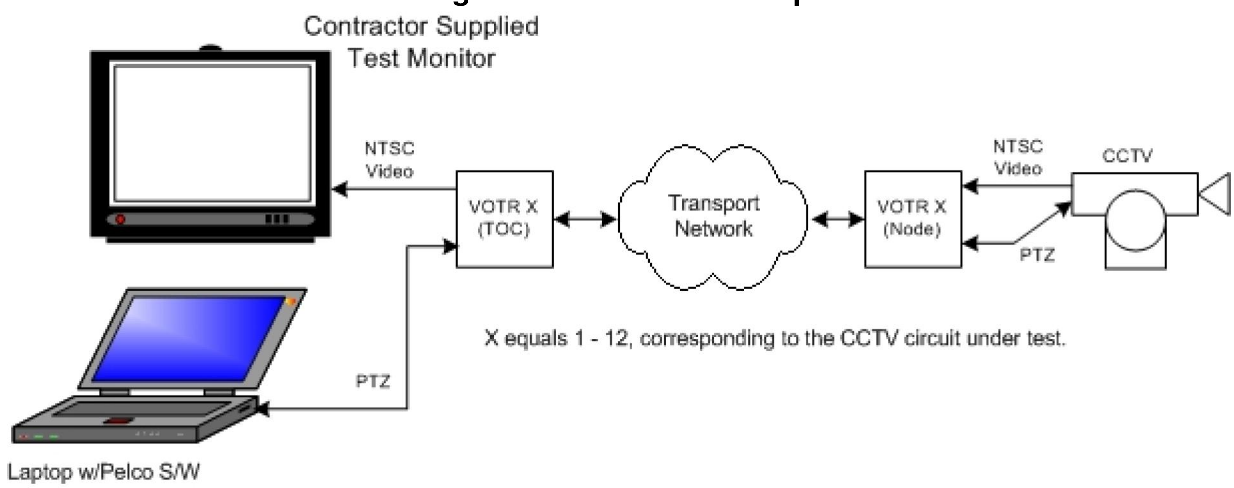
II. CCTV GROUP SUBSYSTEM TESTING:

CCTV Video and Control SST:

1. Test Setup:

Connect the NTSC output of the VOTR of the CCTV circuit under test to the contractor-supplied test monitor. Connect a laptop computer with CCTV control S/W to the data port of the same VOTR per **Figure 1 – CCTV Test Setup**.

Figure 1 – CCTV Test Setup



2. Test Procedure:

The Contractor, using the laptop computer and manufacturer CCTV control software shall verify the quality of the video image in both daylight and nighttime conditions, as well as the proper operation of all user selectable functions of each contractor-installed CCTV camera. The Contactor shall test each camera and record the results on the CCTV test data sheets supplied in **CCTV Video and Control Test Data Sheets**.

III. MODEL 2070 CONTROLLER GROUP SUBSYSTEM TESTING:

A. Test Setup:

The test setup for this testing shall be configured by ADOT TOC personnel using a spare ADOT FMS server running the FMS test software. The spare FMS server will be connected to Nodes 7 and 14 Det/RM circuits via the 32-port terminal server at the TOC and shall communicate with them at a rate of 9,600 bps.

B. Test Procedure:

Test Preparation:

1. Verify successful completion of all 341 Cabinet Stand-Alone tests and Communications Group Subsystem Testing.
2. ADOT shall poll 341 cabinets using the FMS test software. Reports of the testing shall be E-mailed to the contractor. The controller communication response status shall be E-mailed every 4-hours, and the loop detection status shall be E-mailed once per day for the duration of the subsystem testing.

NOTE: Due to known errors related to the Model 2070 controllers operating at 9,600 bps and high traffic volume, the 2070 controller performance verification requirement of less than 1% in any 15-minute period is waived during the hours of 6 AM to 10 AM and 2 PM to 10 PM. Also note that any additional testing (i.e., redundant circuit operation) will not be performed during these hours.

If during the test hours the failure rate of the controllers exceeds the specification, the contractor will immediately alert ADOT. At that time the contractor and ADOT shall examine the traffic speed and volume data (and real time conditions with the CCTV if still practical) to determine whether the failure is real, or caused by the high volume anomaly, despite time of day.

3. The contractor shall fill out test data summary sheets for each report received from ADOT for the test hours specified above. The test data summary sheets are located in **341 Cabinet Test Data Summary Sheets**. These sheets will record Model 2070 communications performance as a percentage of successful responses to server polling, and shall record if the instrumented lanes of traffic are reporting speed and volume data. Reference **Controller Lane Assignments** for a listing of what lanes are instrumented for each detector cabinet.

   Note: If any lanes are reporting speed and volume data that seems unreasonable based on adjacent upstream and downstream detectors, the contractor (preferably accompanied by an ADOT inspector) will visit the cabinet(s) in question and determine if the detectors are malfunctioning or properly recording atypical traffic behavior.

Performance/Field Circuit Redundancy Tests:

For the purpose of test procedure (and data sheet) simplicity, it will be anticipated that the subsystem test will begin at 10:00 AM. If the test begins at different time, the test data sheets shall be modified accordingly.

Hour 0: Contractor to verify field is in full redundant operational configuration. ADOT to begin polling of controller cabinets.

Hour 1: On Node 7, RM/Det Circuit 1: The contractor shall disconnect the A Ring transmit and B Ring receive fiber connections at 341 cabinet #_______ to simulate a fiber break. Note that there should be no degradation in communications performance. After 15 minutes, the contractor shall reconnect the fiber connections.

Hour 1:30: On Node 7, RM/Det Circuit 1: The contractor shall disconnect the B Ring transmit and A Ring receive fiber connections at 341 cabinet #_______ to simulate a fiber break. Note that there should be no degradation in communications performance. After 15 minutes, the contractor shall reconnect the fiber connections.

Hour 2: On Node 7, RM/Det Circuit 2: The contractor shall disconnect the A Ring transmit and B Ring receive fiber connections at 341 cabinet #_______ to simulate a fiber break. Note that there should be no degradation in communications performance. After 15 minutes, the contractor shall reconnect the fiber connections.

Hour 2:30: On Node 7, RM/Det Circuit 2: The contractor shall disconnect the B Ring transmit and A Ring receive fiber connections at 341 cabinet #_______ to simulate a fiber break. Note that there should be no degradation in communications performance. After 15 minutes, the contractor shall reconnect the fiber connections.

Hour 3: On Node 7, RM/Det Circuit 1: The contractor shall unplug the power connection of the OTR at cabinet #_______ to simulate an OTR failure. Note that complete communication failure of the selected cabinet during the test period is expected. After 15 minutes, the contractor shall reconnect the fiber connections.

Hour 3:30: On Node 7, RM/Det Circuit 2: The contractor shall unplug the power connection of the OTR at cabinet #_______ to simulate an OTR failure. Note that complete communication failure of the selected cabinet during the test period is expected. After 15 minutes, the contractor shall reconnect the fiber connections.

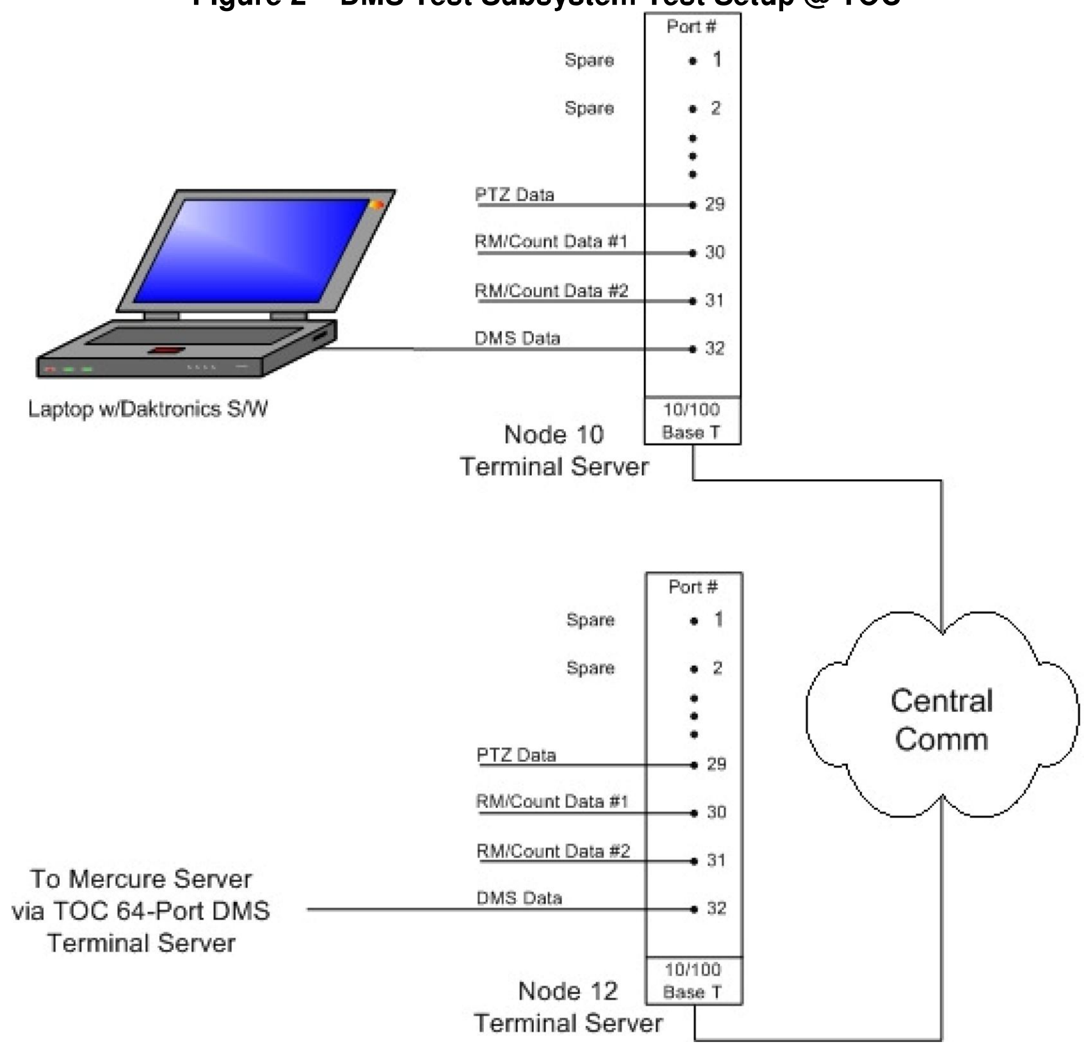
Hour 72: Test ends.

IV. DMS GROUP SUBSYSTEM TESTING:

A. Test Setup:

The existing Mercur (Fiber Optic Display Systems (FDS)) control computer at this time can only be used to communicate with FDS signs. This project involves relocating existing FDS signs as well as the installation of new DMS procured by Daktronics, consequently the central DMS control can not be used for subsystem testing of the new Daktronics signs. Therefore, the subsystem test for the Daktronics sign shall be identical to the Daktronics run stand-alone test procedure in that the sign's proper operation will be verified using a laptop computer running Daktronics control software. The only change being that the laptop's serial communications connection to the sign will be from the TOC via the central communications equipment. See Figure 2 below for an illustration of the test connection.

Figure 2 – DMS Test Subsystem Test Setup @ TOC



Test Procedure:

The Contractor, using a laptop computer loaded with Daktronics control software shall run a pixel test to verify the health of the new signs. For the existing DMS connected to Node 12, the Contractor shall request that ADOT TOC personnel place a message on the DMS to verify it is operational. After each new sign has been verified, all signs (new and existing) shall remain illuminated with an ADOT approved test message for the remainder of the test. During this period, the following steps will be performed on the signs to verify proper field communication circuit redundancy. At the end of the field circuit redundancy testing a final pixel test shall be run on all the new signs. The Contactor shall test each DMS and record the results on the DMS test data sheet supplied in **DMS Test Data Sheet**.

Note: Simulating fiber breaks in the main backbone will not be done during DMS subsystem testing as that function will have already been proven during the 341 Cabinet subsystem testing.

Field Circuit Redundancy Tests:

1. Contractor to verify DMS circuit is in full redundant operational configuration.

2. On Node 7, DMS Circuit: The contractor shall disconnect the A Ring transmit and B Ring receive fiber connections at DMS cabinet #_______ to simulate a fiber break. Note that there should be no degradation in DMS performance. After 15 minutes, the contractor shall reconnect the fiber connections.

3. On Node 7, DMS Circuit: The contractor shall disconnect the B Ring transmit and A Ring receive fiber connections at DMS cabinet #_______ to simulate a fiber break. Note that there should be no degradation in DMS communications performance. After 15 minutes, the contractor shall reconnect the fiber connections.

4. On Node 14, DMS Circuit: The contractor shall unplug the power connection of the OTR at a DMS cabinet #_______ to simulate an OTR failure. Note that complete communication failure of the selected DMS during the test period is expected. After 15 minutes, the contractor shall reconnect the fiber connections.

5. On Node 14, DMS Circuit: The contractor shall disconnect the A Ring transmit and B Ring receive fiber connections at DMS Cabinet #_______ to simulate a fiber break. Note that there should be no degradation in DMS performance. After 15 minutes, the contractor shall reconnect the fiber connections.

CCTV VIDEO AND CONTROL TEST DATA SHEETS

Note: Night time test shall occur no earlier then one hour past sunset.

TEST PARAMETER	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___
Video Quality Test::					
1. Video Performance:	P / F	P / F	P / F	P / F	P / F
Pan / Tilt Test:					
2. Tilt Camera Up	P / F	P / F	P / F	P / F	P / F
3. Tilt Camera Down:	P / F	P / F	P / F	P / F	P / F
4. Pan Camera Right:	P / F	P / F	P / F	P / F	P / F
5. Pan Camera Left:	P / F	P / F	P / F	P / F	P / F
Iris Control Test:					
6. Manually Open Iris:	P / F	P / F	P / F	P / F	P / F
7. Manually Close Iris	P / F	P / F	P / F	P / F	P / F
Focus Test:					
8. Focus Camera (Near Object):	P / F	P / F	P / F	P / F	P / F
9. Focus Camera (far Object):	P / F	P / F	P / F	P / F	P / F
Zoom Lens Test:					
10. Zoom Lens In Optical:	P / F	P / F	P / F	P / F	P / F
11. Zoom Lens in Digital:	P / F	P / F	P / F	P / F	P / F
12. Zoom Lens Out:	P / F	P / F	P / F	P / F	P / F
Blankout Zones Test:					
Verify/Set Blankout Zone(s)					
13. No Video in Blankout Zone(s)	P / F	P / F	P / F	P / F	P / F
Preset Test:					
14. Mainline Freeway (US-60 EB)	P / F	P / F	P / F	P / F	P / F
15. Mainline Freeway (US-60 WB)	P / F	P / F	P / F	P / F	P / F
16. Crossroad (North)	P / F	P / F	P / F	P / F	P / F
17. Crossroad (South)	P / F	P / F	P / F	P / F	P / F
18. Return to Home Position	P / F	P / F	P / F	P / F	P / F
Generation of Text Test:					
19. ADOT Defined Text Displayed	P / F	P / F	P / F	P / F	P / F
Night Time Test:					
20. Video Performance (B/W):	P / F	P / F	P / F	P / F	P / F

Contractor: ____________________ ADOT Vision: ________________________ Date:____________________

CCTV TEST DATA SHEETS (cont'd)

Note: Night time test shall occur no earlier then one hour past sunset.

TEST PARAMETER	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___
Video Quality Test::					
1. Video Performance:	P / F	P / F	P / F	P / F	P / F
Pan / Tilt Test:					
2. Tilt Camera Up	P / F	P / F	P / F	P / F	P / F
3. Tilt Camera Down:	P / F	P / F	P / F	P / F	P / F
4. Pan Camera Right:	P / F	P / F	P / F	P / F	P / F
5. Pan Camera Left:	P / F	P / F	P / F	P / F	P / F
Iris Control Test:					
6. Manually Open Iris:	P / F	P / F	P / F	P / F	P / F
7. Manually Close Iris	P / F	P / F	P / F	P / F	P / F
Focus Test:					
8. Focus Camera (Near Object):	P / F	P / F	P / F	P / F	P / F
9. Focus Camera (far Object):	P / F	P / F	P / F	P / F	P / F
Zoom Lens Test:					
10. Zoom Lens In Optical:	P / F	P / F	P / F	P / F	P / F
11. Zoom Lens in Digital:	P / F	P / F	P / F	P / F	P / F
12. Zoom Lens Out:	P / F	P / F	P / F	P / F	P / F
Blankout Zones Test:					
Verify/Set Blankout Zone(s)					
13. No Video in Blankout Zone(s)	P / F	P / F	P / F	P / F	P / F
Preset Test:					
14. Mainline Freeway (US-60 EB)	P / F	P / F	P / F	P / F	P / F
15. Mainline Freeway (US-60 WB)	P / F	P / F	P / F	P / F	P / F
16. Crossroad (North)	P / F	P / F	P / F	P / F	P / F
17. Crossroad (South)	P / F	P / F	P / F	P / F	P / F
18. Return to Home Position	P / F	P / F	P / F	P / F	P / F
Generation of Text Test:					
19. ADOT Defined Text Displayed	P / F	P / F	P / F	P / F	P / F
Night Time Test:					
20. Video Performance (B/W):	P / F	P / F	P / F	P / F	P / F

Contractor: ______________________ ADOT Vision:__________________________ Date:_______________________

341 CABINET TEST DATA SHEETS

Subsystem Test Begins @ ________ on / /07 **Note: Cross out Test Interval columns that fall into the non-test periods.**
Hour 01:00 – 01:15: Disconnect Circuit 1 A Ring transmit and B Ring receive fibers at Cabinet #_______ (Node 7)
Hour 01:30 – 01:45: Disconnect Circuit 1 B Ring transmit and A Ring receive fibers at Cabinet #_______ (Node 7)
Hour 02:00 – 02:15: Disconnect Circuit 2 A Ring transmit and B Ring receive fibers at Cabinet #_______ (Node 7)
Hour 02:30 – 02:45: Disconnect Circuit 2 B Ring transmit and A Ring receive fibers at Cabinet #_______ (Node 7)
Hour 03:00 – 03:15: Disconnect OTR power connector at Cabinet #_______ (Node 7, Ckt 1)(Failure expected)
Hour 03:30 – 03:45: Disconnect OTR power connector at Cabinet #_______ (Node 7, Ckt 2)(Failure Expected)

	Controller ID	Test Interval 1 00:00 – 04:00	Test Interval 2 04:00 – 08:00	Test Interval 3 08:00 – 12:00	Test Interval 4 12:00 – 16:00	Test Interval 5 16:00 – 20:00	Test Interval 6 20:00 – 24:00	
		Comm. %	Comm. %	Comm. %	Comm. %	Comm. %	Comm. %	Detection P / F
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

Contractor Init: _____; ADOT Init: ______

341 CABINET TEST DATA SHEETS (cont'd)

Hour 36:00 – 60:00:

	Controller ID	Test Interval 7 24:00 – 28:00	Test Interval 8 28:00 – 32:00	Test Interval 9 32:00 – 36:00	Test Interval 10 36:00 – 40:00	Test Interval 11 40:00 – 44:00	Test Interval 12 44:00 – 48:00	
		Comm. %	Comm. %	Comm. %	Comm. %	Comm. %	Comm. %	Detection P / F
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

Contractor Init: _____; ADOT Init: ______

341 CABINET TEST DATA SHEETS (cont'd)

Hour 60:00 – 72:00:

	Controller ID	Test Interval 13 48:00 – 52:00	Test Interval 14 52:00 – 56:00	Test Interval 15 56:00 – 60:00	Test Interval 16 60:00 – 64:00	Test Interval 17 64:00 – 68:00	Test Interval 18 68:00 – 72:00	
		Comm. %	Comm. %	Comm. %	Comm. %	Comm. %	Comm. %	Detection P / F
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								

Contractor Representative: ______________________ Test Date: ______________________

ADOT Representative: __________________________

Controller Lane Assignments

CABINET No.	Address C 0 0	Circuit C 0 2	Node C 0 3	Location	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	Lane 6	Lane 7	Lane 8	ELI	ELO	ELQ	ERI	ERO	ERQ

Note: For Lanes 1 – 8, presence of speed and volume shall be verified.
For Entrance Lanes, (EXX) presence of only volume shall be verified.

◉ - Signifies lanes have a single loop, volume monitoring only.

DMS TEST DATA SHEET

NODE _ DMS

TEST PARAMETER	DMS (Cab ______)	DMS (Cab ______)
Pixel Test	**P** / **F**	**P** / **F**
Field Circuit Redundancy Tests: • All DMS Still Functioning after simulated fiber break • Other DMS continue to operate when selected DMS OTR is off	 **P** / **F** **P** / **F**	 **P** / **F** **P** / **F**
72-Hour Test Message	**P** / **F**	**P** / **F**
Pixel Test	**N/A**	**P** / **F**

NODE _ DMS

TEST PARAMETER	DMS (Cab ______)	DMS (Cab ______)	DMS (Cab ______)	DMS (Cab ______)
Test Message	**P** / **F**	**P** / **F**	**P** / **F**	**P** / **F**
Field Circuit Redundancy Test: • DMS Still Functioning after simulated fiber break	**P** / **F**	**P** / **F**	**P** / **F**	**P** / **F**
72-Hour Test Message	**P** / **F**	**P** / **F**	**P** / **F**	**P** / **F**
Pixel Test	**P** / **F**	**N/A**	**P** / **F**	**P** / **F**

Contractor: ______________________________ Date:_______________

ADOT Vision: ____________________________ ADOT TOC:_____________________________

FMS

SYSTEM ACCEPTANCE TEST PROCEDURE

TABLE OF CONTENTS

I. INTRODUCTION:

The purpose of this System Acceptance Test (SAT) Procedure is to verify that contractor-furnished and/or installed equipment (CCTV, DMS, detection, ramp meters, communications), and existing field devices connected to the new communications system are fully functional and operating per the specification requirements for a 30-day period of time without failure. This test shall demonstrate that the total system is properly installed, free from defects and identified problems, exhibits stable and reliable performance, and completely complies with all contract documents.

During the SAT, the contractor shall maintain an event log containing information regarding any test failures, the actions taken to correct the problem, and their final disposition. A copy of the event log is submitted with this procedure.

The SAT shall test three main groups, which are listed below. A fourth test group, the communications system, is verified by demonstrating proper operation of the three main groups, and is therefore not listed or tested separately.

- CCTV Group
- DMS Group
- Model 2070 Controller Group

The CCTV Group SAT will be performed by the Contractor with ADOT support. The testing will verify video quality as well as proving full control of all remote camera functions (i.e., PTZ) via the TOC operator workstations and Camera Cameleon software. Between scheduled tests performed by the Contractor, ADOT TOC personnel will have access to the CCTV and shall alert the Contractor to any anomalies that may be encountered during regular use.

The DMS Group SAT will be performed by the Contractor with close ADOT support. The testing will verify the contractor-installed DMS performance by operating them from an operator workstation via the Daktronics DMS control server. The existing DMS testing will also be performed by the Contractor with close ADOT support from an operator workstation via the Mercure Control Server. Since these are existing signs, the purpose of this testing is only to verify communication to the sign, not the sign function. Between scheduled tests performed by the Contractor, test messages shall be left on the signs, although ADOT TOC personnel will have access to the DMS for traffic control purposes. ADOT shall alert the Contractor to any anomalies that may be encountered while these test messages are displayed or during regular sign use.

The Model 2070 Controller Group subsystem testing will be performed by the Contractor with close ADOT support. The testing shall verify that the Model 2070 controllers communicate at a rate of no less than 99% over each 24 hour period. The testing shall also verify that all lanes with detection continue to show reasonable vehicle count and speed data, and finally that all ramp meters operate correctly at their proper times of day.

II. SAT PROCEDURE:

The FMS shall be fully functional and operated by TOC personnel with the exception of those tests required to be run by the Contractor. During the 30-day SAT, the following tests shall be run by the Contractor per the **Test Schedule** located in the back of this document.

All test failures, or anomalies shall be recorded on an Event Test Log sheet. An example of this test log is found in **Event Test Log** located in the back of this document**.** The contractor shall submit an updated log to the Engineer after each reported failure, and again after the repair has been completed.

A. CCTV Testing:

TOC operations personnel, using the operator's workstations and Camera Cameleon software shall be using the CCTV every day during the SAT period. If any anomalies occur, it is the responsibility of ADOT to alert the Contractor at the earliest possible time so corrective action can be taken.

Along with the every day use of the CCTV, the Contractor, with ADOT support shall verify the quality of the video image, as well as the proper operation of all user selectable functions of each contractor-installed CCTV camera per the **Test Schedule**. During testing of the cameras, a single monitor shall be used for consistency during the video image quality portion of the testing. The Contractor shall test each camera and record the results on the CCTV test data sheets supplied in **CCTV Test Data Sheets** located in the back of this document.

B. DMS Testing:

1. Existing DMS

TOC personnel shall use the Mercure server to place a test message on each existing sign at intervals specified per the **Test Schedule.** Record message status of existing DMS on **DMS Test Data Sheet** located in the back of this document.

2. Contractor-Installed DMS

The SAT of the contractor-installed DMS shall be two faceted.

a) TOC personnel shall place an ADOT approved test message on the sign that shall remain for the duration of the 30-day SAT. If any anomalies occur, it is the responsibility of ADOT to alert the Contractor at the earliest possible time so corrective action can be taken.

b) The Contractor shall perform a Pixel Test (same as used for both stand-alone and subsystem testing) at intervals specified in the **Test Schedule**.

Record message status and pixel test results on the **DMS Test Data Sheet**.

C. Model 2070 Controller Group Testing:

1. Communication Performance

ADOT shall supply the contractor (via e-mail) a daily spreadsheet listing all the detector stations connected to Node 10. This table shall show the successful communication response percentage of all controllers communicating to Node 10, and individual lane detection data for a 24 hour time period. This data shall be entered into the **341 Cabinet Test Data Sheet** located in the back of this document. Any controller communicating successfully less than 99% of the time, or communicating at a rate of more than 0.1% less then the baseline established in the subsystem test (whichever is less), shall be considered failing.

2. Ramp Meter Verification

In the morning, the Contractor shall drive the US-60 corridor from Crismon Road to Gilbert Road beginning at 07:15 AM and shall verify each ramp meter is on and functioning correctly. The contractor shall repeat this procedure at 09:15 AM to verify that each ramp meter is off. This data shall be entered into the **Ramp Meter Test Data Sheet** located in the back of this document.

In the afternoon, the Contractor shall drive the US-60 corridor from Gilbert Road to Crismon Road beginning at 3:15 PM and shall verify each ramp meter is on and functioning correctly. The contractor shall repeat this procedure at 7:15 PM to verify that each ramp meter is off. This data shall be entered into the **Ramp Meter Test Data Sheet**.

SAT SCHEDULE

	TEST DAY (✓ indicates test(s) specified in procedure required)																																		
TEST	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
CCTV	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Existing DMS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
DMS – Pixel Test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Model 2070 Communication Performance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Ramp Meter Verification	Weekdays Only																																		

Note: If SAT duration is greater than a total of 30 days due to minor failures, cross out the ✓ and place an X in the corresponding box that shows when the testing was actually accomplished.

TEST EVENT LOG SHEET

Event Log No.: ________________________ Date: __________________________

Reported By: __________________________ Time: __________________________

Description of Failure:

____

____

____

____

Failure Type (circle one): Minor Major

If a minor failure, is this failure:

Lasting more than 72 hours:	Yes	No
10% or more of Model 2070 Controllers in any 72-hour period:	Yes	No
A third failure to an individual Model 2070 or CCTV in any 5-day period:	Yes	No
5% or more of all detection equipment, CCTV, comm. equipment, or AC Isolators in any 14-day period:	Yes	No

If any of the above questions are answered yes, the failure type becomes Major, and the SAT is restarted from Day 1.

Resolution of failure:

____

____

____

____

Repair Technician: _____________________ Date: __________________________

Time: __________________________

CCTV TEST DATA SHEET

SAT TEST DAY: 1

Note: Night time test shall occur no earlier then one hour past sunset.

TEST PARAMETER	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.:___
Video Quality Test:: 1. Video Performance:	**P / F**	**P / F**	**P / F**	**P / F**	**P / F**
Pan / Tilt Test: 2. Tilt Camera Up 3. Tilt Camera Down: 4. Pan Camera Right: 5. Pan Camera Left:	 **P / F** **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F** **P / F**
Iris Control Test: 6. Manually Open Iris: 7. Manually Close Iris	 **P / F** **P / F**	 **P / F** **P / F**	 **P / F** **P / F**	 **P / F** **P / F**	 **P / F** **P / F**
Focus Test: 8. Focus Camera (Near Object): 9. Focus Camera (far Object):	 **P / F** **P / F**	 **P / F** **P / F**	 **P / F** **P / F**	 **P / F** **P / F**	 **P / F** **P / F**
Zoom Lens Test: 10. Zoom Lens In Optical: 11. Zoom Lens in Digital: 12. Zoom Lens Out:	 **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F**	 **P / F** **P / F** **P / F**
Blankout Zones Test: 13. No Video in Blankout Zone(s)	**P / F**	**P / F**	**P / F**	**P / F**	**P / F**
Preset Test: 14. CCTV Responds to Presets	**P / F**	**P / F**	**P / F**	**P / F**	**P / F**
Generation of Text Test: 15. ADOT Defined Text Displayed	**P / F**	**P / F**	**P / F**	**P / F**	**P / F**
Night Time Test: 16. Video Performance (B/W):	**P / F**	**P / F**	**P / F**	**P / F**	**P / F**

Contractor: ______________________ ADOT Vision:______________________ ADOT TOC:______________________ Date: _____________

CCTV TEST DATA SHEET (cont'd)

SAT TEST DAY: 1

Note Video Quality performance is compared to the baseline video performance as determined by the subsystem Test.

TEST PARAMETER	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.: ___	CCTV No.:___
Video Quality Test:: 1. Video Performance:	P / F	P / F	P / F	P / F	P / F
Pan / Tilt Test: 2. Tilt Camera Up 3. Tilt Camera Down: 4. Pan Camera Right: 5. Pan Camera Left:	P / F P / F P / F P / F	P / F P / F P / F P / F	P / F P / F P / F P / F	P / F P / F P / F P / F	P / F P / F P / F P / F
Iris Control Test: 6. Manually Open Iris: 7. Manually Close Iris	P / F P / F	P / F P / F	P / F P / F	P / F P / F	P / F P / F
Focus Test: 8. Focus Camera (Near Object): 9. Focus Camera (far Object):	P / F P / F	P / F P / F	P / F P / F	P / F P / F	P / F P / F
Zoom Lens Test: 10. Zoom Lens In Optical: 11. Zoom Lens in Digital: 12. Zoom Lens Out:	P / F P / F P / F	P / F P / F P / F	P / F P / F P / F	P / F P / F P / F	P / F P / F P / F
Blankout Zones Test: 13. No Video in Blankout Zone(s)	P / F	P / F	P / F	P / F	P / F
Preset Test: 14. CCTV Responds to Presets	P / F	P / F	P / F	P / F	P / F
Generation of Text Test: 15. ADOT Defined Text Displayed	P / F	P / F	P / F	P / F	P / F
Night Time Test: 16. Video Performance (B/W):	P / F	P / F	P / F	P / F	P / F

Contractor: ______________________ ADOT Vision:______________________ ADOT TOC:______________________ Date: _____________

DMS TEST DATA SHEET

1. EXISTING DMS TESTING:

	DMS Cabinet _______	DMS Cabinet _______
Successful Message Day 1:	P / F	P / F
Successful Message Day 10:	P / F	P / F
Successful Message Day 20:	P / F	P / F
Successful Message Day 30:	P / F	P / F

2. CONTRACTOR INSTALLED DMS TESTING:

a. Continuous message for 30-day SAT duration:

	SUCCESSFUL DMS OPERATION FOR TEST DAY (P / F)																																			
DMS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36

b. Pixel Test:

	DMS Cabinet _______	DMS Cabinet _______	DMS Cabinet _______	DMS Cabinet _______
Test Pass - Day 1	P / F	P / F	P / F	P / F
Test Pass - Day 30	P / F	P / F	P / F	P / F

Contractor: ______________________ ADOT Vision:______________________ ADOT TOC:______________________ Date: _____________

341 CABINET TEST DATA SHEET

Note: Comm Test Pass criteria for each device is the lesser of the baseline established in the Subsystem Test (minus 0.1%) or 99% (whichever is less).

Enter the Communication Success Rate from the ADOT data into the Comm column, circle any value < 99% and compare it to the SST test data.

Verify all detection lanes are reporting volume, and speed where appropriate, per the lane assignment table following these data sheets. Enter a ✓ if passed and an **X** if failed

	SAT Test Day																					
	1		2		3		4		5		6		7		8		9		10		11	
DEV ID	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det

Contractor: ______________________ ADOT Vision:______________________ ADOT TOC:______________________ Date:____________

341 CABINET TEST DATA SHEET (cont'd)

Note: Comm Test Pass criteria for each device is the lesser of the baseline established in the Subsystem Test (minus 0.1%) or 99% (whichever is less).

Enter the Communication Success Rate from the ADOT data into the Comm column, circle any value < 99% and compare it to the SST test data.

Verify all detection lanes are reporting volume, and speed where appropriate, per the lane assignment table following these data sheets. Enter a ✓ if passed and an **X** if failed

	SAT Test Day																					
	12		13		14		15		16		17		18		19		20		21		22	
DEV ID	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det

Contractor: ______________________ ADOT Vision:______________________ ADOT TOC:______________________ Date:____________

341 Cabinet Test DATA Sheet (cont'd)

Note: Comm Test Pass criteria for each device is the lesser of the baseline established in the Subsystem Test (minus 0.1%) or 99% (whichever is less).

Enter the Communication Success Rate from the ADOT data into the Comm column, circle any value < 99% and compare it to the SST test data.

Verify all detection lanes are reporting volume, and speed where appropriate, per the lane assignment table following these data sheets. In the Det column, enter a ✓ if passed and an **X** if failed.

	SAT Test Day																					
	23		24		25		26		27		28		29		30		31		32		33	
DEV ID	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det	Comm	Det

Contractor: ______________________ ADOT Vision:______________________ ADOT TOC:______________________ Date:____________

CONTROLLER LANE ASSIGNMENTS

CABINET No.	Address C 0 0	Circuit C 0 2	Node C 0 3	Location	Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	Lane 6	Lane 7	Lane 8	ELI	ELO	ELQ	ERI	ERO	ERQ

Note: For Lanes 1 – 8, presence of speed and volume shall be verified.
For Entrance Lanes, (EXX) presence of only volume shall be verified.

⊙ - Signifies lanes have a single loop, volume monitoring only.

RAMP METER TEST DATA SHEET

This test is only run on weekdays during the SAT. In the top two rows write in SAT day and day of week, respectively.

Verify ramp meters are on and functioning properly at their designated times (between 07:00 – 09:00 inbound; 15:00 – 19:00 outbound). Place a ✓ in the respective column if tested passed.

SAT Test Day																					
Day of Week																					
DEV ID	**INBOUND RM**	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off
	OUTBOUND RM	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off

RAMP METER TEST DATA SHEET (Cont'd)

This test is only run on weekdays during the SAT. In the top two rows write in SAT day and day of week, respectively.

Verify ramp meters are on and functioning properly at their designated times (between 07:00 – 09:00 inbound; 15:00 – 19:00 outbound). Place a ✓ in the respective column if tested passed.

SAT Test Day																					
Day of Week																					
DEV ID	**INBOUND RM**	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off
	OUTBOUND RM	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off

RAMP METER TEST DATA SHEET (Cont'd)

This test is only run on weekdays during the SAT. In the top two rows write in SAT day and day of week, respectively.

Verify ramp meters are on and functioning properly at their designated times (between 07:00 – 09:00 inbound; 15:00 – 19:00 outbound). Place a ✓ in the respective column if tested passed.

SAT Test Day																					
Day of Week																					
DEV ID	**INBOUND RM**	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off
	OUTBOUND RM	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off	07:15 On	09:15 Off

Contractor: ______________________ ADOT Vision:_______________________ ADOT TOC:_______________________ Date:____________

Registered Professional Engineer (Civil) CERTIFICATE NO. 40972 REBECCA L. FLY Date Signed 3/8/17 ARIZONA, U.S.A.

EXPIRES: 6·30·19

SECTION 760 CITY OF PHOENIX (SECTION 470) - GENERAL REQUIREMENTS FOR TRAFFIC SIGNAL AND INTERSECTION LIGHTING SYSTEMS

760.1 DESCRIPTION:

It is the purpose of this section to provide general information necessary for completion of the installation of traffic signals, High Intensity Activated Crosswalk (HAWK) Pedestrian Beacon systems and intersection lighting in accordance with the details shown on the Traffic Signal Plan, requirements of these specifications, and City of Phoenix Specifications for Public Works Construction, latest version; which is a combination of the Phoenix Supplement to the MAG Specifications in concert with the MAG Specifications. All electrical systems and appurtenances shall be complete, functional and in operating condition at the time of acceptance.

760.2 DEFINITIONS:

The words defined in the following section shall for the purpose of these specifications have the meanings ascribed to them pertaining to signals and lighting.

760.2.1 Actuation:

The operation of any type of controller initiated by a detector.

760.2.2 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.

760.2.3 Controller:

That part of the controller assembly, which performs the basic timing and logic functions for the operation of the traffic signal.

760.2.4 Controller Assembly:

The complete assembly for controlling the operation of a traffic signal, consisting of a controller unit, and all auxiliary and external equipment housed in a weatherproof cabinet.

760.2.5 Coordinated Traffic Signal System:

A group of signals timed together to provide a specific relationship among signal phases.

760.2.6 Cycle:

A complete sequence of signal indications.

760.2.7 Detector:

A device for indicating the passage or presence of vehicles or pedestrians.

760.2.7.1 Inductive Loop Detector:

A detector capable of sensing the passage or presence of a vehicle (or bicycle for loop placed in an exclusive bike lane) by a change in the inductance characteristics of the wire loop.

760.2.7.2 Pedestrian Detector (Pedestrian Push Button):

A detector for pedestrians, usually of the push button type.

760.2.7.3 Accessible Pedestrian Signal Detector (APS Push Button):

A pedestrian detector that has added capabilities to meet the requirements of the MUTCD Section 4E.

760.2.7.4 Video Detector:

Video Camera capable of detecting the presence or passage of vehicles or pedestrians.

760.2.7.5 Other Detector:

A combination of a sensor and system processor capable of detecting the presence or passage of vehicles, bicycles, or pedestrians. Examples of such detection systems include, but are not limited, to a wireless embedded detector in pavement, infrared camera images, radar detection, or other detection devices used in concert with system processors.

760.2.8 Flasher:

A device used to open and close signal circuits at a repetitive rate.

760.2.9 Flashing Feature:

This feature, when operated, discontinues normal signal operation and causes a predetermined combination of flashing signal lights.

760.2.10 Interval:

The part or parts of the signal cycle during which signal indications do not change.

760.2.11 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, lamp, photo cell, and glass globe or refractor when specified.

760.2.12 Manual Operation:

The operation of a signal controller unit by means of a hand-operated switch.

760.2.13 Mounting Assembly:

The framework and hardware required to mount the signal face(s) and pedestrian signal(s) to the pole.

760.2.14 Pedestrian Signal:

A traffic control signal for the exclusive purpose of directing pedestrian traffic at signalized locations.

760.2.15 Pre-timed Controller Assembly:

A controller assembly for operating traffic signals in accordance with a predetermined fixed-time cycle.

760.2.16 Red Clearance Interval:

A clearance interval, which follows the yellow, change interval displaying a red indication to both the terminating phase and all conflicting phases prior to display of green for the next right-of-way phase.

760.2.17 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 back plate and visors.

760.2.18 Signal Indication:

The illumination of a signal section or other device, or of a combination of sections or other devices at the same time.

760.2.19 Signal Section:

A complete unit for providing a signal indication, consisting of a housing, lens, reflector, lamp receptacle and lamp, or LED unit.

760.2.20 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.

760.2.21 Traffic-Actuated Controller Assembly:

A controller assembly for operating traffic signals in accordance with the varying demands of traffic as registered with the controller unit by detectors.

760.2.22 Vehicle:

Any motor vehicle normally licensed for highway use.

760.2.23 Yellow Change Interval:

The first interval following the green right-of-way interval in which the signal indication for the phase is yellow.

760.3 REGULATIONS AND CODES:

All electrical equipment shall conform to the current standards of the National Electrical Manufacturers Association (NEMA), National Electric Safety Code (NESC), Underwriters' Laboratory Inc. (UL), when applicable. All material 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), requirements of the Traffic Signal Plan, these specifications, the Project Specifications, and to any other codes, standards, or ordinances which may apply. Whenever references are made to any of the standards mentioned, the reference shall be interpreted to mean the code, ordinance, or standard that is in effect at the time of the bid advertisement.

760.4 SOURCE OF SUPPLY:

Developer shall furnish all traffic signal material and equipment required to complete the work except as noted otherwise.

760.4.1 Quality Requirements:

Only materials and equipment conforming to the requirements of these specifications shall be incorporated into the work. Material and equipment shall be new except as may be provided in the Project Specifications.

City of Phoenix reserves the right to reject proposed traffic signal material or equipment if, in the judgment of the Engineer any or all the following may apply:

1) The equipment does not meet the requirements of the specifications.

2) The material or equipment's past field performance has been unsatisfactory.

In addition, City of Phoenix reserves the right to pre-approve traffic signal material and equipment by brand name model or part number which in the judgment of the Engineer meets the intended purpose of these specifications.

Deviations from the pre-approved materials list, if any, will be listed in the project Project Specifications or construction plans.

760.4.2 Approval of Material and Equipment:

All traffic signal materials and equipment shall be approved by the Engineer prior to incorporation in the work. Any work in which materials or equipment not previously approved are used shall be performed at Developer's risk and may be considered as unauthorized and unacceptable and not subject to the payment provisions of the contract. Such materials or equipment may be subject to removal at the discretion of the Engineer.

Developer shall obtain the Engineer's approval before ordering or installing any material or equipment. Developer shall submit three (3) copies of each proposed material and/or equipment list, including shop drawings. Each set shall include a three ring binder with section tabs separating the documentation for each major item being submitted. Submittal shall be to the City prior to or at the pre-construction conference. Allow two (2) weeks for the City to review the submitted documentation for each submittal. To be acceptable, the list shall be complete and comprehensive containing all items to be supplied on the project by Developer, including pre-approved items. COP reserves the right to reject any incomplete or unclear material submittal. All items on the list shall be identified by manufacturer's part number, model, accessories, specification, or other pertinent catalogue information. The materials from any catalog cuts shall be clearly indicated by Developer. If standard manufacturer documentation does not specifically address all the product requirements that are required, then Developer shall obtain a letter from the manufacturer certifying compliance with each referenced requirement that is not indicated on the standard documentation. One (1) copy will be returned to Developer for further action.

All equipment or material specified or shown on signal plans, or other drawings, by brand name, part number, or model number is intended to be descriptive of the type and quality of material or equipment desired. Another equal brand name, part number, or model number may be substituted so long as it is in accordance with these specifications and is equal in form, fit, function, performance, reliability, and is approved by the Engineer.

Developer shall provide complete wiring diagrams for controller assemblies and auxiliary controller cabinets at the time of delivery for testing. Four (4) 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.

Final approval, in writing by the COP, on all items within the submitted documentation is required to be obtained by Developer.

It is Developer's responsibility to ensure adequate lead time in ordering signal equipment to prevent project delay. Developer shall notify the Engineer in the event signal equipment is not received in a timely manner.

760.4.3 Warranties and Guaranties:

In addition to the requirements of Section 108.8, the following is required by the City of Phoenix for traffic signal related items. The warranty period will begin the day the Work of this Section is accepted by the City of Phoenix. Submit all manufacturer warranties to the City of Phoenix prior to installation. Expiration of Developer's warranty under this section does not relieve the manufacturer should the manufacturer warranties exceed that of Developer. The warranty period for the following items are extended beyond the one year requirement as noted herein.

760.4.3.1 LED Indications

Warrant all LED indication modules furnished by Developer for five years following commencement of the warranty period against manufacturing and installation defects.

760.4.3.2 Pedestrian Signal Heads

Warrant the entire pedestrian signal head assemblies, including the housing, doorframe, and visor for two years from the date of acceptance by the COP against defects in workmanship and/or Material.

760.4.3.3 Traffic Signal Heads

Warrant the entire traffic signal head assembly, including the housing, doorframe, and visor for two years from the date of acceptance by the COP against defects in workmanship and/or Material.

760.4.3.4 Detectors

Warrant all detectors, including loops, video detection cameras, pedestrian buttons and APS Pushbuttons for two years from the date of acceptance by the COP against defects in workmanship and/or Material.

760.5 CITY OF PHOENIX FURNISHED MATERIAL AND EQUIPMENT:

Traffic signal material and equipment furnished by City of Phoenix or tested by City of Phoenix that is to be installed by Developer will be made available at the following address:

City of Phoenix Traffic Signal Shop

2141 E. Jefferson St.
Phoenix, Arizona 85034

Developer shall contact the City of Phoenix Traffic Signal Supervisor (602) 262-6733 five working days prior to desired pick-up date to confirm the item list, availability, date and time. Warehouse hours for pick-up and delivery are 8:00 am – 2:00 pm Monday through Friday.

The cost of handling and placing all material and equipment, including pick-up by Developer is included in the contract price of the associated pay item. Developer using Developer's equipment shall load the furnished materials (poles, mast arms, etc.) onto Developer's vehicle for transportation to the project site. COP personnel shall not load the materials. Developer shall be responsible for any damage that occurs during the loading process.

Developer will be held responsible for all material and equipment received. The Traffic Signal Supervisor or designee will issue a receipt for the materials provided. All materials will be issued in serviceable condition; Developer will note any exceptions on the receipt. The receipt will be placed in the project file and a copy given to Developer. The cost to make good any shortages or deficiencies, from any cause whatsoever and for any damage which may occur after receipt will be deducted from any monies due or becoming due to Developer.

760.6 INSTALLATION OF TRAFFIC SIGNALS AND RELATED ITEMS:

760.6.1 General:

Developer shall furnish labor and supervision with experience in the construction of the traffic signals and all materials, equipment, tools, transportation, and supplies required to complete the work in an acceptable manner; within the time specified, and in full compliance to these specifications, terms of the contract, the Traffic
Signal Plan and COP Traffic Signal Details.

Developer shall have a competent supervisor capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the construction of traffic signals assigned to the project. Developer's supervisor shall possess a current International Municipal Signal Association (IMSA) Level II Traffic Signal Electrician Certification. Developer shall have a complete set of construction drawings including current City of Phoenix standards on site at all times during signal & lighting systems construction.

A Level II IMSA certified Technician/Electrician must be on each Work Site at all times while work is being performed on traffic signal and other traffic control systems installed within the City of Phoenix.

Conductor splices and terminations may only be made by a qualified Journeyman Electrician, who has successfully completed a recognized four (4) year electrical apprenticeship program or equivalent training, or by a person enrolled in a recognized four

(4) year electrical apprenticeship program, while under the direct supervision of a Journeyman Electrician

760.6.2 Traffic Signal Plan:

The Traffic Signal Plan graphically describes the location of signal component parts, the equipment and materials to be used, and the standards for construction. The plans shall be supplemented by City of Phoenix Standard Details or other drawing(s) deemed necessary for the acceptable completion of the work.

After completion of the project, Developer shall provide the Engineer with a set of as-built drawings on clean prints of the original drawings. The as-built drawing shall indicate in a neat and accurate manner all changes and revisions in the original design. As-built drawings shall be submitted before final payment for completed work will be made.

760.7 MAINTENANCE OF TRAFFIC SIGNALS AND RELATED ITEMS DURING CONSTRUCTION:

Unless otherwise specified, the City of Phoenix or ADOT will operate and maintain the existing traffic signal equipment during construction. Once new traffic signal equipment is in place and accepted, the City of Phoenix will assume operation and maintenance responsibilities.

Unscheduled traffic signal work or maintenance calls, performed by the City or ADOT caused by Developer damage or negligence to an existing signalized intersection, will be billed directly to Developer.

SECTION 761 CITY OF PHOENIX (SECTION 471) - ELECTRICAL UNDERGROUND INSTALLATION

761.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing electrical conduit, and pull boxes for traffic signals and intersection lighting including jacking, drilling, excavating, placing, and compacting backfill material in accordance with the locations shown on the Traffic Signal Plan

761.2 MATERIALS:

761.2.1 Electrical Conduit:

All conduit and conduit fittings shall be listed by UL, and conform to NEC standards. Except as specified below, all conduit to be installed underground or in concrete structures shall be rigid polyvinyl chloride (PVC) conforming to the requirements of UL 651 for Rigid Nonmetallic Conduit. PVC conduit and conduit fittings shall be Schedule 40, heavy wall, manufactured from high impact material and shall be rated for use at 90º C.

All exposed conduit and conduit fittings to be installed above ground shall be rigid metallic type manufactured of galvanized steel conforming to requirements of UL 6 for Rigid Metallic Conduit and to NEC standards.

761.2.2 Pull Boxes:

Pull boxes, pull box covers, and pull box extensions shall be constructed of polymer concrete with reinforced heavy-weave fiberglass. Pull boxes and covers shall be concrete gray color, rated for and meet AASHTO H-20 specifications. Pull boxes shall be stackable for extra depth. Box sizes shall be acceptable industry standard and use nominal lid sizes of:

#3.5 Junction box 10” x 15”
5 Junction box 13” x 24”
#7 Junction box 17” x 30”

Additionally, boxes shall be a minimum of 12” in depth, and have no floors or mouse holes.

Covers shall be cast to allow securing with two (2) corrosion resistant metallic hex bolts with corrosion resistant metallic washers and nuts. Covers shall also be cast with a non skid resistant surface and have a nominal thickness of two inches and meet AASHTO H-20 specifications.

The words “TRAFFIC SIGNAL” shall be cast in the pull box covers in 1-inch high letters.
At the request of the Engineer, Developer shall furnish pull box plans and specifications.

Chipped or cracked pull boxes, covers, and extensions will not be accepted.

Metal covers are **NOT** acceptable.

761.2.3 Detectable Mule Tape:

A detectable mule tape is a flat, woven, polyester tape with an insulated locating conductor. The conductor shall be a metallic 22 gauge insulated wire. The mule tape shall be a minimum ¼" width with a pull strength of 400 pounds.

761.3 CONSTRUCTION REQUIREMENTS:

761.3.1 General Requirements for Installation of Electrical Conduit:

Conduit shall be furnished and installed at the locations and of the sizes shown on the Traffic Signal Plan. Unless changes are necessary to avoid underground obstructions all underground conduit shall be installed in a straight line from pull box to pull box and/or from foundation to pull box and shall be of one continuous size. Any change in conduit routing must be approved by the Engineer and documented by Developer on as-built traffic signal plans.

Conduit will be placed in a variety of locations such as under existing pavement or sidewalk, under sod or other pervious surface, under new pavement or attached to a structure such as a bridge pier, metal or wood pole. Conduit under existing pavement or sidewalk requires additional labor and materials over that which would be required under new pavement, sod, or other pervious surface. The payment for this section will be divided into three categories, Under Existing Pavement, Under New Pavement or Landscaping, and Attached to Structure. Developer can choose the method of construction for each type.

All PVC conduits shall be stored and handled in an approved manner to minimize ultraviolet deterioration due to exposure to sunlight.

The PVC conduit shall be cut square and trimmed to remove all rough edges. PVC conduit connections shall be of the solvent weld type. Purple primer conforming to the requirements of ASTM F 656 shall be applied to the joined surfaces prior to use of cement. The joint cement shall be the gray PVC cement conforming to the requirements of ASTM D 2564. Where a connection is made to rigid metallic conduit, the coupling used shall be a PVC female adapter.

All existing conduits and conduit embedded in concrete structures shall be cleaned out with a mandrel and blown out with compressed air.

Field PVC conduit bends shall be made without crimping or flattening, using the longest radius practical but not less than specified by the NEC. Collapsed conduit, no matter how small, is not acceptable. The number of bends between pull boxes or between pull box and foundations shall not contain more than equivalent of two quarter bends (180 degrees, total), including the bends at the pull boxes or foundations, unless authorized by the Engineer.

Conduit entering a pull box or foundation shall be fitted with a factory made 90 degree elbow with a minimum sweep radius per the table below:

Conduit Size	Sweep Radius
2 inches	15 inches
2 ½ inches	18 inches
3 inches	21 inches

Conduit entering pull boxes shall terminate a minimum of 3” inside the box wall. The conduit shall be between 2” and 4” above the bottom. Conduit entering through the bottom of a pull box shall be located near the sides and ends and extend no more than 4” above the bottom of the pull box including the length of the conduit bell end 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.

Conduit for future use shall have a detectable mule tape. All conduits shall have a No. 10 AWG bare copper wire installed that extends 36 inches beyond each end of the PVC conduit run between pull boxes and foundations. The pull rope, if needed, and bond wire shall be coiled and inserted into the conduit so as to be easily recovered from either end. Conduit ends shall be capped with conduit end cap fittings after the pull rope is installed. Conduit end cap shall remain in place until wiring is started. When end caps are removed, PVC ends 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 steel conduit ends.

Developer shall place a warning tape in all open trenches in which conduit is placed. All warning tape shall be buried at a depth of 6” to 8” below final grade.

Where conduit is to be installed under existing roadway pavement by jacking or drilling methods, the jacking and/or drilling pits shall be kept 2 feet clear of the edge of the pavement.

Conduit stub-outs under curbs or roadway edges for loop detection lead-in conductors shall conform to the requirements of COP Standard Details

Installation of conduit for underground electrical service shall be in accordance with the Standard Details, as shown on the Traffic Signal Plan and in accordance with the requirements of the utility company providing electrical service. Conduit installed in railroad right-of-way shall be installed in accordance with the requirements of the railroad company.

761.3.2 Conduit Depth Requirements:

Conduits installed in protected areas such as behind curbs, under sidewalks, etc. that are not subject to any vehicular traffic shall be at a minimum depth of 24 inches below final grade. Conduits installed under roadways, driveways, or any open area where there is the possibility of vehicular traffic, shall be installed at a minimum depth of 24 inches below final grade. Unless otherwise stated on the plans, conduit depths shall not exceed 40 inches. When conduit cannot be installed at the minimum depth, it shall be completely encased in 4" of class C concrete in accordance with MAG Section 725.

761.3.3 Trenching, Backfilling, and Compaction:

Trenches shall not be excavated wider than necessary for the proper placement of conduit and pull boxes. Trenching shall be done in accordance with MAG Section 601. Backfilling, compaction, and bedding of conduit runs shall be in accordance with MAG Section 601.4.9.

Open trench excavation across any existing paved areas, shall have two (2) parallel cuts made at a distance not to exceed 16 inches. All removal and replacement of existing paved areas shall be in accordance with MAG Section 336.

Open trench excavation across an existing Portland concrete area shall have two (2) parallel cuts made at a distance not to exceed 16 inches. All removal and replacement of existing Portland concrete areas shall be done in accordance with MAG Section 336.

After each excavation is complete and materials in place, Developer shall notify the Engineer for inspection, and under no circumstances shall any underground material or equipment be covered with fill without proper approval.

761.3.4 Installation of Pull Boxes:

Pull boxes of the type specified on the Traffic Signal Plan shall be furnished and installed at the locations shown on the Plan. Pull boxes shall be installed in accordance with COP Standard Details. All relocation of pull boxes to avoid driveways and/or other structures shall be approved by the Engineer and documented by Developer on the as-built traffic signal plans.

Pull boxes shall be set and adjusted so that they are flush at curb or sidewalk grade. When no grade is established, pull boxes shall be set as requested by the Engineer. All pull box covers shall be secured with the required bolts and washers before final acceptance of the project. All pull boxes shall be left in a clean condition, free of dirt and debris upon completion of the work. Drainage sump 18" required as per COP Detail Sheet

SECTION 762 CITY OF PHOENIX (SECTION 472) - TRAFFIC SIGNAL FOUNDATIONS

762.1 DESCRIPTION:

The work under this section shall consist of furnishing all materials and constructing all traffic signal foundations and other designated pole foundations including signal poles, as well as cabinet and electrical service pedestal foundations for the traffic signals in accordance with the locations and details designated on the Traffic Signal Plan. Pole foundations shall include all conduits, conduit elbows, anchor bolts, re-bar cages, grounding electrode, and forms required for construction of the foundation. The traffic signal pole foundations shall conform to the requirements of COP Traffic Signal Details or ADOT Standards for ADOT approved poles and related pole foundations.

The controller and power service pedestal cabinet foundations shall conform to the requirements of COP Traffic Signal Details.

762.2 MATERIALS:

762.2.1 Excavation and Backfill:

Trenches shall not be excavated wider than necessary for the proper placement of conduit and pull boxes. Trenching, backfilling, and compaction shall be done in accordance with MAG Section 601.

All excavations within the roadway shall be backfilled and compacted in accordance with MAG Section 211.

762.2.2 Concrete:

Concrete used for all foundations shall be class ‘A’, 3000 psi concrete with a 5” slump and shall be in accordance with the requirements of MAG Section 725.

Concrete Mix design shall be submitted for approval prior to use as stated in the Conformed Technical Provisions and DBMA.

762.2.3 Anchor Bolts:

All anchor bolts shall be in accordance with referenced details, for the relevant traffic signal foundations.

All anchor bolts shall be threaded at the top and conform to the plans.

All materials furnished shall meet the Buy America requirements (as specified in 23 USC 313, 23 CFR § 635.410 and the DBMA Exhibit 2-7 (Buy America Certification).

762.2.4 Rebar Cage:

All rebar cages shall be in accordance with referenced details.

All materials furnished shall meet the Buy America requirements (as specified in 23 USC 313, 23 CFR § 635.410 and the DBMA Exhibit 2-7 (Buy America Certification).

762.2.5 Electrical Conduit:

All electrical conduit and conduit fittings shall be sized as per the plans sheets and in accordance with these specifications. All foundation conduits shall be grey Schedule 40 PVC.

762.2.6 Grounding Electrode:

The grounding electrode shall be in accordance with these specifications and COP Traffic Signal Details.

A 25 foot coil of #4 AWG stranded bare copper grounding electrode shall be installed at the base of the signal pole foundations and extend centered, two feet above the top of the foundation.

Traffic signal controller and power service pedestal foundations shall have a 1 inch PVC ground rod sleeve and a 5/8 inch x 8 foot bonded copper grounding rod installed.

762.3 CONSTRUCTION REQUIREMENTS:

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. Any damage by Developer's operation shall be replaced or reconstructed where determined by the Engineer at the expense of Developer. 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 Developer, as directed by the Engineer. After each excavation is completed, Developer shall notify the Engineer for inspection. Under no circumstances shall any underground materials or equipment be covered with fill without the approval of the Engineer.

At the end of each working period, all excavations shall be barricaded or covered, or both, 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 Project Specifications.

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.

The elevation of signal pole foundations shall be set as follows unless otherwise noted within the construction plans or Project Specifications. Signal pole foundations shall be set flush (+/_ ½”) with the existing or new sidewalk when sidewalk is present. Where curb exists without sidewalk, the foundations shall be set flush with a surface defined by a 1.5% upward slope from the top of curb (+/_ ½”). Where there is no curb or sidewalk pole foundations shall be as shown on the project plans. The dimensions and locations of foundations shall be as specified on the project plans; however, the Engineer may direct that changes be made in locations due to obstructions or other existing conditions. Any change in locations shall be documented by Developer on as-built traffic signal plans. Developer shall verify top of foundation elevations with the Engineer prior to foundation construction.

Prior to pouring concrete, the grounding electrode shall be placed at least 6” below the required depth of the foundation and covered with 6” of soil.

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 concrete.

If the soil is not stable, a deeper foundation than specified may be required or forms shall be used as determined by the Engineer. The forms shall be of the proper size and dimensions and shall be rigid and securely braced.

Foundation forming material shall extend no more than 20 inches below the foundation final grade and shall be removed after placement and curing of concrete.

Anchor bolts shall be oriented such that the bolt pattern sides are both parallel and perpendicular to the roadway centerlines unless otherwise specified on the Traffic Signal Plan. A 25-foot coil of No. 4 AWG bare copper conductor shall be installed 4” below the foundation and covered with 4 “of fill material such that no part of the coils will be in contact with the concrete foundation. An extension of the No. 4 AWG bare copper wire shall extend into the pole. Anchor bolts, conduit, and rebar cage shall be centered within the foundation, set at the specified height and plumb within ±1/2 degree. During placement of concrete, anchor bolts shall be securely held in proper alignment, position, and height with a suitable template.

After excavations are completed and anchor bolts and conduit installed, Developer shall notify the Engineer for inspection. Under no Circumstances shall concrete be placed without approval of the Engineer.

The concrete pour shall be continuous and consolidated by means of vibrators. All exposed surfaces of the foundation shall receive a finish that is smooth, level, and free of form marks.

Type 'A' and 'Pedestrian' pole foundations, cabinet foundation, and service pedestal foundation shall set for a minimum of five (5) days prior to installation of poles and/or cabinets. Type ‘LM’, ‘SM’, ‘SR’, ‘SQ’ and standard ADOT pole foundations shall set for ten (10) days prior to installation of poles.

SECTION 763 CITY OF PHOENIX (SECTION 473) - DETECTORS

763.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing vehicular and pedestrian detectors at the locations and sizes shown on the Traffic Signal Plan and in accordance with the requirements of these specifications and the COP Traffic Signal Details. Shielded Loop Detector Cable shall be installed and paid for under Electrical Conductors.

763.2 MATERIALS:

763.2.1 Loop Detector Sensor Wire:

Loop detector sensors shall be of the size and type specified on the Traffic Signal Plan and shall conform to the requirements of COP Traffic Signal Details. Roadway loop detector sensor wire shall conform to IMSA specification 51-5 with orange jacket and installed in accordance with the requirements of these specifications and COP Traffic Signal Details.

763.2.3 Cold Applied Emulsion Sealant:

The loop sealant shall be a single component asphaltic emulsion sealant designed to fill and seal inductive loop saw cuts. Loop sealant shall be "Tri-American TA-500" or approved equal.

SPECIFICATIONS

TEST PARAMETER	LIMITS	TEST METHOD
Residue by evaporation, weight percent	70 min	ASTM D 2939
Ash content, weight percent	50 min	ASTM D 2939
Firm set time, hours	4 max	ASTM D 2939
Brookfield viscosity, Poise RVT Spindle #3, 10 RPM at 75 ± 2 º F	50 to 125 °F	
Tensile strength, psi	20 min	ASTM D 2523
Elongation, %	2.0 min	ASTM D 2523
Flexibility	No full depth cracks	ASTM D 2939 SEE NOTE BELOW
Resistance to water	No blistering, re-emulsification or loss of adhesion	ASTM D 2939, Alternative B

NOTE: Flexibility: Except air-dry specimens to constant weight at 75º ± 5º F and 50º ± 10º F relative humidity. Condition the mandrel and specimens for 2 hours at 75º ± 2º F before test.

763.2.4 Pedestrian Detectors (Pedestrian Push Buttons):

All pedestrian detectors shall be in accordance with the Americans with Disabilities Act Accessibility Guidelines (latest revision). Pedestrian Push buttons shall be installed as per COP Traffic Signal Details, and meet the following specifications:

1. Body and cover shall be cast aluminum using four (4) brass or stainless steel Phillips head screws, #8 x 32 x 1", for securing the cover to the body.
2. Body and cover must have an industry standard bolt pattern and design to allow for retrofit of existing units in the field.
3. Body shall be without a sign mount and approximately three (3) inches in diameter.
4. Operation button shall be stainless steel two (2) inches in diameter, (large ADA), with a tamper-proof vandal resistant housing.
5. Operating switch shall be mechanical (no exceptions).
6. The switch shall be the phenolic-enclosed SPST-type with momentary contacts.
7. The switch shall operate in the normally open position.
8. The switch shall have screw-type terminals and shall have a rated life of not less than one million operations.
9. The contacts shall be rated at 15 amps and 125 volts AC.
10. Cover and body will be painted black. Powder coated will be accepted.
11. The body of each pedestrian push button assembly shall have a ½" to ¾" hole located in the center of the base assembly. There shall also be two (2) 5/16" holes in the base assembly 1" above and 1" below the center point in the back of the housing.
12. Each base assembly shall have a curved back or be supplied with a "U" channel mounting bracket to facilitate the mounting of the assembly on round pole surfaces.
13. The mounting bracket shall be 2 ½" long and 1 1/8" wide with 3/8" flanges on each side. Each mounting bracket shall have a 7/8" hole in the center of the bracket and 5/16" holes located 1" above and 1" below the center of the 7/8" hole.

763.2.5 Accessible Pedestrian Signal Detector (APS Push Buttons):

A. General:

1. Conform to applicable sections of the current MUTCD Chapter 4E, Pedestrian Control Features as specified herein.
2. All features fully operational when the traffic signal is in stop-and-go mode.
3. All features non-operational when the traffic signal is in flash mode.
4. Interchangeable with a non-accessible type pedestrian pushbutton with no modifications to the Controller Assembly (CA) or Controller Unit.
5. Audible transducer integral with the APS&D housing, adjacent to the pushbutton.

B. Electrical:

1. Metallic components either grounded or insulated to preclude an electrical hazard to pedestrians under all weather conditions.
2. All features powered by the 110VAC Walk signal and the 110VAC Don’t Walk signal so that additional conductors from the CA are not needed.

C Audible Pushbutton Locator

1. Frequency: repeating tone at one (1) cycle per second
2. Tone duration: ≤ 0.15 seconds
3. Volume:
   a. Minimum setting of zero
   b. Manually adjustable initial setting
   c. Automatically adjusted after initial setting. Volume increased in response to a temporary increase in ambient noise and subsequently decreased with a decrease in ambient noise.
   d. Maximum volume: 100 dBA which is the approximate sound pressure of a gasoline powered lawn mower nearby.
   e. Automatic volume adjustment independent of other APS&Ds at the intersection.
   f. May be disabled without affecting operation of audible pedestrian signal.
   g. Silent only during walk interval. Active all other times.

D. Vibratory Tactile Arrow Pushbutton

1. Pushbutton contained in a circular assembly which fits inside the housing and is attached to the housing with 4 screws.
2. ADA compliant: Size: ≥ 2.0” (50) diameter, Actuation force: ≤ 5 ft-lb (22.2 N)
3. Shape: Circular, raised slightly above housing so that it may be actuated with the back of a hand
4. Tamper-proof, vandal-proof, weatherproof, freeze-proof, impact-resistant design and construction.
5. Actuation method: Piezo technology. Mechanical not allowed.
6. Operation: Vibrates only when walk signal is displayed. Inactive all other times
7. Tactile Arrow:
   a. Attached to surface of the button assembly by a tamperproof method that allows direction of arrow to be field adjusted left or right to be parallel to the corresponding crosswalk.
   b. Raised slightly above surface of pushbutton, minimum 0.125” (0.3).
   c. Size: Length ≥ 1.5” (38), Height ≥ 1.0” (25)
   d. Color: Sharp contrast to background color of pushbutton and housing

E. Audible Walk Interval

General:

1. Operation independent of other APS&Ds at intersection.
2. Active only during the walk interval (when the walk signal is displayed).
3. Volume:
   a. Minimum setting of zero
   b. Manually adjustable initial setting

c. Automatically adjusted after initial setting. Volume increased in response to a temporary increase in ambient noise and subsequently decreased with a decrease in ambient noise.
d. Automatic volume adjustment independent of other APS&Ds at the intersection.
e. Maximum volume: 100 dBA which is the approximate sound pressure of a gasoline powered lawn mower nearby.

4. Duration:
   a. Default method: Automatically set by the duration of the visual walk signal display.
   b. When selected: Manually set when rest-in-walk is used for a concurrent pedestrian movement.
5. Audible sounds that mimic any bird call are not allowed.

F. Type A, Percussive Tone:

1. Repeating tone at eight (8) to ten (10) ticks per second.
2. Tone frequency: Multiple frequencies with a dominant component at 880 Hz which creates a “tick - tick - tick…” sound.

G. Pushbutton Housing/Sign Frame/Sign

1. One piece die cast aluminum meeting requirements of ASTM B85.
2. Sign frame designed to accept 9" x 12" (230 x 300) four-hole advisory sign.
3. Flat back to facilitate surface mount.
4. Available brackets to either pedestal top-mount or pole side-mount on pole diameter range of 3½" (89) to 15" (380).
5. Available brackets to allow mounting two (2) APS&Ds to the same 3½” (89) pole, facing ≥ 60 degrees apart, at the same height.

A. Wire entrance through the rear.
B. Stainless steel mounting hardware.
C. Color: Dark Green, Federal No 14056, Federal standard No. 595
a. Finish: Housing/Frame and all mounting brackets either:
   a. Painted with 3 coats of infrared oven-baked paint before assembly.
   b. Primer: Baked iron oxide which meets or exceeds FS TT-P-636.
   c. Second coat: Exterior-baking enamel, light gray, which meets or exceeds FS TT-E-527.
   d. Third coat: Exterior-baking enamel, which meets or exceeds FS TT-E-489.
   e. Electrostatic powder coated after chemically cleaned.
   f. Sign: CT DOT Sign No. 31-0845

763.3 CONSTRUCTION REQUIREMENTS:

763.3.1 Vehicular/Bike Loop Detector Sensors:

763.3.1.1 General:

Vehicular loop detector sensors of the size and type specified on the Traffic Signal Plan shall be installed in accordance with the locations shown on the Traffic Signal Plan and the requirements of these specifications. Any change in loop detector sensor location or deviation in loop detector sensor installation not in accordance with these specifications must be approved by the Engineer and documented by Developer on as-built signal plans. The installation of the detectors shall be such that the operation shall not be affected by temperature changes, water, ice, rain, snow, chemicals, or electromagnetic noise.

763.3.1.2 Loop Detector Sensor Conductor Installation:

1. Loop placement will be as shown on the plans. Developer will mark loops in the field and the locations approved in writing by the COP before work on the loop may begin.
2. Slots and cores are to be saw cut and drilled into the final asphalt/concrete base course lift as shown in the COP Standard Details.
3. To insure that all saw cuts are true and straight a loop sensor layout shall first be made on the pavement surface.
4. Slots are to be ½" (one-half inch) wide and of sufficient depth to allow 2" (two inches) of sealant coverage.
5. Drill cores, located in corners and ends of center cuts, are to be 2 ½" (two and one-half inches) in diameter and 2 ½" (two and one-half inches) deep.
6. The sawed slot shall extend to the curbside PVC conduit for each loop sensor.
7. Separate lead-in sawed slots extending from the loop to the stub-out conduit shall be cut for each loop sensor.
8. Slots are to be blown out and dried before installation of wires.
9. Loop conductors are to be installed ONLY in the presence of the COP's representative.
10. Loop detector conductors will not be spliced.
11. Each loop is to be wound in the direction and number of turns indicated on the City of Phoenix Details.
12. Loop lead-ins from the loop to the junction box are to be wound at three turns per foot. Twisted pairs will be taped full length from the exit of the sawed loop slot in the roadway to the connection with the shielded loop detector cable in the junction box.
13. The beginning conductor will be banded in the junction with the symbol "S", and the loop identified by a number of taped rings as shown on the Plans.
14. Each loop will be provided with a minimum of 6' (six feet) of slack in the twisted pair of conductors at the junction box when measured from the top of the junction box.
15. Loops are to be sealed only after completion of successful testing.
16. Testing may be conducted ONLY in the presence of the COP's representative.

    Tests are to include the following:
    Meggar Test – A 600 volt meggar test will show not less than 10 (ten) megohms resistance to ground.
    Continuity – Loop circuit resistance is not to exceed 2 (two) ohms.
17. Successful completion of tests will be documented in writing by the COP.
18. After completion of successful testing, the loops are to be sealed.

19. Sealant is to be poured into the slots and drill cores and struck flush with the roadway surface. Excess sealant will be removed from the surface of the roadway.
20. The conduit entrance to the roadway will be sealed in accordance with the COP Traffic Signal Details.

763.3.1.3 Sawcut Sealant:

The loop sensor conductors shall be permanently anchored in the sawed slot using the cold applied single component emulsion sealant as specified. The sealant shall completely surround the loop sensor conductors and fill the sawed slot to within 1/8 inch of the pavement surface. Surplus sealant shall be removed from the road surface without the use of solvents. Traffic lane closure shall remain in place until the sealant is set up; Developer shall cleanup sealant tracking problems at no additional cost to the City.

The emulsion sealant shall be thoroughly mixed per the manufacturer's recommendations. The emulsion sealant may be poured directly from container or any other suitable applicator, applied into saw cuts.

763.3.1.4 Loop Detector Sensor Connection:

Each pair of loop sensor conductors entering the curb-side pull box shall be identified as to which loop it represents (i.e. inside lane, outside lane, through lane, or left turn lane) as per COP Standard Details. Each conductor pair shall also be marked to signify its winding direction, "S" for start and "F" for finish.

Up to three loop detector sensors can be connected to one shielded loop detector cable per curb-side pull box at a corner of an intersection. Shielded loop detector cable shall run continuous and unspliced from curb-side pull box to the controller cabinet. The loop sensor conductors shall be spliced to the shielded loop detector cables in the adjacent curb-side pull box with each loop having its own splice to an individual twisted pair in the shielded loop detector cable. Shielded Loop Detector Cable is paid for under separate item.

763.3.2 Pedestrian Push Button:

Drill appropriate size hole for wire entrance and tap screws as provided by manufacturer's installation instructions at the appropriate height. Mount push buttons to the pole using the hardware as specified by the manufacturer.

Pedestrian push buttons will be wired from the terminal block in the push button to the point of connection in the hand hole at the base of the traffic signal pole plus an additional 16 inches beyond the hand hole with continuous lengths of single conductor wire of the appropriate color. Pedestrian push button wires will not be taped together except at the hand hole in the pole base as shown on the Plans and through drilled pole wire entrance as described herein.

763.3.3 APS Push Button:

Drill appropriate size hole for wire entrance and tap screws as provided by manufacturer's installation instructions at the appropriate height. Mount APS push buttons to the pole using the hardware as specified by the manufacturer. Install APS controller unit in the appropriate pedestrian signal head.

APS Pedestrian push buttons will be wired from the terminal block in the push button to the point of connection in the hand hole at the base of the traffic signal pole plus an additional 16 inches beyond the hand hole with continuous lengths of single conductor wire of the appropriate color. Pedestrian push button wires will not be taped together except at the hand hole in the pole base as shown on the Plans and through drilled pole wire entrance as described herein. APS push buttons have a four conductor cable that is to be installed in the pole to connect with the APS Controller Unit. If the cable provided is of insufficient length, splice a four conductor cable with the same color conductors as recommended by the manufacturer to complete the circuit.

SECTION 764 CITY OF PHOENIX (SECTION 475) - ELECTRICAL POWER SERVICE AND CONTROLLER CABINET

764.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing electrical power service pedestal and controller cabinets in accordance with the location and details on the Traffic Signal Plan, COP Standard Details, the requirements of these specifications, and the specifications of the utility company serving the location.

764.2 MATERIALS:

764.2.1 Electrical Power Service Pedestal: Each electrical power service pedestal system consists of the service pedestal cabinet, electrical service equipment, wiring, and wiring devices.

764.2.1.1 Service Pedestal Cabinet:

The electrical service meter pedestal cabinet shall consist of the meter socket, circuit breaker panel, test bypass facilities, pedestal locking device, ground mount enclosure, and necessary fittings all of which shall conform to the requirements of COP Standard Details, the Traffic Signal Plans, and the project Project Specifications listed below.

764.2.1.2 Service Pedestal Cabinet Assembly:

Provide tamperproof cabinets to provide 120/240 VAC 60-hertz electrical service.

1. Fabricate the cabinet from 12-gauge steel with piano hinged doors and provisions for padlocks.
2. Equip the rear of the cabinet with a removable utility access cover with provisions for a padlock.
3. Provide the cabinet with a standard 4-jaw meter socket.
4. Provide 200 amp utility landing lugs in the utility section.
5. Provide a 100 amp 10K AIC main breaker in the user section of the distribution panel.
6. Provide for up to 6 copper bussed and fully wired circuits.
7. Provide the following circuits in the distribution panel:
8. 15-amp, single pole breaker for the traffic signal.
9. 15-amp, single pole breaker for the luminaire.
10. 15-amp, single pole breaker for the “Smart Sign”
11. Finish: Fully coat the cabinet inside and out with a primer/paint system powder coat
12. Color: Light green

764.2.1.3 Electrical Service Equipment and Wiring:

Electrical service equipment, wiring, and wiring devices shall be in conformance with NEMA, the NEC, COP Details, and the specifications of the utility company providing electrical service.

1. Breakers: All circuit breakers shall have an interruption capacity of 10,000 amperes and supplied as indicated in the wiring schematic diagram.
2. Meter Loop Assembly: The meter loop assembly shall be bonded and grounded in accordance with the requirements of these specifications.
3. Conductors: Conductor size and color shall be as specified on the Traffic Signal Plan conductor schedule and in accordance with the requirements of these specifications. All electrical apparatuses shall be UL listed.
4. Ground rods for the Service Pedestal Cabinets are to be copper clad steel, a minimum of 5/8 inch by 8 feet long.
5.

764.2.2 Controller Cabinet Assembly:

Cabinet types and configurations shall be supplied as specified on the Traffic Signal Plans, COP Standard Details, and in accordance with these specifications.

Developer shall supply the following traffic signal controller:

Econolite Controller:
ASC/3 NEMA Controller ASC3 (Includes Ethernet Module & Data key)

TS2/Type 1 "P" Plug-N-Go Cabinet 8 phase Cabinet with two fans (Includes flasher, flash transfer relay, jumpers, detectors and all necessary equipment).

Ancillary Equipment

EDI Bus Interface Unit - Part # - EDI-BIU700 (3 per cabinet)

EDI Malfunction Management Unit Smart Monitor - Part # - EDI-MMU16LE (1 per cabinet)

Ruggedcom RS900-HI-D-TX-TX-00 Non-Fiber Network Switch - Switch must be a “Managed” switch, At least three levels of security, has to be IP addressable, minimum of (6) Ethernet ports, must have serial and Ethernet interface access ports, must be AC+ powered, and must meet same temperature specs as the controller 160 degree operating range.

Developer shall deliver the signal controller and controller cabinet assembly to Traffic Signal Shop, 2141 E. Jefferson Street for final configuration testing and programming. Developer shall coordinate the proposed delivery date and time with the Traffic Signal Warehouse (602) 495-2083 at least 3 weeks prior to Developer’s anticipated installation date.

A 12" high cabinet extension ring shall be provided for each cabinet. Extension ring shall be bolted to the cabinet during installation in the field. The ring shall be made of 10 Ga. aluminum sheeting and finished with a 2.5 mil high gloss white power coating.

764.3 CONSTRUCTION REQUIREMENTS:

764.3.1 Electrical Power Service Pedestal:

Power Service Pedestal System:

The electrical power service pedestal shall be assembled and installed on a concrete foundation at the location shown on the Traffic Signal Plan and in accordance with COP Standard Details. Concrete foundation is a separate pay item.

Provide Electrical Service

A. Developer is responsible to obtain the electrical service provider's connection point (Power Source). Plans indicate the desired location of the Power Service Pedestal based on the best information available at the time plans were completed. Developer will affirm and accommodate the point of connection.
B. At notice to proceed, the City of Phoenix will furnish Developer with address numbers for all new electrical service pedestal points in the City of Phoenix.
C. Developer shall be responsible for contacting the appropriate electrical service provider, arranging, scheduling, signing, and paying for agreements, line extensions and any other fees and arrangements necessary to energize the intersection traffic signal system or other controls in accordance with the plans.
D. In addition to the requirements of these Specifications, Developer shall comply with all construction requirements of the electrical service provider regarding materials, inspection or other constructions, fees or scheduling necessary to energize the devices included in the plans.
E. Upon final acceptance, Developer shall arrange for the transfer for all electrical service to the entity identified by the City of Phoenix.
    1. Connect grounding buss bar to the cabinet foundation grounding rod using a bare #4 AWG solid copper wire. Attach the grounding wire to the ground rod with an appropriate connector.
    2. Seal the service pedestal cabinet bases to the foundation using a commercial grade clear silicone sealer.
    3. For power pedestal cabinet foundations, use anchor bolts as required by the manufacturer of the cabinet, at least 5/8 inch in diameter by 18 inches long.
    4. For service pedestal foundations, anchor bolts will extend four (4) inches above the finished grade of the foundation.
    5. Minimum cabinet foundation curing times (NO EXCEPTIONS) before loading is seven (7) days.

764.3.2 Controller Cabinet Assembly:

Developer is only responsible to deliver the controller cabinet and all related electronics to the City as noted above.

Developer shall adhere to the minimum cabinet foundation curing times (NO EXCEPTIONS) of seven (7) days when installing the controller cabinet extension ring and scheduling the City to install the controller cabinet.

Controller cabinet extension rings will be secured to the foundation with ½"-13 x 5" masonry stud anchors at a minimum. Masonry stud anchors are to be installed in accordance with the product manufacturer's instructions. Three inches of threaded stud will extend above the finished grade of the Controller Cabinet foundation.

City of Phoenix shall install the controller cabinet to the controller cabinet extension ring previously installed by Developer to the cabinet foundation. City of Phoenix will terminate field wiring after all field circuits have been proofed for proper operation.

TS2/Type 1 "P" Plug-N-Go Cabinet 8 phase Cabinet with two fans (Includes flasher, flash transfer relay, jumpers, detectors and all necessary equipment).

Ancillary Equipment

EDI Bus Interface Unit - Part # - EDI-BIU700 (3 per cabinet)

EDI Malfunction Management Unit Smart Monitor - Part # - EDI-MMU16LE (1 per cabinet)

Ruggedcom RS900-HI-D-TX-TX-00 Non-Fiber Network Switch - Switch must be a “Managed” switch, At least three levels of security, has to be IP addressable, minimum of (6) Ethernet ports, must have serial and Ethernet interface access ports, must be AC+ powered, and must meet same temperature specs as the controller 160 degree operating range.

Developer shall deliver the signal controller and controller cabinet assembly to Traffic Signal Shop, 2141 E. Jefferson Street for final configuration testing and programming. Developer shall coordinate the proposed delivery date and time with the Traffic Signal Warehouse (602) 495-2083 at least 3 weeks prior to Developer’s anticipated installation date.

A 12” high cabinet extension ring shall be provided for each cabinet. Extension ring shall be bolted to the cabinet during installation in the field. The ring shall be made of 10 Ga. aluminum sheeting and finished with a 2.5 mil high gloss white power coating.

764.3 CONSTRUCTION REQUIREMENTS:

764.3.1 Electrical Power Service Pedestal:

Power Service Pedestal System:

The electrical power service pedestal shall be assembled and installed on a concrete foundation at the location shown on the Traffic Signal Plan and in accordance with COP Standard Details. Concrete foundation is a separate pay item.

Provide Electrical Service

A. Developer is responsible to obtain the electrical service provider’s connection point (Power Source). Plans indicate the desired location of the Power Service Pedestal based on the best information available at the time plans were completed. Developer will affirm and accommodate the point of connection.
B. At notice to proceed, the City of Phoenix will furnish Developer with address numbers for all new electrical service pedestal points in the City of Phoenix.
C. Developer shall be responsible for contacting the appropriate electrical service provider, arranging, scheduling, signing, and paying for agreements, line extensions

and any other fees and arrangements necessary to energize the intersection traffic signal system or other controls in accordance with the plans.

D. In addition to the requirements of these Specifications, Developer shall comply with all construction requirements of the electrical service provider regarding materials, inspection or other constructions, fees or scheduling necessary to energize the devices included in the plans.
E. Upon final acceptance, Developer shall arrange for the transfer for all electrical service to the entity identified by the City of Phoenix.
    1. Connect grounding buss bar to the cabinet foundation grounding rod using a bare #4 AWG solid copper wire. Attach the grounding wire to the ground rod with an appropriate connector.
    2. Seal the service pedestal cabinet bases to the foundation using a commercial grade clear silicone sealer.
    3. For power pedestal cabinet foundations, use anchor bolts as required by the manufacturer of the cabinet, at least 5/8 inch in diameter by 18 inches long.
    4. For service pedestal foundations, anchor bolts will extend four (4) inches above the finished grade of the foundation.
    5. Minimum cabinet foundation curing times (NO EXCEPTIONS) before loading is seven (7) days.

764.3.2 Controller Cabinet Assembly:

Developer is only responsible to deliver the controller cabinet and all related electronics to the City as noted above.

Developer shall adhere to the minimum cabinet foundation curing times (NO EXCEPTIONS) of seven (7) days when installing the controller cabinet extension ring and scheduling the City to install the controller cabinet.

Controller cabinet extension rings will be secured to the foundation with ½"-13 x 5" masonry stud anchors at a minimum. Masonry stud anchors are to be installed in accordance with the product manufacturer's instructions. Three inches of threaded stud will extend above the finished grade of the Controller Cabinet foundation.

City of Phoenix shall install the controller cabinet to the controller cabinet extension ring previously installed by Developer to the cabinet foundation. City of Phoenix will terminate field wiring after all field circuits have been proofed for proper operation.

SECTION 765 CITY OF PHOENIX (SECTION 476) - SIGNAL INDICATIONS AND MOUNTINGS

765.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing vehicular and pedestrian traffic signal indications and mounting assemblies in accordance with the types and locations shown on the Traffic Signal Plan, COP Standard Details, and the requirements of these specifications. Traffic Signals, except pedestrian type, for newly signalized intersections, shall be of the same manufacturer and material.

765.2 MATERIALS:

765.2.1 Banding:

Banding employed for mounting traffic signals, pedestrian signals and other traffic control equipment for mast arm or pole mounted devices is to be of stainless steel a minimum of .030 inch thick by 1/2 inch wide.

765.2.2 Vehicular Traffic Signal Heads:

Vehicular traffic signal heads shall be assembled of standard 12 inch (300mm) lens size signal sections with the number of sections or combination of sections specified on the Traffic Signal Plan, COP Standard Details and the requirements of the Manual on Uniform Traffic Control Devices.

The optical performance and design of traffic signal heads shall conform to the requirements of the Institute of Transportation Engineers Standards for Vehicular Traffic Control Signal Heads (VTCSH).

765.2.2.1 Traffic Signal Head Assemblies:

Provide twelve inch traffic signal head assemblies consisting of Light Emitting Diode (LED) vehicle signal display sections and associated mounting hardware for pole or mast arm mounting, as required.

Fasten signal head assemblies together to form a complete signal face so that any section may be rotated about a vertical axis and oriented at any angle with respect to an adjacent section.

A. Traffic signal heads:

1. Assemble each traffic signal head from one or more individual Light Emitting Diode (LED) vehicle signal display sections put together to create a one-way signal face with multiple possible industry standard configurations of red, yellow, and green ball or arrow sections equipped with a back plate.

2. Provide 12-inch traffic signal head assemblies that consist of individual sections of the number and configuration shown on the Plans, fastened together to produce a single unit.
3. Provide 12-inch signal heads with a 7 to 10 inch tunnel visor, a one-piece 5-inch aluminum non-louvered back plate, and an LED module for each section.
4. Fit the sections securely together to prevent the entrance of dirt and moisture.

B. Section housing:

1. Provide one-piece, polycarbonate housings for each section complete with a top, a bottom, and sides, and with black color impregnated into the material.
2. Equip each section housing with a rectangular polycarbonate door meeting the minimum requirements of ASTM B 85.
3. Provide two hinge lugs on the left of each housing section and with latch screw lugs on the right side of the housing.
4. Provide openings in both the top and bottom of the housing to accommodate standard 1-1/2 inch pipe fittings.
    a. Provide a Shurlock boss in the bottom opening having 72 clean, sharp teeth that provide full engagement, angled at 90 degrees, and having a depth of 5/64 inch.
    b. Provide two indentations in the top opening designed to receive a Shurlock ring to provide positive positioning of the head when mounted from a mast arm or span wire hanger.
    c. Provide a means of positive alignment when indexing each section by using mating bosses and recesses.
    d. When used with Shurlock fittings, the radial angular grooves of the Shurlock boss, must provide positive positioning of the entire signal head and eliminate rotation or misalignment of the signal.

Provide each housing section with a minimum of four mounting points, two on each side, to secure the back plate to the signal head.
Housing door:

a. Provide housing doors consisting of a one piece, polycarbonate housing door for each signal section with black color impregnated into the material.
b. Provide two hinge lugs on the left of each door and latch paws on the right side of each door.
c. Provide hinge pins that are easily removable without the need for special tools.
d. Provide a corrosion resistant, stainless steel latch screw and wing nut on the right side of the housing to allow opening and closing the signal door without the use of any tools.
e. Form the inside of the door with a gasket groove and provide a weather-proof and mildew resistant resilient polyethylene gasket which seats against a raised bead on the housing when the door is closed to make a positive weather proof and dustproof seal.

f. On the outer face of the door and equally spaced about the circumference of the lens opening, provide four tapped holes to accommodate the signal head visor.
g. Provide four 18-8 Type 304 stainless steel truss head screws to attach the signal head visor.

C. Signal Head Visors:

1. Equip each signal place with a tunnel style (open bottom) visor that is approximately 7 to 10 inches long. Tunnels requiring Louvers shall have a full tunnel.
2. Provide visors blanked, formed, and welded from .050 inch thick 3105-H25 aluminum alloy or polycarbonate.
3. Design and fabricate the visors with attaching ears (slotted tabs) to facilitate installation.
    a. Construct the visor so it can be installed or removed from the signal head without removing the attaching screws or opening the housing door.
    b. Construct the visor so the axis of the visor does not deviate more than 3.5 degrees or less than 3 degrees downward from horizontal.

D. Directional Louvers:

1. Where shown on the plans, directional louvers with a 3 degree cutoff 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. The outer cylinder and the vanes shall be 0.032 inches minimum thickness, and the vanes shall be 0.016 inches minimum thickness.
2. Tunnels requiring Louvers shall have a full tunnel.

E. Light Emitting Diode Vehicle Signal Display Sections:

Equip each signal section with an LED vehicle signal module for each signal head section, including balls and arrows.

1. Provide LED traffic signal modules meeting all the requirements identified in the 1998 Interim LED Purchase Specification of the Institute of Transportation Engineers, except as may be herein listed.
    a. Provide single, self-contained LED signal module devices with an integral power supply in the sealed LED module.
    b. Affix a manufacturer's label that includes all of the information listed in Section 3.6 of the ITE Interim LED Specification and the date of manufacture to each LED module.
    c. Construct the LED's with an AlInGaP substrate
2. Provide a weather tight module that fits securely in the housing and connects to the traffic signal head wiring terminal block.

a. Design LED traffic signal modules to fit traffic signal housings that meet the specifications established herein.
b. Design the terminal block only for crimped on terminal connectors.

1. LED Environmental Requirements - If not indicated on the plans, the LED module shall be rated for the –40º C (-40º F) to +74º C (164º F) temperature range.
2. LED Module Photometric Requirements - The AGENCY requires the light output of the LED modules supplied by Developer and covered by the ITE Purchase Specification referenced meet the requirements of Section 4 of that ITE Interim LED Purchase Specification, the 44-point test identified in paragraph 6.4.2.1 and the single point test identified in paragraph 6.4.2.2.
3. LED Module Electrical Requirements - The LED module is to be connected to the terminal block using two color-coded copper wires. The wire is to be No. 20 AWG with 30 mill jacketed insulation. The wire is to be rated for 600 volt AC. The insulation is to be rated for 105º C (220º F).
4. LED Dimming - All LED modules are not to be equipped with dimming circuitry.
5. Failed State Impedance – The module is to be equipped as provided in Section 5.8 of the ITE Interim LED Purchase Specification.
6. LED Module Compatibility - The recommendation stated in Technical Note #2 of the Institute of Transportation Engineers 1998 Interim LED Purchase Specification is adopted. All LED are to be compatible with approved load switches and conflict monitors. Developer will include in the material submittal a list of all control equipment known to be incompatible with the submitted LED module. This list is to include all known equipment as well as that employed in this contract
7. Wiring: Each LED module is to have wiring color coded. The color code will relate to the display provided by the module as follows:

Function	Color
Common (Neutral)	White
Red Ball or Arrow Driver	Red
Yellow Ball or Arrow Driver	Yellow
Green Ball or Arrow Driver	Green

F. Terminal blocks:

1. Each complete signal head will be equipped with a six position, twelve terminal, barrier type strip terminal block phenolic terminal block.
2. The terminal blocks are to be located in the in the bottom section of vertically arrayed signal head assemblies and in the red ball section of 5 section mast arm mounted side by side arrayed signal head assemblies.
3. The white, red, yellow, and green signal section leads will be attached to the same side of the terminal strip.

G. Colors and finishes:

1. Signal Head Color: All Vehicle signal heads are to be color impregnated Impregnate a black color into the material of all polycarbonate surfaces,

including the inside and outside of the signal housing, the door, and the visors.
2. Back Plate Finish: The back plates are to be finished with a low gloss two-part high solids enamel paint with ultraviolet inhibitors. Powder coating is an acceptable alternative.

H. Mounting Hardware:

1. For mast arm mounted signal head assemblies, install an elevator plumbizer below the red section of the signal head as shown on the Traffic Signal Standard Details.
2. When signal head assemblies are equipped with an elevator plumbizer, provide the top and bottom sections of the assemblies with a gasketed closure in the 1 ½ " openings.
3. Cast elevator plumbizers from bronze, and provide smooth castings or machine the plumbizer to remove all sharp edges.
4. When required, equip the signal head with a mast arm mounting bracket assembly consisting of a banded pole plate and a 2-inch support tube designed for rigidly mounting a signal head equipped with an elevator plumbizer on a mast arm.
5. For pole mounted signal heads, provide each signal head assembly with a set of mounting brackets consisting of the following:
   A. Two 1 1/2 inch pipe elbows each with a serrated surface having 72 teeth.
   B. Two 1 1/2 inch chase nipples with 2 1/2-inch hex heads.
   C. Two 12 inch Schedule 40 pipe arms.
   D. Two band-on style pole brackets.

Include additional nipples and steel lock nuts as necessary to complete the assembly as shown on the Traffic Signal Details.

Finish the mounting hardware for mast arm or pole mounting with paint or powder coating in a high gloss black.

I) Wiring:
Traffic signal heads will be wired from the terminal block in the signal head to the point of connection in the hand hole at the base of the traffic signal pole plus an additional 16 inches beyond the hand hole with a continuous length of IMSA 19-1 cable. For size and number of conductors see wire code tables in Standard detail.

The white conductor inside the IMSA cable from each signal head shall be connected to the white #10 neutral conductor in the hand hole at the base of the traffic signal of the pole.

Connections to the terminal block in the signal heads will be made with a hand formed "J" hook for solid conductors. Provide manufactured crimp on connector of appropriate size when stranded conductors are used.

Cables for mast arm signal heads will pass through de-burred 1" installer drilled cable entrances. All others installer drilled de-burred cable entrance holes will be ½".

765.2.3 Pedestrian Signal Head:

The optical performance and design of pedestrian signal heads shall conform to the requirements of the Institute of Transportation Engineers Standards for Pedestrian Traffic Control Signal Indications (PTCSI).

765.2.3.1 Pedestrian Signal Head Assembly:
Provide pedestrian signal head assemblies consisting of a signal housing with a door assembly and visor, a Countdown Light Emitting Diode (LED) pedestrian display module, and associated mounting hardware.

When the housing, door assembly and visor, and LED display module are fully assembled, they must provide a weatherproof and dustproof enclosure that meets or exceeds current ITE standards.

1. **Signal Housing**:

    a. Provide a single section aluminum pedestrian signal housing.
    b. Signal Housing Dimensions (Nominal): 19 inches wide by 18 1/2 inches high by 8 1/2 inches deep.
        I. Tolerance: Plus or minus 1/2 inch.
        II. Dimensions include the visor and door.
    c. Integrally cast two equally spaced mounting lugs into the top and bottom of the housing with stainless steel pins and wing nut assemblies to serve as the door hinges and latches.
    d. Cast standard 1-1/2 inch openings, complete with reinforcing ribs for transferring stress
    e. Cast a standard signal hardware configuration having 72 serrated teeth for maintaining a positive orientation of the signal face into the bottom opening.

2. **Door Assembly:**

    a. Provide a door assembly consisting of a die cast, one piece, corrosion resistant aluminum alloy frame with two cast lugs on the bottom and two cast latch slots on the top of each door.
    b. Attach the door to the housing using stainless steel detent spring pins on the bottom and stainless steel captive wing nut and eyebolt assemblies that drop into the latch slots on the top.
    c. Design the door assembly to open from the top and hinge down for servicing without the use of any tools.

3. **Visor:**

a. Equip the door with an integral blank out egg crate visor fabricated from black impregnated ultra violet stabilized and flame retardant polycarbonate.
b. Design the egg crate to consist of a series of nominally 0.030-inch thick material formed into one-inch squares rotated 45 degrees to form diamonds and which are also bisected by 1-1/2 inches deep horizontal louvers.
c. Provide a substantial exterior framework that allows the visor to be securely attached to the doorframe with stainless steel screws.

4. Light Emitting Diode (LED) Pedestrian Display Module:

a. Provide a Light Emitting Diode (LED) pedestrian display module with 9" numerals as per MUTCD, capable of displaying international symbols with count down capabilities.
b. Provide LED international symbols of a "Hand", a "Man", and Countdown numerals, sized and colored to conform to the latest ITE (PTCSI) standards.
c. Provide filled symbols, and not outlined symbols.
d. Blackout the entire area around the legend so that light does not project through any area other than the legend.
e. Construct the LED's with an AllnGaP substrate.
f. Provide an LED countdown timer that detects the "DON'T WALK" cycle and begins its countdown based on that duration and that blanks out the countdown display when a timing change occurs.
g. Fit the module lens with a one-piece EPDM gasket to provide a waterproof and dustproof seal when the door assembly is closed.across the housing surface, into the top and bottom of the housing.
h. Optically, the pedestrian signal head shall display brightly and uniformly, the alternate symbol messages "HAND" in Portland orange, **"COUNTDOWN NUMERALS" IN Portland orange** and "WALKING PERSON" in lunar white under all ambient light conditions. The message symbols shall not be seen (blank-out) when the message symbol is not energized.
i. The lunar white and Portland orange LED, solid state controls, and transformers for energizing the LED shall be encased in a plug-in module. The HAND and WALKING PERSON symbol message lens shall be ultraviolet stabilized polycarbonate. The HAND and WALKING SYMBOL message shall be full indications only.

5. Mounting Hardware:

For each pedestrian signal head assembly, provide a set of mounting brackets consisting of the following:

I. Two 1 1/2 inch pipe elbows each with a serrated surface having 72 teeth.
II. Two 1 1/2 inch chase nipples with 2 1/2-inch hex heads.
III. Two 12 inch Schedule 40 pipe arms.
IV. Two band-on style pole brackets.

V. Include additional nipples and steel lock nuts as necessary to complete the assembly as shown on the Plans.

6. Pole Plates:

a. Provide 3-inch wide by 5 3/8-inch long band-on style pole plates with a 1 1/2-inch NPT center hole.
b. Provide the pole side of the plate with a curvature of approximately 2 3/16 inches and a chord length of approximately 3 inches.
c. Machine, ream, or cast the inside and outside of each pole plate, elbow, chase nipple, and pipe arm to remove all sharp edges.

7. Finish:

a. Prior to applying an electrostatic, oven cured powder coat finish, sandblast, clean, and chemically seal all exterior surfaces of the pedestrian head housing, door frame, and the side of the pole mounting hardware.
b. Finish the housing, door frame, and mounting hardware with a high gloss black, and the visor frame with a low luster flat black.

8. Wiring:

a. Pedestrian signal heads will be wired from the terminal block in the pedestrian signal head to the point of connection in the hand hole at the base of the traffic signal pole plus an additional 16 inches beyond the hand hole with a continuous length of 3 conductor IMSA 19-1 cable. For size and number of conductors see wire code tables in standard details.
b. The white conductor inside the IMSA cable from the pedestrian head shall be connected to the white #10 neutral conductor in the hand hole at the base of the traffic signal pole.
c. Connections to the terminal block in the signal heads will be made with a hand formed “J” hook for solid conductors. Provide manufactured crimp on connector of appropriate size when stranded conductors are used.
d. Cable from pedestrian signal heads will pass through a de-burred ½” installer drilled cable entrance hole.

SECTION 766 CITY OF PHOENIX (SECTION 477) - INTERSECTION LIGHTING

766.1 DESCRIPTION:
The work under this section shall consist of furnishing and installing LED luminaires for intersection lighting in accordance with the location shown on the Traffic Signal Plan and the requirements of these specifications.

766.2 MATERIALS:

766.2.1 General:

Intersection lighting materials shall conform to the type and location of the luminaire as indicated on the Traffic Signal Plan. All luminaires shall be supplied with an individual photoelectric cell.

The luminaire shall be 113 watt, LED, and shall be capable of operating on primary voltages of 120 to 277 volts, 60 Hz AC. The luminaire shall be of the horizontal cut-off (cobra head) type and gray in color unless otherwise specified on the plans. The light distribution pattern shall be Asymmetric Medium and be rated at 16,600 Lumens with a 4,000K color temp, unless otherwise specified and shall conform to the Illumination Engineering Society Standards (IES).

Each luminaire shall be furnished with an instruction sheet which clearly shows installation procedures.

766.2.2 Luminaire Housing:

The luminaire housing shall be fabricated from a corrosive resistant metal material and have a baked on enamel finish. The housing shall be composed of three (3) sections, an upper housing section and two (2) lower housing sections. The upper housing section retains the reflector, LED lamps, and the photo electric control receptacle. One (1) of the lower housing sections is the lens door frame and shall retain the 90-degree cut-off type flat glass lens. The other lower housing section shall be the ballast module door. The ballast module door shall contain the major electrical components.

The ballast module door shall be lowered by loosening a single stainless steel captive screw. After lowering, the ballast module door shall be removed by unplugging a quick disconnect electrical plug and lifting the module off its hinges. The hinged lens door housing shall be latched to the upper housing by a spring loaded, single-action latch. The housing shall have a slip fitter for mounting on a 2-inch mast arm tenon and shall be adjustable for leveling ±3 degrees from the horizontal.

766.2.6 Photo Electric Control:

PEC: The photo electric control (PEC) shall be rated at 105-305volt, 60 Hz AC 1,800 volt-ampere. The operating temperature range shall be from -40º F to +158º F and 100 percent relative humidity. The PEC shall be a conventional glass-faced hermetically sealed ½” cell. A 3-5 second time delay shall be incorporated into the PEC circuit to prevent cycling at night by transient lights which might be focused on the PEC.

The PEC shall turn-on at 1.5 ±0.2 foot candles and turn-off at 1.5.1 +\- .25 foot candles. The PEC shall be UL listed for rain-tight applications. A built-in 40,000 Amp surge protector shall be provided to protect the PEC from lightning induced and line voltage transients.

The PEC incorporate a twist lock mount with a Neoprene gasket meeting ASTM D 1056 specifications. The control shall have an operating life of 20 years.

The cover shall be of a green color and be made of Polypropylene with UV inhibitors.

766.2.6 Luminaire Wire:

Developer shall provide an IMSA 19-1 Cable, 3 conductor, #16 solid or stranded with a PVC outer jacket from the luminaire to the point of connection in the junction box. Cable to be identified and wired as shown conductor table.

766.3 CONSTRUCTION REQUIREMENTS:

Luminaires of the size specified shall be furnished and installed at the locations shown on the Signal Plan and COP Standard Details. Unless otherwise specified the luminaire shall be adjusted to the horizontal. All wiring shall be in compliance with the NEC, the requirements of COP Standard Detail Sheets and as shown on the plans. The intersection lighting circuit shall not be connected to the same service leg to which the controller cabinet assembly is connected.

SECTION 767 CITY OF PHOENIX (SECTION 478) - ELECTRICAL CONDUCTORS

767.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing electrical conductors for traffic signals and intersection lighting in accordance with the Traffic Signal Plan and requirements of these specifications.

767.2 MATERIALS:

767.2.1 Electrical Conductors:

The wire shall be annealed copper and shall be uncoated unless otherwise specified. Unless otherwise indicated, the wire shall be solid for number 10, 12, 14, and 16 AWG and smaller diameter wire, conforming to the latest requirements of ASTM B 3 for annealed bare copper wire. Conductors for sizes number 8 AWG and larger diameter wire shall be stranded and shall conform to ASTM B 8 for Class B stranding, unless otherwise specified, the conductors shall be insulated with THW grade thermoplastic compound 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 of coating. The insulation thickness shall conform to the requirements of the NEC. Conductor insulation shall be a solid color unless otherwise specified. The color shall be continuous over the entire length of the conductor.

Wire and cable shall be UL listed and rated at 600 volts unless otherwise specified. The UL label shall be present on each reel, coil, or container of wire or cable. When requested, Developer shall submit to the Engineer the manufacturer's written certification that the product conforms to the requirements of these specifications.

Conductor colors and sizes for use in traffic signal and intersection lighting shall be as specified on the Traffic Signal Plan conductor schedule, and the COP Standard Details.

Wire Tagging:

Individual conductors for each vehicular and pedestrian phase group shall be secured together by two layers of plastic electrical tape and tagged with an approved wire I.D. marker as shown on the COP Standard Details. Cables for each vehicular and pedestrian phase group shall be wrapped with two layers of plastic electrical tape and tagged with an approved wire I.D. marker as shown on the COP Standard Details. Wires and cables shall be individually marked in all cabinets, pole hand holes and in pull boxes as per COP Standard Details.

Shielded Loop Detector Cables:

Loop detector lead-in shielded cables shall be six conductor A.W.G. #18, stranded, twisted, three pair, tinned copper, polyethylene insulated cable with a polyethylene jacket, rated at 600 volts and 140 degrees Fahrenheit and shall be in conformance with IMSA Specification 50-2.

IMSA Cables:

IMSA cable shall be used when specified on the plans. IMSA 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 IMSA

Specification 19-1. Wire insulation color assignment shall be in accordance with COP Standard Details.

The IMSA 19-1 cable shall be provided with the number and size of conductors as specified on the plans. All cable with less than 42 conductors shall be solid or stranded copper as specified on the plans. All 42 conductor IMSA Spec 19-1 cable shall be constructed as follows: Two (2) layers of 21 conductors A.W.G. #16 stranded. Each layer will contain 21 color conductors per IMSA Spec 19-1, Table 5.1 and separated by a clear Mylar tape. The colors and tracers shall be permanent and an integral part of the insulation and shall not be painted, surface coated, or adhered to surface. Ink strips are unacceptable. Conductor insulation colors shall be standard IMSA colors (as shown by the following table). Cable conductor color, phase, and interval assignments shall be in accordance with COP Standard Details.

Conductor Number	Insulation Color	Stripe Color	Conductor Number	Insulation Color	Stripe Color
1	Black	---	11	Blue	Black
2	White	---	12	Black	White
3	Red	---	13	Red	White
4	Green	---	14	Green	White
5	Orange	---	15	Blue	White
6	Blue	---	16	Black	Red
7	White	Black	17	White	Red
8	Red	Black	18	Orange	Red
9	Green	Black	19	Blue	Red
10	Orange	Black	20	Red	Green
			21	Orange	Green

Note: Only first 20 are used in a 20 Conductor cable. Conductor color schedule will repeat for the second set of 21 conductors in an IMSA 42 conductor cable.

Single Conductor Wire:

Wire under this specification shall be composed of a solid or stranded copper conductor as noted above and insulated by a polyvinyl chloride compound. The insulated conductor shall be completely enclosed in a nylon jacket. The conductor shall be copper and shall, before insulating, conform to the requirements of ASTM B-3, latest revision. Stranded conductors may be either concentric or bunch stranding and shall conform to the circular mil area and physical requirements specified in ASTM Designation B-8, latest revision, for concentric stranding or ASTM Designation B-174, latest revision, for bunch stranding. The insulating compound shall be polyvinyl chloride. The insulation shall be applied concentrically about the conductor. The thickness of the insulation shall not be less than specified in Table 1. The method of measurement for thickness and the apparatus used shall be in accordance

TABLE 1 INSULATION THICKNESS		
Conductor Size, AWG	Minimum Acceptable Average Thickness	Minimum Acceptable Thickness at any Point
20-12	15 mils	13 mils
10	20 mils	18 mils
8	30 mils	27 mils

with Underwriters Laboratory, Inc. Standard UL 62 (ANSI C33.1).

The insulation after application to the conductor shall comply with the requirements specified in accordance with Underwriters Laboratory, Inc. Standard UL 62 (ANSI C33.1). The insulation of the finished conductor before the jacket is applied shall withstand, without breakdown, the application of a 60 Hertz or 3,000 Hertz, 7,500 volt essentially sinusoidal spark test potential (RMS) in accordance with the method and using equipment specified in Underwriters Laboratory, Inc. Standard UL 83 (ANSI C33.8). The insulation color shall be specified by COP Standard Details. A tight fitting nylon compound jacket shall be applied over the conductor and comply with the requirements specified in ASTM D-4066, latest revision. The thickness of the jacket shall be as specified in Table 2. The method of measurement for thickness and apparatus used shall be in accordance with Underwriters Laboratory, Inc. Standard UL 62 (ANSI C33.1).

TABLE 2 INSULATION JACKET THICKNESS		
Conductor Size, AWG	Minimum Acceptable Average Thickness	Minimum Acceptable Thickness at any Point
20-10	0.004 inches	0.003 inches

All single conductors shall have plain, distinctive, and permanent markings on the outer surface throughout their entire length showing the manufacturer's name or trademark, insulation type, conductor size, voltage rating and the number of conductors in the cable. Insulation colors shall be permanent and an integral part of the insulation and shall not be applied as a surface treatment coating.

EVP Detector Cable:

The EVP Detector Cable shall be a three conductor A.W.G. #20 stranded, tinned copper insulated wires with an A.W.G. #20 tinned copper uninsulated drain wire. The insulation for the three wires shall be PVC, of the following colors, blue, orange and yellow. The cable shall have a black PVC outer jacket rated for 600 Volts.

EVP Confirmation Light Cable:

The EVP Confirmation Light Cable shall be a two conductor A.W.G. #18 stranded, tinned copper insulated wires. The insulation for the two wires shall be color coded PVC. The cable shall have a gray PVC outer jacket rated for 300 Volts.

767.3. WIRING PROCEDURES:

767.3.1 General Requirements:

All wiring shall be in conformance with the NEC and the requirements of these specifications. All wire nuts and other wiring devices shall be UL listed. Conductor sizes and colors shall be as specified on the Traffic Signal Plan conductor schedule. 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, conductors' ends shall be taped for moisture protection until connections are made. Approved splices are permitted in pull boxes, pedestals, pole hand holes, and cabinets.

Conductors shall have a minimum of 36 inches of slack above the top of the pull box.

All phase wiring shall be boxed at the intersection, terminated and spliced in the junction boxes.

767.3.2 Conductor Splices:

Splices shall be made utilizing wire nut connectors (Ideal underground model numbers 60, 64, and 66, or approved equal). Wire nut shall be pre-filled with Silicone-based sealants for moisture and corrosion, UL listed to 486D for direct burial, and a shell rated for 105 C. Wire stripping length and wire size combinations shall be in accordance with the manufacturer's instructions supplied with the wire nut connector. Soldered connections will not be permitted. All phases shall be spliced in all pull boxes and unused phase wiring shall be covered with insulating tape.

767.3.3 Bonding and Grounding:

All metallic enclosures such as cabinets, pedestals, poles, 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 No. 10 AWG bare solid copper bond wire installed with suitable connections to form a continuous grounded system.

At each service disconnect, 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 5/8 inch in diameter and 8.0 feet long. The rod shall be driven vertically into the ground to a minimum 7.5 feet below the surface. If the rod cannot be driven vertically, it shall be installed in accordance with article 250-83 of the NEC. The ground rod may be located in a pull box. The service equipment neutral (grounded conductor) and the system grounding conductor (No. 10 AWG bond, solid) shall be connected to the ground rod with a copper-plated bolt or a brass bolt on the ground clamp.

The grounding electrode system shall be in accordance with articles 250-81 and 250-83 of the NEC.

Pole foundations shall have 25 feet of number 4 AWG bare copper conductor coiled and placed at the bottom of the excavation before concrete is poured. Pole foundation grounding electrodes 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 prior to final connection of the utility service. 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 3 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 the 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 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. Developer 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.

SECTION 768 CITY OF PHOENIX (SECTION 479) - REMOVAL AND SALVAGE OF EXISTING TRAFFIC RELATED FACILITIES

768.1 DESCRIPTION:

It is the purpose of this section to provide information necessary for completion of the removal and disposal of traffic signal equipment and materials as shown on the Traffic Signal Plan to be removed.

768.2 REMOVAL AND SALVAGE OF EXISTING TRAFFIC RELATED FACILITIES:

768.2.1 General:

All removals shall be done in accordance with Section 350, as shown on the Traffic Signal Plan, and as detailed below. Any item noted on the Traffic Signal Plan or these Details to be salvaged shall be delivered to the COP Traffic Signal Shop or as directed by the Engineer. Delivery to the Traffic Signal warehouse shall include unloading the salvaged materials at a designated warehouse location by Developer using Developer's own equipment. Two working days (forty-eight hours minimum) in advance of the intended date of delivery, Developer shall coordinate the proposed date, time, and items to be delivered with the COP Traffic Signal Supervisor (602) 262-6733. Warehouse hours for receiving deliveries are 8:00 am – 2:00 pm Monday through Friday. The address for the City warehouse is:

City of Phoenix Traffic Signal Shop
2141 E. Jefferson St.
Phoenix, Arizona 85034

Remove, deliver and unload in good condition any existing equipment identified by the COP as salvageable by to the location designated by the COP. Dispose of all signal hardware identified by the COP as non-salvageable or scrap material. Non-salvageable material becomes the property of Developer. Cost of providing for its proper storage and ultimate disposal to meet Federal or State requirements is incidental to the payment for the removal of the item.

Deliveries of salvaged or obsolete traffic signal equipment to the location designated by the COP will be done in accordance with a schedule submitted to and approved by the COP no less that 24 hours in advance of the action.

Material will be inventoried upon delivery and identified with the intersection from which the material was removed.

768.2.2 Signal Poles:

For signal poles, remove, transport and unload mast arm poles, mast arms, poles and posts identified as salvageable by the COP as described in these Specifications. Disassemble mast arm poles and mast arms before transporting. Leave hand hole covers in place.

Remove all signal mounting hardware from poles and mast arms before transporting. Attaching hardware and anchor bolt nuts and washers may be bulk packed for delivery.

768.2.3 Controller Cabinet and Power Pedestal:

For controller cabinets including internal electronics and power pedestals identified as salvageable by the COP the field wiring will be disconnected, and all loose electronics in the control cabinet will be removed. Both the controller cabinet or power pedestal may be ground mounted or pole mounted. The controller cabinet, loose electronic devices, and power pedestals will be transported and unloaded as described in these Specifications.

768.2.4 Foundations:

Foundations within the ultimate curb and gutter of the roadway shall be part of roadway plans and removed in accordance with Section 350. The Traffic Signal Plans will identify foundations to be removed in accordance with this section. Existing Type “A” poles, pedestrian push-button poles, power pedestals, and controller cabinets will be removed in their entirety as well as any other foundations less than 42 inches in depth. Deeper foundations such as those for mast arm poles must be removed to a minimum of 10 inches below the finished grade of the sidewalks or landscaping. Voids created by the removal of the foundations will be backfilled with natural material compacted to match the density of the surrounding material.

768.2.5 Incidental Traffic Items:

This item provides for the removal of all incidental traffic items some of which will be salvageable such as signal heads, pedestrian heads, luminaires, pedestrian push buttons and non-salvageable such as junctions boxes, conduit, wiring, loops, and loop lead-ins. Prior to removal of any items, Developer shall meet with COP to identify specific salvageable materials which will be transported to the location noted above. Items identified as non-salvageable, shall be become the property of Developer and disposed of in accordance with applicable State or Federal regulations.

Junction boxes rendered obsolete by the signal construction will be removed and disposed of by Developer. Conduit runs shallower than 24 inches will be removed. Existing conduit runs with 24 inches or more of cover (when compared to the finished grade) may be abandoned in place. Developer will remove all wire and cable from conduits to be abandoned in place. Developer will dispose of all conduit, wire, and cable removed. For loops and loop lead-ins in saw cut they are to be abandoned in place. Conduit for twisted pair loop lead-in must be cleared of wire, and may be abandoned in place or removed, at Developer’s choice. If removed, any damage to existing pavement to remain is to be repaired at Developer’s expense.

SECTION 769 CITY OF PHOENIX (SECTION 900) - LED ILLUMINATED STREET SIGNS

769.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing LED illuminated street signs at each signalized intersection. The LED Illuminated street signs must look and operate the same as the existing signs throughout the City. An existing sign is available for Developer's inspection at the Traffic Signal Shop, 2141 E. Jefferson St., Phoenix. AZ. Arrangements to see the sign can be made by contacting the Traffic Signal Supervisor at 602-262-6733.

769.2 MATERIALS:

An aluminum frame slightly larger than the dimensions for the sign face. The frame shall hold the LED lighting fixtures to produce the light source for the internally illuminated sign. A translucent sign face will be on both sides of the sign structure.

The illuminated face shall be Lexan, 3/16 inch thick sheet, as a substrate; with a green EC film and Translucent Reflective Sheeting.

LED products shall be compatible with existing signs.

IMSA 19-1 Cable, 3 conductor, #14 solid with a PVC outer jacket

769.3 CONSTRUCTION REQUIREMENTS:

769.3.1 Size and Style:

The actual size of the illuminated sign face is provided in the table below. The sign cabinet will be larger than these dimensions and will include the size(s) of the cabinet lip that is used to hold the sign face in place.

ITEM NO.	SIZE	STYLE
769.1001	20 inches x 8 feet	two illuminated faces, double-sided sign
769.1002	20 inches x 9 feet	two illuminated faces, double-sided sign
769.1003	36 inches x 8 feet	two illuminated faces, double-sided sign

769.3.2 Sign Design:

The sign design shall include the street name, block number with direction, and City of Phoenix logo. The City will provide Developer with Gerber Omega or Gerber Graphics Advantage files via email. The name of the font to be used is the Clearview One Highway font. Developer's computer sign cutter shall be able to use True Type fonts to run this program.

The sign background shall be green with white letters, City logo, and borders. Developer shall produce the green background with the green EC film.

769.3.3 Sign Face Fabrication Process:

Developer shall install the sign sheeting to the Lexan substrate and the EC film to the reflective sheeting in accordance with the recommended procedures of the manufacturer.

A hand or motor driven squeeze roll applicator must be used with an application pressure of 60-80 psi. Use of soap and water for the application process will not be acceptable.

769.3.4 Sign Cabinet Fabrication and Wiring Process:

Sign cabinet shall be of good workmanship, water resistant with weep-holes to drain condensation. The sign and sign cabinet must be rectangular in shape with a smooth, clean appearance without the presence of ridges or angles other than right angles. Developer shall provide the proposed sign design shop drawings including mounting details for approval prior to ordering the signs. The shop drawings including the cantilever mounting mechanism shall be approved by an Arizona Licensed Structural Engineer.

To prevent reflection from the street light above the sign, the sign cabinet must be designed to angle slightly down toward the traffic. In addition, the cabinet will also leave a slight overhang to shield the sign face from the street light above. The exact angle and size of the overhang is left up to Developer.

The sign cabinet shall be painted with enamel paint to the City of Phoenix green to match the color of the traffic signal poles being supplied under this contract.

The sign cabinet shall be designed for ease of maintenance. The cabinet shall include top-hinged doors on both sides and have two prop rods for each door to stabilize them when open. The doors must open up, not open down or slide down or sideways.

The sign cabinets must include LED lighting assemblies internal to the sign. The LED sign shall operate on a 240 Volt luminaries' circuit which has no accompanying neutral.

Each sign shall be supplied with an individual photo electric switch to provide for dusk to dawn operation. This switch must be placed in the sign housing in such a manner that it will not be influenced by the luminaries located above the sign.

Install a IMSA 19-1 Cable, 3 conductor, #14 solid with a PVC outer jacket continuous without splice from the sign junction box to the junction box located below traffic signal pole marked and terminated as shown on the Traffic Signal Plans and COP Standard Details.

SECTION 770 CITY OF PHOENIX (SECTION 901) - WIRELESS NETWORK RADIO

770.1 DESCRIPTION:

The work under this section shall consist of furnishing and installing a wireless network radio at designated signalized intersections as shown on the Traffic Signal Plans.

770.2 MATERIALS:

Provide Tropos Model 7320 with a weatherized gateway plate. Each radio shall come with a Tropos Control Server License.

CAT 5e Cable:

1. Conductor Material: BC - Bare Copper
2. Insulation Material: PO - Polyolefin
3. Outer Shield Material : Foil
4. Outer Shield Material: Aluminum Foil-Polyester Tape/TC - Tinned Copper
5. TC Braided Stainless Steel Shield
6. Outer Jacket Material: Industrial Grade PVC - Polyvinyl Chloride Plenum (Y/N): N
7. Outer Jacket Color – Teal

Power Connector and Cable:

1. 3-wire,watertight female Remke PVC mini-link plug compatible with male connector on radio
2. IMSA 19-1, 3 conductor #16 cable

770.3 CONSTRUCTION REQUIREMENTS:

Install the wireless mesh radio on the horizontal portion of the luminaire mast arm adjacent to the luminaire. The radio should be installed as level as possible using the leveling instrument on the radio with the antennas in the vertical position. Install female mini-link plug to 3 conductor power cable in accordance with manufacturer requirements to ensure watertight connection, or use manufacturer supplied plug with 3' cord and provide a weatherproof connection between the supplied 3' cord and the IMSA 19-1 conductor cable. Connect watertight plug to the radio and install supplied 3 wire power cable continuous without splice from the radio (or weatherproof splice at end of 3' cord) to the junction box located below traffic signal pole as shown on the Traffic Signal Plans and COP Standard Details. Leave a 5' coil of spare cable.

Install CAT 5e cable from the radio to the controller cabinet as shown on the Traffic Signal Plans and COP Standard Details continuous without splice. On the controller cabinet end, leave a 10' coil of spare cable.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
49430
GREGORY
PATRICK
FLY
Date Signed 8-30-19
ARIZONA U.S.A.
EXPIRES: 3-31-21

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.

801-3 Construction Requirements:

All landscape excavation shall be performed in reasonably close conformity to the lines, grades, dimensions and cross sections on the project plans.

SECTION 803 LANDSCAPE PLATING MATERIALS:

803-1 Description:

The work under this section shall consist of finish grading surfaces, eradicating grasses, weeds and undesirable vegetation, furnishing, hauling, placing and compacting imported materials for plating embankment slopes, dikes and other designated areas, all in accordance with the details shown on the project plans and the requirements of these specifications.

803-2 Materials:

803-2.02 Decomposed Granite and Granite Mulch:

Decomposed granite and granite mulch shall be free of lumps or balls of clay and shall not contain calcareous coatings, caliche, organic matter or foreign substances. Each type/color of material shall be from a single production source or from multiple sources and shall present a uniform appearance throughout the project. The gradation of the decomposed granite and granite mulch shall be as specified on the plans.

803-2.03 Rock Mulch:

Rock mulch shall be free of calcareous coating, caliche, organic matter or other foreign substances.

803-2.04 Salvaged Surface Soils (Desert Pavement):

Salvaged surface soil shall be salvaged from within the top 4-8 inches of the existing on-site soil horizon in Character Area 2 (between east of Desert Foothills Parkway to 51st Avenue) as shown on the plans. Salvaged surface soils shall contain a mixture of the cobble, vegetation and soil within the top 4-8 inches of the native desert areas in Character Area 2.

803-3 Construction Requirements:

803-3.01 Soil Backfill and Plating Material

Areas to receive plating material (decomposed granite, granite mulch and rock mulch) shall be cleared of all undesirable vegetation, brush, trash, or rock which is two inches in diameter or larger. Rocks over 2" in diameter can remain in place in areas to receive salvaged surface soils. Undesirable vegetation, grasses and weeds shall be eradicated with an approved herbicide or by mechanical/manual means.

The soil backfill and plating material shall be spread and shaped to conform to the lines, grades and cross sections shown on the project plans.

803-3.02 Decomposed Granite and Granite Mulch:

Decomposed granite or granite mulch shall not be placed until the required irrigation distribution systems, and acceptable finished grading have been completed within the area.

The surface areas upon which decomposed granite or granite mulch is to be placed shall be graded and compacted to a density of 85 percent of the maximum density as determined in accordance with the requirements of the applicable test methods.

In all ADOT and Developer maintained Decomposed Granite and Rock Mulch locations, the Contractor shall provide one application of an approved pre-emergent herbicide following final spreading and grading of the Decomposed Granite and Rock mulch. The pre-emergent herbicide shall be watered in to activate the herbicide per manufactures recommendations after placement of the herbicide. Pre-emergent herbicide applications during the Landscape Establishment period shall be as detailed on the Landscape and Irrigation General Notes, Sheet L-320.001, General Granite/Seed and Hardscape Notes, note 3.The Pre-emergent herbicide shall be watered in to activate the herbicide per manufacture's recommendations after placement of the herbicide.

Decomposed granite or granite mulch shall be fractured/crushed rock that is angular in shape. Decomposed granite or granite mulch shall be evenly distributed over the designated areas. The depth of the decomposed granite or granite mulch shall be within 1/2 inch of the depth as shown on the project plans.

After rough spreading and rough grading of the granite mulch and decomposed granite within the designated areas, the granite mulch and decomposed granite shall be raked to evenly blend the granite mulch and decomposed granite.

The granite mulch and decomposed granite shall be saturated with water to optimum moisture level to aid in the compaction of the granite mulch and decomposed granite. Any erosion which occurs or is caused as a result of the operation and installation of granite mulch or decomposed granite shall be corrected by the contractor prior to approval by the Independent Quality Firm.

803-3.03 Rock Mulch:

The surfaces upon which the rock mulch is to be placed shall be fine graded and compacted to 90 percent of the maximum density as determined in accordance with the requirements of the applicable test methods of the ADOT Materials Testing Manual.

Rock mulch shall be fractured/crushed rock that is angular in shape and 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.

The surface areas upon which rock mulch is to be placed shall be treated with one application of an approved pre-emergent herbicide prior to installation of the rock mulch and one application of an approved pre-emergent herbicide following placement. The Pre-emergent herbicide shall be watered in to activate the herbicide per manufacturers recommendations after placement of the herbicide.

The depth of the rock mulch shall be within 1/2 inch of the depth as shown on the project plans.

After placing and grading the rock mulch, the Developer shall water the mulch with a light spray to remove fine material from the surface.

803-3.04 Salvaged Surface Soils (Desert Pavement)

Salvaged surface soils shall be stockpiled in areas within the project limits for use and placement on new cut and fill slopes, 2:1 and flatter within Character Area 2 (between east of Desert Foothills Parkway to 51st Avenue).

Surface soil shall be salvaged from all proposed excavation (cut) and embankment (fill) areas, within Character Area 2 (between east of Desert Foothills Parkway to 51st Avenue).
If hard rock is encountered at the salvage locations, the Developer may abandon soil salvaging in that area and re-establish the soil collection boundaries at other locations in Character Area 2. The Developer shall keep records of the boundaries of the soil salvage and exclusion areas.

Vegetative matter shall remain in the soil and may include leaves, twigs, roots, branches (less than 2 inches in diameter and less than 2 feet in length), slash and other minor debris generated during the clearing and grubbing operations. Stumps shall be removed.

Salvaged surface soil shall be windrowed or stockpiled at the Developer's discretion at locations as determined by the Developer to facilitate installation of salvaged surface soils at the locations as shown on the plans. Soil shall not be located within washes or arroyos. The soils shall not be piled higher than 8'.

SECTION 804 TOPSOIL:

804-1 Description:

The work under this section shall consist of furnishing, hauling, amending and placing topsoil in accordance with the requirements of the approved Plating Report (Topsoil).

804-2 Materials:

All topsoil for use in planting operations shall be from the on site sources as identified in the approved Plating Report (Topsoil).

All soils analysis, sampling, amendments, and test results are as specified in the Plating Report (Topsoil).

804-3 Construction Requirements:

Topsoil for use on the project shall be stockpiled at locations as determined by the Developer and amended as required at the stockpile locations.

All topsoil material is for use in the expanded planting pits only, during the planting operations, as approved in the Plating Report (Topsoil).

The Developer shall be responsible for ensuring stockpile locations are adequately sized, amended and used solely for the purpose in which they are intended at the planting locations as shown on the plans.

SECTION 805 SEEDING:

805-1 Description:

Seeding shall consist of tillage; furnishing and applying compost, chemical fertilizer, and sulfur; furnishing and planting the contract-specified seed mix; and furnishing, applying and affixing final mulch cover to all areas designated on the project. Areas to be seeded are those areas as shown on the plans, or designated by the Landscape Architect.

805-2 Materials:

805-2.02 Seed:

The species of seed shall be as shown in the TP attachment 450-2 for Low Grass and Forbs mix, Tall background mix and Wash mix. Locations of each mix type are as shown on the project plans.

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 or strain of seed, the percentage of germination, purity and weed content, and the date of analysis which shall not be more than fifteen months prior to the delivery date. The Developer shall provide all Certificates of Analysis from the seed testing laboratory to ADOT Roadside Development Section and the Independent Quality Firm.

The specified seed shall be obtained from seed suppliers through harvesting of wildland collections, or field-grown seeds grown prior to or during the contract period.

Weed content of the specified seed mix shall not exceed 0.5 percent.

The Developer shall provide all seed tag labels to the Independent Quality Firm. The Developer shall store seed under dry conditions, at temperatures of between 35 °F and 120 °F, and out of direct sunlight. Prior to using the seed, the Developer shall provide a certification letter to the Independent Quality Firm that the seed was stored as specified herein.

Legume seed shall be inoculated with appropriate bacteria cultures, in accordance with the culture manufacturer's instructions.

Application rates of seed as specified are for Pure Live Seed (PLS). PLS is determined by multiplying the sum of the percent germination of seeds, including hard or dormant seeds, by the percent purity.

Substitution of the contract-specified seed will only be allowed if evidence is submitted documenting that the Developer has made a diligent effort to obtain the contract-specified seed from either seed suppliers or collectors, and that the contract-specified seed will not become available prior to the time specified for seeding in the Developer's approved construction schedule.

805- 2.03 Tacking Agent:

Tacking agent shall be a naturally occurring organic compound, and shall be non-toxic. The tacking agent shall be a product typically used for binding soil and mulch in seeding or erosion control operations. Approved types shall consist of mucilage or gum by dry weight as active ingredient obtained from guar or plantago. The tacking agent shall be labeled indicating the type and mucilage purity.

Tacking agent swell volume shall be tested by an approved testing laboratory using the USP method. Material shall have a swell volume of at least 24 milliliters per gram. Tacking agent rates shall be adjusted to compensate for swell volume variation. Material tested with lesser swell volume shall have the tacking agent rate increased by the same percentage of decrease in swell volume from the standard 30 milliliters per gram. Material tested with greater volume may reduce tacking agent rates by the same percentage of increase in swell volume from the standard 30 milliliters per gram. Tacking agent shall be pure material without starches, bentonite, or other compounds that would alter the swell volume test results of mucilage, or the effectiveness of the tacking.

805-2.04 Thermally-Refined Wood Fiber:

Wood cellulose fiber mulch shall be from thermo-mechanically processed wood, processed to contain no growth germination inhibiting factors. The mulch shall be from virgin wood manufactured and processed so the fibers will remain in uniform suspension in water under agitation to form homogenous slurry. Paper products will not be considered as virgin wood. The thermally-refined wood fiber mulch shall have the properties shown in Table 2 below:

TABLE 2	
Virgin Wood Cellulose Fiber	90% min.
Recycled Cellulose Fiber	10% max.
Ash Content	0.8% +/-0.3%
pH	4.5 +/-1.0
Water Holding Capacity	10:1 (water:fiber) Min.

805-2.05 Straw Mulch for Hydraulic Application:

Hydraulically applied straw mulch shall be wheat or rice straw processed to various particle sizes, mixed with water and tacking material, and applied as a non-clogging slurry using a hydroseeder. A minimum of 70 percent of the wheat or rice straw in the mix shall be not less than 1/2 inch ± 1/4 inch in length. Straw particles may be longer provided that the particles can be used with the selected hydroseeder without clogging. Hydraulically applied straw mulch, as furnished by the manufacturer, may contain up to 10 percent paper or cotton materials in dry weight, as well as 5 to 20 percent of wood fiber in dry weight. The combined dry weight percentage of paper, cotton, and wood fiber materials together shall be not less than 15 percent nor more than 30 percent of the hydraulically applied straw mulch.

Hydraulically applied straw mulch material from the following sources shall be acceptable:

Hydra Matrick
North American Green
5401 St Wendel-Cynthia Road
Poseyville, IN 47633
Phone: 1-800-772-4297

Hydro Straw
Hydrostraw LLC
3676 W 9000 N Road
Manteno, IL 60950
Phone: 1-800-545-1755

Shot Straw
Rio Ranches LLC
PO Box 156
Palo Verde, AZ 85343
Phone: 602-680-8320

DuraBlend 361
PrimeOne Products LLC
PO Box 30816
Spokane, WA 99223
Phone: 509-981-8555

805-2.06 Chemical Fertilizer and Sulfur:

Chemical fertilizer shall be composed of a mixture of one part sulfur-coated urea 25-4-8, one part monammonium phosphate 11-52-0, and one part methylene urea 38-0-0. The sulfur-coated urea, a blended fertilizer 25-4-8, shall have approximately 80 percent of the nitrogen defined as slow release, and contain 5 percent Iron, 10 percent sulfur and trace amounts of zinc and manganese. The result shall be a 24-18-2 chemical blended fertilizer, as specified herein.

In addition to the fertilizer mixture, agricultural sulfur compounds, comprised of between 80 percent and 96 percent sulfur, shall be applied at the rate specified in Section 805-3.02.

805-2.07 Water:

Water shall be free of oil, acid, salts or other substances which are harmful to plants.

805-2.08 Compost:

Compost shall consist of composted organic vegetative materials. Prior to being furnished on the project, compost mulch samples shall be tested for the specified microbiological and nutrient conditions, including maturity and stability, by a testing laboratory approved for testing of organic materials. Such testing shall have been performed within six months of time the compost is to be furnished to the project. Written test results shall be submitted to the Independent Quality Firm.

Compost material shall be dark brown in color with the parent material composted and no longer visible. The structure shall be a mixture of fine and medium size particles and humus crumbs. The maximum particle size shall be within the capacity of the Developer's equipment for application to the constructed slopes. The odor shall be that of rich humus with no ammonia or anaerobic odors.

Compost shall meet the requirements of Table 3 below:

TABLE 3	
Cation Exchange Capacity (CEC)	Greater than 50 meq/100 g
Carbon:Nitrogen Ratio	Less than 20:1
pH (of extract)	6.0 – 8.5
Organic Matter Content	Greater than 25%
Total Nitrogen (not added)	Greater than 1%
Humic Acid	Greater than 5%
Maturity Index	Greater than 50% on Maturity Index at a 10:1 ratio
Stability	Less than 100 mg O^2/Kg compost dry solids – hour

Hydraulically applied compost shall meet the requirements of Table 4 below:

TABLE 4	
Cation Exchange Capacity (CEC)	Greater than 55 meq/100 g
Carbon : Nitrogen Ratio (C : N)	Less than 20 :1
PH (of extract)	6.5 – 8.5
Organic Matter Content	Greater than 35%
Total Nitrogen (not added)	Greater than 1%
Micronutrients (added)	S, Ca, Mg, Na, Fe, Al, Mn, Cu, Zn, B
Stability Indicator, CO2 Evolution: Biologically Available C (BAC)	Less than 4mg CO2-C/g OM/day is desirable. From 4 through 8mg CO2-C/g OM/day is acceptable. Greater than 8mg CO2-C/g OM/day is not acceptable.

805-3 Construction Requirements:

805-3.01 General:

(A) Seeding Operations:

At least two weeks prior to beginning seeding, the Developer shall complete and submit a batch mix and seed application form to the Independent Quality Firm for approval.

The Developer shall notify the Independent Quality Firm at least two days prior to commencing any phase of seeding operations for the remainder of the project.

The equipment and methods used to distribute seeding materials shall provide an even and uniform application of seed, mulch, and other materials at the specified rates.

Unless specified otherwise, seeding operations shall not be performed on undisturbed soil outside the clearing and grubbing limits of the project or on steep rock cuts.

Seeding shall be done during suitable weather and soil conditions for tillage and placement of materials. Seeding operations shall not be performed when wind exceeds 10 miles per hour or if conditions would prevent uniform application of materials or would carry seeding materials into areas not designated for seeding.

805-3.02 Tillage:

Where equipment can operate, the area to be seeded shall be prepared with a disk, ripper bar, chisel plow, or with other devices to provide thorough soil cultivation to the depth specified below.

For areas too steep to be prepared for seeding after the slope has been completed tillage shall be accomplished with appropriate equipment as the slope is being constructed. On slope areas, all tillage shall be directional along the contours of the areas involved.

Cut slopes shall be prepared with ridges and deep tillage, or shall be mini-benched. On 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.

Cut slopes and fill slopes flatter than 3:1 (horizontal to vertical) shall be tilled a minimum of 8 inches in depth. All slopes steeper than 3:1, and areas which could potentially be affected by underground utilities, and/or rocky soil conditions shall be tilled to a minimum depth of 4 inch or to the extent practicable, and left in a roughened condition as they are constructed.

Care shall be taken during the seeding operations to prevent damage to existing trees and shrubs in the seeding area.

Tillage, where adjacent to the roadway shall be a minimum of two inches in depth for the first ten feet from the edge of pavement.

Tillage may require passing the equipment over the area several times to provide thorough soil cultivation. Furrows from tillage shall be no more than 12 inches apart. No work shall be done when the moisture content of the soil is unfavorable to tillage.

All competitive vegetation shall be uprooted prior to seeding and the soil shall be left in a friable roughened condition free of clods or large stones over four inches in any dimension, and other foreign material that would interfere with the seeding operation.

Regardless of the method of seeding application, all areas prepared with tilling shall have chemical fertilizer and soil amendments (sulfur and compost) uniformly applied and incorporated into the soil prior to final tillage and seeding.

Chemical fertilizer and sulfur shall be applied at the rate of 200 pounds each per acre. Compost shall be applied at the rate of 15 cubic yards per acre.

Bulk compost shall be applied to areas to be seeded at the specified rate of **15 cubic yards per acre** prior to final tillage for incorporation into the soil seedbed. Unless otherwise approved by the Independent Quality Firm, bulk compost shall be applied to all areas where equipment can be operated for final tillage in order to incorporate into the soil seedbed.

Areas where bulk compost cannot be applied by broadcast methods, compost shall be applied hydraulically. Hydraulically applied compost shall be applied at the rate of 1,500 pounds per acre to cut slopes or on other areas prior to final tillage for incorporation into the soil seedbed. Hydraulically applied compost may be combined with soil amendments, and fertilizer in the same slurry. Seed shall be applied separately.

Slopes 3:1 and flatter shall have fertilizer, sulfur, and compost tilled into a minimum of the top four inches of the surface. Slopes steeper than 3:1 shall have fertilizer, sulfur, and compost uniformly broadcast to the surface of the soils. Fertilizer and sulfur shall not be applied hydraulically to any seeded areas.

805-3.03 Seeding:

(A) General:

Hydroseeding shall be the preferred method for seed distribution for all slopes. Any areas to be seeded manually shall be completed after the final soil tillage and prior to any hydroseeding.

Hydraulically applied straw mulch shall be applied on all seeded areas, as specified in Sections 805-3.04, within 24 hours of seed application. Seeding application shall be accomplished prior to application of hydraulically applied straw mulch. Combining the seed application process with the mulching process will not be acceptable.

Unless otherwise specified, seeding areas shall not be watered after planting.

(B) Hydroseed Method:

All seeded areas shall be hydroseeded. The contract-specified seed shall be applied in a slurry containing 200 pounds of thermally-refined wood fiber and a minimum of 40 pounds tacking agent per acre. Seed shall not be in the slurry for more than 30 minutes. Hydroseeded areas shall also be mulched, as specified in Sections 3.04 or 3.05, within 24 hours of application of the seed.

(C) Manual Application:

Manually applied seeds shall be broadcast evenly to produce uniform distribution over the seeded areas.

805-3.04 Applying Straw Mulch:

(A) General:

Within 24 hours after each area is planted, straw mulch shall be uniformly applied at the minimum rates as shown in Section 805-3.05, Table 4 below.

During seeding and mulching operations, care shall be exercised to prevent drift and displacement of materials. Mulch material which is placed upon trees and shrubs, roadways, structures, and upon any areas where mulching is not specified, or which is placed in excessive depths on mulching areas, shall be removed. Mulch materials which are deposited in a matted condition shall be loosened and uniformly spread to the specified depth over the mulching areas. Any unevenness in materials shall be immediately corrected by the Developer. In addition, the operation shall minimize production of dust or other airborne particulate matter during application of straw mulch, either by moistening the straw, modifying equipment with misters, or through other means.

805-3.05 Hydraulically Applied Straw Mulch with Tacking Agent:

Areas seeded shall have hydraulically applied straw mulch with tacking agent applied at the variable rates shown in the Table 4 below.

TABLE 4		
Slope (H:V)	**Hydraulically Applied Straw Mulch (Pounds per acre)**	**Tacking agent (Pounds pure mucilage per acre)**
Flat to 6:1	2,000	150
From greater than 6:1 to 3:1	2,500	150
Greater than 3:1	3,000	200
Erosive Soil Slopes or Highly Erosive Areas	3,500	250

The Developer shall submit a batch (tank) mix quantity schedule for mulch application to the Independent Quality Firm for approval prior to mixing hydraulically applied straw mulch and tacking agent in a slurry. Batch mixing and coverage will be monitored throughout the seeding operations. The Developer shall coordinate the mixing and application operations with the Independent Quality Firm in advance of all mixing.

SECTION 806 TREES, SHRUBS AND PLANTS:

806-1 Description:

The work under this section shall consist of furnishing and planting trees, shrubs, cacti and other plants (nursery stock) and transplanting trees and cacti (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; incorporation of topsoil, watering, staking, guying, pruning; the cleanup of the area; application of pre-emergent herbicides; removal of grass, weed and undesirable vegetation; application of rodent repellent; disposal of unwanted and deleterious materials; and the care and maintenance; all in accordance with the details shown on the project plans.

806-2 Materials:

806-2.01 Nursery Stock:

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.

All plants shall be in a 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 of 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 previously listed conditions, may be cause for rejection of the plants.

All plants shall comply with Federal and State laws requiring inspection for diseases and infestations.

806-2.03 Local Stock:

Local stock shall be secured from within the project limits for transplanting and will be designated on the project plans.

806-2.04 Prepared Soil:

Prepared soil for use in expanded planting pits (except cacti) shall consist of 70% Topsoil as specified in Section 804, 30% soil conditioner and chemical fertilizers. Chemical fertilizers shall be as specified herein. Clods or stones exceeding 2 inches in diameter and foreign matter deemed objectionable by the Independent Quality Firm will not be allowed. All excess soil excavated from the plant pits shall be disposed of off the project site, in a manner acceptable to the Independent Quality Firm. Alternatively, contractor may site batch topsoil/conditioner mixture by placing topsoil, conditioner and fertilizers directly on planting pit mixing thoroughly in place with an auger. Contractor shall ensure site batched mixture meets 70% / 30% requirement specified herein. Site mixture may be verified by the Independent Quality Firm

806-2.05 Water:

Water shall shall be free of oil, acid, salts or other substances which are harmful to plants. All sources shall be from approved, potable water sources as shown on the project plans.

806-2.06 Chemical Fertilizer:

Chemical fertilizers for use in prepared soil shall consist of two pounds of water soluble, powdered or granulated elemental sulfur. Elemental sulfur shall be 85 to 95 % sulfur and 5% Iron. Chemical fertilizer shall be a blended mixture of one part sulfur-coated urea 25-4-8, one part monammonium phosphate 11-52-0, and one part methylene urea 38-0-0. The sulfur-coated urea blended fertilizer shall have 80 percent of the nitrogen defined as slow release, and contain 5 percent iron, 10 percent sulfur and trace amounts of zinc and manganese.

To ensure quality control, amendments shall be inspected separately before adding to soil conditioning compost. The chemical fertilizer shall be furnished from the supplier as a blended mixture.

Amendments shall be inspected separately before adding to soil conditioner to ensure quality control. PRE-PACKAGING OF AMENDMENTS IS PROHIBITED.

Soil conditioner shall be as per Section 806-2.09.

806-2.07 Lumber and Tree Stakes:

Tree stakes, supports and braces shall be sound, straight construction grade treated Douglas fir, lodge pole pine, heart redwood or other species approved by the Independent Quality Firm. Douglas fir stakes and braces shall have a nominal dimensions of two by two inches and lodge pole pine stakes shall have a diameter of two inches or greater. Tree stakes and braces may be furnished either rough or dressed.

Lumber stored at the project site shall be neatly staked on skids a minimum 4 inches above the ground and shall be protected from the elements to prevent damage or warping.

806-2.06 Hardware:

Nails, lag screws, staples and other hardware shall be galvanized and of commercial quality. All bolts and lag screws shall be furnished with galvanized malleable washers.

If the contractor chooses to use wire for tree staking in lieu of nylon straps as shown on the plans, all wire shall be new soft annealed galvanized wire of minimum 12 guage. Wire shall have new rubber covers, ½" minimum diameter, vinyl or two ply fabric bearing rubber hose.

806-2.08 Existing Plant Material:

The contractor is advised that there are existing plants identified on the project plans that are to remain in place. The contractor shall be responsible for maintaining all existing plants and providing an adequate water supply to existing plants affected by construction activities as shown on the plans. Existing plants that are removed, damaged or destroyed shall be replaced with trees and shrubs of the same species and similar size, as approved by the Landscape Architect.

806-2.09 Soil Conditioner:

Soil conditioner shall consist of composted organic vegetative materials. Prior to being furnished on the project, compost mulch samples shall be tested for the specified microbiological and nutrient conditions, including maturity and stability, by a testing laboratory approved for testing of organic materials. Written test results shall be submitted to the Engineer for approval.

Compost material shall be dark brown in color with the parent material composted and no longer visible. The structure shall be a mixture of fine and medium size particles and humus crumbs. The maximum particle size shall be within the capacity of the contractor's equipment for application to the constructed slopes. The odor shall be that of rich humus with no ammonia or anaerobic odors.

Compost shall also meet the requirements of table shown below:

Compost	
Cation Exchange Capacity (CEC)	Greater than 50 meq/100 g
Carbon: Nitrogen Ratio	Less than 20:1
pH (of extract)	6.0 – 8.5
Organic Matter Content	Greater than 25%

Total Nitrogen (not added)	Greater than 1%
Humic Acid	Greater than 5%
Maturity Index	Greater than 50% on Maturity Index at a 10:1 ratio
Stability	Less than 100 mb 02/Kg compost dry solids – hour

806-3 Construction Requirements:

806-3.01 General:

All planting shall be in accordance with the details and requirements as designated on the project plans. Plant materials shall be approved as specified under Subsection 806-3.03 in coordination with the Independent Quality Firm.

806-3.02 Excavation:

The Developer shall be responsible for laying out all plantings areas and staking plant locations in reasonably close conformity to the dimensions and locations as shown on the project plans. The developer shall review for potential conflicts. Conflicts shall be reviewed by the Landscape Architect.

In the event that field conditions such as subsurface utilities, impervious materials or inadequate drainage necessitate relocation of planting areas, the developer will designate new locations in consultation with the Landscape Architect.

Prior to excavation of plant pits, all planting areas shall be graded to the lines and grades as designated on the project plans.

Planting pits shall be excavated to the dimensions indicated on the project plans and shall have vertical sides and horizontal bottoms.

When excavation of planting pits is difficult and poor drainage may result, the pit shall be filled with water in order to check drainage. After 12 hours, any pit (and planting location) that has not drained fully after it has been filled will be relocated.

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. While in transit, plants shall be protected at all times against freezing temperatures, the sun, the wind and other adverse weather conditions. During transportation in closed vehicles, plants shall receive adequate ventilation to prevent "sweating." Plants delivered in a wilted condition will be rejected.

The Developer shall notify the Landscape Architect and Field Engineer at least 48 hours prior to the date for inspection of plants at any Arizona plant source or at the project site. The Inspector will inspect all plants for conformity with the specifications and, upon acceptance, planting may begin. Plants to be inspected for conformity with the plans and specifications by the Landscape Architect's discretion.

Plants shall conform to the recommended specifications set forth in the "American Standard for Nursery Stock." All plant balls shall be firm and intact. Plants whose stems are loose in the ball will be rejected.

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 the roots shall be kept moist.

806-3.04 Planting:

(A) General:

No planting shall be done until installation and acceptance of the irrigation system in total or in increments for each project segment. The initial watering and all subsequent watering of the planting shall be done using the newly constructed irrigation system.

(B) Nursery Stock:

After the planting pits are refilled with amended topsoil, and the irrigation system has been installed and accepted, the planting pits shall be pre-watered by the irrigation system for a minimum duration of 12 hours. Planting shall begin a minimum of 24 hours following the pre watering period. If plant pits are allowed to dry prior to planting the plant pits shall be re-watered as specified.

Planting shall not be done in excessively moist soils or conditions not satisfactory for planting in accordance with accepted horticultural practice.

Plants in containers shall be planted the same day the containers are cut.

The Developer shall actively water plants to maintain a healthy vigorous growing condition during the planting period.

Plants shall be removed from containers such that the root ball is not broken. Plants with broken rootballs or with root balls that fall apart shall be rejected by the Independent Quality Firm. Plants shall be planted plumb and centered in the plant pit.

Backfill material shall be prepared soil as specified herein. Backfill shall be carefully applied in lifts of not more than 18 inches, hand compacted and firmed around the rootball so as to eliminate all soil voids. Each lift of backfill shall be watered thoroughly before placing next or final lift of backfill. Plant pits shall not be totally saturated or flooded.

Any excess soil which is not used for planting backfill maybe evenly distributed in the adjacent landscape areas if it does not unreasonably interfere with the final grading operations. All planting areas shall be graded to a reasonably smooth condition after completion of planting.

Plants shall be set to a depth such that after backfilling and watering, the top of the root ball is level with the surrounding grades. Plants that settle more than 1 inch shall be reset.

After planting all plants shall be thoroughly irrigated until the backfill soil is saturated to optimal conditions.

(C) Local Stock:

The Developer shall take all necessary precaution to protect and minimize all damage to local stock during transport and planting operations. All stock shall be properly supported during transport and planting. Plant trunks shall be protected at points of contact with slings, cables or other support techniques with suitable protective materials such as canvas, burlap, carpet remnants or other suitable materials, in conformance with the Salvage Operation Plan.

806-3.05 Pruning and Staking:

Plants shall be pruned in order to remove dead twigs, branches or to ensure proper form for each type of plant to the standard shape for its species.

Trees shall be staked and supported as shown on the project plans. Plants shall be maintained in a straight, vertical position. Stakes shall be driven at least 6 inches into undisturbed ground at the bottom of the plant pit. Stakes shall be positioned to clear the root system of the plant to protect the integrity of the roots.

Tree ties and guy wires shall be periodically inspected and adjusted as necessary to prevent ‘girdling’ or injury to tree trunks and branches.

Tree shall be secured to the stakes as shown on the project plans, after backfilling and planting operations are complete. Plants shall be irrigated a minimum of 48 hours prior to staking to ensure the plant rootball has settled into its planting location.

806-3.06 Care and Protection of Trees, Shrubs and Plants:

The Developer shall be responsible for maintaining and protecting all planting areas, 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 all weeds and undesirable vegetation as specified; 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 and pests; and taking all precautions necessary to prevent damage from cold, frost, sunburn or other hazards. All existing undesirable grasses and weeds shall be eradicated with herbicides or manual methods and disposed of by the Developer.

The Developer shall remove and replace all dead plants and all plants that show signs of failure to grow or which are injured or damaged so as to render them unsuitable for the purpose intended, as determined by the Landscape Architect. The Developer may, delay replacement of plants killed by frost until such time that frost is not imminent.

Any person or persons applying pesticides shall be licensed in accordance with the requirements of Title 3, Chapter 2, Arizona Revised Statutes, Article 6, Section 3-377.

All planting areas shall be kept free of weeds. The Developer shall notify the Independent Quality Firm 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 conform to Environmental Protection Agency requirements. The Developer shall keep a record of all applications, types of herbicide used such as pre- or post-emergent, rates and methods of application, and the dates and locations of such applications on forms supplied by the Inspector. A copy of this record shall be submitted to the Independent Quality Firm after each application.

SECTION 808 WATER DISTRIBUTION:

808-1 Description:

The work under this section shall consist of furnishing all materials, equipment, tools and labor necessary to install a complete, automatic and functioning landscape irrigation distribution system in accordance with the details and at the locations shown on the project plans and the requirements of these specifications. The work shall also consist of the design and installation of a complete and functioning temporary landscape irrigation distribution system at locations as shown on the plans.

Water distribution plans are, in general, diagrammatic. The exact location of component units of the water distribution system will be dependent on field conditions.

The following water distribution terms, conditions, and component descriptions shall apply for installation of water distribution systems and/or landscape irrigation systems:

Main lines and/or pressure mains are defined as the piping under constant pressure. Supply mains are defined as the piping from a water source to a water storage facility and may or may not be under constant pressure. Submains shall be the piping between a control valve (manual or automatic) and a pressure regulating device and not under constant pressure. Lateral piping is that on the discharge side of a control valve or pressure regulating device and not under constant pressure.

808-2 Materials:

808-2.01 Components:

(A) Backflow Prevention Unit:

Backflow prevention units shall be reduced pressure type and the size as specified on the project plans. Backflow preventers and components shall conform to applicable codes, regulations, the project documents and the performance requirements of the Foundation for Cross Connection Control Research, University of Southern California. All testing of backflow prevention devices shall be as specified by the Foundation for Cross Connection Control Research, U.S.C.

(1) Reduced Pressure Backflow Preventer:

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 three pounds per square inch greater than the pressure in the zone between the two check valves. The relief valve shall remain open until a positive pressure differential of three pounds per square inch 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 replacement 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
Hydrostatic Test Pressure	300 psi
Temperature Range	33 ^{o}F – 210 ^{o}F

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 preventer shall be factory assembled and tested prior to delivery.

The backflow preventer insulation shall be one-inch thick, all-service jacket, heavy density glass fiber, sectional pipe insulation with vinyl coated, embossed, vapor barrier laminate. The jacket shall have a pressure sensitive, self-sealing lap. All insulation shall receive an exterior protective cover of 0.016-inch aluminum secured with 3/8-inch aluminum straps located six inches center to center.

(B) Gate Valve:

Gate valves shall be the type and size specified on the project plans. Identification of the valve by trade name, manufacturer and/or model number shall be stamped or cast on the valve body or on a permanently attached metal plate or tag. Unless otherwise specified, valves installed above ground shall be equipped with handwheels. Valves installed below grade shall be equipped with an operating nut or a cross handle.

(1) Gate Valve (1 1/2 Inch or Smaller):

Gate valves 1 1/2 inches or smaller shall be Class 125, bronze body, nonrising stem type with solid disc, screwed bonnet and required operator.

The bronze components of the valve shall conform to the requirements of ASTM B 62 with the exception of the stem which shall conform to ASTM B 371, Alloy 694. The handwheel, where required, shall be non-corrosive metal.

Valve end connections shall be as specified and as detailed on the project plans.

(2) Gate Valve (2 Inches or Larger):

Gate valves two inches or larger in size shall be iron body, bronze mounted and shall conform to the requirements of Federal Specification WW-V-58 Class 1, Type 1, for Class 125 valves having non-rising stem, bolted bonnet and solid resilient wedge configuration.

End connections and required operator shall be as detailed on the project plans and/or as specified by the Federal Specifications.

(C) Remote Control Valve:

The remote control valves shall be the types and sizes as specified on the project plans. The manufacturer's name and identification shall be cast molded or stamped on the valve body or on a permanently attached metal plate or tag. Valves shall have a minimum service rating of 150 pounds per square inch. Valve bodies, bonnets and component parts shall be as specified herein.

All valves shall have accurately machined or molded valve seat surfaces and internal parts. End connections shall be machined or molded female I.P.S. thread unless otherwise specified. Electrically operated valves shall be fully compatible and fully functional in all modes with the automatic controller device specified for the project.

(1) Remote Control Valve (Plastic):

The plastic remote control valve shall be a normally closed, 24-volt A.C., 50/60-cycle, solenoid-actuated globe pattern, diaphragm-type valve capable of regulating water flow for the specified system operation. Valve pressure rating shall not be less than 200 pounds per square inch.

The valve body and bonnet shall be constructed of glass filled nylon with the handle, rings and diaphragm hardware of Acetal. Diaphragm shall be constructed of nylon reinforced Nitrile rubber. "O" rings shall be Ethylene Propylene rubber. Valve stem shall be brass and all studs and flange nuts shall be stainless steel.

The valve shall be actuated by a low power, epoxy encapsulated 24-volt A.C., 50/60-cycle solenoid with an in-rush power requirement of 0.41 amperes (9.9 VA) and a holding current of 0.23 amperes (5.5 VA). Control water pressure for the solenoid actuator shall be delivered from the inlet of the valve to the actuator by means of an internal or external passage particular to the valve size.

Each valve shall be equipped with a manual on-off control and flow adjustment control. Manual operation of the valve shall be by manual internal or external bleed.

The valve construction shall be such as to provide for all internal parts to be removable from the top of the valve without disturbing the valve installation.

(D) Automatic Controller (C202P Maintenance Areas):

Controller Software

Each controller shall be able to operate:

Up to 200 zones along a two-wire path and/or a conventional wire path

Up to 25 moisture sensors

Up to 8 temperature sensors, which monitor and control program operation based on temperature thresholds

Up to 8 normally open or normally closed event device inputs

Up to 8 normally open or normally closed master valves and/or pump starts for the entire system

Up to 8 flow sensors or meters, which manage and monitor flow across a site as independent or connected hydraulic systems organized into mainline groupings

Up to 8 independent mainlines for control and management of separate water delivery systems

Up to 110 device loads on the two-wire path

1, 2, and 4 station decoders = ½ load
12 to 24 station powered decoders = 2 loads
Soil moisture sensor = 1 load
Flow decoder = 3 loads
Event device = 1 load

Up to 99 completely independent programs

Up to 15 solenoids concurrently over two-wire

Up to 2 typical solenoids per 12 station powered decoder or up to 4 typical solenoids per 24 station powered decoder over conventional wire plus 2 additional solenoids using the specially designated ports

The controller shall display on-screen help. The on-screen help shall be available in both English and Spanish. The help text language shall be user-configurable.

The operator shall be able to establish 3 levels of security for users of the controller: Operator, Programmer, and Administrator.

Configuration

The controller shall search for and identify all devices connected to the two-wire and list them according to device type and serial number.

The controller shall be capable of addressing or re-addressing any two-wire decoder from the controller by re-assigning the device's serial number to a new zone address.

The controller shall assign any station or terminal number on a multi-station decoder from the controller to any zone address in any order, in any program.

The controller shall support full two-way communication with all devices and monitor two-wire voltage and communication integrity, solenoid voltages, current, and status (reported as open/short/OK).

Programming

The controller shall be capable of managing 99 programs, including up to 8 start times per program with overlapping run times.

The controller shall automatically stack overlapping programs. The system can run any number of programs concurrently if permitted by the concurrent zone settings.

The controller shall allow run times for zones from 1 minute to 23 hours 59 minutes.

The controller shall support program prioritization and progression to allow control of which landscape areas get watered first, and/or to prioritize water rations during restricted water allocations.

The controller shall be able to adjust seasonal water budget from 25% to 200% by program.

The controller shall allow an operator to enable or disable each zone.

The controller shall allow an operator to set a "water window" by program on a per hour basis for each day of the week, which suspends watering beyond a set time and resumes watering when another window opens.

The controller shall allow a program to be started by the following conditions:

Start time

Moisture percent

Temperature value

Event decoder contacts open/closed

The program shall be capable of using the following schedules:

Day intervals in even days

Odd days

Odd days excluding the 31st

User defined interval

Custom 7-day calendar

Historical day interval calendar with customizable half-months

The controller shall be able to irrigate in the following modes:

Timed (standard time-based watering)

Soil moisture based

The controller shall be able to group zones into scheduling groups as follows:

Primary – Primary zones can be time based or soil moisture based.

Linked – The settings for a linked zone match the settings of the assigned primary zone.

Messages and Alerts

The controller shall display an on-screen, historical-run-time chart that includes the time watered for last 6 days by program.

The controller shall display an on-screen historical water used chart that includes the actual water used for the last 6 days by the flow meter.

The controller shall display a 6-day scalable soil moisture history graph with integrated run-time bar chart.

The controller shall display all pause and stop conditions in message screens that are accessible from the main screen. The system displays one message for each condition, and the user can clear each message.

The controller shall display high flow alerts, low flow alerts, pause messages and conditions, and rain delays, wire faults, as well as other operating conditions.

The controller shall display messages generated from diagnostic tests initiated by the controller and by the user.

Reports and Graphs

The controller's main screen shall be able to display water usage, soil moisture graphs, design flow or actual flow, two-wire current, program reports, pause reports, and zone status by program (shown as a color representing watering, soaking, waiting, paused, disabled, and error) without affecting any active programs.

The controller shall be able to log data collected from each flow meter, moisture sensor, temperature sensor, and zone run time.

The controller shall have the ability to report:

The last date a program ran

The next run date of a program

Water consumption used by program per run estimation

14 days of moisture readings displayed graphically

Water flow estimation in gallons per minute (gpm)

Total daily, current month, and previous month's water consumption estimation in gallons

Actual water used and flow rate for each flow meter

A report for every pause condition event

Monthly water budget

Intelligent Soak Cycles

The controller shall have the ability to perform Intelligent Soak Cycles™ to prioritize cycles for zones that have already started to water over zones that have not started.

The controller shall have the ability to program cycle times and soak times between 0 minutes and 23 hours 59 minutes.

Master Valves

The controller shall support up to 8 normally open and/or normally closed master valves and/or pump starts for the entire system.

Each master valve shall be assignable to any program or all programs.

The controller shall have the ability to manage a pump or other loads switched with a relay on a per program basis.

The controller shall be able to operate normally open and normally closed master valves.

Flow Monitoring and Management

The operator shall be able to manually enter a design flow for each zone, with or without an installed flow meter.

The controller shall be able to learn flow rates by turning each zone on, one at a time, allowing the flow rate to stabilize, and then recording the flow of each zone back to the controller.

The operator shall be able to configure pipe fill time for each point of connection.

The controller shall display real-time flow updated every 15 seconds when watering.

The controller shall be able to learn flow for zones assigned to one mainline, while zones assigned to another mainline(s) shall be allowed to continue irrigating.

The operator shall be able to schedule learn flow cycles for individual zones or for all zones assigned to a program.

The controller shall intelligently schedule watering based on available flow or design flow to maximize concurrent valve operation and minimize total water time by mainline.

The controller shall support up to 8 mainlines.

The controller shall allow a program to be assigned to any one mainline.

The controller shall be able to limit the number of concurrent zones using the design flow.

The controller shall allow a programmed flow variance from 0 to 100%, where 0 is equal to off.

In an “overflow event,” the controller shall close master valves and halt all irrigation by program.

Moisture Sensor

The controller shall support up to 25 individual soil moisture sensors.

The controller shall have the ability to automatically adjust run times and/or day intervals based on soil moisture readings.

The controller shall override a programmed run time or day interval when it detects a soil moisture reading that exceeds the assigned shut-off value.

Using a moisture sensor, the controller shall be able to determine the water capacity of the soil and establish a lower limit threshold for the sensor.

The controller shall provide a moisture limit that is accurate within ±3%.

Water Management

The controller shall support water source prioritization and intelligent secondary water source management to control which water sources are used first.

The controller shall support empty and full indicators from moisture sensors and switches to optimize management of cisterns, ponds, rainwater catchment and other water storage systems.

The controller shall support a settable wait time after an empty condition is met.

The controller shall support per-program prioritized daily water rationing across multiple water sources.

System Backups

The controller shall be able to export all data to a USB flash drive including:

All events

All programming

Run times (including manual run times)

Water used

Moisture logs

Temperature logs

Alarm logs

Program summary report

Test all results

The controller shall have the ability to load all programming information directly from a USB flash drive.

All programming shall be saved in non-volatile memory.

The controller shall save running events and logs every 10 minutes to non-volatile memory.

Diagnostics

The controller shall have the ability to reprogram the solenoid drive current of the decoder from the controller without uninstalling or removing the decoder from the field.

The controller shall be able to detect and report a “two-wire over current.”

The controller shall be able to read and report the current of the two-wire during normal running conditions.

The controller shall be able to test each individual zone and display:

Two-wire voltage drop

Valve voltage

Current

Decoder serial number

The controller shall run a weekly diagnostic test on normally open master valves to help prevent a normally open master valve from “sticking” open.

Manual Operation

The operator shall be able to manually operate one zone or all zones of a program with programmable concurrent zones and run times.

The operator shall be able to manually start or stop a program.

When running a manual zone, the controller shall allow the user to advance watering to the next zone or return to a previous zone while not affecting the programming of the controller.

Start, Stop, Pause

When a moisture sensor, event device, or temperature device (such as an air temperature sensor or a soil moisture/temperature sensor) is connected, the controller shall be able to:

Start a program

Stop a program

Pause any program

The user shall be able to configure the pause in 1 minute increments from 0-24 hours. Watering will resume when the pause condition is removed and the allotted time has passed.

Event Scheduling

The controller shall be able to schedule 8 controller-wide event dates plus 8 event dates per program during which watering is disabled.

Central Control and Remote Control

The controller shall be able to connect to irrigation central control software and virtual Irrigation controller access when configured with an approved communication module.

The controller shall support the following communication options: built-in Ethernet, Wi-Fi, cellular modem, Ethernet radio, and long haul Ethernet.

The operator shall be able to configure, program, and operate all zones from the irrigation central control software.

The operator shall be able to receive email and text message alerts when connected to the irrigation central control software.

The operator shall be able to perform manual operations remotely with the irrigation central control software.

Hardware

The controller display shall have a high-contrast 3.5-inch (8.9 cm) screen with a resolution of 320x240 at 65,536 colors. The LCD brightness shall be a minimum of 200 lumens.

The controller shall have a 100 Base-TX Ethernet jack.

The jack shall accept RJ45 connectors.

The jack shall be compliant with CAT5, CAT5e, and CAT6 Ethernet cable.

The jack shall be RoHS compliant.

The jack shall meet or exceed IEEE 802.3 standards.

The jack shall have indicator LEDs.

Power Specifications

The controller shall come standard with a 120 VAC transformer, which has apparent power of 40 VA.

The controller shall not exceed 30 VAC RMS output on the two-wire.

The controller shall be able to support up to a 1.45 amp output current.

The controller shall have 3 levels of surge protection built into the controller including a replaceable and fusible surge protection PC board.

The controller shall have a minimum of a 1 picosecond surge response time.

Controller Enclosures

The controller shall pedestal mounted.

The pedestal shall be pre-assembled enclosure shall be 17.38″ W x 36.25″ H x 12.63″D (44 cm W x 92 cm H x 32 cm D).

The pedestal enclosure shall be a NEMA type 3R rainproof enclosure manufactured entirely of 16-gauge 304-grade stainless steel. The main housing shall be louvered for cross flow ventilation. Filter screens shall cover all louvers to help protect internal components from water spray, insects, and dust. A stainless steel backboard shall be provided for the purpose of mounting electronics and other types of equipment. The backboard shall be mounted on 4 stainless steel bolts that will allow for removal of the backboard.

A stainless steel cam-style lock shall be mounted in the door for security.

The pedestal shall come complete with lightning and surge protection and all terminals shall be factory labeled. The pre-assembled enclosure shall come with an on/off switch to isolate the controller along with a GFI receptacle.

The enclosure and installed equipment shall carry a conditional 5-year warranty.

The controller shall be able to operate in environments ranging from 32°F to 140°F (0°C to 60°C) ambient temperatures.

(E) Control Wire:

The 24-volt control and common wire for operation of remote control valves shall be AWG 14 size, UL approved, 600-volt, type UF single conductor wire with 60-mil PVC insulation. All control ("hot") wiring shall be a contrasting color to the white common or ground wire. Black wire will not be acceptable for use on any 24-volt control circuit. Control wire color requirements apply to City of Phoenix and ADOT maintenance areas only. Control wires to water distribution valves used for shrubs shall be a different color than those used for trees. The wire for 2 wire path shall be AWG 12 size, UL approved, 30 VAC RMS.

(F) Automatic Controller (COP Maintenance Areas):

The work consists of furnishing and installing the automatic controllers complete, stainless steel enclosure, conduit, separate controller grounding rod, grounding wire and grounding clamp, necessary 120 volt wiring, installation in enclosure, 24 volt control and common wires, pull boxes, excavation and backfilling at the locations designated on the project plans and in accordance with the details shown and these Special Provisions.

The irrigation system automatic controllers shall have four independently controllable programs, with five start time per program.

Run times for each station shall be capable of being set from one minute to nine hours 59 minutes in one minute increments.

All stations shall be able to be turned on/off manually for a selectable period of time.

Each controller shall be housed within a 14-gauge stainless steel security pedestal specifically constructed for the specified controller.

The controller shall have a non-volatile memory to retain programs during power outages

The 24-volt control and common wire for operation of remote control valves shall conform to the requirements of Subsection 808-2.01(E).

All control ("hot") wire shall be of a contrasting color to white common or ground wire. Black wire will not be acceptable for use on any 24 volt control circuit.

Control wires to shrub valves shall be of a different color than those to tree valves. Wire color(s) shall be approved by the Landscape Architect prior to installation.

The controller grounding shall provide a shunt path for surges and spikes in the primary and secondary lines/loads. The grounding components shall include 3, 5/8 inch x 10 foot copper clad grounding rods, 10 inch round valve boxes for ground rod enclosure and No. 10 bare copper wires and bronze acorn-clamps.

Back-indication wires from sensors, flow meters and safety devices shall consist of an individual control ("hot") wire from each device and one common ground wire for all devices common to one general location. The back indicator terminals shall be located at each automatic controller.

Back-indication wires shall be 24 volt, UF single conductor, AWG No.14 as specified in Subsection 808-2.01(F) of the Standard Specifications. Back indicator wire colors shall be other than that used for the control and ground wire to remote control valves.

The controller shall include surge protection grounding as recommended by the manufacturer, in order to protect the controller circuits from lighting strikes.

(G) Pressure Regulator:

The work shall consist of furnishing and installing the pressure regulator riser assembly complete, including excavating, backfilling, valve box, pressure regulator and other appurtenances, at the locations designated on the project plans and in accordance with the details shown and these special provisions.

The pressure regulator shall be of the non-adjustable pre-set type consisting of a two-piece, sonic welded body molded from Acrylonitrile Butadiene Styrene containing a valve housing of Acetyl plastic and a rolling diaphragm of Ethylene Propylene (EPDM) material. The internal spring shall be of stainless steel.

Each regulator shall have a flow range from 0.33 GPM to 12 GPM with a regulated nominal outlet pressure of 20 PSI with an inlet pressure range of 0 to 120 PSI.

The pressure regulators shall have 3/4 inch FPT inlet and 3/4 inch MHT outlet for installation as detailed on the project plans.

Each pressure regulator riser shall be provided with a 1/8 inch MPT Schrader type pressure-check valve that shall be used in conjunction with the specified pressure gauge/tire chuck to verify system performance.

(H) Pipe:

(1) Polyvinyl Chloride (PVC):

Plastic pipe and fittings shall conform to the requirements of the National Sanitation Foundation and bear their stamp.

Materials used in the manufacture of PVC pipe and fittings shall conform to the requirements of ASTM D 1784, Class 12454-B.

PVC pipe shall conform to the requirements of ASTM D 2241 for SDR-PR pipe and ASTM D 1785 for Schedule 40 and Schedule 80 pipe.

The pipe classification and the pressure rating will be specified on the project plans or ..

PVC pipe, unless otherwise specified, shall be plain-end solvent weld or bell-end solvent weld. Bell-end solvent weld pipe shall conform to the requirements of ASTM D 2672.

PVC piping shall be assembled with solvent weld, socket type fittings.

All PVC fittings shall conform to one or more of the following requirements:

(a) ASTM D 2466 for Schedule 40 socket type fittings.

(b) ASTM D 2467 for Schedule 80 socket type fittings.

(2) Steel:

Galvanized and black steel pipe shall conform to the requirements of ASTM A 53.

All threaded steel pipe fittings shall be heavy pattern, banded, malleable iron with a rating of 150 pounds per square inch working pressure. Fittings shall be galvanized or black steel appropriate to the piping being used. Flanges or flanged fittings, where specified, detailed or required, shall be Standard, Class 125 or Extra Heavy, Class 250 conforming to ANSI B 16.1.

The type of pipe and fittings which shall be used will be specified on the project plans.

(3) Copper

All copper pipe shall be rigid or non-rigid copper, Type K Standard, meeting the requirements of Federal Specification WW-T 799 and ASTM B 88. Fittings shall be standard copper, wrought and cast. Solder shall be of the lead free type.

(I) Master Valve/Flow Sensor:

The master valve and flow meter shall be a combination master valve and flow sensor shall be of rugged, heavy-duty construction, fast and highly reliable double-chambered valve. The master valve shall be in a normally closed configuration.

The master valve shall have no straight pipe installation requirement and be highly accurate over a large range of flows. It shall be equipped with a magnetically driven sealed register with totalizer and be two-wire ready with no additional decoders required. Master valve for COP controllers do not require decoders.

The master valve/flow sensor shall be compatible with the controllers and have pre-configured K and Offset values.

Maximum Working Pressure: 235 psi, Minimum Working Pressure: 14 psi.

Inlet and outlet connections shall be National Pipe Thread or ANSI Flange.

The body material shall be cast iron with polyester coating.

The diaphragm material shall be reinforced natural rubber.

Electrical wire shall be two-wire (30 VAC RMS). Electrical wire for COP master valve shall be 14 gauge as required by the manufacturer.

(J) Emitters:

The work shall consist of furnishing and installing the multi outlet emitter assemblies, at the locations designated on the project plans, to include excavating and backfilling. The work shall be accomplished in accordance with the project plans details, and these Special Provisions.

The emitter assembly shall consist of the emitter unit (Threaded Inlet), polyethylene supply tubing, flexible vinyl distribution tube, polypropylene tube stake and appropriate polyethylene adapters required to connect emitter to supply tubing and emitter assembly to rigid PVC emitter lateral as detailed.

The emitter case shall be made of durable black, heat resistant acetyl plastic material. It shall be resistant to temperature variation, ultraviolet radiation, smog, (ozone), and common liquid fertilizer and weed spray. The case shall completely encompass the silicone diaphragm, protecting it from potentially harmful environmental factors.

The emitters shall be of the non-compensating, continuous flushing type, based on the pressure cascade principal using a series of flexible orifices.

The emitter shall be capable of continuous, clog free operation with 30- mesh (minimum) filtration. 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 flexible orifice silicone diaphragms.

The emitter shall function with a system pressure range of 15 PSI minimum to 30 PSI maximum. The emitter flow variation of the one G.P.H emitter shall not exceed 1.06 G.P.H at 120 degrees F. or 1.07 G.P.H at 150 degrees F. Emitter manufacturing variability shall not exceed 0.05 G.P.H.

The multi-outlet emitter shall be capable of delivering one of the following quantities from each of the six outlets of the emitter regardless of the number of outlets open:

G.P.H.	at	**P.S.I.**
1.00		20
1.15		25
1.34		30
	or	
2.00		20
2.30		25
2.68		30

The supply tubing for emitters shall be flexible polyethylene shall be for pressure application, manufactured from 100 percent Union Carbide G-Resin 7510 Natural 7 virgin resin with minimum 2 percent carbon black content and with the following physical characteristics:

I.D.	0.250 inches
O.D.	0.350 inches
Wall Thickness	0.050 inches

The flexible distribution tube for use with multi-outlet emitter shall be a black vinyl blend suitable for use as emitter outlet tubing with the following physical characteristics:

I.D.	0.160 inches
O.D.	0.220 inches
Wall Thickness	0.030 inches

The distribution tube shall be capable of being bent around a 7/8-inch mandrel without kinking.

808-2.02 Water Distribution System:

Water distribution systems which include unique or variable components not listed in Subsection 808-2.01 shall conform to the component requirements specified on the plans.

808-2.03 Landscape Irrigation System:

Landscape irrigation systems which include unique or variable components not listed in Subsection 808-2.01 shall conform to the component requirements specified on the plans.

808-3 Construction Requirements:

808-3.01 Materials and Equipment:

The Developer shall submit to the Independent Quality Firm, manufacturer's product sheets of the materials and equipment it proposes to use. The Developer shall have materials and equipment correctly marked on each copy of the manufacturer's product sheets. These product sheets shall also show the catalog numbers, manufacturer's name, model numbers, sizes, capacity, complete specifications, instructions, design data and/or drawings, 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 project plans and these Specifications.

All water distribution system equipment shall be installed in accordance with the printed instructions of the manufacturer, the project plans, and these specifications.

All irrigation construction materials for single use on the project shall be supplied from a single manufacturer.

808-3.02 Permits, Warranties and Guaranties:

All warranty, guaranty, operation and/or maintenance manuals provided by the manufacturer for any item shall be furnished to the Independent Quality Firm prior to final acceptance of construction of the project.

808-3.03 General Requirements:

Any use of potable water by the Developer shall be through approved backflow prevention devices. All backflow prevention devices shall be in place prior to the Developer using any water from the municipal water system. All water use during construction shall be in accordance with the project Irrigation Water Use and Conservation plan.

Prior to beginning trench excavation, the Developer shall lay out the system or systems by providing approved indicators at the location(s) of major components such as piping runs, valves, pumps, backflow preventers and tanks. Equipment structures and enclosures shall be indicated as shown on the project plans.

The Developer 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.

The Developer 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 Independent Quality Firm. The Developer shall provide two complete manuals of all materials, equipment, parts, and manufacturer's installation, maintenance and owner manuals, to the Independent Quality Firm prior to final construction acceptance.

All enclosures shall remain closed and locked, and all valve box covers shall be in place throughout the construction period, except when actual work is in progress on the respective unit.

The Developer shall furnish to the Independent Quality Firm sufficient numbers of pressure gauges with tire chucks, which shall be used in the testing and necessary adjustment of the emitter system during construction.

All pressure regulators shall be tested at 90-day intervals throughout the construction phase. Regular tests shall be performed a minimum of three working days prior to regularly scheduled project inspections.

Plastic pipe shall be delivered to the site in unbroken bundles or packages and shall be wrapped such that pipe ends are adequately protected. If the pipe is delivered from a local warehouse, the pipe need not be bundled or wrapped.

Upon delivery to the site, the Developer 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 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. 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. Maximum distance between the plant pit and piping shall be determined by maximum supply lengths as specified on the project plans.

Additional flushing of the irrigation system, in addition to those specified, may be required to assure proper function of the system, including emission points.

Testing of the irrigation system valves shall be performed at system operating pressure or 60 pounds per square inch, whichever is greater.

Trenches shall be excavated to uniform grade and shall be no wider than is necessary for the proper installation of the pipe, fittings and control wiring. The bottom of the trench shall be firm and free from large or sharp rocks.

Where pavement or other impervious material is encountered in the excavation of trenches, such material shall be removed and wasted by the Developer.

All pipe, fittings and system components shall be clean prior to installation and shall be maintained in that condition during installation.

Plastic pipe shall be uniformly bedded and covered to the depth indicated on the project plans. Bedding and backfill material shall be compacted by approved water settlement methods and, after backfilling has been completed, the surface shall be brought to the elevation of the adjacent ground.

Requirements for slack or "snaking" of PVC pipe shall be in accordance with the pipe manufacturer's recommendation. PVC pipe and fittings shall be clean prior to installation and shall be maintained in that condition during installation.

Where two or more piping systems are indicated on the project plans as adjacent, they shall be placed within a common trench and at the depths indicated.

Where threaded plastic to metal or plastic to plastic connections are required, the metal connections shall be worked first. A non-hardening, manufacturer recommended sealant/lubricant compatible with the plastic fittings and/or components shall be used and the joint shall be hand tightened with the final tightening not to exceed one turn with a strap wrench.

Threaded PVC Schedule 80 nipples, thread-one-end (T.O.E.) and PVC Schedule 80 couplings, solvent weld, shall be used where threaded plastic connectors are required. Threaded PVC male or female adapters are not acceptable, unless otherwise specified.

Cement, solvents, thinners and joint compounds shall be compatible with and of the kind recognized by the industry as proper for use with the plastic pipe and fittings involved. Solvent weld pipe and fittings shall be assembled using appropriate primers and solvents designated by the manufacturer for use with Schedule 40 and/or Schedule 80 fittings.

All wire connections for No. 10 or larger shall be wrapped in accordance with the requirements of Subsection 732-3.02(B).

All control valve boxes and pressure regulator boxes shall be labeled with a brass tag acceptable to the Inspector.

All wire shall be tagged in accordance with the requirements of Subsection 732-3.02(C). Flexible conduit shall be supported within 12 inches of any cabinet or fitting in accordance with the requirements of NEC 350 and in a workmanlike manner acceptable to the Inspector.

All surfaces or components requiring protective paint shall receive the finish as specified in Sections 610 and 1002.

At no time shall any plant material, new or existing, be allowed to remain without water for any period which will result in stress to the plant material.

The Developer shall furnish and install a 6” round valve box at each lateral end cap, in accordance with detail as shown on the project plans.

Water distribution and/or irrigation systems shall be installed, tested, and operational prior to installation of any plant materials.

Flush end caps shall be installed as shown on the project plans or as to promote good flushing of the entire irrigation system. Additional flushing of the irrigation system, in addition to those specified, may be required to assure proper function of the system including emission points.

808-3.04 Bedding and Cover Material:

Bedding and cover material for PVC piping, flexible emitter hose and control wiring shall conform to the following gradation requirements when tested in accordance with Arizona Test Method 201:

Sieve Size	Percent Passing
No. 4	100
No. 16	30 - 80
No. 50	0 - 30
No. 100	0 - 25
No. 200	0 - 20.0

All piping and control wire shall be installed as detailed on the project plans and shall have the minimum cover shown.

Gravel sumps, as detailed on the project plans, shall be crushed coarse aggregate Number 57 conforming to the requirements of AASHTO M 43.

808-3.05 Components:

Components shall be as required by the details shown on the plans, and as specified herein.

(A) Backflow Prevention Unit:

The backflow prevention unit shall be installed with necessary supports as required by the project plans. The piping, as detailed shall not be considered as adequate support. The supports shall receive protective paint finish as specified on the project plans.

All exposed piping and unit bodies used in conjunction with the backflow preventer and the backflow preventer shall receive a protective covering of insulation as specified.

Access to all drains, vents, operators, unions or relief's shall be maintained and the insulation shall not restrict their operation.

The backflow prevention units shall be tested in accordance with the requirements as specified in the Manual of Cross-Connection Control Recommended Practice, as published by the Foundation for Cross-Connection Control Research, University of Southern California.

Testing of backflow prevention unit shall be performed by the authorized service-test personnel before final construction acceptance. In addition, testing shall be performed following any repairs or servicing of units. Test reports shall be recorded on forms provided by the Inspector.

All backflow prevention devices shall be in place, tested and approved for use prior to the Developer using water from any potable water system.

All testing shall be with available water pressure from the approved points-of-connection (P.O.C.). Bench testing remote from the designated location of the unit will be unacceptable.

(B) Gate Valve:

Gate valves shall be the size(s) as indicated in the project plans. Gate valve size shall be equal to the larger adjacent pipe size as indicated on the project plans.

All gate valves installed beyond structure lines shall be installed within specified valve boxes. No valves shall be placed beneath structures, sidewalks, roadway surfaces or within structural walls or columns.

Concrete support blocks for mainline gate valves shall be the type and size indicated on the project plans. Support blocks shall be installed under the gate valve body and shall not contact or support the adjacent pipe and fittings. Support blocks shall be placed on undisturbed soil.

Gate valves installed in valve boxes or enclosures below grade shall be exposed in entirety within the valve box. Extensions shall be added to valve boxes as necessary to prevent the surrounding soil or gravel sump from encroaching on the valve body and associated piping or fittings.

(C) Remote Control Valve:

Remote control valves shall be installed as detailed on the project plans. Size of valves shall be as shown on the plans.

Unless otherwise detailed or specified, all remote control valves for use on irrigation systems shall be preceded by a gate valve. The gate valve shall be the size detailed or sized to the larger of either the control valve or the adjacent pipe.

Remote control valves, accompanying gate valves and other required appurtenances shall be completely exposed and accessible within the valve box. Valve box extension shall be added as necessary to provide valve access and inspection/maintenance.

(D) Automatic Controllers:

C202P Maintenance Areas

Automatic controllers shall be installed to the concrete pad as detailed and specified in the project plans.

The controller shall be connected to the master valve and flow sensor as recommended by the manufacturer.

Controller enclosures shall remain closed and locked throughout the project duration except when actual work is in progress on the respective unit.

Remote control valve wire shall terminate within the automatic controller cabinet at the manufacturer supplied terminal strip. All connections shall be labeled as to function and/or valve number. Incoming electrical supply circuit(s) shall be separated from the low voltage circuits by approved conduits or separator panels as approved by NEC and prevailing local codes.

COP Maintenance Areas:

The controller enclosure shall be secured to the concrete pad as detailed on the project plans.

The controller shall be connected to the master valve and flow sensor as recommended by the manufacturer.

One spare control wire shall be run to the furthest valve in each wire and mainline segment. Color of spare wire shall be different from color of control wires. All wires shall be labeled as to function and/or valve number.

A wiring schematic shall be placed in each controller cabinet. The schematic shall show all wire connections including the wire connections at the controllers and field splices in pull or junction boxes, such as those not occurring in scheduled and planned valve boxes.

The contractor shall enable the evapotranspiration features of the controller to allow for automatically adjusting the station runtime.

The work shall also include that the contractor supply a copy of the controller program for approval by the Independent Quality Firm.

(E) Control and Ground Wire:

Remote control wire (24-volt and 2 wire) shall be installed as specified by the project plans.

Control wires to be installed through pipe sleeves shall be encased in PVC electrical conduit of appropriate size to contain the required number of conductors as determined by standard conduit sizing tables. Conduits shall extend one foot beyond each end of the sleeve unless otherwise noted and terminate in approved valve boxes as detailed on the project plans.

Wire connections at remote control valves and at field splices shall be made with specified wire connectors installed as recommended by the manufacturer. No field splices of 24-volt wiring shall be made unless the length between connections or splices exceeds 2,500 feet. Necessary splices shall be made at remote control valve boxes or separate splice boxes.

Field splices for 2 wire path shall occur at all valve and grounding locations as specified by the manufacturer. Maximum length of 2 wire path shall not exceed 8000 feet from the controller.

Control and ground wire throughout the project shall be neatly bundled and taped with plastic electrical tape at 10-foot intervals between splices and/or connections.

(F) Emitters:

The Developer shall add no more than five additional single outlet emitters or one multi-outlet emitter per circuit, as detailed. Any additional emitters required and exceeding the above indicated amount must be approved by the Landscape Architect. .

The Developer shall assume full responsibility for the correct installation of the emitter 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.

The Developer shall use the appropriate installation tools as recommended by the respective manufacturers for correct installation of emitters and emitter tubing.

The multi-outlet emitter assembly shall have the emitter placed above the finish grade with the distribution tubing buried as detailed on the project plans.

The supply tubing for emitters shall extend from the ¾" PVC lateral to the emitter and enable the emitter to be located so that the distribution tubing from the emitter to the plant does not exceed 15 foot in length.

The emitter supply tubing shall be buried in micro-trenches, to place the supply tubing at a minimum depth of 3 inches and shall extend from emitter laterals and terminate within the boundaries specified in the irrigation "Emitter/Emission Point Placement" Detail shown in the project plans. In cases where multi-outlet emitters irrigate more than one individual plant, micro-trenches for supply tubing shall be extended to an intermediate point terminating equidistantly to those plants to be irrigated by the shared emitter.

The flexible vinyl distribution tubing shall be placed in mini-trenches from the emitter to the locations at the plants as shown on the Emitter/Emission Point Placement detail shown on the project plans. The trenches shall be 4" deep – 2" below finish grade plus 2" below top of granite to ensure that the tubing doesn't "surface" over time.

The tube stake required to position the distribution tube shall be manufactured of 20 percent glass-filled polypropylene, minimum 6 inches overall length with slotted top to retain the distribution tube as detailed at the location(s) shown on the project plans.

(G) Insulation:

All exposed pipe, fittings and unit bodies used in conjunction with the backflow preventers, and filter units as well as all exposed piping and valves at the water storage facilities and pumping facilities shall receive a protective covering of insulation. Access to all drains, vents, operators, unions or relief's shall be maintained and shall not be restricted in their operation by the insulation.

Insulation shall be installed in a workmanlike manner with no voids or openings which will deter from the effectiveness of the insulation.

The Developer shall assume full responsibility for the correct installation of the insulation and shall arrange with the manufacturer for the services of a qualified manufacturer's representative to be on hand at the start of the insulation installation and as necessary during installation to assure proper application of all insulation materials.

(H) Pressure Regulator:

Each pressure regulator riser shall be constructed as shown on the project plans.

The pressure regulator riser shall be completely exposed and accessible within the valve box.

808-3.06 Water Distribution System Testing:

Following completion of the installation of mains, control valves, gate valves and other components, and after all solvent-welded joints have cured for 24 hours, the water distribution system and/or landscape irrigation system shall be tested.

Under no circumstances will air pressure be acceptable for testing.

The Developer shall flush and bleed all lines prior to testing. Metal or plastic caps shall 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 procedures. During testing, all fittings and couplings shall be visible for inspection. Any failures evident during the test shall be repaired and the system retested before backfilling. The Developer shall furnish the necessary equipment required to perform the piping tests.

Any mechanical failures or leaks which develop during testing shall be repaired or the defective materials shall be removed and replaced. After replacements or repairs have been made, the entire testing procedures shall be repeated until it is determined that there are no leaks or failures in the irrigation system.

The pressure mains and sub-mains shall be subjected to a static pressure test of 120 pounds per square inch for a minimum period of two hours. During this time all solvent-welded and threaded connections and component parts shall be inspected to determine that no leaks exist.

After installation of emitter laterals and supply tubing, but before installation of emitters, the emitter laterals and supply tubing shall be subjected to one hour of pressure testing, (pounds per square inch) at maximum lateral operating pressure during which time components shall be inspected for leakage.

All valves shall be tested in sequence, starting at the valve most remote from the source of water supply, to subject the mainlines to surge pressure. All valves shall be operated manually. All electric remote control valves shall also be tested electrically.

809 LANDFORM GRAPHICS:

The work shall consist of providing all equipment, materials and labor for constructing the landform graphics at the locations as shown on the project plans.

The work shall consist of the following:

Furnishing and installing metal edging.

Furnishing and installing 6 inch underground drain pipe system.

Furnishing and installing rock mulch and granite mulch materials.

Furnishing and painting/staining granite mulch materials.

809-1 Materials:

(a) Metal Edging:

Edging shall be 3/16 x 5 inches, 6063 alloy-extruded aluminum of T6 hardness with black anodized finish. Edging is to lock together with no offset or overlap at the joints. Each section shall have five stake punch-outs fabricated into them, which locks stakes ¼ inch below top of edging.

Section stakes are to be extruded aluminum 6061 Alloy T6, 12 inches long.

(b) Rock Mulch and Granite Mulch

Rock mulch and granite mulch material color selections acceptable for use inside of the landform graphics are as shown on the plans:

Gradation requirements for rock mulch and granite mulch material within the landform graphics are as shown on the plans.

(c) Underground Drainage System:

The drain pipe system shall consist of 6-inch diameter flexible high density polyethylene, (HDPE) perforated and non-perforated pipe and shall conform to ASTM F405. The polyethylene pipe fittings shall be compatible for use with the flexible high density polyethylene, (HDPE) perforated and non-perforated pipe and shall conform to ASTM F405.

Filter fabric shall be “High Survivability” and conform to the requirements of Subsections 913-2.05 and 1014 - 4.03 A of the Standard Specifications.

Wire mesh screen shall be made of aluminum or stainless steel and have a minimum mesh size of ¼” X ¼” mesh openings or as approved by the Developer.

Trench drain rock and sump rock shall be 1 inch screened, washed aggregate as shown on the project plans and details. The 1 inch screened and washed aggregate in the trench drains and sumps shall be covered by the granite mulch as shown on the detail sheets in the project plans.

Trench drain and sump rock shall meet the following gradation requirements:

Sieve Size	**Percent Passing**
1-1/2 inch	100
1 inch	95-100
½ inch	0-5

(d) Painting/Staining:

The contractor shall apply paint or stain to granite mulch within the landform graphics as shown the project plans.

Element to be Painted	**Color**	**Color Chip Number**
Landform Graphic Granite Mulch	Black	Black Deco – AC 144N

All granite mulch that is to be painted/stained within the landform graphics shall be clean, screened material, according to the requirements above. All fines shall be screened out for painting of the material.

The acrylic emulsion paint shall be ready-mixed at the manufacturer's plant. If staining is desired over painting; stain to be liquid, not powder form.

Acrylic emulsion paint or stain shall be furnished in new, unopened, air-tight containers which are clearly labeled with the exact title of the paint material, name and address of manufacturer, date of paint manufacturer and the lot or batch number. The containers shall conform to U.S. Department of Transportation Hazardous Material Shipping Regulations. All MSDS sheets shall be provided and kept on file at the project site.

Physical and Chemical Requirements:

The water-borne acrylic emulsion paint shall conform to the requirements of Federal Specifications TT-P-19D for paint, Acrylic Emulsion, Exterior. The following are physical and chemical requirements for TT-P-19D paint, which shall be adhered to unless otherwise specified.

Material Property Requirement		Test Method
Resin 100 percent Acrylic		ASTM 2621
Volatile Organic Content (LB/gal)	2.1 max.	ASTM 3960
Total Solids by Weight (percent)	50 min.	ASTM 2369
Total Solids by Volume (percent)	40 min.	ASTM 2697
Nonvolatile Organic Content by Weight (percent)	19 min.	ASTM 3723
Consistency (KU)	80—100	ASTM D562
Fineness of Dispersion	4 min.	ASTM 1210
Dry Time, Set-to-Touch	10 Minutes min.	ASTM 1640
Dry Time, Thorough	2 hours max.	ASTM 1644

Performance Requirements:

The paint/stain shall be applied to the rock surface and tested in a Q-U-V accelerated weathering tester according to ASTM G53, for 300 hours, utilizing UVB-313 lamps and the exposure cycle as specified in 4.3.5.2 of Federal Specification TT-P-19D. The paint/stain weatherized in this manner shall show no appreciable change in color or appearance due to fading, chalking, or material reaction.

All performance requirements listed in Section 3 of Federal Specification TT-P-19D will be met as specified, when tested according to the applicable test methods as set forth in Section 4.

809-2 Construction Requirements:

All work shall be completed in accordance with the details shown on the project plans and the requirements of these specifications.

The Developer shall be responsible for all erosion repairs on project site that may occur during granite mulch or rock mulch color review and approval process at no cost to the Department.

Granite material next to the metal edging shall be raked to gradually pull the granite mulch away from the metal edging so that not less than ¼ inch of the top of the metal edging is exposed to prevent the intermixing of materials on both sides of the metal edging.

(a) Layout:

The Developer shall construct the Landform Graphics in accordance with the landform graphics layout as shown on the plans and as provided by the Landform Graphic Layout Artist.

The landform graphics shall be laid out and field adjusted to meet site conditions and adjusted accordingly to provide maximum visual effectiveness and visibility from various roadways, bridges, ramps, and other visual perspectives as per the approval by the Landscape Architect. .

(b) Edging:

Edging shall be installed per the manufacturer's instructions and as shown on the plans. Edging shall be staked in sections with a minimum of five stakes per section and a minimum of one stake added, as required, every 18" on curves to provide an even radius without bowing of the edging. Section stakes are to be installed on the inside of figure no less than ¼ inch below the top edge out of view.

End stake adapters shall be at all start/stop points to secure critical areas and at all other locations as determined by the Landscape Architect and installed on the inside of figure no less than ¼ inch below the top edge out of view.

(c) Underground Drainage:

Wire screens shall be installed at the outlets of the drainpipe, and filter fabric shall be installed lining sides, bottom and top of the trench drains and sumps as detailed on the project plans.

The Developer shall furnish and install underground drainage on the slopes at each location shown on the project plans and in the details.

The 6 inch diameter flexible HDPE perforated drain lines be placed as closely as possible to the locations as shown on the plans. The Developer may need to make slight adjustments to the drain lines as required. Each perforated drain line at the top of the slope shall be installed within a 18" D x 12" W trench drain filled with 1 inch screened and washed aggregate as shown on the project plans and details. Each 6 inch diameter flexible HDPE perforated drain line occurring at the mid-section of the slope through the landform graphic, shall be installed within a 18" D x 12" W trench drain filled with 1 inch screened and washed aggregate as shown on the project plans and details.

The non-perforated drainpipes that run perpendicular to the trench drain shall be constructed down the slope and shall daylight into a sump at the toe of slope as shown on the project plans and details. Trench soil compaction of these non-perforated drainpipes shall be performed in 2 inch lifts at 90 percent of maximum density without compressing the drain pipes.

The Developer shall install each trench drain and sump lined with filter fabric, and filled with 1 inch screened and washed aggregate as shown on the project plans and details.

The 1 inch screened and washed aggregate at the trench drains and sumps shall be covered by the granite mulch as shown on the project plans and details.

(d) Painting or Staining:

Surface preparation shall include washing of all rock surfaces as recommended by the manufacturer, to remove all dirt, dust, curing agents, form release agents, efflorescence, scale or other foreign substances which could be detrimental to the paint application or color. All granite mulch surfaces to be painted shall be clean, completely dry, unless otherwise recommended by the paint manufacturer, and free of frost or other foreign substances at the time of the application of paint. Washing the surface may be necessary to remove fine dust left over to provide better paint adhesion.

The Developer shall provide such protection as is necessary to prevent damage to the work, or to property or persons, because of cleaning or painting operations.

After the granite mulch has been prepared for the application of paint/stain and before application, the Developer and the Independent Quality Firm shall inspect the surfaces to be painted and agree that the surfaces are satisfactory for the paint/stain to be applied.

The Developer shall paint or stain by the following requirements:

The method of application, the rate of application, the number of coats of application (minimum of two normally), and the surface temperature range of application shall be in accordance with the manufacturer's written recommendations.

The painting-staining method of coloring rock must coat all sides of the rock surface. The application of paint-stain to the rock material shall be accomplished as follows:

(1) Install the rock in its designated place; spray the top and side surfaces of the rock; allow the paint-stain to dry; rake the rocks to turn them over and spray the unpainted-stained surface and sides; allow to dry and touch up any scraped, chipped or uncolored rock with the same paint-stain.

The Independent Quality Firm will perform random inspection testing of the completed paint/stain finish. Such testing shall consist of the same adhesion tests specified herein under Subsection 1002-3(D) "Resistance to Accelerated Weathering", of the Standard Specifications, to verify penetration and adhesion of the paint/stain finish. Areas that show evidence of flaking shall be cleaned as previously specified, and refinished to match the paint/stain finish of the surrounding granite/aggregate surfaces.

(e) Protection of Work:

The Developer shall be responsible for all damages or defacement to the landform graphics during the duration of the project. All damages and/or defacement to the landform graphics shall be repaired/replaced as directed and approved by the Landscape Architect.

810 LANDFORM GRAPHIC LAYOUT ARTIST:

810-1 Description:

The work consists of the layout of the landform graphics performed by an approved graphic layout artist with landform graphic layout experience.

The graphic layout artist shall meet the minimum experience requirements below and be approved by the Independent Quality Firm prior to layout work on the graphics. The approved graphic layout artist shall perform and/or supervise all the layout work required. This will include providing all materials, tools, and equipment, necessary to lay out the landform graphics.

The final landform graphic layouts will be approved by the Developer and Landscape Architect prior to construction of the landform graphics. The layout of the landform graphics shall be adjusted in the field to meet actual site and visual conditions as directed by the Landscape Architect.

The graphic layout artist shall provide the Developer a summary of experience in laying out a minimum of 3 large-scale landform graphic art elements on sloping grades, using professional construction methods, materials, and equipment for the construction of large-scale landform graphics or other equivalent large scale art objects as depicted on the project plans.

The graphic layout artist shall provide a visual photographic portfolio of past similar landform graphic work that the graphic layout artist has performed in the field. The graphic layout artist shall include documentation of completed projects, including location, date, and contact information with phone number of owner's representative.

The Developer will notify the contractor of approval of the proposed graphic artist within 10 working days of the submittal. Rejection and resubmittal of the graphic artist qualifications will not be reason to extend the project duration.

810-2 Materials:

Layout materials at a minimum shall include the following:

> Flexible PVC pipe, fluorescent spray paint, gypsum powder (white color), rebar stakes, plastic safety caps, rope, line string, tape measure, survey stakes, survey flags, survey ribbon, matting, mallet, gloves, personal safety equipment, and other essential items, as required to layout the landform graphics. The graphic layout artist shall submit a list of the proposed layout materials, tools, and equipment for approval.

810-3 Construction Requirements:

The graphic layout artist shall walk the site of the proposed landform graphic area and evaluate the final contour and finish grading quality of the area prior to layout and the Developer shall make the necessary finish grade improvements in order to make an even surface for landform graphics. The graphic layout artist shall also evaluate the location and position of the proposed landform graphic.

The graphic layout artist shall layout the landform graphics from survey reference points as shown on the plans as provided by the projects registered land surveyor. The graphic layout shall flag, stake, provide grid system, or other reference items for the purpose of establishing the size and scale of the landform graphic image on grade as depicted in the project plans and details.

The graphic layout artist shall provide a rough sample outline of the proposed landform graphic for the purpose of reviewing the scale, position, location, and viewing angle of the graphic image on grade relative to existing built and landscape features on site. The graphic layout artist shall obtain the approval from the Landscape Architect and make all adjustments prior to proceeding with the final layout work.

When the landform graphic is composed of repetitive modules, the graphic layout artist shall layout a minimum of three full scale landform graphic modules of the graphic image on grade to be reviewed and approved by the Landscape Architect. When the graphic image is a solitary design, the layout of three modules shall be omitted per the direction of the Landscape Architect.

After the approval of the module layouts, the graphic layout artist shall then proceed with the final layout of the complete proposed landform graphic for final approval. Construction of the landform graphic shall not begin until final approval is given for the layout by the Independent Quality Firm and the Landscape Architect.

The layout adjustments may require multiple enlargements, reductions, shaping and positioning to achieve the satisfactory visual results to fit the site conditions and provide maximum visual appeal from the roadway, ramps, and bridge perspectives.

The approved graphic layout artist shall be fully involved in performing all the work and necessary supervision required under this item during the layout of the landform graphics.

The graphic configurations shall be laid out with the approved materials, tools, and equipment as described above along the centerlines of the graphics, for approval of the Independent Quality Firm and Landscape Architect.

Necessary traffic control shall be coordinated with the Developer.

The approved graphic layout artist shall review the contractor's installation of metal edging and placement of inert materials for conformance to graphic layout and colors specified on landscape design plans.

811 CITY OF PHOENIX SPECIFICATION – CATHODIC PROTECTION

PART 1 - GENERAL

811.1.01 SECTION INCLUDES

A. Cathodic protection systems for corrosion mitigation of underground piping systems. The piping systems are 48” Concrete Cylinder Pipe (CCP) with zinc packaged anodes for cathodic protection (CP) and zinc ribbon anodes for piping inside the casing. The 16” Ductile Iron Pipe (DIP) with standard magnesium anodes for CP and magnesium ribbon anodes for piping inside the casing.

B. CP packaged anodes are designed for 25 year life.

C. Piping insulated flange kits shall be furnished and installed by Contractor between existing and new pipe installation.

811.1.02 WORK BY OTHERS

A. Dielectric coatings bonded to pipe.

811.1.03 INFORMATIONAL SUBMITTALS

A. Manufacturer’s catalog sheets marked as necessary to indicate type, model, or catalog number for:
1. Anodes.
2. Conductor.
3. Test stations.
4. Reference Electrodes.
5. Zinc Grounding Cells.

PART 2 - PRODUCTS

811.2.01 SYSTEM DESCRIPTION

. Equipment or structures to be cathodically protected:
1. Underground piping using galvanic anodes. Testing required.

811.2.02 STANDARD PACKAGED MAGNESIUM ANODES

A. Furnish each standard-potential magnesium anode as a packaged assembly with insulated lead wire. Packaged assembly shall consist of permeable cloth bag containing anode and special compacted backfill. Anode shall be centered in bag and completely surrounded by backfill.

B. Standard-potential magnesium anode alloy shall be Grade AZ63C, complying with ASTM B843 and shall have the following composition in percent by weight:

Element	Percent
Aluminum	5.3 to 6.7
Manganese	0.15 to 0.7
Zinc	2.5 to 3.5
Silicon	0.30 maximum
Copper	0.05 maximum
Nickel	0.003 maximum
Iron	0.003 maximum
Other	0.05 each and 0.30 maximum total
Magnesium	Others

C. Backfill shall have following composition in percent by weight:
1. Ground hydrated gypsum: 75%.
2. Powdered Wyoming bentonite: 20%.
3. Anhydrous sodium sulfate: 5%.

D. Packaged anode component specifics:
1. Bare anode dimensions: 4-3/8” x 4” X 60” (110 mm x 100 mm x 1500 mm).
2. Bare anode weight: 60 lb (27.2 kg).
3. Lead wire: Type XHHW-2 insulated; 8 AWG stranded copper.
4. Lead wire length: 30’ (9 m).
5. Approximate backfill weight: 66 lb (30 kg).

E. Manufacturer: Magnesium Corporation of America (Magcorp) or Timminco Corporation, Aurora, Colorado or equal.

811.2.03 MAGNESIUM RIBBON ANODES

A. Furnish each magnesium ribbon anode extruded around a galvanized steel core. The ribbon anode shall be furnished in rolls of sufficient length to prevent splicing.

B. High-potential magnesium anode alloy, complying with ASTM B843 and shall have the following composition in percent by weight:

Element	Percent
Aluminum	0.010 maximum
Manganese	0.50 to 1.30
Copper	0.02 maximum
Nickel	0.001 maximum
Iron	0.03 maximum
Other	0.05 each and 0.30 maximum total
Magnesium	Others

C. Anode component specifics:

1. Anode cross section dimensions: 3/8” x 3/4” (10 mm x 20 mm).
2. Bare anode weight: .23 lb/ft (.34 kg/m).
3. Lead wire: Type XHHW-2 insulated; 8 AWG stranded copper.
4. Anode length: determined on drawings.

D. Manufacturer: Mesa Products or equal.

811.2.04 ZINC PACKAGED ANODES

A. Furnish each zinc anode as a packaged assembly with insulated lead wire. Packaged assembly shall consist of permeable cloth bag containing anode and special compacted backfill. Anode shall be centered in bag and completely surrounded by backfill.

B. Zinc anode alloy shall comply with ASTM B418 and shall have the following composition in percent by weight:

Element	Percent
Aluminum	0.005 maximum
Cadmium	0.003 maximum
Lead	0.003 maximum
Iron	0.0014 maximum
Copper	0.002 maximum
Zinc	Others

A. Backfill shall have following composition in percent by weight:
1. Ground hydrated gypsum: 75%.
2. Powdered Wyoming bentonite: 20%.
3. Anhydrous sodium sulfate: 5%.

B. Packaged anode component specifics:
1. Bare anode dimensions: 2” x 2” X 60” (50 mm x 50 mm x 1500 mm).
2. Bare anode weight: 60 lb (27.2 kg).
3. Lead wire: Type XHHW-2 insulated; 8 AWG stranded copper.
4. Lead wire length: 30’ (9 m).
5. Approximate backfill weight: 60 lb (27.2 kg).

C. Manufacturer: Mesa Products or equal.

811.2.05 ZINC RIBBON ANODES

A. Furnish each zinc ribbon anode extruded around a galvanized steel core. The ribbon anode shall be furnished in rolls of sufficient length to prevent splicing.

B. Zinc anode alloy, complying with ASTM B418 and shall have the following composition in percent by weight:

Element	Percent
Aluminum	0.005 maximum
Cadmium	0.003 maximum

Element	Percent
Copper	0.002 maximum
Lead	0.003 maximum
Iron	0.0014 maximum
Zinc	Others

C. Anode component specifics:
1. Core diameter 0.135 in (3.4 mm)
2. Anode cross section dimensions: 5/8” x 7/8” (14 mm x 22 mm).
3. Bare anode weight: 1.2 lb/ft (1.8 kg/m).
4. Anode length: determined on drawings.

D. Manufacturer: Platt Bros. & Co., Plattline II or equal.

811.2.06 ZINC GROUNDING CELL

A. Furnish each zinc grounding cell as a packaged assembly with two insulated lead wires. Packaged assembly shall consist of permeable cloth bag containing two zinc anodes and special compacted backfill. Anodes shall be separated by 1” insulating spacers, centered in bag and completely surrounded by backfill.

B. Zinc anode alloy shall comply with ASTM B418 and shall have the following composition in percent by weight:

Element	Percent
Aluminum	0.005 maximum
Cadmium	0.003 maximum
Lead	0.003 maximum
Iron	0.0014 maximum
Copper	0.002 maximum
Zinc	Others

C. Backfill shall have following composition in percent by weight:
1. Ground hydrated gypsum: 75%.
2. Powdered Wyoming bentonite: 20%.
3. Anhydrous sodium sulfate: 5%.

D. Packaged anode component specifics:
1. Each bare anode dimensions: 1.4” x 1.4” X 60” (36 mm x 36 mm x 1500 mm).
2. Each bare anode weight: 33 lb (15 kg).
3. Lead wire: Type HMWPE insulated; 6 AWG stranded copper.
4. Lead wire length: 6’ (2 m).
5. Approximate total backfill weight: 119 lb (54 kg).

E. Manufacturer: Stuart Products or equal.

811.2.07 ANODE LEAD CABLES

A. Attach concentrically to anode.

B. Capable of withstanding minimum load of 400 lb when subjected to pull test.

C. Poured-solder connection between anode and cable.

D. Insulate connection above joint with high voltage electrical pothead compound with pouring temperature greater than 135°C.

811.2.08 CONNECTORS

A. Compression ring tongue terminals shall be single-hole, uninsulated, compression type terminal lugs made of corrosion-resistant copper, bronze, or nickel-plated brass.

B. Compression ring tongue terminal part numbers shall be as indicated in table below:

Wire Size	Stud Size	Ring-Tongue Terminal Part No.	Manufacturer
2.5 mm^2 or 14 AWG	M6 or 1/4”	YAV12-G3	Burndy Corporation
4 mm^2 or 12 AWG	M6 or 1/4”	YAV10-T3	Burndy Corporation
6 mm^2 or 10 AWG	M6 or 1/4”	YAV10-T3	Burndy Corporation
10 mm^2 or 8 AWG	M6 or 1/4”	YAV8C-L1	Burndy Corporation

C. Solder connections, unless indicated otherwise, shall be made with 50-50 solid solder and nonacid flux.

D. Butt splice connectors:

Stranded Cable Size	Connector Type	Manufacturer
14-10 AWG	Hylink, Type YSV	Burndy
8 AWG	Pan-Term Splice-Type SCS	Panduit
6 AWG and larger	Copper Hylink, Type YS	Burndy

E. Compression connectors: Burndy Type YC-C “Crimpit.”

F. Repair pipe coating at lead wire or joint bond connections by use of Mesa Products Inc. “Thermit Weld Caps” and “Thermit Weld Mastic,” Royston Laboratories, Inc. “Handy Caps,” or equal.

811.2.09 EXOTHERMAL WELDS

A. Exothermal connection welding charge formulation, equipment selection, and welding procedures shall be as recommended by manufacturer of exothermal weld materials for size, shape, and composition of materials being welded.

B. Where manufacturer offers choice of exothermal weld materials, recommended materials for cast iron pipe shall be used for ductile iron pipe.

C. Welding charge formulation, tools and equipment selection for size, shape, and composition of materials being welded shall be as specified in tables. Weld molds shall be complete with appropriate handles.

D. Materials: Erico Products, Inc., “Cadweld”; “Thermoweld,” a Division of Continental Industries, or equal.

Welds to Horizontal Steel Surfaces			
Conductor Size	Weld Metal Cadweld Part No.	Surface	Weld Frame and Mold Cadweld Part No.
8 AWG	CA-15	Flat (4” and larger pipe)	CAHAA-1G
8 AWG	CA-15	3/4” to 3-1/2” pipe	CAHAA-1GA

Welds to Vertical Steel Surfaces			
Conductor Size	Weld Metal Cadweld Part No.	Surface	Weld Frame & Mold Cadweld Part No.
8 AWG	CA-15	Flat (12” and larger pipe)	CAVST-1G
8 AWG	CA-15	4” to 10” pipe	CAVST-1GB
8 AWG	CA-15	3/4” to 3-1/2” pipe	CAVST-1GA

811.2.10 SPLICE INSULATION KITS

A. Cable splice insulation kits shall consist of transparent mold and epoxy resin insulating compound.

B. Sizing and application of splice insulation kits shall be in accordance with manufacturer's recommendations and as specified.

C. Wye splice kits: 3M Company Scotchcast 90-B1 Durichlor 51 Anode Company “Durco-Cast Universal Splice Kit SK-40”.

D. Butt splice kits: 3M Company Scotchcast 82-A Series or Durichlor 51 Anode Company “Durco-Cast Universal Splice Kit SK-40.”

811.2.11 ELECTRICAL TAPE

A. Insulating materials for splice or tap connections on galvanic systems shall consist of varnished cambric tape, rubber tape, and vinyl tape.

B. Taping materials:
1. Varnished cambric tape: 3M Company Scotch 2520, or equal.
2. Rubber tape: 3M Company Scotch 130C.
3. Vinyl tape: 3M Company Scotch Super 33+.

C. Tape for color-code identification of lead wires: 3M Company Scotch 35.

811.2.12 FLUSH MOUNTED TEST STATION

A. Flush mounted field test stations shall consist of an ABS plastic vault, 18” (0.5m) long by 5” (125mm) in diameter complete with terminal block and cast iron locking cover.

B. Provide terminal blocks with 7 nickel-plated marine brass terminals and 1 nickel-plated marine brass jumper strap.

C. Cover fastener: Stainless steel.

D. Enclosure shall be painted yellow and cast with “CP Test.”

E. Manufactured by CP Test Services or equal.

811.2.13 UNDERGROUND COPPER SULFATE IR FREE REFERENCE ELECTRODE

A. Saturated, gelled, copper-copper sulfate type, and packaged in special backfill, with 75’ of No. 14 AWG stranded copper lead wire with high molecular weight polyethylene insulation.

1. One black insulated lead wire for coupon connected to pipe.
2. One brown insulated lead wire for coupon.
3. One Yellow insulated lead wire for reference electrode.

B. Underground reference electrodes shall have 20-year minimum design life.

C. Manufacturer: Farwest Corrosion Model Stealth7, or equal.

811.2.14 PIPING JOINT INSULATED FITTINGS AND MATERIALS

A. Each insulated flange kit shall include following:

1. One Type "E," full-faced insulating and sealing flange gasket, consisting of 1/8” (3.175 mm) thick retainer with special ring seal. Inside diameter shall be 1/8” (3.175 mm) less than inside diameter of flange in which it is to be installed. PSI “Linebacker,” Advance Products “Trojan,” or equal.
2. One full length bolt insulating sleeve, 1/32” (0.794 mm) thick, for each flange bolt.
3. Two flat insulating washers, 1/8” (3.175 mm) thick, for each flange bolt.
4. Two flat steel backing washers, 1/8” (3.175 mm) thick, for each flange bolt. Backing washer outside diameter shall be not larger than outside diameter of insulating washer.

B. Insulating materials, unions, bushings, weld-end fittings, and mechanical couplings for various pipe fluids and fluid temperatures shall be based on application as specified below.

C. Insulated fitting material and sizes not listed shall be as required for type and size fitting for each of insulated fitting locations.

Type	Fluid	Material Temperature Range	Sleeves	Insulating Washers	Gasket / Retainer	Seal Element	Remarks
1	Air	-65 to 225°F	Mylar	Phenolic	Phenolic	Nitrile	Note 3

Type	Fluid	Material Temperature Range	Sleeves	Insulating Washers	Gasket / Retainer	Seal Element	Remarks
2	Water	-65 to 250ºF	Mylar	G-10	G-10	Nitrile	Note 3
3	Hot water	-20 to 280ºF	Mylar	G-10	G-10	Viton	Note 3
2	Sea water	-65 to 250ºF	Mylar	G-10	G-10	Nitrile	Note 3
4	Steam	to 450ºF	Nomex	G-7	G-7	Teflon	Note 1
8	Steam	to 450ºF	Nomex	G-7	Johns Manville "Yellow Jacket 986"	N/A	Hydro-carbons present
9	Steam	to 700ºF	Durabla “Durlon 8600” white	Durabla “Durlon 8600” white	Durabla “Durlon 8600” white	N/A	Steam pressure not to exceed 1500 psi
5	Steam	to 400ºF	Nomex	G-3	G-3	Teflon	
6	Ammonia, Dry	-65 to 200ºF	Mylar	G-10	G-10	Teflon	Notes 3, 4
2	Carbon Dioxide	-65 to 225ºF	Mylar	G-10	G-10	Nitrile	Note 3
2	Hydrogen	-65 to 250ºF	Mylar	G-10	G-10	Nitrile	Note 3
1	Nitrogen	-65 to 225ºF	Mylar	Phenolic	Phenolic	Nitrile	Note 3
7	Oxygen	-65 to 250ºF	G-10	G-10	G-10	Teflon	Note 2
1	Natural gas	-65 to 225ºF	Mylar	Phenolic	Phenolic	Nitrile	Note 3
6	Gasoline	-65 to 225ºF	Mylar	G-10	G-10	Teflon	Note 3
6	Propane	-65 to 225ºF	Mylar	G-10	G-10	Teflon	
3	Petroleum, crude	-20 to 280ºF	Mylar	G-10	G-10	Viton	Note 3
3	Fuel oil, #6	-20 to 280ºF	Mylar	G-10	G-10	Viton	Note 3
3	Fuel oil, diesel	-20 to 280ºF	Mylar	G-10	G-10	Viton	Note 3

Type	Fluid	Material Temperature Range	Sleeves	Insulating Washers	Gasket / Retainer	Seal Element	Remarks
3	Sewage	-20 to 280ºF	Mylar	G-10	G-10	Viton	Note 3

Notes:

1. Do not expose G-7 materials or used with any trace amount of hydrocarbons.
2. Type 7 are organic materials that will feed fire if leak occurs and ignition source exists.
3. For pipe diameters over 24" (200 mm) or ANSI Class pressure ratings of 600 lb (272 kg) or greater, use G-10 sleeves and G-10 washers.
4. Ammonia (wet): Data to 100ºF (38ºC) only. (Same materials as dry).

811.2.15 LEAD WIRE

A. Pipe lead wires: 2 Type HMWPE cables, size 8 AWG.

811.2.16 CONCRETE CYLINDER PIPE COATING REPAIR MATERIALS

A. Materials used to repair mortar coated steel or concrete cylinder pipe coating at lead wire or joint bond connections shall be the same material as originally used to coat the pipe.

811.2.17 GLASS REINFORCED PVC CASING INSULATORS

A. Casing insulators, which electrically isolate the carrier pipe from the casing pipe, shall be coated steel bands with 2 inch wide glass reinforced plastic runners. Casing insulator inner liners shall be of PVC. Casing insulator construction, sizes, and Model numbers shall be as required for the carrier and casing pipe sizes indicated below:

1. 16” DIP carrier pipe, Model C8G-2, spaced every 8’ (2.4m) maximum.
2. 48” CCP carrier pipe, Model C12G-2, spaced every 10’ (3m) maximum.

B. Casing insulators shall be within 1’ (.3m) of casing end and placed within 2’ (.6m) on each side of a coupling or pipe joint.

C. Manufacturer: PSI Industries, Farwest Corrosion or equal.

811.2.18 CASING END SEALS

A. Casing end seals for single carrier pipes shall be flexible to allow for longitudinal movement of the carrier pipe due to expansion or contraction and shall be of material suitable for the application. The casing seals shall be supplied with Type 304 stainless steel bands, clamps, and sealers, as applicable, for connecting to the pipes.

B. Manufacturer: PSI Industries model KG or equal.

811.2.19 WIRE AND CABLE MARKERS

A. Markers for wire and cable circuits shall be of opaque nylon material consisting of marker board, nonreleasing holding device, and cable fastening tail.

B. Design holding devices to allow fastening tail to pass around cable and through holding device so removal of cable marker can be accomplished only by cutting it loose from cable.

C. Marker board: Not less than 3/8” (10 mm) wide, 3/4” (19 mm) long, and 25 mils thick, with one side roughened to hold ink from marking pen.

D. Cable markers: Thomas & Betts "TY-RAP" identification ties or Panduit Corporation "PAN-TY" Type PLF marker ties.

E. Marking pen ink: Suitable for marking on nylon and shall be black, permanent, and waterproof.

F. Marking pen: Thomas & Betts "TY-RAP" No. WT163M-1 or Panduit Corporation Part No. PFX-0.

811.2.20 TEST EQUIPMENT

A. 8” (200 mm) saturated copper-copper sulfate solution portable reference electrode: M. C. Miller Co. Inc., Model RE7, Tinker and Rasor Model 8A, or equal.

B. Miscellaneous flexible test leads.

C. High-input impedance dc voltmeter with millivolt scale and built-in ohmmeter: Wavetek Model HD110, John Fluke Mfg. Co Model 87 hand-held multimeter or equal.

D. Low-resistance dc milliammeter: M.C. Miller Company Model B-3 Series, Simpson Model 250 VOM, John Fluke Mfg. Company Model 85 or 87 hand-held multimeter or equal.

E. Insulation checker: M.C. Miller Company Gas Electronics Model 601 or equal.

PART 3 - EXECUTION

811.3.01 ANODE INSTALLATION

. Install in hole with minimum diameter of 10" (250 mm). Auger hole to approximate depth of 10' (3 m) minimum or as shown on drawings.

A. Depth of burial of packaged galvanic anodes shall be such that uppermost part of packaged anode is at least as deep as bottom of pipe it is protecting.

1. Unless solid rock is encountered, uppermost part of packaged anode shall be a minimum of 4’ (1.2 m) beneath finished grade at burial location.
2. Penetration of layers of rock or movement of boulders may be required to properly place anodes. It is not intended that anodes be installed in such a manner, or in locations that penetration of solid rock is necessary.

B. If solid rock is encountered at depth that will not permit installation of anode vertically, investigation of immediate area shall be made to determine if anode can be installed at specified depth nearby.

1. If anode cannot be installed at location, anode shall be installed vertically closer to surface so long as earth cover over top of anode is at least 2’ (600 mm) as approved by Engineer.
2. If depth of solid rock is such that 2’ (600 mm) earth cover cannot be maintained over vertically installed anode, horizontal installation of anode shall be considered as approved by Engineer.

C. Horizontally installed anodes shall be placed with approximately 6” (150 mm) of earth fill between anode package and solid rock.

1. Maximum elevation of horizontally installed anode shall be such that elevation of top of anode package is same as elevation of top of protected pipe at anode location.
2. Deviations from standard vertical anode installation as indicated on anode installation detail shall be as approved by Engineer.

D. If packaged galvanic anodes are received in a protective paper or plastic bag, do not remove bag until immediately before burying anode.
1. Permeable cloth bag containing special backfill shall remain intact.
2. Galvanic anode burial location shall be approximately 10' from closest point on protected pipe or as shown on drawings.
3. After burial of packaged galvanic anode but before backfilling of anode excavation, pour minimum of 5 gallons of water over and around anode package.
4. Backfill packaged galvanic anodes with clean earth, free from rocks. Do not backfill anodes with sand.

811.3.02 RIBBON ANODES

A. Ribbon anodes shall be installed as shown on the drawings, as recommended by the manufacturer, and as specified herein.

B. To the extent possible, ribbon anodes shall remain continuous for the entire length of the casing and shall be strapped to the pipe within the casing at 1 foot intervals or less using the nonmetallic strapping materials, and as indicated on the drawings.

C. Cable-to-anode connections shall be made as shown on the drawings using crimp connectors of proper size to accommodate the steel wire core of the ribbon anode and the copper cable to be used as lead wire. Only enough anode material shall be removed from the end to expose sufficient steel wire core for installation of crimp connectors.

D. Before installing crimp connectors and making connections, the exposed core wire shall be cleaned by lightly filing with a good quality fine tooth steel file. Emery cloth, sand paper, or other such materials shall not be used. Crimp connectors shall be installed using proper tooling to make cable-to-anode compression connections, taking care to ensure that no bending, kinking, or other damage occurs to the cable or to the steel wire anode core.

811.3.03 WIRE AND CABLE ACCESSORIES

A. Install lead wire and cable at minimum of 3' (1 m) below grade. Where lead wire is connected to pipe or to field test stations, minimum of 18" (450 mm) of slack shall be left in lead wire to permit settling of backfill without stressing electrical connection.

B. Install and terminate lead wires as follows:
1. Terminate pipe lead wires at each field test station.
2. Attach pipe lead wires to pipe on top center line and separate minimum distance of 12" (300 mm).
3. After coating of pipe lead wire connections, strap each pair of pipe lead wires to pipe they are connected to using specified strapping material.
4. Pipe lead wires shall contain minimum of 18" (450 mm) of slack near pipe connection point to compensate for pipe movement and backfill settlement.
5. Splices in pipe lead wire not permitted.
6. Pipe lead wires shall be clearly identified, with regard to which pipe they are connected to, from time they are initially connected to pipe using specified permanent cable markers. Continually maintain identification markings throughout construction and ensure each pipe lead wire is clearly and correctly marked when finally terminated in field test stations.

811.3.04 FIELD TEST STATIONS

A. Install field test stations above buried pipeline or as shown on the drawings. Where it is impracticable to locate field test station directly above pipe because of interference with normal use of area, field test station shall be located nearby, in relatively protected location.

1. Does not interfere with normal use of area.

B. Field test station terminations shall be arranged on field test station terminal boards and shall be installed as specified herein and as indicated on drawings.

C. Connections at field test stations shall be made with single hole, uninsulated, compression type terminal lugs made of corrosion-resistant copper, bronze, or nickel-plated brass.

D. Terminals, terminal lugs, jumpers, link bars, and any other terminal board metal parts or hardware installed in flush mounted field test stations shall be coated with conductive, oxidation inhibiting compound as specified.

E. Solid conductors shall additionally be soldered in terminal lug before terminating lug in field test station.

F. Attach permanent, legible identification markers to each lead wire in each field test station. Identify each pipe lead wire with pipe diameter and service, as a minimum. Anode lead wires shall be identified as "Mg Anode" or "ZN Ribbon." Underground reference electrode lead wires for pipe installation shall be identified as "Coupon" or "Cu-CuSO$_4$".

811.3.05 EXOTHERMAL WELDS

A. Use: cable-to-steel structure connections.

B. Exothermal welds shall be made using new molds, sleeves, and cartridges sized in accordance with welding equipment manufacturer's recommendations for particular application.

C. Completed welds shall be capable of withstanding moderate hammer blows. Porous or deformed welds not acceptable.

D. Do not coat or cover exothermal weld until it has been observed for conformance by Owner.

E. Cable connections to pipe:

Pipe Material, Wall Thickness	Connection Process
Ductile iron	Exothermal welding
Steel, 0.145” (3.6 mm) and thicker	Exothermal welding
Copper or brass; and steel less than 0.145” (3.6 mm) thick	Soldering, using 50-50 solid solder and nonacid flux
Stainless steel	Silver brazing
Polypropylene lined carbon steel, with cast iron fittings or cast iron flange	Exothermal welding to cast iron flanges or fittings
Mortar coated steel or concrete cylinder pipe	Bolting to factory attached studs, exothermal welding, or alternate method

	acceptable to Engineer

F. Wire sizes 10 AWG (3.3 mm) and smaller: Exothermal connections to pipe shall be made by installing copper sleeve around copper wire in weld area prior to welding to improve quality of weld and to increase thermal capacity of wire in weld area.

G. Do not cover or coat connection to pipe until it has been observed for conformance by Owner. Owner may reject any connection if it fails when cable is pulled, breaks loose from pipe when struck at an angle with a hammer, or does not appear to be a complete, properly shaped or made. Owner observation in no way relieves Contractor of performance of connection.

811.3.06 SPLICES

A. Splices shall only be applied where specifically permitted.

B. Compression connection installed underground shall additionally be soldered before insulation and burial.

811.3.07 UNDERGROUND REFERENCE ELECTRODES

A. Store and maintain underground reference electrodes in dry environment and above freezing temperatures until activation and installation.

B. Activate underground reference electrodes by complete immersion in clean, fresh water for approximately 8-12 hours prior to installation.

C. Install horizontally below frost line, in permanently moist soil, with minimum of 6” (150 mm) of clean earth fill between electrode package and surrounding rock.

D. After burial of packaged reference electrode, but before backfilling or covering excavation, pour 5 gallons of water over reference electrode, cover with clean soil and test activated reference electrode for proper operation.

811.3.08 PIPING ISOLATION

A. Install flange insulating kits in pipe flanges and insulating unions or couplings.

B. Electrically isolate connecting piping and equipment, and maintain minimum of 6” (150 mm) physical separation from reinforcing steel, structural steel, copper grounding system, or other buried piping from piping designated to receive insulated fittings or cathodic protection.

C. Bolting at insulated flanges shall consist of studs and nuts with sufficient stud length to allow at least one full stud thread protruding through each nut. Sleeves shall extend into insulating washers.

D. Install insulated fittings above grade, or inside underground vaults or manholes, or wrap underground insulated flange with polyethylene encasement. Provide sufficient clearance around fitting to permit easy access for maintenance and testing.

E. Insulated fittings installed underground shall be installed with field test station and zinc grounding cell.

F. Test insulated fittings after installation.

811.3.09 PIPE SYSTEM TESTS

A. Application: Underground piping or cross-country pipeline cathodic protection system tests, associated piping isolation tests, and associated cathodic protection system component tests.

B. Perform aboveground insulated fitting tests using insulation checker after piping installations are completed. Tests shall verify ineffectively insulated pipe fittings and insulated flanges using high-frequency insulation checker.

C. Do not disassemble or rework insulated flange after insulated fitting tests are satisfactorily competed.

811.3.10 INSULATED FITTING EFFECTIVENESS TEST (during installation)

A. Prior to performing tests, calibrate insulation checker as recommended by manufacturer. As tests are performed, observe insulation checker meter to verify meter needle remains fully deflected to right. Defective checker will be indicated by a less than full scale deflection.

B. For insulation tests to be valid using specified instrument, establish firm metal-to-metal contact between each probe of insulation checker and applicable metallic components of fitting under test.

C. Test for effectiveness of insulated pipe fittings by connecting insulation checker probes on either side of insulating component. Insulating, nonmetallic component is normally visible.

D. For insulated flange, insulating component that separates piping components is flange gasket. Test for effectiveness of insulated flange by connecting one insulation checker probe to each pipe flange.

E. Number of tests required per insulated fitting shall be based on size of fitting. Perform tests at approximately 6” (150 mm) intervals around circumference of insulated fitting. Failure of insulation test at any location around circumference of fitting indicates ineffectively insulated fitting.

811.3.11 INSULATED FLANGE COMPONENT TEST (during installation)

A. Test to determine defective components of ineffectively insulated flanges. Connections shall be made to bolt or stud, not to nut, at specified.

1. Test insulation between first bolt to be tested and Side "A" of insulated flange. Place mark on edge of Side "A" flange if bolt insulation is not effective. In similar manner, test insulation between bolt under test and Side "B" of insulated flange. Place mark on edge of Side "B" flange if bolt insulation is not effective. Bolt shall be shorted to both Side "A" and to Side "B" flange to cause insulated flange to be ineffective.
2. Flange bolts are that are fully insulated with insulating washer beneath each bolt head and nut are typically isolated from both sides of flange, but require isolation from only one side to be effective (either Side "A" or Side "B"). Flange bolts are that are insulated with one insulating washer beneath either bolt head or nut are typically isolated from only one side of flange when effective.
3. Check insulation of each bolt in turn, marking ineffectively insulated bolts as required. If all bolts are effectively insulated from pipe, shorted gasket is indicated.

B. Shorted bolts may be removed one at a time to replace insulating sleeve and washers without taking pipe out of service. If fitting is of type where bolt or stud is not threaded into one of flanges, restrain bolt or stud from rotating when tightening nuts, therefore preventing threads from damaging insulating sleeve.

1. Steel backing washers shall be approximately same outside diameter as insulating washer to prevent steel washer from bridging bolt to flange.
2. When shorted bolts have been effectively isolated, re-test flange.

C. If flange fails tests again, and bolts are effectively insulated from both flange faces, shorted gasket is indicated.

811.3.12 UNDERGROUND REFERENCE ELECTRODE TEST (during installation)

A. 8” (200 mm) saturated copper-copper sulfate solution portable reference electrode: Clean reference electrode copper rod and fill with fresh copper-sulfate and distilled water saturated solution within 30 days of testing time.

B. Pour minimum of 10 gallons (38 liters) of water over and around electrode package after each underground reference electrode is installed to thoroughly saturate with water.

C. Place mild steel stake or rod in firm contact with soil, several feet from reference electrode package.

D. Connect negative test lead of specified dc voltmeter to reference electrode lead wire.

E. Firmly connect voltmeter positive test lead to mild steel stake or rod. Measure and record dc voltage on voltmeter. Copper-copper sulfate type underground reference electrodes, stable negative reading between -0.4 and -0.8 volts shall be obtained with lead wires connected as described above for installation to be acceptable.

811.3.13 GALVANIC ANODE CATHODIC PROTECTION TESTS

A. Above and underground electrical and mechanical connections made to cathodically protected piping systems, and electrical isolation shall be complete prior to final testing.

B. Cathodically protected piping and anodes shall have been completely backfilled for at least 30 days prior to initiating final testing. Contractor may elect to perform its own verification tests prior to final tests.

C. Measure current from each pipe connected galvanic anode as follows:
1. If one anode lead wire is connected to pipe in field test station, remove jumper between anode lead wire and pipe lead wire.
2. Connect positive terminal of specified low-resistance dc milliammeter to pipe lead wire and connect negative terminal of milliammeter directly to anode lead wire.
3. Measure and record anode current flow and polarity.
4. Polarity of measurement shall be positive, indicating direction of current flow is from pipe to anode.
5. If more than one anode lead wire is connected to pipe in field test station, disconnect one of anode lead wires from pipe lead wire while leaving other anode lead wire(s) tightly connected.
6. Connect positive terminal of specified low-resistance dc milliammeter to pipe lead wire and connect negative terminal of milliammeter directly to disconnected anode lead wire. Measure and record anode current flow and polarity.
7. Disconnect negative terminal of milliammeter from first anode, tightly connect first anode to pipe while disconnecting second anode, and connect negative terminal of milliammeter to second anode.
8. Measure and record anode current flow and polarity.
9. Repeat this procedure for each connected anode. Polarity of each measurement shall be positive, indicating direction of current flow is from pipe to anode.
10. Repeat above procedures using spare pipe lead wire.

11. Restore jumper and lead wires to original positions.

D. Anode open circuit potential test to determine if galvanic anodes are active and undamaged shall be made using voltmeter, flexible test leads, and portable reference electrode. Measurements shall be made as follows:

1. At field test station, remove jumper between anode lead wire and pipe lead wire. Connect negative terminal of voltmeter to portable reference electrode and connect positive terminal of voltmeter directly to anode lead wire. Polarity of measurement shall be negative if meter is connected as indicated above.
2. Place portable reference electrode in moist soil, free of vegetation, on surface adjacent to anode. Record potential measurement and location where reference electrode was placed.
3. Restore jumper to original position across anode lead wire terminal and pipe lead wire terminal.
4. Measured open circuit potentials shall be stable and shall be -1.6 volts or more negative for "high potential" magnesium galvanic anode to be considered active and undamaged.

E. After satisfactory anode current and anode open circuit potential measurements have been obtained for test station connected anodes on isolated piping system, pipe system potential measurements shall be made using voltmeter, flexible test leads, and portable reference electrode specified. Measurements shall be made as follows.

1. At each field test station, connect negative terminal of voltmeter to portable reference electrode and connect positive terminal of voltmeter directly to spare pipe lead wire.
2. Place portable reference electrode in moist soil, free of vegetation, on surface directly over pipe.
3. Record measurement and location where portable reference electrode was placed. Polarity of measurement shall be negative if meter is connected as indicated above.
4. At locations where underground reference electrodes are installed, measurements shall be made as follows:

A. At each field test station, connect negative terminal of voltmeter to underground reference electrode and connect positive terminal of voltmeter directly to spare pipe lead wire.

B. Record potential measurement. Polarity of measurement shall be negative if meter is connected as indicated above.

F. Underground pipe galvanic anode system test data for each electrically separate piping system or pipeline shall indicate:

1. Pipe-to-soil potentials shall be less than or equal to negative 0.90-volt at each measurement location.
2. Total measured anode current shall be less than or equal to 0.05-mA per square foot of coated pipe surface.

811.3.14 PIPE LEAD WIRE CONTINUITY TEST (during installation)

A. Perform tests using voltmeter, flexible test leads, and milliammeter.

1. At field test station, remove jumper between anode lead wire and pipe lead wire.
2. Connect specified voltmeter between two pipe lead wires, measure and record potential.
3. If no potential exists, use ohmmeter to measure resistance between two pipe lead wires. Resistance reading will be total reading. To get resistance of only pipe lead wires subtract resistance of meter lead wires. Resistance readout shall not be fluctuating and shall measure less than 0.1 ohm to be acceptable.

B. In cases where potential exists, reading will not remain stable, high resistance exists between pipe lead wires, or one or both of pipe lead wires may be damaged. To determine if either of pipe lead wires is damaged perform following:

1. Verify anodes are satisfactorily terminated in test station by performing anode open circuit potential test.
2. Where anodes are satisfactorily terminated in test station, connect dc milliammeter in place of jumper and measure current that flows from one of pipe lead wires to anode and record current measured. Repeat procedure for other pipe lead wire.
3. If there is none or minimal current flow, pipe leads are discontinuous and shall be repaired.
4. Restore jumper to original position across anode lead wire terminal and pipe lead wire terminal.

811.3.15 RIBBON ANODE CURRENT MEASUREMENTS.

A. Ribbon anode current at each casing location shall be measured as follows. At one casing field test station at a time, disconnect the ribbon anode lead wire from the carrier pipe lead wire jumper. Connect the milliampere circuit of the specified meter between the ribbon anode lead wire and the carrier pipe lead wire jumper. Measure and record the current which flows from the carrier pipe to the ribbon anode. Verify the polarity of the reading is positive when connecting the meter positive lead wire to the carrier pipe and the meter negative lead wire to the anode. Reconnect and firmly tighten the ribbon anode lead wire terminal to the carrier pipe lead wire jumper.

811.3.16 FIELD QUALITY CONTROL

A. Test shall verify correct installation and performance of cathodic protection systems and associated equipment and materials.

B. Test data shall be recorded for each test performed and submitted as specified

C. Underground reference electrode tests and component tests shall be performed prior to complete backfilling, otherwise tests may be conducted in any sequence selected by Contractor.

D. Ensure necessary safety precautions are taken and provide equipment, materials, and labor for performance of tests.

E. Within 15 calendar days after completion of cathodic protection tests, submit complete report of test results to Engineer. Results will be interpreted and Contractor advised whether or not system is acceptable.

F. If test results indicate system to be unacceptable, make necessary repairs, retest, and resubmit new test results. Procedure shall be repeated until satisfactory results are obtained and materials, equipment, and installations meet specification requirements. Corrective action shall include restoration of other construction and facilities disturbed by repair work.

811.3.17 MANUFACTURER’S FIELD SERVICES

A. Provide services of qualified corrosion engineer to review installation procedures and supervise installation and testing of cathodic protection systems. Corrosion engineer shall be acceptable to Owner and Engineer.

811.3.18 MAINTENANCE

A. Cathodic protection system shall require routine maintenance inspections after installation to monitor performance.

Registered Professional Engineer
CERTIFICATE NO. 49430
GREGORY PATRICK FLY
Date Signed 11-11-20
ARIZONA U.S.A.

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. Chain link fence shall be either Type 1 or 2 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 fabric shall be constructed of either zinc-coated steel or aluminum-coated steel. Posts, hardware and fittings shall be either zinc-coated steel or aluminum-coated steel. 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 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 Independent Quality Firm and will require written approval by the Independent Quality Firm 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 inches. 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 applied to the zinc coating prior to application of the organic topcoat.

(C) H-Section Posts:

H-section posts shall be manufactured from steel conforming to the minimum requirements of AASHTO M 223, Grade 42, and shall meet the zinc coating, strength and dimensional requirements of AASHTO M 181 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 M 181 for Type I roll-formed posts. The required coating shall be a hot-dip zinc coating in accordance with the requirements of AASHTO M 181 for Grade 1 steel posts or a coating system meeting the exterior coating requirements of AASHTO M 181 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 shown in Table 2 of AASHTO M 181 for Type I or II wire when tested in accordance with AASHTO T 68.

Chain link fence 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 of wire surface area. The wire used for aluminum-coated chain link fence fabric shall be coated before weaving into fabric. The wire used in the manufacture of the fabric shall be 11 gauge for all fence fabric 60 inches or less in height and shall be nine gauge for fabrics greater than 60 inches in height.

Chain link fence fabric shall be woven throughout in the form of approximately two-inch square mesh. Fabric 60 inches or less in height shall be furnished with knuckling on one selvage and barbing on the other, and fabric over 60 inches shall be furnished with barbing on both selvages.

902-2.05 Tension Wire and Fabric Fasteners:

Tension wire shall be seven gauge (0.177 inch diameter) coil spring steel wire of good commercial quality with a minimum tensile strength of 75,000 pounds per square inch, and shall be zinc-coated or aluminum-coated. Zinc-coated steel wire shall have a minimum coating of 0.8 ounces per square foot of uncoated wire surface. Aluminum-coated steel wire shall have a minimum coating of 0.4 ounces per square foot 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 diameter and breaking strength as the fence fabric being fastened. The minimum weight of zinc-coating shall conform to the requirements of ASTM A 641, Class 3. The minimum weight of aluminum coating shall be 0.4 ounces per square foot 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 diameter adjustable rods. Truss tighteners shall have a strap thickness of not less than 1/4 inch.

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 by 3/4-inch steel flat bars. Stretcher bar bands shall be 1/8-inch by one-inch 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.

Gate frames shall be constructed of not less than 1-1/2 inch steel pipe and interior vertical members shall be constructed of not less than one-inch 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 for 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, D1.1-80 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 three inches 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 Requirements:

902-3.01 General:

Existing fences that are to remain in place and which have been damaged by the Developer's operations shall be replaced or restored by the Developer.

902-3.02 Setting Posts:

Line posts shall be spaced at not more than 10-foot 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 intervals or midway between pull posts when the distance between such posts is less than 1,000 feet and more than 500 feet.

All posts shall be placed in a vertical position, except in unusual locations where the posts must 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 either the inward or outward facing side of the posts. The fabric shall be stretched taut and fastened to the posts and 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 two inches 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. The fabric shall be fastened to the line posts with the wires or post clips spaced at intervals not exceeding 14 inches and to the tension wires with the wires or hog rings spaced at 18 inches center to center.

Chain link fabric may be attached facing away or towards the mainline roadway.

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 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.

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, wildlife 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 shall be submitted for all materials except for Subsection 903-2.02, Posts and Braces, and Subsection 903-2.04, Fencing Wire. Subsections 903-2.02 and 903-2.04 will be sampled and tested in accordance with methods used by the Independent Quality Firm and will require written approval by the Independent Quality Firm 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 within a given fence line.

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 steel wire with four-point 14-gauge barbs spaced five inches apart and shall be either zinc-coated (Class 1) or aluminum-coated, conforming to the requirements of ASTM A 121.

(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 No. 11 (Grade 60) woven steel fence fabric with stay wires spaced six inches apart and shall be either zinc-coated (Class 1) or aluminum-coated, conforming to the requirements of ASTM A 116.

903-2.05 Stays and Fasteners:

Stays shall be 9-1/2 gauge 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 ounces per square foot 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 diameter as the fence fabric being fastened.

The minimum weight of zinc-coating shall be 0.3 ounces per square foot 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 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 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, two inch by two inch by four feet for the latch board and two inch by two inch by two feet for the pry stick. Steel latch board and pry stick shall be fabricated from the same type of steel utilized for line posts.

903-3 Construction Requirements:

903-3.01 General:

In areas where there is livestock, the Developer shall take all measures necessary to restrict the livestock to the land where it is being kept. The Developer 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 Developer's operations shall be replaced or restored.

903-3.02 Setting Fence:

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 five 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 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 Inspector, 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 to any post assembly.

Where fence lines are interrupted by openings for gates, 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 post assemblies, all longitudinal wires shall be attached to each intervening line post at the height and spacing as 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 four inches plus or minus for barbed wire fence and game fence and one inch 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 one cubic foot. Fence sag weights shall weigh not less than 100 pounds 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 and in accordance with the details shown on the project plans. If the length of the flood gate is such that 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.

SECTION 904 CHAIN LINK CABLE BARRIER:

904-1 Description:

The work under this section shall consist of furnishing all materials and constructing chain link cable barrier fence at the locations and in accordance with the details shown on the project plans and in accordance with the requirements of the plans and these specifications.

904-2 Materials:

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

The wire rope and swaged connection assembly and the associated nuts and washers shall conform to the requirements for the cable assembly specified under Subsection 1012-2, except that the length of the wire rope and the stud bolts shall be as shown on the project plans, and the wire rope shall conform to the requirements of AASHTO M 30, Class B, Type II.

Concrete shall be Class S Portland cement concrete conforming to the requirements of Section 1006.

Welded wire fabric shall conform to the requirements of Section 1003.

The chain link fence fabric, ties, fasteners, hardware and other fittings shall be of the dimensions shown on the project plans and shall conform to the requirements of Subsection 902-2.

All structural steel shall conform to the requirements of ASTM A 36, except that the anchor plate shall be made of steel conforming to the requirements of ASTM A 572 or A 588. All structural steel shall be galvanized in accordance with the requirements of ASTM A 123.

904-3 Construction Requirements:

In addition to the requirements of this section, the construction of the chain link cable barrier shall conform to the applicable requirements of Section 902 and Section 905.

The excavation for the concrete anchor block shall be to the neat lines shown on the project plans, with a maximum of three inches outside those lines. The entire volume of the excavation shall be filled with concrete.

The chain link cable barrier shall be constructed at the location shown on the project plans. The chain link fence and cables shall follow the contours of the finished ground surface. The cables shall have only enough tension to prevent them from sagging more than one inch between clamps.

SECTION 905 GUARDRAIL:

905-1 Description:

The work under this section shall consist of furnishing all labor, equipment, and materials to install guardrail, guardrail transitions, tangent and flared guardrail terminals, and end anchors, constructed new, reconstructed, or constructed guardrail from salvage in accordance with the locations and details shown on the plans and the requirements of these specifications, including all necessary components and delineation.

905-2 Materials:

Materials for guardrail, guardrail transitions, end anchors, and reflector tabs shall conform to the requirements of Section 1012 and the plans.

Materials for tangent and flared guardrail terminals shall conform to the requirements of the approved manufacturer drawings and specifications. Only those tangent and flared guardrail terminals shown on the plans will be allowed.

Prismatic guardrail-mounted barrier markers shall conform to the requirements of Section 1008. Prismatic guardrail-mounted barrier markers shall be ultraviolet-resistant, and shall have a trapezoidal-shaped body in accordance with Technical Provisions.

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. This material shall be configured into a rectangular body that is flat, curvilinear or tubular with a width of between three and four inches. The minimum reflective area for L-shaped and T-shaped markers, attached to the top of wooden posts, and U-shaped markers, attached to the top of steel I-beam posts, shall be ten square inches. The reflectorized surface for flexible vertical guardrail markers attached to the approach side of posts shall be three inches wide by five inches long.

Adhesive materials for applying reflective sheeting to guardrail terminals, metal or plastic guardrail reflector tabs, and flexible guardrail markers shall be in accordance with the sheeting manufacturer's recommendations.

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.

Reflective sheeting for object markers on tangent and flared guardrail terminals, and reflective sheeting used for all other guardrail markers, including flexible guardrail markers and reflector tabs, shall conform to the requirements of Section 1007.

Transparent colors, inks and paints used in fabrication shall be of the type and quality recommended by the sheeting manufacturer. Transparent colors shall be applied with screen mesh P.E. 157 using fill pass.

Tangent and flared guardrail terminals, flexible guardrail markers, reflective sheeting products and inks approved for use are shown on the Department's Approved Products List (APL). Copies of the most current version of the APL are available on the internet from the Arizona Transportation Research Center (ARTC), through its PRIDE program.

905-3 Construction Requirements:

905-3.01 General:

The construction of the various types of guardrail, guardrail transitions, tangent and flared guardrail terminals, and end anchors shall include the assembly and erection of all component parts complete at the locations shown on the project plans. All materials shall be new except as provided for under Subsections 905-3.04 and 905-3.05.

The various types of guardrail shall be constructed with wood blocks on either steel or wood posts, except where the post materials to be used are specified on the 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 with two coats of zinc paint, in accordance with Section 1002.

Where field cutting or boring of wood posts and blocks is permitted, the affected areas shall be treated in accordance with the American Wood Preservers Association Standard M4.

Where wood posts with rectangular sections are used, the posts shall be set so that the longest dimension is perpendicular to the rail.

All bolts shall extend beyond the nuts a minimum of two threads, except that all bolts on posts adjacent to pedestrian traffic shall be cut off 1/4 inch from the nut.

All bolts shall be securely tightened unless torque requirements are specified on the plans or manufacturer's drawings.

Guardrail elements shall be spliced by lapping in the direction of traffic in the nearest adjacent lane.

When guardrail is being constructed, or reconstructed under traffic, the Developer shall conduct its operations so as to constitute the least hazard to the public and construction personnel. 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, grade, and spacing shown on the plans. Earthwork placement, grading, compacting, and bituminous surfacing shall be completed prior to installation of the guardrail posts.

Wood posts shall be placed in pre-punched, or pre-drilled pilot holes and driven the final 10 inches to grade. Steel posts shall either be driven full depth, or placed in manually or mechanically dug holes and driven the final 10 inches to grade. Pre-punched post holes, or full depth post driving shall not be used at locations where damage to the curb, gutter, sidewalk, buried items, shoulders, pavement or MSE wall reinforcements might occur.

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 unfinished work, shall be removed and replaced.

Where curb, gutter, sidewalk, buried items, shoulders, pavement or MSE wall reinforcements are disturbed in the construction of guardrail, the damage shall be repaired.

Where the top surface of a box culvert 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. 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 eliminated and nested steel W-beam shall be placed in accordance with the requirements of Subsection 905-3.09.

The space around and under the posts placed in manually or mechanically dug holes shall be backfilled with moist soils placed in compacted lifts.

Wood blocks shall be toe-nailed to the wood posts with one 16-penny galvanized nail on each side of the top of the block. Blocks shall be set so that the top of the block is no more than 1/2 inch above or below the top of the post, unless otherwise shown on the project plans.

Rail elements shall be spliced at 25-foot intervals or less. Rail elements shall be spliced at posts unless otherwise shown on the project plans. Rail elements at joints shall have full bearing. When the radius of curvature is 150 feet or less, the rail elements shall be shop curved.

905-3.03 Guardrail End Anchors:

End anchors shall be installed in accordance with the plans. Foundation tubes shall be supplied as part of the end anchor. Foundation tubes shall be installed with an approved driving head. The tubes shall not be driven with the wood post in place. Foundation tubes may also be installed in drilled holes. When foundation tubes are placed in drilled holes, the space around and under the tubes shall be backfilled with moist soils placed in compacted lifts. The foundation tube shall not protrude more than four inches above the ground as measured along a five foot cord. Guardrail end anchor foundations should not be driven or drilled through MSE wall reinforcements, and damage to the reinforcements should be repaired.

905-3.05 Reconstruct Guardrail:

Existing guardrail, guardrail transitions, tangent and flared guardrail terminals, end anchors, and other guardrail systems shall be removed and reconstructed at the locations shown on the project plans, and in accordance with the provisions specified herein for new construction.

When reconstruct guardrail is specified, posts shall be completely removed and then reconstructed. When end anchors are removed, the existing concrete foundation shall be fully removed and the hole backfilled with moist soil in compacted lifts.

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 to be unsuitable for reuse or if the quantities of existing materials are insufficient to complete the work, the Developer shall furnish new materials in sufficient quantities to complete the work Reconstructed tangent and flared guardrail terminals and end anchors shall be installed with new foundation tubes.

Where new bolt holes in rail elements are permitted and approved by the Inspector, the holes shall be made by drilling or punching. Flame-cut bolt holes will not be permitted. All metal cut in the field shall be cleaned and painted in accordance with Subsection 905-3.01.

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 concrete box 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.

Where field-cutting or boring of wood posts or blocks is required, the affected areas shall be treated in accordance with Subsection 905-3.01.

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.

905-3.09 Nested Guardrail:

This work shall consist of furnishing and constructing nested guardrail, Type 1, 2, or 3, including all materials, in accordance with the requirements of the project plans.

Nested guardrail consists of additional steel W-beam sections attached as an appurtenance to guardrail.

905-3.10 Tangent and Flared Guardrail Terminals:

Tangent and flared guardrail terminals shall be installed in accordance with the manufacturer's specifications and approved drawings. When shown on the plans as alternatives, all tangent-type or flare-type terminals shall be from the same manufacturer without mixing brands. Prior to starting work, the Developer shall submit the current version of the manufacturer's approved drawings and installation manuals for each type of guardrail terminal to be installed on the project. In case of discrepancy or conflict, the current manufacturer's specifications and approved drawings shall govern. Manufacturer's dimensions relative to the finished surface shall be measured along a five-foot cord.

Earthwork placement, grading, compacting, and bituminous surfacing shall be completed prior to installation of posts for guardrail terminals. The Developer shall install the posts in a manner that prevents heaving or other damage to the surface material.

905-3.11 Guardrail Delineation:

(A) General:

Flexible guardrail markers shall be either L-shaped, U-shaped (for steel I-beam posts), or T-shaped delineators, or flexible vertical delineators. Flexible L-shaped, U-shaped, and T-shaped delineators shall be installed on the top of the posts, and shall be placed as close as possible to the roadway edge of the post with the retroreflective surface facing oncoming traffic of the nearest traveled lane. Flexible vertical delineators shall be installed on the side of the post facing oncoming traffic, level and true, with the retroreflective sheeting 38 inches above the roadway surface.

When nails are used to secure delineation to the top of wood posts, a minimum of two nails shall be driven at an angle to prevent the post from splitting. Side-mounted flexible vertical delineators shall be secured to wood posts with two 1/8-inch diameter by two-inch long galvanized lag screws and flat washers. Side mounted delineation shall be secured to metal posts by drilling two holes through the post and attaching with two galvanized 1/8-inch diameter by 3/4-inch long bolts, flat washers, and lock nuts.

The color of the retroreflective portion of the barrier markers and flexible delineators shall conform to the color of the adjacent edge line. Silver-faced guardrail reflector tabs shall be installed on the right hand side of all roadways and ramps. Yellow-faced tabs shall be installed on the left-hand side of one-way roadways and ramps. Field application of retroreflective sheeting will not be allowed. The manufacturer shall apply all sheeting in the factory.

(B) Guardrail Delineation:

Guardrail reflector tabs shall be installed on the W-beam at every sixth post, beginning with the post number shown in Table 905-1. On radial sections of guardrail, the reflector tabs shall be placed on the W-beam at every other post.

The slotted part of reflector tabs shall be installed under the guardrail bolt head with the reflector facing 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.

(C) Tangent and Flared Guardrail Terminal Delineation:

Delineation for tangent and flared guardrail terminals shall be compatible with the average project elevation and traffic direction shown on the plans. The Developer shall maintain consistency within the project limits by selecting the same type of delineation for all similar installations.

For tangent and flared guardrail terminals used on a project with an average elevation of less than 4,000 feet, the Developer shall use either prismatic barrier markers, L-shaped or T-shaped markers, or flexible vertical delineators on the posts shown in table 905-1.

When using L-shaped or T-shaped markers with the ET-PLUS in asphalt pavement areas, or with the SRT-350 regardless of pavement surface, the Developer shall substitute U-shaped markers or flexible vertical delineators (for steel I-beam posts) for post number two, regardless of project elevation.

The configuration of reflective sheeting object markers on the approach faces of the ET-PLUS, SKT-350, and FLEAT-350 shall conform to Plans. The dimensions of the object marker decals for the approach faces of the FLEAT-350, SKT-350, and ET-PLUS shall be modified as needed to fully cover the head configuration. The configuration and type of reflective sheeting object markers on the departure sides of the ET-PLUS, SKT-350, or FLEAT-350 shall conform to Plans.

The configuration of reflective sheeting on the approach side of the SRT-350 end-piece shall consist of three diamond shapes, each with side dimensions of four inches, vertically stacked corner-to-corner, and placed in the center of the approach face.

TABLE 905-1
GUARDRAIL DELINEATION POST PLACEMENT

Terminal Type	Prismatic Barrier Marker Post Numbers	Begin Reflector Tabs and Flexible Markers* With Post Number
ET-PLUS or SKT-350	2, 4, 6, 8	10
SRT-350 or FLEAT-350	2, 4, 6	8

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, sidewalk, sidewalk ramps, driveways, and valley gutters at the locations shown on the project plans in accordance with the details shown on the plans and the requirements of these specifications.

The plans may reference certain Standard Specifications and Standard Details for concrete curbs, gutters, sidewalks and driveways promulgated by the Maricopa Association of Governments (MAG).

When MAG Standard Specifications and Standard Details are specified for certain items of work, the description, materials and construction requirements for those items shall conform to the requirements of the MAG Standards in Parts 200 through 700, except as may be superseded or supplemented by these Specifications. Part 100 and the fifteen pages of forms in the MAG Standard Specifications are not applicable.

MAG Standards are available from:

Maricopa Association of Governments
302 North 1st Avenue, Suite 300
Phoenix, Arizona 85003
602-254-6300

Copies are also available on the Internet at http://www.mag.maricopa.gov.

References to Sections of MAG in these Specifications will be so designated. All other sections and subsection specifications referenced shall be construed to be these Specifications unless otherwise stated herein.

908-2 Materials:

908-2.01 Concrete:

Concrete shall be Class B concrete conforming to the requirements of Section 1006.

908-2.02 Expansion Joint Filler:

Expansion joint filler shall be 1/2-inch bituminous or nonbituminous preformed strips conforming to the requirements of Subsection 1011-6.

908-2.03 Concrete Curing Compound:

Curing compound shall be liquid membrane-forming compound conforming to the requirements of AASHTO M 148, Type I, Class A.

908-2.04 Detectable Warning Strip:

Detectable warning strips shall consist of a pre-fabricated mat with truncated domes aligned in a square grid matrix on a flat substrate, or other pre-fabricated materials meeting the requirements of the Plans and C-05.30 for installation details. Detectable warning strips shall contrast visually with the sidewalk ramp, and shall conform to the current requirements of the Public Right of Way Accessibility Guidelines (PROWAG). Detectable warning strips shall be pre-fabricated from durable material approved by the Independent Quality Firm. All detectable warning strips installed within the project limits shall be the same type, unless shown otherwise on plans.

Only those pre-fabricated detectable warning strips shown on the Department's Approved Products List (APL) shall be used. Copies of the most current version of the APL are available on the internet from the Arizona Transportation Research Center (ATRC), through its PRIDE program.

908-3 Construction Requirements:

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, driveway, valley gutter, sidewalk ramp, or sidewalk, the material on which they are to be placed shall be compacted to a depth of at least six inches 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.

All soft or unsuitable material shall be removed to a depth of not less than six inches below subgrade and replaced with material.

Single curb, curb and gutter, 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 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.

The subgrade and forms shall be watered immediately in advance of placing concrete. Concrete shall be placed in the forms and thoroughly consolidated. 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. 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 radius unless a larger radius is indicated on the plans. When concrete placed in curb 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 radius.

Expansion joints shall be constructed at tangent points of curb returns, at structures, and at a maximum of 60-foot intervals. 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 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 radius.

Contraction joints (weakened-plane joints) shall be constructed at a maximum of 15-foot 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 in width or greater.

Longitudinal contraction joints shall be constructed in the center of sidewalk having a width greater than seven feet. 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 two inches. The final joint finishing shall be accomplished with a jointer tool having a radius of 1/4 inch leaving a finished joint depth of a minimum of 3/4 inch. Sawed joints shall be sawed to a depth of two inches or one-third the thickness of the concrete, whichever is greater.

Scoring lines, where required, shall have a minimum depth of 1/4 inch and a radius of 1/8 inch. 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.

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 one gallon per 150 square feet 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 straightedge. Any deviation in excess of 1/4 inch shall be corrected.

The face, top, back, and flow line of the curb and gutter shall be tested with a 10-foot straightedge or curve template, longitudinally along the surface.

Any deviation in excess of 1/4 inch shall be corrected.

No vehicular traffic will be allowed on driveways until the concrete has reached at least 60 percent of the required 28-day strength.

The top surface of detectable warning strips, exclusive of the truncated domes, shall be within ± 1/16 inch of the sidewalk ramp surface in accordance with the requirements of the PROWAG. Detectable warning strips shall be installed in accordance with manufacturer's instructions and current industry practice. In case of discrepancy the manufacturer's instructions shall govern.

SECTION 909 SURVEY MONUMENTS:

909-1 Description:

The work under this section shall consist of furnishing all materials and installing concrete monuments, including cast iron frames and covers; furnishing cast iron frames and covers; or removing and resetting existing frames and covers at the locations shown on the project plans 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. The standard marker cap will be furnished by the Department. Section line marker caps shall be furnished by the Developer, and shall be stamped in accordance with Manual of Surveying Instructions 1973, published by the Department of Interior, Bureau of Land Management. Survey monuments shall be magnetically detectable.

909-2.02 Frames and Covers:

Frames and covers shall conform to the requirements of Subsection 1004-6 for gray iron castings. The bearing face of the frame 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.

909-3 Construction Requirements:

909-3.01 Survey Monuments:

Excavation for new monuments shall be the depths designated on the plans. The monuments shall be backfilled with suitable material tamped into place to provide a stable and 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 Developer's option, 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.

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 shown on the project plans and in accordance with the details shown on the plans and the requirements of these specifications.

910-1.01 Barrier Aesthetics:

Barrier aesthetics shall be as specified in the project plans and specifications.

910-2 Materials:

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 4,000 pounds per square inch at 28 days.

Reinforcing steel shall be in accordance with the requirements of Section 1003.

Dowels shall be corrosion resistant coated dowel bars conforming to the requirements of AASHTO M 254, Type A.

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.

Joint sealant barrier shall be latex sealing compound conforming to the requirements of ASTM C 834, applied as recommended in ASTM C 1193.

910-3 Construction Requirements:

910-3.01 General:

Unless otherwise required by the project plans, concrete barrier shall be constructed by any of the following methods or combinations thereof, at the Developer's option:

(A) Cast-in-place by slip-form or extrusion
(B) Cast-in-place by fixed forms
(C) Precast

Concrete barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the project plans.

When concrete barriers are to be constructed on recently completed bridges, the barriers may be constructed once the bridge deck concrete has achieved 100% of design strength and the deck concrete has a minimum age of 7 days.

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 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.

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 of well compacted, dense concrete. At the option of the Developer, concrete may be made with 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 Developer 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 of 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 product. Barrier that cannot be refinished to meet the specifications for a Class II finish shall be removed and replaced at the Developers expense. Barrier that has unsatisfactory alignment and straightedge tolerance shall be penalized 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.

Further, the equipment shall be operated under sufficient uniform restraint to the forward motion 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 Developer from survey marks. The forming portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine 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) This subsection not used.

(2) The top and exposed faces of the barrier shall comply with the following tolerances to be accepted.

(a) When a 10-foot long straightedge is placed on the top surface of the barrier, it shall not vary by more than 1/2 inch from the straightedge.

(b) When a 10-foot long straightedge is placed along the face of the barrier, it shall not vary by more than 3/4 inch from the straightedge.

(c) The horizontal alignment shall not deviate by more than that allowed in Section 401 when placed adjacent to Portland Cement Concrete Pavement.

All other barrier dimensions shall not deviate by more than 3/4 inch from plan's alignment.

Those portions of the barrier not in compliance with the minimum requirements specified herein shall be removed and replaced.

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 Independent Quality Firm may waive the specified additional finishing to produce a Class II finish.

The barrier shall be cast in sections of the length shown on the project plans and the edges of the joints between sections shall be rounded to a 1/4-inch radius.

After the concrete has cured for seven days, the joint shall be filled to a depth of at least one inch with joint sealant.

When a 10-foot long straightedge is placed on the top and along the faces of the barrier, the surface shall not vary more than 1/4 inch 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 Inspector may reject it or allow refinishing. 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 one inch deep, so that grout is exuded for the full length on both sides of the base when the section is set 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 one inch, 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 long straightedge is placed on the top and along the faces of the barrier, the surface shall not vary more than 1/4 inch from the straightedge.

SECTION 911 RIGHT-OF-WAY MARKERS:

911-1 Description:

The work under this section shall consist of furnishing all materials and installing new right-of-way markers, including reference markers, or removing and resetting existing right-of-way markers, at the locations shown on the project plans and the requirements of these specifications.

911-2 Materials:

911-2.01 Concrete:

Concrete shall be utility concrete conforming to the requirements of Section 922.

911-2.02 Steel:

Steel shall conform to the requirements of AASHTO M 183 for structural carbon steel.

911-2.03 Paint:

Paint shall be of the types specified on the plans and shall conform to the requirements of Section 1002.

911-3 Construction Requirements:

Right-of-way markers shall consist of a survey monument and a reference marker. The survey monument shall be cast-in-place concrete with a standard marker cap. The standard marker cap will be furnished by the Department.

Excavation for right-of-way markers shall be to the dimensions shown on the plans. Concrete shall be placed in accordance with the requirements of Section 922 and the standard marker set in the fresh concrete.

The right-of-way markers and reference markers shall be set vertically in the ground. The reference markers shall be painted and lettered as shown on the plans.

Existing right-of-way markers, including reference markers, designated for removal and resetting shall be carefully removed and reset at the new locations in the manner specified herein for right-of-way markers. If required, the reset reference markers shall be painted as specified on the plans for new reference markers. Markers broken or damaged in removing and resetting shall be replaced.

SECTION 912 SHOTCRETE:

912-1 Description:

The work under this section shall consist of furnishing all materials and applying shotcrete on prepared surfaces at the locations and in accordance with the details shown on the plans and the requirements of the 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, supplementary cementitious material, 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 and Equipment:

912-2.01 Portland Cement and Water:

Portland cement and mixing water shall conform to the requirements of Subsections 1006-2.01 and 1006-2.02, respectively.

912-2.02 Aggregate:

(A) Fine Aggregate:

Fine aggregate shall conform to the requirements of Subsection 1006-2.03(B).

(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	100
3/8 inch	85 - 100
No. 4	0 - 30
No. 8	0 - 10

No. 16	0 - 5

912-2.03 Admixtures:

Admixtures shall conform to the requirements of Subsection 1006-2.04.

Air-entraining admixtures will be required for shotcrete placed at an elevation of 3,000 feet or above. Air content will be measured in accordance with AASHTO T 152.

When the wet-mix process is used, the air content will be measured just prior to pumping, and shall not be less than seven percent nor more than ten percent.

When the dry-mix process is used, the air content will be measured from the in-place material that has been shot, and shall not be less than four percent nor more than seven percent.

912-2.04 Reinforcing Steel:

Reinforcing steel bars or welded wire fabric shall conform to the requirements of Section 1003.

912-2.05 Equipment:

Equipment for use with the dry mix process shall be capable of metering the 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 Independent Quality Firm. The pneumatic feed type shall be capable of discharging the concrete or 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 flow of material. The size of the delivery hose shall be within the range of 1-1/4 to 2-1/2 inches.

912-2.06 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 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 or less. The pressure shall be increased at least five pounds per square inch for each additional 50 feet of hose or fraction thereof.

912-3 Construction Requirements:

912-3.01 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 Developer uses a drum-type mixer, the mixing time shall be not less than one minute. The mixed material shall be utilized promptly after mixing. Any unused 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 564 pounds of combined Portland cement and supplementary cementitious material per cubic yard, fine aggregate, chemical and/or air-entraining admixtures, and water mixed to a desired consistency, generally to a slump in the range of 1-1/4 to four inches.

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:

The Developer shall determine the mix proportions and shall furnish concrete for pneumatic placement which contains a minimum of 658 pounds of combined Portland cement and supplementary cementitious material per cubic yard of concrete and which attains a minimum 28-day compressive strength of 3,000 pounds per square inch, unless otherwise specified. Fine aggregate and coarse aggregate shall conform to the requirements of Subsection 912-2.02. The total mix shall contain 15 to 20 percent coarse aggregate, by weight. The water/cementitious material ratio shall not exceed 0.50. In no case shall the slump be greater than four inches.

If ready-mixed concrete is used, it shall conform to the requirements of ASTM C 94.

912-3.02 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. The surfaces shall be thoroughly compacted and shall be uniformly moistened so that water will not be drawn from the freshly placed shotcrete.

912-3.03 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.

912-3.04 Steel Reinforcement:

Steel reinforcement shall be as shown on the project plans and shall conform to the requirements of Section 605.

912-3.05 Placement of Shotcrete:

The velocity of the shotcrete as it leaves the nozzle shall be maintained uniform and at a constant rate for the given job conditions. The nozzle shall be held perpendicular to the working surface and at a proper distance, generally between two and five feet, to ensure maximum compaction with minimum rebound of the shotcrete.

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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 degrees F nor until an ascending air temperature rises above 35 degrees F. Temperature shall be taken in the shade away from artificial heat.

912-3.06 Testing:

Tests to determine the physical quality of the shotcrete will be performed by the Inspector during the work as required. The Developer shall prepare test panels and obtain cores as specified herein.

Test panels at least 12 inches square and as thick as the structure being constructed, but not less than three inches thick, shall be prepared by gunning shotcrete mix into a frame which has been placed on a flat piece of plywood. Test panels shall be cured in the same manner as the production work, as specified in Subsection 912-3.09.

The contractor shall obtain three cores from each test panel in accordance with Arizona Test Method 317. The cores shall have a minimum diameter of three inches and a length to a diameter ratio (L/D) of at least 1.00. The cores must be obtained under the observation of an ADOT representative.

The cut surfaces of the cores will be carefully examined for soundness and uniformity of the material and shall be free from laminations and sand pockets.

The three cores will be tested by the Inspector for 28-day compressive strength in accordance with Arizona Test Method 317. Unless otherwise specified, the cores shall have an average compressive strength of at least 3,000 pounds per square inch.

912-3.07 Construction Joints:

Construction joints shall be tapered to a shallow edge of one inch thick over a width of one foot, except where the joint will be subjected to compressive loading. If such is the case, or if joints are at slab intersections, full depth vertical joints shall be constructed and special care taken to avoid or remove trapped rebound at the joint. The entire joint shall be thoroughly cleaned and wetted prior to the application of additional shotcrete.

912-3.08 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, the surface of the shotcrete shall have a natural gun finish.

912-3.09 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 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 one gallon per 100 square feet.

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 the 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 at the locations and as shown on the project plans.

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 (SSD) specific gravity of the rock shall be a minimum of 2.4 as determined in accordance with the requirements of Arizona Test Method 210, modified to specify that testing shall be performed on three-inch maximum to plus No. 4 size material. Rock used to construct dumped riprap shall be angular in shape. For wire tied riprap, either rounded or angular rock is acceptable. 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 shown herein for the various types of bank protection. Control of the gradation will be by visual inspection.

The acceptability of the rock will be determined by the Inspector by visual inspection and/or testing. If testing is required, suitable samples of rock shall be taken in the presence of the Inspector in advance of its expected use. 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.

During construction of the bank protection, the Developer shall provide two samples of rock for the intended use. The size of each sample for dumped riprap and riprap (slope mattress) shall be at least five tons. The size of each sample for grouted riprap, wire tied riprap, gabions, and rail bank protection shall be at least 500 pounds. One sample shall be provided at the construction site and may be a part of the finished bank protection. The other sample shall be provided at the quarry. These samples will be used as a frequent reference for judging the gradation of the rock supplied. Any difference of opinion between the Inspector and the Developer shall be resolved by checking the gradation of two random samples of the rock.

Material that is deemed unsatisfactory by the Inspector shall be replaced with acceptable material.

(B) Grouted Riprap:

Gradation of the rock for grouted riprap shall be as specified in these specifications 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 exceeding the least dimension of the wire mesh opening. The maximum size rock, 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.

(E) Gabions:

Rock for gabions shall be well graded, varying in size from four to eight inches.

(F) Riprap (Slope Mattress):

Rock for slope mattress shall be well graded with 70 percent exceeding three inches. The maximum dimension of a single rock shall not exceed the least dimension of the gabion.

Broken concrete may be used upon approval of the Engineer.

(G) Rail Bank Protection:

Rock used to construct rail bank protection shall be well graded, varying in size from four to 12 inches.

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 ounces per square foot of actual surface.

Woven wire fabric shall be galvanized and shall conform to the requirements of ASTM A 116, except that the minimum weight of the zinc coating shall conform to the requirements of ASTM A 641, Class 3.

Wire fabric shall be of the diameter, spacing, pattern, and dimensions shown on the plans. The selvage on each sheet of mesh shall be galvanized steel wire with a minimum diameter 25 percent larger than that used in the body of the mesh.

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

(B) Miscellaneous Fittings and Hardware:

Miscellaneous fittings and hardware shall be of the type and size provided by the manufacturer of the major item to which they apply and shall be galvanized in accordance with the requirements of AASHTO M 232.

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

(C) Tie Wires:

Tie wires shall be of good commercial quality and the 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 641, Class 3. At the option of the contractor, approved wire fasteners may be used on gabions, slope mattresses, or wire fabric in lieu of tie wires.

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

(D) Steel Cable:

Steel cable shall be zinc-coated steel structural wire rope conforming to the requirements of ASTM A 475, seven-wire strand, Class A, for the diameter shown on the plans.

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

(E) Railroad Rail:

Railroad rails may be new or used. If used rails are furnished, they shall be free from rust and 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, two-inch diameter steel pipe conforming to the requirements of ASTM A 53, or 3-inch by 3-inch by 3/8-inch structural steel angles conforming to the requirements of ASTM A 36. 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 size.

Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

913-2.03 Bedding Material:

Bedding material shall consist of granular material having a maximum dimension of two inches, unless specified differently on the approved RFC plans, and shall be free of clay or organic material.

913-2.04 Grout:

Grout shall consist of Portland cement, aggregate, and water. It may also contain supplementary cementitious material. Portland cement, aggregate, water, and supplementary cementitious material shall conform to the requirements of Section 1006. Chemical admixtures may be used. Chemical admixtures shall conform to the requirements of Subsection 1006-2.04, except no admixtures containing chlorides or nitrates shall be used. Air-entraining admixtures, conforming to the requirements of Subsection 1006-2.04, will be required for grout placed at elevations of 3000 feet or above.

The grout shall meet the requirements given in the table below.

MINIMUM CEMENTITIOUS MATERIAL CONTENT: LBS PER CY *(SEE NOTE 1)*	***MAXIMUM WATER/CEMENTITIOUS MATERIAL RATIO (W/CM): LB./LB.***	***SLUMP: INCHES*** *(SEE NOTE 2)*	***AIR CONTENT: PERCENT*** *(SEE NOTE 3)*
850	0.60	9 ± 2	0 – 8
Note 1: A maximum of 25 percent of the cementitious material, by weight, may consist of an approved Class F fly ash, conforming to the requirements of ASTM C 618.			
Note 2: When grout is used for Grouted Riprap, the slump shall be in the appropriate range to permit gravity flow into the interstices with limited spading and brooming. The consistency of the grout shall be as approved by the Inspector.			
Note 3: For placement of grout at elevations of 3000 feet or above, the air content shall be a minimum of 4 percent and a maximum of 8 percent.			

The aggregate shall consist of fine aggregate; however, at the option of the contractor, No. 8 coarse aggregate may be used in the grout. If No. 8 coarse aggregate is used, the volume shall be a maximum of 35 percent of the total aggregate volume.

For plant-mixed grout, the proportioning, mixing, and placing shall be in accordance with the applicable requirements in Section 1006.

For on-site mixing, grout that has been mixed more than one hour shall not be used.

Retempering of grout will not be permitted.

913-2.05 Bank Protection Fabric:

Fabric shall be supplied in accordance with and conform to the material requirements of Subsections 1014-1 and 1014-5, respectively. Special attention shall be given to the required survivability of the fabric, as noted on the plans.

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; the slump shall be from three to five inches; 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	100
1/4 inch	45-89
No. 200	0-12.0

Sacks for sacked concrete riprap shall be made of at least AASHTO M 182, Class 3, burlap and shall be approximately 19-1/2 by 36 inches measured inside the seams when the sack is laid flat, with an approximate capacity of 1.25 cubic feet. Sound, reclaimed sacks may be used.

913-3 Construction Requirements:

913-3.01 General:

Areas on which bank protection is to be constructed shall be in reasonable conformance with the lines and grades shown on the project plans and shall be clear of any deleterious materials prior to placement of bank protection.

913-3.02 Bank Protection Fabric:

When 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 fabric shall be loosely laid and not placed in a stretched condition.

The strips shall be placed to provide a minimum 12 inches 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 fabric exceeds 18 inches, 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 four inches 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 fabric in such a manner as not to damage the fabric. If, in the opinion of the Inspector, the fabric is damaged or displaced to the extent that it cannot function as intended, the Developer shall repair the fabric.

913-3.03 Dumped Riprap:

The rock shall be placed to 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 stones 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 stone blanket. Pressure grouting shall not unseat the stones, 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 25 to 50 percent of the depth of the maximum size stone is exposed. For a smooth surface, grout shall fill the interstices to within 1/2 inch of the surface.

Grout shall not be placed when the descending air temperature falls below 40 degrees F nor until the ascending air temperature rises above 35 degrees F. Temperatures shall be taken in the shade away from artificial heat.

Curing of the grout shall be in accordance with the requirements of Subsection 912-3.09.

At the option of the Develpoer, shotcrete conforming to the requirements of Section 912 may be furnished in lieu of grout.

913-3.06 Slope Mattress Riprap:

The mattress bed 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 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 selvaged or bound so that the joints formed by tying the selvages 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. Stone shall be placed in close contact within the unit so that maximum fill is obtained. The units may be filled by machine with sufficient hand work to accomplish the requirements of this specification.

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 four inches or by a spiral tie having a complete loop every four inches. 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 lines 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 diameter 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 selvaged or bound so that the joints formed by tying the selvages have at least the same strength as the body of the mesh.

Gabions shall be placed to conform with the project plan details. Stone shall be placed in close contact in the unit so that maximum fill is obtained. The units may be filled by machine with sufficient hand work to accomplish 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 stone 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 one cubic foot 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 foundation course shall consist of a row of headers placed directly above the double row of stretchers. The third and remaining courses shall consist of a double row 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 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 Inspector. The Inspector 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 two hours during the daytime for a period of four 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 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.

If hard material is encountered during driving before minimum penetration is reached and it has been demonstrated to the satisfaction of the Inspector that additional attempts at driving would result in damage to the rails, the Engineer shall be contacted to determine if additional work is to be performed, such as jetting or drilling, in order that minimum penetration may be obtained or the Engineer 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.

SECTION 914 WALLS AND MISCELLANEOUS STRUCTURES:

914-1 Description:

The work under this section consists of furnishing all materials and constructing walls and miscellaneous structures at the locations and in accordance with the details shown on the project plans.

914-2 Materials:

Concrete shall be Class S and of the compressive strength shown on the project plans. Concrete and reinforcing steel shall conform to the requirements of Sections 1006 and 1003, respectively. Masonry materials shall conform to the requirements specified on the project plans.

914-3 Construction Requirements:

Rustication, color coating or other wall treatments shall be in accordance with the details shown on the project plans or as specified.

Excavation and backfill shall be in accordance with the requirements of Subsection 203-5.

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. 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 approved SWPPP.

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 three feet plus the burial depth in length and may be made of either wood or steel. Soft wood posts shall be at least three inches in diameter, or nominal two-inch by four-inch and straight enough to provide a fence without noticeable misalignment. If oak posts are used, the size may be reduced to 1-1/2 by 1-1/2 inches with a minus tolerance of 1/8 inch, provided that the cross sectional area is a minimum of 2.25 square inches. Steel posts shall have a minimum weight of 1.3 pounds per foot, 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 32 inches high and should be a minimum of 14 gauge steel wire mesh.

915-2.05 Fasteners for Wooden Posts:

Wire staples shall be No. 17 gauge and shall have a crown at least 3/4-inch wide and legs at least 1/2-inch long. Staples shall be evenly spaced with at least five per post.

Nails shall be 14 gauge, one inch long with 3/4-inch button heads. Nails shall be evenly spaced with at least four per post.

915-3 Construction Requirements:

915-3.01 Silt Fence Installation:

The Developer shall install a temporary silt fence as shown on the plans, and at other locations as required to control discharge. 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 six inches in a trench so that no flow can pass under the barrier. The trench shall be backfilled and the soil compacted over the geotextile.

915-3.02 Post Installation:

Posts shall be set a minimum of 18 inches into the ground and spaced a maximum of six feet apart. Where an 18-inch post depth is impossible to achieve, the posts should be adequately secured to prevent overturning of the fence due to sediment loading and ponding pressure.

915-3.03 Wire Support Fence:

When wire support fence is used, the wire mesh shall be fastened securely to the upstream side of the post. The wire shall extend into the trench a minimum of two inches and extend a minimum of 32 inches above the original ground surface.

915-3.04 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 eight to ten inches of fabric is left at the bottom to be buried. The fabric shall be installed in the trench such that six inches of fabric is against the side of the trench and two to four inches 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 as specified by the manufacturer shall be provided.

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.

915-4 Maintenance Requirements:

Maintenance requirements shall be as stated in the Stormwater Pollution Prevention Plan (SWPPP).

SECTION 919 CONCRETE GORE PAVING:

919-1 Description:

Section 919 Concrete Gore Paving is not being used.

SECTION 920 CONCRETE CHANNEL LINING (6"):

920-1 Description:

The work under these items shall consist of furnishing all materials, equipment and labor for constructing concrete channel lining of the thickness specified and in accordance with the details shown at the locations designated on the project plans. The work includes backfill for cutoff walls and anchor slabs, furnishing and placing concrete and reinforcing steel, including dowels, support slabs, water stops, geo-composite drain, weep holes, and coring for thickness tests.

920-2 Materials:

Concrete shall be Class S, f'_c=3000 psi minimum shall conform to the requirements of Section 1006 of these Specifications.

Reinforcing steel shall be Grade 60 as designated in the project plans and in accordance with Section 1003 of these Specifications.

Liquid membrane-forming compound shall conform to the requirements of Subsection 1006-2.05 of these Specifications.

920-3 Construction Requirements:

Reinforcing steel shall be placed in accordance with Section 605 of these Specifications.

Concrete shall only be placed on solid compacted material in accordance with Section 601. The channel shall be thoroughly sprinkled with water in a manner satisfactory to the Inspector prior to the placement of concrete. Pre-wetting using transit mix trucks will not be permitted.

The finished surface shall be free of all honeycomb, rock pockets, or voids.

Hydrophilic water stops shall either be Greenstreak Hydrotite Hydrophilic Rubber Waterstops, Earth Shield Type 23 Hydrophilic Waterstops, ADEKA MC2010MN Hydrophilic Waterstops, or equal.

Water stops shall be placed at all joints between the channel lining and adjoining headwalls, wing walls, box culverts and drop inlet structures in accordance with the details shown on the project plans and the manufacturer's recommendations.

The finished surface shall be textured transversely with steel tines before initial concrete set to produce a uniform rough texture, anti-skateboarding/rollerblading treatment. The grooves shall be 3/16 inch wide and 3/16 inch deep. The center spacing of the grooves shall be 2 ½ inches. The contractor shall insure surface is rough enough to produce the intended purpose.

PVC weep holes are to be constructed in the channel lining and channel transition walls between vertical joints spaced at 10 feet (max). The weep holes shall be provided only on the side of the lined channel where there is no adjacent freeway cut slope. Portions of the channels that do not parallel the freeway alignment shall have weep holes on both sides. The weep holes will be constructed of 4 inch PVC pipe extending through the channel lining. The area behind the weep holes will be backed by geocomposite drain material per the details shown in the plans.

Immediately following the surface finishing operation, liquid membrane compound shall be applied at a rate of one gallon per 100 square feet.

For the purpose of determining acceptability for thickness, the thickness of the lining will be determined by the average caliper measurement of cores taken by the contractor at locations designated by the Inspector. The cores will be measured in accordance with the AASHTO T 148 except that the nine length measurements will be read directly to the nearest 0.001 of an inch. The average of the nine measurements shall be reported to the nearest 0.01 of an inch.

A test unit shall be each 1,000 square yards, or fraction thereof, of concrete lining placed in each day's operation. One core shall be obtained from each unit. Measurement of the cores will be made by the Inspector and compared with the thickness required by the project plans. The minimum diameter of cores shall be four inches. The Developer shall fill all core holes as approved by the Inspector.

The length of each core will be considered to be the average thickness of the lined channel within the unit.

If the length of each core in each unit is not deficient by more than 0.25 of an inch, the unit will be considered acceptable.

If the average length of the core in any test unit is deficient by more than 0.25 of an inch but less than 1.00 inch, two additional cores shall be taken at designated points as determined by the Inspector within the unit and the length of these three cores will be averaged. If the average length of the three cores is deficient by more than 0.25 of an inch, the unit represented by these cores will be considered deficient and the Developer shall remove and dispose of all panels that are deficient in thickness and replace it. Inspector can request additional testing to determine extent of deficient channel lining.

The test unit will be unacceptable if the length of any core is deficient in thickness by more than 1.00 inch. If the test unit is found to be deficient the Developer shall remove and dispose of all panels that are deficient in thickness and replace it.

All cores will be checked for location of reinforcement for each unit. Reinforcement will be considered acceptable providing its location is as designated on the project plans with a permissible variation of plus or minus 1.0 inch, as measured from the finished surface of the cores. Additional cores will not be required to replace cores void of reinforcement due to core location.

A sample for strength tests will be taken at random for each 1,000 square yards of consecutively placed concrete.

Concrete represented by a strength test of at least 95 percent of the required 28-day compressive strength will be acceptable.

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 for right-of-way markers and survey monuments; 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.

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 Developer and shall conform to the size designation and gradation requirements of AASHTO M 43. The contractor may substitute commercially available sacks of redi-mix concrete, suitable for the intended purpose. Should such substitution be approved, the cement content specified herein and the requirements of subsection 922-2 shall not apply.

922-3 Construction Requirements:

Mixing and placing of the concrete shall conform to the requirements of recognized practice. 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 470 pounds.

All exposed concrete shall be finished to a smooth surface.

(925SRVY, 08/16/19)

SECTION 925 CONSTRUCTION SURVEYING AND LAYOUT:

925-1 Construction Survey - General:

The work under this section shall consist of furnishing all materials, personnel, and equipment necessary to perform all surveying, staking, establishment of all pit boundaries, laying out of haul roads, and verification of the accuracy of all existing control points which have been provided by the Department. The control point verification process shall include locating and making ties to all section line, right-of-way, and roadway monuments in the vicinity of the proposed work. Included in this work shall be all calculations required for the satisfactory completion of projects, including grade and drain, overlay, safety, landscape, rest areas, structures, surfacing projects, or combinations thereof, in conformance with the plans and specifications. The work shall include establishing and marking 'as-built' elevations on bridges, and culverts. The work shall be done under the direction of a registered professional engineer or a registered land surveyor employed by the contractor. The crew chief shall be (National Society of Professional Surveyors) NSPS Certified Level III, (National Institute for Certification in Engineering Technologies) NICET Certified Level III, or a registered Land Surveyor-in-Training. A minimum of 50 percent of the survey crew shall be either NSPS Certified Level II or NICET Certified Level II. All work affecting real property boundaries as described in Arizona State Board of Technical Registration Standards shall be performed under the direction of a registered land surveyor licensed in the State of Arizona.

All existing cadastral corners, such as section corners, quarter corners, intersecting street centerline monuments, and property corners that are destroyed by the contractor shall be re-established by a registered land surveyor employed by the contractor.

Measurement of all pay quantity items will be the responsibility of the Department.

When utility adjustments are a part of the contract, the contractor shall perform all layout work and set all control points, stakes and references necessary for carrying out all such adjustments.

The contractor shall not employ or engage the services of any person or persons in the employ of the Arizona Department of Transportation for the performance of any of the work as described herein.

925-2 Materials, Personnel and Equipment:

Materials and equipment shall include, but shall not necessarily be limited to, vehicles for transporting personnel and equipment, properly adjusted and accurate survey equipment, straightedges, stakes, flagging, and all other devices necessary for checking, marking, establishing and maintaining lines, grades and layout to perform the work called for in the contract. The contractor shall furnish competent personnel to perform the survey work and layout.

Traffic control devices and procedures for construction surveying shall be in accordance with the requirements of the MUTCD and associated ADOT Supplement.

Field books or other electronic data collection records used by the contractor for recording survey data and field notes shall be available for inspection by the Department at any time and shall become the property of the Department upon completion of the work.

925-3 Construction Survey Requirements:

925-3.01 General:

Prior to beginning any survey operations, the contractor shall furnish to the Engineer, for approval, a written outline detailing the method of staking, marking of stakes, grade control for various courses of materials, referencing, structure control, pavement markings, and any other procedures and controls necessary for survey completion. A part of this outline shall also be a schedule which will show the sequencing of the survey and layout work, throughout the course of the contract, listing a percentage of completion for each month. Section 1150, Chapter 11 of the ADOT Construction Manual shall be used by the contractor as a guide in the preparation of this outline. The ADOT Construction Manual is available on the Department's website, through the Construction and Materials Group.

When design survey is established and shown on project plans, the Department will provide a minimum of 3 control points within 1 mile of the project site, and centerline geometry information for the contractor's use. Department furnished control points set in the field will be identified to the contractor. On projects without design survey, the Department will identify record drawings from which the contractor can establish construction survey.

The contractor shall verify the accuracy of the control points established by the Department prior to use. The contractor shall, as part of the control point verification process, locate and make ties to any section line, right-of-way, and roadway monuments which will be affected by the proposed work. After verification of these points, the contractor shall notify the Department in writing of the results.

The contractor shall establish an accurate construction centerline and bench marks for the proper layout of the work as described herein.

Traverse and control points established by the contractor shall be provided to the Department as follows:
For horizontal control, the contractor shall run a traverse from which construction centerline can be established. The control points, delineated by iron pins, marks in concrete, or similar devices, shall be located to minimize the likelihood of their destruction during construction activities. Coordinates of these points or ties to construction centerline shall be provided to the Department.

For vertical control, the contractor shall establish bench marks for the entire length of the project at horizontal intervals not to exceed 2,500 feet.

Traverse or control points set by the contractor shall be identified in the field to the Department.

When GPS is utilized, the contractor will furnish the GPS localization results to the Department at least seven days before beginning construction layout survey work. The Engineer may order the GPS localization calibration and associated 3D model to be broken into two or more zones to maintain the localized relationship between control points and original ground.

The established initial right-of-way monuments shall be protected in place and re-established by the contractor, if disturbed, at no additional cost to the Department.

For locating and establishing ties to section line, right-of-way, and roadway monuments, the contractor shall follow the standards listed in Subsection 925-3.02(B).

Throughout the work, when design survey is established and shown on project plans, the contractor shall set all stakes including centerline stakes; offset stakes; reference point stakes; slope stakes; pavement lines, curb lines and grade stakes; stakes for sewers, roadway drainage, pipe, under drains, clearing, paved gutter, guardrail, fence, survey monuments and culverts; blue tops for subgrade, subbase and base courses; control points for bridges, bridge piers, abutments, footings, pile cutoff, pile layout, pier caps, bridge seats, bridge beams, girder profiles and screed elevations; supplemental bench marks; permanent as-built elevation marks; and all other horizontal or vertical controls necessary for complete and accurate layout and construction of the work. Regardless of the staking method, construction stakes shall be marked in such a manner that all construction personnel can easily identify the stake location, elevation, and other appropriate information. The coordinates of any new control points established by the contractor during the course of the work shall be given to the Engineer within five working days of control point establishment.

On surface treatment projects, and other projects without horizontal control, stakes indicating locations shall be placed every 500 feet, unless otherwise defined in the Special Provisions. Locations may be painted on the pavement in place of staking when approved by the Engineer.

If errors are discovered during the verification process, and control points do not agree with the geometrics shown in the plans, the contractor shall promptly notify the Engineer in writing, and explain the problem in detail. The Engineer will advise the contractor within five working days of any corrective actions which may be deemed necessary.

Directed changes to the work shall be reimbursed under Subsection 925-5 and additional contract time may be considered for any delays.

The contractor shall be responsible for the proper layout and accuracy of all property markers which are required by the project plans.

Structure sites shall be accurately profiled and cross-sectioned, and structure control points shall be set and checked to assure the proper construction or installation of each structure. Profiles shall be approved by the Engineer prior to constructing or installing each structure. All profile survey data shall be entered in field books, or electronic reports satisfactory to the Engineer and preserved as a permanent project record.

The contractor shall exercise care in the preservation of stakes, references and bench marks and shall reset them when any are damaged, lost, displaced or removed.

On all projects, the centerline layout for the final surface course shall be established by instrument survey by the contractor and shall serve as marks for permanent traffic centerline striping. On projects requiring contractor striping, the contractor shall set points at intervals of not greater than 50 feet for each traffic lane at the beginning and ending of each yellow stripe, and at the beginning and ending of gores and tapers.

The contractor shall also provide control points on the roadway, satisfactory to the Engineer, corresponding to the locations of all transition points for all lines of striping, including the beginnings, ends, breaks, and changes in the striping, including all tapers in the striping, and pavement edges when necessary to establish striping.

A minimum of two weeks prior to any paving activities, the contractor, the contractor's surveyors, the pavement marking subcontractor, and the Engineer shall meet to discuss the survey control for the applications of all temporary detour and permanent striping. At this meeting the contractor shall provide a written plan, satisfactory to the Engineer, to provide survey control and layout of the temporary detour and permanent striping in a timely manner.

On projects that include no-passing zones, the contractor shall also coordinate the survey layout of such zones with the ADOT No Passing Zone Crew. The contractor shall contact the ADOT No Passing Zone Crew at the phone number provided on the project plans at least five working days before placement of the related pavement marking.

On projects where traffic is being carried through the work zone, pavements shall be marked for traffic centerline delineation before the end of each work shift. Temporary pavement markings shall conform with the requirements set forth under Subsection 701-3.05 of these specifications and any subsequent modifications thereto.

Any discrepancies in grade, alignment, earthwork quantities, locations or dimensions detected by the contractor shall immediately be brought to the attention of the Engineer. No changes in the project plans will be allowed without the approval of the Engineer. Requests for verification of earthwork quantities shall be in accordance with Subsection 203-2.01.

The Department reserves the right to make inspections and random checks of any portion of the staking and layout work. If, in the Engineer's opinion, the work is not being performed in a manner that will assure proper controls and accuracy, the Engineer will order any or all of the staking and layout work redone at no additional cost to the Department.

If any portion of the contractor's staking and layout work is ordered redone, resulting in additional rechecking by the Department, the Department shall be reimbursed for all costs for such additional checking. The amount of such costs will be deducted from the contractor's monthly estimate.

Inspection of the contractor's layout by the Engineer and the acceptance of all or any part of it shall not relieve the contractor of its responsibility to secure the proper dimensions, grades and elevations.

925-3.02 Resetting Monuments:

(A) General:

The contractor shall be responsible to maintain all existing monumentation, including section line and roadway monumentation. Monumentation disturbed during construction shall be re-established by the contractor, and recorded at the appropriate county recorder's office, at no additional cost to the Department.

(B) Monumentation Standards:

Section corner, quarter corner, and property corner monuments shall be re-established following the procedures in the Manual of Surveying Instructions 2009, published by the U.S. Department of the Interior, Bureau of Land Management, and all applicable statutes and requirements specified in the current Arizona State Board of Technical Registration's "Arizona Boundary Survey Minimum Standards."

(C) Procedures:

Section line and roadway monumentation re-established by the contractor shall bear the registration number of the Land Surveyor in responsible charge of the location.

Monuments used to define section lines shall be stamped in accordance with Manual of Surveying Instructions 2009, published by the Department of Interior, Bureau of Land Management. Roadway monumentation shall be stamped in accordance with the requirements of the appropriate municipal jurisdiction. Right-of-way monuments shall be stamped in accordance with the ADOT Right-of-Way Standards.

Monuments that are re-established shall be recorded at the appropriate county recorder's office, and a copy of the Corner Recordation documentation shall be submitted to the Engineer within five working days of recordation.

925-3.03 Office Survey Work:

The contractor shall be compensated for office work associated with project survey under the following circumstances:

(A) When the project plans fail to provide sufficient information to lay out the project or any part thereof.

(B) When the contractor performs office survey work based on erroneous plans information which results in the duplication of work.

(C) If the Department should change any plans information for which the contractor has already performed office work which results in the duplication of that work.

The contractor shall not be due compensation for any office survey work that includes the following:

(A) When information provided in the plans is sufficiently complete and accurate to allow additional information necessary for the complete layout of the project to be routinely calculated.

(B) When the contractor fails to inform the Engineer of discovered plan errors prior to the performance of extra office survey work.

The contractor shall inform the Engineer in a timely manner of any omissions, ambiguities, or errors which the contractor feels may result in extra office survey work, so as not to delay the project or create unnecessary calculations.

All office survey work shall be documented by the contractor and verified by the Engineer for compensation. Documentation shall consist of at least a detailed office diary specifically addressing the work involved in the alleged problem area. The contractor may be required to provide the calculations, charts, graphs, drawings, or other physical evidence which verifies the extra work.

925-3.04 Survey Manager:

The contractor shall be compensated for a survey manager when deemed necessary for extra work ordered by the Engineer. The use of a survey manager, along with all survey manager duties required as a result of the additional work, must be authorized in advance by the Engineer. The survey manager shall be a Registered Land Surveyor in the State of Arizona.

925-4 Method of Measurement:

Construction surveying and layout will be measured on a lump sum basis.

One-, two-, and three- person survey parties, survey managers, and office survey technicians will be measured by the hour to the nearest half hour.

925-5 Basis of Payment:

Payment for construction surveying and layout will be made at the contract lump sum price and will be made as follows:

The approved schedule showing the sequencing and percentage of the survey and layout work, as submitted under Subsection 925-3.01, shall be the basis on which monthly progress payments shall be made. This schedule shall be subject to periodic review, at the request of the contractor or the Department, if the survey and layout work lags or accelerates. If necessary the schedule will be revised to reflect changes in survey and layout progress. When approved by the Engineer, the revised schedule will become the basis of payment.

If additional staking and layout are required as a result of additional work ordered by the Engineer, such work will be paid under items listed in the table below.

Item	Predetermined Rate
9250101 - One-Person Survey Party	$110 per hour
9250102 - Two-Person Survey Party	$150 per hour
9250103 - Three-Person Survey Party	$190 per hour
9250106 - Survey Manager	$175 per hour
9250105 – Office Survey Technician	$85 per hour

Payment will be made at the respective predetermined unit prices listed in the table above. No additional payment will be made for overtime hours. Should such additional work require the contractor to pay travel and subsistence costs for the survey party or survey parties utilized, payment for travel and subsistence will be made under the provisions of Subsection 109.04, except that no mark-up will be allowed for profit and overhead. The Engineer will determine whether the additional work shall be performed by the contractor or by Department forces.

The amount per hour for a one-person, two-person, or three-person survey party includes the cost of all work necessary to complete the extra work.

Traffic control and flagging, including any necessary because of the additional staking and layout required as a result of extra work ordered by the Engineer, or additional work resulting from contract expansion and ordered by the Engineer, shall conform to the requirements of Section-701, Maintenance and Protection of Traffic, and will be measured and paid under the respective contract items.

No payment will be made for the resetting of stakes, references, bench marks, and other survey control unless directed by the Engineer.

The amount per hour for a survey manager and an office survey technician shall include all necessary office supplies and equipment.

Unless otherwise directed by the Engineer, requests for payment for additional survey work performed shall be submitted prior to the end of the monthly estimate billing period during which the work is performed.

925-6 Right of Way Monumentation - General:

The R/W Monumentation Survey process shall commence at the earliest of the following 2 occasions: a) at such time when the final R/W monuments can be safely set, or b) at least 2 months prior to the end of all construction. After notification, the R/W Consultant will be tasked with performing the Final R/W Monumentation Survey. The R/W Consultant will also locate/tie-in any sectional corner monuments that were replaced by the Construction Contractor, In cases where the R/W Consultant had previously located the sectional corner monument prior to construction, and if the sectional corner monument set by the Construction Contractor was set within positional tolerance, but was not punched/stamped by the Construction Contractor, the R/W Consultant shall punch/stamp the monument as required.

925-6.01 Positional Tolerance:

Any sectional monuments that are set by the Construction Contractor that are determined by the R/W Consultant to be out of tolerance, as compared to the position of the prior monument, will be reset by the Construction Contractor. A section corner monument set by the Construction Contractor shall be considered out of tolerance if a punch mark identifying the actual location of the corner cannot be placed on the cap.

925-6.02 Drivable Monument Requirements and Specifications - Highway R/W monuments:

Near the end of the construction phase, the R/W Consultant shall set an acceptable drivable type monument (refer to diagrams A-1 & A-2) for the final R/W monument at locations. The body of the final monument that will typically be set by the R/W On-Call Consultant will be magnetically detectable, have a diameter of one-half inch to 1 inch, and a minimum length of 24 inches. A three-inch aluminum or brass cap will be attached to and placed over the top of the body of the monument. The top of the cap can be flat or domed. The informational items that shall be stamped into the cap are:

a) The R/W Consultant registrant's license number
b) The year (four digits)
c) The words "ADOT ROW"
d) The full R/W project (TRACS) number (i.e. 260 GI 272 H4472)
e) The reference Station as shown on the R/W plans (i.e. 105+58.73)
I) The point number — as assigned by the R/W Consultant and shown on the R/VV Monumentation Survey
g) A circular punch mark at the actual point location (do not use a triangle or plus/cross symbol)

The lettering size will be 3/16ths of an inch high. Refer to diagram A-2 for the positioning of each text item. When ordering the caps for each project, the R/W Consultant shall have as many of the items as possible pre-stamped into the cap by the manufacturer, with the exception of the punch mark.

In loose soil conditions, the body of the monument shall be 36 inches in length and/or concrete will be poured around the body of the monument to stabilize it. If the location of the monument is in bedrock or similar substance, then a hole will be drilled into the bedrock so that magnetic material can be placed under the cap, and the cap will be fastened with epoxy glue.

In urban areas the top of the monument will typically be set flush to the ground surface or approximately one-tenth of a foot below the ground surface, depending on circumstances. In rural areas the top of the monument will typically be set flush with the ground surface to one-tenth of a foot above the ground surface.

925-6.03 Witness Posts — Highway R/W Monuments:

After the R/W Consultant sets the final R/W monument, a witness post shall also be typically set next to the monument. The witness post will be of a durable fiberglass construction, such as carsonite. The post will be 2-1/2 inches wide, and a minimum of 5 feet in length. The post will be driven in to the ground to a depth of at least 18 inches, and shall leave a minimum height of 3 feet above the surface. Where extra stability is needed, an anchor kit will also be utilized in the installation of the witness post. Whenever possible, the witness post will be set on the right of way line at a distance of 1 foot from the monument, in the direction of increasing station from the monument. Refer to diagram A-1.

The witness post shall be brown in color. A decal will be attached to the face of the post at the top end. The decal will face the highway. The decal shall have a white background with black lettering. The decal should be UV resistant whenever possible. The size of the decal will be approximately 2-3/8 inches wide and 8-1/2 inches long. Refer to diagram A-1 for decal text.

In urban areas, the witness post will not typically be set for each point, unless otherwise directed by the Department.

925-6.04 Use of Witness Corners and Reference Marker Monuments - Highway R/W monuments:

If the R/W corner position falls in a location that is deemed un-settable for physical or other reasons, the R/W On-Call Consultant will first try to set a witness corner monument on the right of way line, as close as is practicable to the actual corner. If setting a witness corner is impractical, the R/W Consultant will set 2 reference marker monuments at convenient locations in the vicinity of the actual corner, within the ADOT right of way. The reference monuments can be set in one of the two following manners: a) approximately at 45 degree angles from the actual corner location, as measured from the right of way line(s), or b) set perpendicular on a straight line as referenced to the centerline of the highway, opposite the actual corner location - i.e. a 5 foot and 10 foot offset at the same station as the corner being referenced. When practicable, the witness corners and reference monuments will be set to a whole foot distance from the R/W corner position. Refer to diagram A-3.

If a witness corner is set, the stamping on the cap will also include three additional items to the items listed in Section 925-6.03, 1) the letters “WC", 2) an arrow pointing in the direction of the actual corner, and 3) the distance from the witness corner to the actual corner. Station information in this situation shall not be included on the cap. Refer to diagram A-3.

If reference monuments are set, the stamping on the cap will also include three additional items to the items listed in Section 925-6.03, 1) the letters “RM”, 2) an arrow pointing in the direction of the actual corner, and 3) the distance from the reference monument to the actual corner. Station information in this situation shall not be included en the cap. Refer to diagram A-3.

If in the R/W Consultant’s judgment and as agreed upon by the R/W Plans Section, it is not viable to set either a witness corner or reference monuments for a right of way corner location, an alternative type of permanent monument such as a MAG nail and washer with the R/W Consultant registrant's license number and firm name shall be set.

925-6.05 Drivable Monument Requirements and Specifications — Permanent easement monuments:

Near the end of the construction phase, the R/W Consultant will set an acceptable drivable type monument (refer to diagram A-4) for the final monument at permanent easement locations. The body of the final monument that will typically be set by the R/W On-Call Consultant will be magnetically detectable, have a diameter of one-half inch to 1 inch, and a minimum length of 18 inches. A two-inch aluminum or brass cap will be attached to and placed oVer the top of the body of the monument. The top of the cap can be flat or domed. The informational items that shall be stamped into the cap are:

a) The R/W On-Call registrant's license number
b) The year (four digits)
c) The words "ADOT ROW"
d) The R/W project (TRACS) identifier number (i.e. H4472)
e) The reference Station as shown on the R/W plans (i.e. 128+59.50)
f) The designation of the type of permanent easement, such as “DE" or ”SE”
g) The point number - as assigned by the R/W Consultant and shown on the R/W Monumentation Survey
h) A circular punch mark at the actual point location (do not use a triangle or plus/cross symbol)

The lettering size will be 3/16ths of an inch high. Refer to diagram A-5 for the positioning of each text item. When ordering the caps for each project, the R/W Consultant shall have as many of the items as possible pre-stamped into the cap by the manufacturer, with the exception of the punch mark.

In loose soil conditions, the body of the monument shall be 24 to 36 inches in length and/or concrete will be poured around the body of the monument to stabilize it. If the location of the monument is in bedrock or similar substance, then a hole will be drilled into the bedrock so that magnetic material can be placed under the cap, and the cap will be fastened with epoxy glue.

In urban areas the top of the monument will typically be set flush to the ground surface or approximately one-tenth of a foot below the ground surface, depending on circumstances. In rural areas the top of the monument will typically be set flush with the ground surface to one-tenth of a foot above the ground surface.

925-6.06 Witness Posts - Permanent easement monuments:

After the R/W Consultant sets the final permanent easement monument, a witness post shall also be typically set next to the monument. The witness post will be of a durable fiberglass construction, such as carsonite. The post will be 2-1/2 inches wide, and a minimum of 5 feet in length. The post will be driven in to the ground to a depth of at least 18 inches, and shall leave a minimum height of 3 feet above the surface. Where extra stability is needed, an anchor kit will also be utilized in the installation of the witness post. Whenever possible, the witness post will be set at a 45-degree angle from the monument, inside the easement, several tenths of a foot from the monument. Refer to diagram A-4.

The witness post shall be white in color. A decal will be attached to the face of the post at the top end. The decal will face toward the inside of the permanent easement. The decal shall have a white background with black lettering. The decal should be UV resistant whenever possible. The size of the decal will be approximately 2-3/8 inches wide and 8-1/2 inches long. Refer to diagram A-4 for decal text.

In urban areas the witness post may not be set for each point, if the post will cause a hazarcl to the property where the permanent easement lies upon or to the public.

925-6.07 Use of Witness Corners and Reference Marker Monuments - Permanent easement monuments:

If the permanent easement corner position falls in a location that is deemed un-settable for physical or other reasons, the RM Consultant will first try to set a witness corner monument on the easement line, as close as is practicable to the actual corner. If setting a witness corner is impractical, the R/W Consultant will set 2 reference marker monuments at convenient locations in the vicinity of the actual corner, inside the ADOT easement. The reference monuments will be set in the following manner: a) approximately at 45 degree angles from the actual corner location, as measured from the permanent easement line(s). When practicable, the witness corners and reference monuments will be set to a whole foot distance from the permanent easement corner position. General reference is made to diagram A-3.

If a witness corner is set, the stamping on the cap will also include three additional items to the items listed in Section 925-6.05, 1) the letters "WC", 2) an arrow pointing in the direction of the actual corner, and 3) the distance from the witness corner to the actual corner. Station information in this situation shall not be included on the cap. General reference is made to diagram A-3.

If reference monuments are set, the stamping on the cap will also include three additional items to the items listed in Section 9245-6.05, 1) the letters “RM", 2) an arrow pointing in the direction of the actual corner, and 3) the distance from the reference monument to the actual corner. Station information in this situation shall not be included on the cap. General reference is made to diagram A-3.

If in the R/W Consultant’s judgment and as agreed upon by the R/W Plans Section, it is not viable to set either a witness corner or reference monuments for a permanent easement corner location, an alternative type of permanent monument such as a MAG nail and washer with the R/W Consultant registrant's license number and firm name shall be set.

925-6.08 Discovery of Existing Right of Way Monuments:

When the R/W Consultant is setting new monuments along the existing right of way line, a situation may be encountered where an existing monument is in the general vicinity of the calculated corner position. The existing monument may be an ADOT type monument, or a private monument. In this situation, the R/W Plans Section and the registrant will decide if a new monument will be set or not, with the stipulation that a new monument shall not be set any closer than one foot from an existing monument, and that a new monument shall be set if the calculated position is greater than three feet from the existing monument. In no situation shall the Consultant remove or otherwise alter the existing monument, unless approval or direction is given by the R/W Plans Section. An exception to this is if the existing monument is within positional tolerance as defined by the current Arizona Boundary Survey Minimum Standards, and, the existing monument has no identification and/or pedigree, the registrant has the option of either affixing his registration number to the monument, or refurbishing it with a new ADOT right of way drivable monument as described above.

When the R/W Consultant is setting new monuments along the new right of way line, the situation may be encountered where an existing monument is in close proximity of the calculated corner position and that it can be determined that the existing monument was intended to have been set for the legal corner position. The existing monument will typically be a private monument, If the existing monument is within positional tolerance as defined by the current Arizona Boundary Survey Minimum Standards, the R/W Consultant will accept the existing monument. If the existing monument has no identification and/or pedigree, the registrant has the option of either attaching his registration number to the monument, or refurbishing it with a new ADOT right of way drivable monument as described above. If the existing monument is out of positional tolerance, the registrant will refer to the instructions in the preceding paragraph.

SECTION 929 MECHANICALLY STABILIZED EARTH (MSE) WALLS:

929-1 Description:

929-1.01 General:

The work under this section consists of designing, furnishing all materials and constructing Mechanically Stabilized Earth (MSE) retaining walls in accordance with these specifications and in compliance with the lines and grades, dimensions and details shown on the project plans and the working drawings and design provided by the Wall Manufacturer and Wall Designer.

The Developer shall provide the MSE wall designer with a complete set of project plans and specifications and shall ensure that the wall design is compatible with all other project features that can impact the design and construction of the wall. The following terms are used in this specification for identification of various entities for which the Developer shall be fully responsible:

ADOT Materials Policy and Procedure Directive No. 24, “Requirements for the Approval of Mechanically Stabilized Earth (MSE) Wall Systems”, shall be used in conjunction with the requirements of the specifications.

Term	Entity
Wall Manufacturer	The entity contractually retained by the Developer to provide materials and construction services for an accepted MSE wall system as identified in Subsection 929-1.03.
Wall Designer	The entity contractually retained by the Developer to provide design of an accepted MSE wall system as identified in Subsection

929-1.03. The wall designer may be a representative of the wall manufacturer.

929-1.02 Certifications:

(A) Certification of Review of Geotechnical Report(s):

The Wall Manufacturer and Wall Designer shall be responsible to review all available geotechnical investigation reports.

(B) Certification of Design Parameters:

See Subsection 929-2.01 herein specified.

(C) Certification of Materials:

See Subsections 929-3.04, 929-3.07 and 929-3.10 herein specified.

929-1.03 Accepted Systems:

The Developer shall select one of the appropriate ADOT pre-approved earth retaining systems to be constructed for the MSE walls designated on the plans.

Pre-approved systems are listed under category “Proprietary Retaining Walls” in the Approved Products List (APL). Copies of the most current version of the APL are available on the Internet from the ADOT Research Center, through its Product Evaluation Program.

The features of the system furnished, including design and configuration of precast elements, fasteners, connections, soil reinforcements, joint fillers, geotextile filter and other necessary components, shall be those that have been pre-approved.

The height and length to be used for any system shall be that which will effectively retain the earth behind the wall for the loading conditions and the contours, profile, or slope lines shown on the plans, or on the approved working drawings, and in accordance with all relevant internal and external stability design criteria.

929-1.04 Manufacturer’s Field Representative:

The manufacturer’s field representative performing the work described in this specification shall have, in the past three years, successfully installed at least four MSE retaining walls of heights, lengths and complexity similar to those shown on the plans and meeting the tolerances specified herein. The manufacturer’s field representative may make field changes in coordination with IQF and the Developer’s Geotechnical Engineer. Any such changes shall be documented in writing within 24 hours of the approved changes. This written document shall be sealed by the manufacturer’s design engineer, who is registered as a Civil Engineer in the State of Arizona.

929-1.05 MSE Pre-Activity Meeting:

A pre-activity meeting will be scheduled prior to commencement of MSE wall construction activity. As a minimum, this meeting shall be attended by the Inspector, Developer (including wall construction crew chiefs), MSE Wall Manufacturer's and MSE Wall Designer's representatives. No wall construction activity shall be performed until the Developer's final submittals have been approved as having satisfactorily resolved all review comments and the pre-activity meeting has been held.

929-1.06 Wall Aesthetics:

Wall aesthetics shall be as specified in the project plans and these specifications.

929-2 Submittals (Working Drawings and Design):

929-2.01 Submittals:

The submittals required shall include working drawings, construction procedures, supporting design calculations, verification of experience, and a transmittal letter. The transmittal letter shall only list the documents included in the submittal. No technical information shall be included in the transmittal letter.

Working drawings and calculations shall be sealed by an engineer, who is registered as a Civil Engineer in the State of Arizona. The MSE Wall Design/Manufacturer shall document on the working drawings all design parameters and assumptions made in the design. The following statement shall be included near the P.E. seal on the first sheet of the working drawings: "All design parameters and assumptions are validated through notes or details on these drawings".

Working drawings, design calculations, and MSE supplier's construction procedures modified for site-specific conditions shall be submitted to the Engineer for review.

Construction of the wall shall not commence until the complete wall package (drawings, calculations, and construction procedures) has been properly submitted in accordance with the Technical Provisions section CR 455.3.2. Fabrication of any of the wall components before this time shall be at the sole risk of the Developer.

929-2.02 Working Drawings:

The Developer shall submit complete working drawings and specifications for each installation of the system.

Working drawings shall include the following at a minimum:

(1) Layout of the wall including plan and elevation views;

(2) All design parameters and assumptions including design life;

(3) Existing ground elevations and utilities impacted by the wall that have been field verified by the Developer for each location;

(4) Complete details of all elements and component parts required for the proper construction of the system at each location and any required accommodations for drainage systems, foundation subgrades or other facilities shown on the contract documents;

(5) The working drawing submittal shall clearly detail any special design requirements. These special design requirements may include, but are not limited to; structural frames to place reinforcements around obstructions such as deep foundations and storm drain crossings, drainage systems, placement sequence of drainage and unit core fill with respect to reinforced (structure) fill behind a wall face using modular block facing units, guardrail post installation, scour protection, foundation subgrade modification, all corner details (acute, obtuse and 90 degrees), slip joints, connection details of MSE walls with other cast-in-place structures, wedges, shims and other devices such as clamps and bracing to establish and maintain vertical and horizontal wall facing alignments;

(6) A complete listing of components and materials specifications; and

(7) Other site-specific or project specific information required by the contract.

929-2.03 MSE Wall Design:

(A) General:

The working drawings shall be supplemented with all design calculations for the particular installation as required herein. Installations that deviate from the pre-approved design shall be accompanied by supporting stability (internal, external, and global/overall and/or compound) calculations of the proposed structure as well as supporting calculations for all special details not contained in the pre-approved design. The MSE wall designer/supplier shall note all deviations of the proposed wall design from the pre-approved design. The Developer's Engineer will review and evaluate the information submitted, and determine if additional testing will be required for acceptance of the proposed deviations.

The proposed design shall satisfy the design parameters shown on the project plans and listed in these specifications, and comply with the design requirements of the following documents:

- FHWA (2009), “Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes; Publication No. FHWA-NHI-10-024 and FHWA-NHI-10-025; Authors: Berg, R. R., Christopher, B. R., and Samtani, N. C.

- AASHTO (2012), “AASHTO LRFD Bridge Design Specifications”, 6th Edition, including latest Interims.

All references made to AASHTO (2012) herein shall mean “AASHTO LRFD Bridge Design Specifications”, 6th Edition, including latest Interims.

Maximum reinforcement loads shall be calculated using the “Simplified Method” as presented in AASHTO (2012) and as per the requirements specified herein. No other design method will be allowed.

Sample analyses and hand-calculations shall be submitted to verify the output from software used by the MSE wall designer. Sample analyses and hand calculations shall be required for complex walls having geometries and loading conditions that are not readily amenable to computer analysis. Failure modes, including circular, non-circular, and multi-part wedge, shall be analyzed for deep-seated global stability and compound stability to verify the most critical failure case.

Unless otherwise specified in the contract, all structures shall be designed to conform to the requirements shown in Table 929-1 and other requirements specified herein.

TABLE 929-1
DESIGN PARAMETERS

Description	Limit State	Value	Note
1. Design Life	All limit states	75 Years	
2. Effective (Drained) Friction Angle			
a. Retained Backfill	All limit states	32° min	11
b. Reinforced Backfill	All limit states	34° to max 40°	1
3. Length of soil reinforcement, B	All limit states	0.7H min or 8-ft whichever is more	2,11
4. Limiting eccentricity	Strength (all)	B/4 (soil), 3/8B (rock)	
	Service I	B/6 (soil), B/4 (rock)	
5. Coefficient of Sliding Friction	Strength (all)	$\tan[\min(\phi_r, \phi_f, \phi_i)]$	3
6. Resistance factors			
a. Sliding	Strength (all)	1.0	4
b. Bearing	Strength (all)	0.65	5
c. Overall (slope) stability			
I. Deep Seated Stability	Service I	0.65	6
II. Compound Stability	Service I	0.65	6
d. Pullout resistance			
I. Static	Strength (all)	0.90	7
II. Combined static/earthquake	Strength (all)	1.20	7

e. Tensile resistance of metallic reinforcements and connectors			
I. Static - Strip reinforcement - Grid reinforcement	 Strength (all) Strength (all)	 0.75 0.65	 8 8,9
II. Combined static/earthquake - Strip reinforcement - Grid reinforcement	 Strength (all) Strength (all)	 1.00 0.85	 8 8,9
f. Tensile resistance of geosynthetic reinforcements and connectors			
I. Static	Strength (all)	0.90	
II. Combined static/earthquake	Strength (all)	1.20	

Notes:

1	A minimum friction angle of 34 degrees shall be substantiated by laboratory tests discussed in Subsection 929-3.05(D). If the measured friction angle in laboratory tests as per Subsection 929-3.05(D) is greater than 40-degrees then the friction angle in the analysis shall be limited to 40-degrees.
2	H is the design height of the wall and is defined as the difference in elevation between from the finished grade at top of wall and the top of leveling pad. The top of the leveling pad shall always be below the minimum embedment reference line as indicated on the plans for that location. The length of the soil reinforcement, B, is measured from the backface of the wall facing unit. In case of grid type reinforcements the length of the soil reinforcement is measured from the backface of the wall to the last full transverse member. For modular block facing units, the total length of the reinforcement, BT, as measured from the front face of the wall is the length B as defined above plus the width of the modular block unit (the horizontal dimension of the block unit measured perpendicular to the wall face). Depending on the configuration of the reinforcements and properties of the various actual fills selected by the Developer, the minimum length of the reinforcement may need to be increased to satisfy the required resistance factors for deep-seated global stability and compound stability analyses.
3	ϕ_r= friction angle of reinforced wall fill. ϕ_f = friction angle of foundation soil. ϕ_I = friction angle of the interface between reinforcement and soil for cases of sheet reinforcement such as geotextiles. All friction angles are effective (drained) friction angles. Refer to Geotechnical Report for friction angle of foundation soil.
4	Passive resistance shall not be considered in evaluation of sliding resistance.
5	For all limit states, the design loading for the MSE retaining wall system shall not exceed the factored general and local bearing resistances specified in the Geotechnical Report(s).

6	For earthquake loading condition, a resistance factor of 0.90 shall be used. A resistance factor of 0.65 (equivalent factor of safety, FS=1.5) shall be satisfied for permanent (final configuration) condition of the MSE wall with minimum embedment. The consideration of depth of embedment is applicable only for deep-seated global and compound stability analyses. For all other internal and external stability evaluations of MSE walls, the depth of embedment shall not be considered.
7	Live load due to vehicular traffic shall be included in the computations to determine the maximum tensile forces in reinforcement layers, but shall be neglected in the computations for pullout resistance. Intensity of live load shall be considered as a uniform surcharge using the equivalent height of soil in accordance with Article 3.11.6.4 of AASHTO (2012).

8	Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with Article 6.8.3 of AASHTO (2012) and apply to net section less sacrificial area.
9	Applies to grid reinforcements connected to a rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.
10	Unless otherwise specified, all resistance factors shall be taken as 1.0 when investigating an extreme event limit state.
11	Applicable Geotechnical Reports shall be reviewed for Design Parameters that may exceed these minimums. The Geotechnical Reports govern in the event of a conflict.

For metal bar mat and welded wire grid (mesh type) reinforcement MSE walls:

1. The ka multiplier for the Simplified Method shall be determined based on the kr/ka ratio line for “Metal Bar Mats & Welded Wire Grids” as shown in Figure 4-10 of FHWA (2009) or Figure 11.10.6.2.1-3 of AASHTO (2012) for assessment of both reinforcement pullout and reinforcement rupture.
2. Except for localized facing elements such as slip joint facing units and corner facing units, metal bar mat and welded wire grid reinforcement configuration shall include a minimum of three longitudinal wires. A corner is defined as the portion of the wall that extends from the corner point of intersection of two wall faces to the location where the ends of the reinforcements that can be placed without encountering either face of the wall that forms the corner point.
3. The reduced diameter of both longitudinal and transverse wires after corrosion losses shall be used for internal (pullout and tensile breakage) and compound stability analysis.
4. The center to center spacing between longitudinal wires shall not exceed six inches.
5. The center-to-center spacing between transverse wires shall not be less than SOPT as defined in Table 3-6 of FHWA (2009).
6. All internal stability analysis shall be performed on a linear foot basis for a single five-foot wide panel. Use of two or more panel widths for internal stability analysis is not

permitted.

(B) Subsurface Drainage Systems:

Walls shall be provided with subsurface drainage measures as shown on the project plans and specifications. As a minimum, an underdrain system shall be provided for leading subsurface and surface water away from the backfill and outside the limits of the wall. Geocomposite drains, if used for subsurface drainage, shall be in accordance with Subsection 203-5.02 and 203-5.03(C) of the specifications.

(C) Obstructions in Backfill:

(1) General:

Where obstructions, such as deep foundations or storm drains crossings, are located in the reinforced backfill zone, cutting of reinforcements to avoid obstructions shall not be permitted. A minimum offset of one diameter but not less than three (3) feet shall be maintained between the face of any pipe crossings and the back face of retaining wall panels. A minimum clearance of three (3) feet shall be maintained between the face of any other obstruction and the back face of retaining wall panels unless MSE wall obstruction is included in the design of the wall.

(2) Horizontal Deflection of Reinforcements:

In the horizontal plane at a reinforcing level, a deviation up to fifteen (15) degrees from the normal to the face of the wall may be allowed for strip reinforcement and bolted connection. This deviation is herein referred to as the splay angle. Grid reinforcements may not be splayed, unless connection has been specifically fabricated to accommodate a splay and connection detail has been approved by the Department. If used, the splay in grid reinforcements is limited to five (5) degrees. For obstructions that cannot be accommodated with splayed reinforcement, structural frames and connections shall be required, and shall be designed in accordance with Section 10 (“Steel Structures”) of AASHTO (2012) for the maximum tension in the reinforcements. The structural frame design shall be such that bending moments are not generated in the soil reinforcement or the connection at the wall face. The design, along with supporting calculations, shall be included in the working drawings.

(3) Vertical Deflection of Reinforcements:

Vertical deflection of the reinforcement to avoid obstructions such as utilities along the wall face shall be limited to a maximum of 15 degrees from normal to face of wall. Bends in the reinforcement shall be smooth and gradual to ensure that galvanization remains intact.

(D) Hydrostatic Pressures:

For walls potentially subject to inundation, such as those located adjacent to rivers, canals, detention basins or retention basins, a minimum hydrostatic pressure equal to three (3) feet shall be applied at the high-water level for the design flood event. Effective unit weights shall be used in the calculations for internal and external stability beginning at levels just below the equivalent surface of the pressure head line. Where the wall is influenced by water fluctuations, the wall shall be designed for rapid drawdown conditions which could result in differential hydrostatic pressure greater than three (3) feet. As an alternative to designing for rapid drawdown conditions, Size 57 coarse aggregate, as specified in AASHTO M 43, shall be provided as reinforced backfill for the full length of the wall and to the maximum height of submergence of the wall. Separation geotextile, as specified in Subsection 1014-4.04(A), shall be provided at the interface of the Size 57 coarse aggregate and reinforced backfill above it, and at the interface of the retained backfill behind it. Adjoining sections of separation geotextile fabric shall be overlapped by a minimum of 12 inches.

(E) Acute Angle Corners:

When two intersecting walls form an enclosed angle of 70 degrees or less, the affected portion of the wall shall be designed for bin-type lateral pressures with at-rest earth pressure coefficients in accordance with AASHTO (2012) Article 11.10.1 for the extent of the wall where the full length of the reinforcement cannot be installed without encountering a wall face. Acute angle corner structures shall not be stand-alone separate structures and shall be connected to the MSE wall by extending reinforcement into the MSE wall behind the acute angle corner section. Computations shall be provided that demonstrate deformation compatibility between the acute angle corner structure and the rest of the MSE wall. Full-height vertical slip joints shall be provided at the acute angle corner and after the last column of panels where full length of the reinforcements can be placed. The soil reinforcement attached to the slip joints shall be oriented perpendicular to the slip joint panels and shall be the full design length. Special connection and compaction details shall be provided on the working drawings.

(F) Spacing of Metallic Reinforcement for Flexible Face Wall Systems:

For permanent walls, vertical and horizontal spacing of metallic reinforcements for flexible face (welded wire or similar) wall systems shall not exceed 18 inches. The stiffness of the facing and spacing of reinforcements shall be such that the maximum local deformation between soil reinforcement layers shall be limited to less than 1½ inches. Facing elements shall not yield in bending and tension.

For temporary walls, i.e., walls with less than 36 months service life, the Developer may adjust the stiffness of the facing and spacing of the reinforcements such that the local deformation between the reinforcement is within the elastic range in bending and tension, and the overall geometry meets the line and grade requirements for the temporary walls.

(G) Soil Reinforcement for Modular Block Wall (MBW) Systems:

The soil reinforcement lengths and percent coverage at a given reinforcement level shall be in accordance with the plans. All soil reinforcement shall be positively connected to the modular block facing units by a connection that is capable of resisting 100% of the maximum tension in the soil reinforcements at any level within the wall. Detailed documentation for connection strength shall be submitted as noted in Subsection 929-3.10. The vertical spacing of the soil reinforcement for walls with modular block facing units shall be as follows:

7. The first (bottom) layer of soil reinforcement shall be no further than 16 inches above the top of the leveling pad.

8. The last (top) layer of soil reinforcement shall be no further than 20 inches on the average below the top of the uppermost MBW unit.

9. The maximum vertical spacing between layers of adjacent soil reinforcement shall not exceed 32 inches. For walls deriving any part of their connection capacity by friction the maximum vertical spacing of the reinforcement should be limited to two times the block depth (front face to back face) to assure construction and long-term stability. The top row of reinforcement should be one-half the vertical spacing.

(H) Initial Batter of Wall:

The initial batter of the wall, both during construction and upon completion, shall be within the vertical and horizontal alignment tolerances included in this specification. The initial batter of the wall at the start of construction and the means and methods necessary to achieve the batter shall be provided on the working drawings or the Wall Manufacturer's Construction and Quality Control Manual. The initial batter may be modified at the start of construction by the manufacturer's field representative based on the evaluation of the backfill material selected by the Developer. Any such changes shall be documented in writing within 24 hours of the approved changes. This written document shall be sealed by the manufacturer's design engineer who is registered as a Civil Engineer in the State of Arizona. Details of the wedges or shims or other devices, such as clamps and external bracing used to achieve or maintain the wall batter, shall be as shown on the working drawings and/or the Wall Manufacturer's Construction and Quality Control Manual. Permanent shims shall comply with the design life criteria, and shall maintain the design stress levels required for the walls.

(I) Slip Joints:

For walls with rigid precast concrete panels, vertical slip joints shall be included in the wall face and shown on the approved working drawings. Slip joints are defined as independent precast concrete elements that provide for additional displacements and rotations over a typical vertical joint between panels. Independent corner elements are considered slip joints. The vertical slip joints shall be applied at the following locations:

1. Boundaries of limits where differential settlement exceeds 1/100.

2. All locations where level pad elevations between adjacent panels changes by more than 5 feet.

3. All corners within an MSE wall.

4. Each side of a stiff element under the wall such as a reinforced concrete box culvert (RCBC) or another large cast-in-place structure.

The soil reinforcements attached to the slip joints shall be oriented perpendicular to the slip joint panels and shall be the full design length. Special connection and compaction details shall be provided on the working drawings.

(J) Walls Constructed on Fill:

For walls constructed on embankment fill, material in front of the wall shall be placed and compacted to its final configuration before the wall is constructed to 50 percent of its final height.

929-3 Material Requirements:

929-3.01 Precast Concrete Elements:

Precast concrete elements shall conform to the requirements for precast minor structures in Sections 601 and 1006. The concrete shall be Class S with minimum design strength of 4,000 pounds per square inch. The mix design shall conform to the requirements of Subsection 1006-3.

Prior to casting, all embedded components shall be set in place to the dimensions and tolerances designated in the plans and specifications. Rustication for wall aesthetics shall be in accordance with project plans, specifications, and applicable requirements of Sections 601, 610, 1002 and 1006.

(A) Concrete Testing and Inspection:

Precast concrete elements shall be subjected to compressive strength testing in accordance with Subsection 1006-7.05, and inspected for dimensional tolerances and surface conditions in accordance with Subsections 601-3.05 and 601-4.02 respectively. Panels delivered to the site without the Independent Quality Firm acceptance stamp will be rejected.

(B) Casting:

Precast concrete face panels shall be cast on a horizontal surface with the front face of the panel at the bottom of the form. Connection hardware shall be set in the rear face. The concrete in each precast concrete panel shall be placed without interruption and shall be consolidated by deploying an approved vibrator, supplemented by such hand tamping as may be necessary to force the concrete into the corner of the forms, and to eliminate the formation of stone pockets or cleavage planes. Form release agents as specified in Subsection 601-3.02(C)(1) shall be used on all form faces for all casting operations.

The Developer shall advise the Independent Quality Firm of the starting date for concrete panel casting at least 14 calendar days prior to beginning the operation if the casting operation is within the State of Arizona, or 21 calendar days if the casting operation is outside the State of Arizona.

(C) Finish:

(1) Non-Exposed Surfaces:

Rear faces of precast concrete panels shall receive a Class I finish in accordance with Subsection 601-3.05.

(2) Exposed Surfaces:

The type of finish required on exposed surfaces shall be as shown in the plans.

(a) Exposed Aggregate Finish:

(1) Prior to placing concrete, a set retardant shall be applied to the casting forms in accordance with the manufacturer's instructions.

(2) After removal from the forms and after the concrete has set sufficiently to prevent its dislodging, the aggregate shall be exposed by a combination of brushing and washing with clear water. The depth of exposure shall be between ⅜ inch and ½ inch.

(3) An acrylic resin sealer consisting of 80 percent thinner and 20 percent acrylic solids by weight shall be applied to the exposed aggregate surface at a rate of one (1) gallon per 250 square feet.

(b) Concrete Panel Finish:

Concrete panel finish shall be in accordance with Subsection 601-3.05.

(D) Tolerances:

Precast concrete elements shall comply with Subsection 601-4.02(B)(1) and 601-4.02(B)(4). Connection device placement shall be within ± ⅜ inch of the dimensions shown on the working drawings. Panel squareness as determined by the difference between the two diagonals shall not exceed ½ inch.

(E) Identification and Markings:

The date of manufacture, the production lot number, and the piece mark shall be inscribed on a non-exposed surface of each element.

(F) Handling, Storage, and Shipping:

All panels shall be handled, stored, and shipped in such a manner to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported in firm blocking to protect panel connection devices and the exposed exterior finish. Storing and shipping shall be in accordance with the manufacturer's recommendations.

(G) Compressive Strength:

Precast concrete elements shall not be shipped or placed in the wall until a compressive strength of 3,400 pounds per square inch has been attained. The facing elements shall be cast on a flat and level area and shall be fully supported until a compressive strength of 1,000 pounds per square inch has been attained.

(H) Precast Concrete Panel Joints:

(1) General:

Where the wall wraps around an inside corner, a corner block panel shall be provided with flange extensions that will allow for differential movement without exposing the panel joints. The back face of vertical and horizontal joints shall be covered with geotextile filter. Joint filler, bearing pads, and geotextile filter shall be as recommended by the wall manufacturer and shall meet the requirements shown on the approved working drawings.

If required, as indicated on the plans, flexible open-cell polyurethane foam strips shall be used for filler for vertical joints between panels, and in horizontal joints where pads are used.

All joints between panels on the back side of the wall shall be covered with a geotextile meeting the requirements for filtration applications as specified by AASHTO M 288. The minimum width shall be one (1) foot.

(2) Bearing Pads:

All horizontal and diagonal joints between panels shall include bearing pads. Bearing pads shall meet or exceed the following material requirements:

- Preformed EPDM (Ethylene Propylene Diene Monomer) rubber pads conforming to ASTM D 2000 Grade 2, Type A, Class A with a minimum Durometer Hardness of 70.

- Preformed HDPE (High Density Polyethylene) pads with a minimum density of 0.946 grams per cubic centimeter in accordance with ASTM D 1505.

The stiffness (axial and lateral), size, and number of bearing pads shall be determined such that the final joint opening shall be ¾ ± 1/8 inch and shall be shown on the working drawings. The MSE wall designer shall submit substantiating calculations verifying the stiffness (axial and lateral), size, and number of bearing pads assuming, as a minimum, a vertical loading at a given joint equal to 2.5 times the weight of facing panels directly above that level. As part of the substantiating calculations, the MSE wall designer shall submit results of certified laboratory tests in the form of vertical load-vertical strain and vertical load-lateral strain curves for the specific bearing pads proposed by the MSE wall designer. The vertical load-vertical strain curve should extend beyond the first yield point of the proposed bearing pad.

929-3.02 Steel Components:

Steel components shall conform to the applicable requirements of Sections 605 and 1003.

(A) Galvanization:

Soil reinforcement steel shall be hot-dip galvanized in accordance with AASHTO M 111 (ASTM A-123). Connection hardware steel can be galvanized by hot-dipping or other means, provided the method satisfies the requirements of AASHTO M 111 (ASTM A-123). A minimum galvanization coating of 2.0 oz/ft^2 (605 g/m^2) or 3.4 mils (85 μm) thickness is required. Soil reinforcement steel shall be adequately supported while lifting and placing such that the galvanization remains intact. Steel members with damaged (peeled) galvanization shall be repaired according to ASTM A780-01 and as specified in approved working drawings.

(B) Metallic Reinforcing Strips and Tie Strips:

Reinforcing strips shall be hot-rolled from bars to the required shape and dimensions. The strips' physical and mechanical properties shall conform to the requirements of ASTM A-572, Grade 65 minimum.

Tie strips shall be shop fabricated of hot-rolled steel conforming to the requirements of ASTM A 1011, Grade 50 minimum. The minimum bending radius of the tie strips shall be ⅜ inch. Galvanization shall be applied after the strips are fabricated, inclusive of punch holes for bolts as shown on approved drawings.

(C) Metallic Reinforcing Mesh:

Reinforcing mesh shall be shop fabricated of cold-drawn steel wire conforming to the requirements of AASHTO M 32, and shall be welded into the finished mesh fabric in accordance with AASHTO M 55. Galvanization shall be applied after the mesh is fabricated. A minimum galvanization coating of 2.0 oz/ft^2 (605 g/m^2) or 3.4 mils (85 µm) thickness is required.

(D) Connector Pins:

Connector pins and mat bars shall be fabricated and connected to the soil reinforcement mats as shown in the approved working drawings. Connector bars shall be fabricated of cold drawn steel wire conforming to the requirements of AASHTO M 32.

(E) Welded Wire Fabric:

All welded wire fabric shall conform to the requirements of AASHTO M 32, AASHTO M 55, and the approved working drawings. Welded wire fabric shall be galvanized in conformance with the requirements of ASTM A-123.

(F) Fasteners:

Connection hardware shall conform to the requirements shown in the approved working drawings. Connection hardware shall be cast in the precast concrete panels such that all connectors are in alignment and able to transfer full and even load to the soil reinforcement. Once the reinforcement is connected to the panel, the amount of slack shall not exceed ⅛ inch between the connector and the reinforcement during field installation. Fasteners shall be galvanized and conform to the requirements of AASHTO M 164 or equivalent.

929-3.03 Geosynthetic Reinforcement:

Geosynthetic soil reinforcement shall be limited to geogrids manufactured from polypropylene or high density polyethylene. The geogrid shall be a regular network of integrally connected polymer tensile elements, with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil. Geogrid structure shall be dimensionally stable and able to retain its geometry under manufacture, transport, and installation.

The nominal long-term tensile design strength (T-AL) of specific geosynthetic material shall meet or exceed the creep and durability reduction factors required by the wall manufacturer, as well as those required by AASHTO (2012). The minimum installation damage reduction factor shall be 1.5.

929-3.04 Certificate of Analysis for Soil Reinforcements:

The Developer shall furnish the Independent Quality Firm with a Certificate of Analysis for all materials.

For geosynthetics, the Certificate of Analysis shall verify that the supplied geosynthetic is the type approved and as measured in full accordance with all test methods and standards specified herein. The manufacturer's certificate shall state that the furnished geosynthetic meets the requirements of the specifications, as evaluated by the manufacturer's quality control program. In case of dispute over validity of values, the Developer shall supply test data from an agency-approved laboratory to support the certified values submitted.

For metallic wall reinforcement, a mill test report containing the ultimate tensile strength for the soil reinforcement shall be included in the certification. For metallic wall reinforcement, a mill test report containing the galvanization coverage shall be included in the certification. For metallic mesh wall reinforcement, a mill test report containing the ultimate weld strength for the soil reinforcement shall be included in the certification.

929-3.05 Reinforced Backfill Material:

(A) General:

Reinforced backfill material shall be free of shale, organic matter, mica, gypsum, smectite, montmorillonite, or other soft poor durability particles. Portland Cement Concrete rubble may be used if it meets the select backfill requirements and is approved by the Wall Manufacturer and Wall Designer.

(B) Soundness:

The reinforced backfill material shall have a soundness loss of 30 percent or less when tested in accordance with AASHTO T 104 using a magnesium sulfate solution with a test duration of four cycles. Alternatively, the material shall have a soundness loss of 15 percent or less when tested in accordance with AASHTO T 104 using a sodium sulfate solution with a test duration of five cycles.

(C) Gradation and Plasticity Index:

Gradations will be determined by Arizona Test Method 201 and shall be in accordance with Table 929-2, unless otherwise specified. The reinforced backfill shall be well-graded in accordance with the Unified Soil Classification System (USCS) in ASTM D 2487. Furthermore, the reinforced backfill shall not be gap-graded.

Plasticity Index (PI), as determined in accordance with AASHTO T 90, shall not exceed six.

Table 929-2
BACKFILL GRADATION REQUIREMENTS

Sieve Size	Percent Passing
4 inch (See Note)	100
No. 40	0-60
No. 200	0-15

Note: Maximum particle size shall be limited to ¾ inch for geosynthetics and epoxy- or PVC-coated reinforcements unless the Developer provides tests that have evaluated the extent of construction damage anticipated for the specific fill material and reinforcement combination. Construction damage testing shall be performed in accordance with the requirements of Chapter 5 of Publication No. FHWA NHI-09-087, dated November 2009 ("Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes.")

(D) Internal Friction Angle Requirement:

The reinforced backfill material shall exhibit an effective (drained) angle of internal friction of not less than 35 degrees and as shown in the applicable Geotechnical Reports, as determined in accordance with AASHTO T 236.

The test shall be run on the portion finer than the No. 10 sieve. The sample shall be compacted at optimum moisture content to 95 percent of the maximum dry density, without rock correction, as determined in accordance with the requirements of Arizona Test Method 225. The sample shall be tested at the compacted condition without addition of water.

No direct shear testing will be required when 80 percent or more of the material is larger than ¾ inch.

(E) Electrochemical Requirements:

The reinforced backfill material shall meet the electrochemical requirements of Table 929-3 when metallic soil reinforcement is used and Table 929-4 when geosynthetic soil reinforcement is used. For all soil reinforcements, the organic content of backfill shall be equal to or less than one (1) percent, determined in accordance with AASHTO T-267.

Table 929-3
ELECTROCHEMICAL REQUIREMENTS FOR METALLIC REINFORCEMENTS

Characteristic	Requirement	Test Method
pH	5.0 to 10.0	AASHTO T-289
Resistivity, min. (See Note)	2,500 ohm-cm	AASHTO T-288
Chlorides, max.	100 ppm	ASTM D 4327
Sulfates, max.	200 ppm	ASTM D 4327
Note: Backfill material will be acceptable when the moving average of the last three tests for resistivity is at least 2,500 ohm-cm, and no single test is less than 2,400 ohm-cm. For resistivity values greater than 5,000 ohm-cm, the sulfate and chlorides tests are not required. For resistivity values greater than 3,000 ohms, use the alternate test procedure for AASHTO T-267 utilizing extended drying periods and back calculating the results to the entire backfill sample.		

Table 929-4
ELECTROCHEMICAL REQUIREMENTS FOR GEOSYNTHETIC REINFORCEMENTS

Base Polymer	Property	Requirement	Test Method

Polyolefin (PP and HDPE) (See Note)	pH	> 3.0	AASHTO T-289
Polyester	pH	> 3.0 and < 9.0	AASHTO T-289
Note: PP = Polypropylene HDPE = High Density Polyethylene			

For all soil reinforcements, the organic content of backfill material shall be equal to or less than 1% by weight as determined by the following:

1. Visually inspect sample retained on #10 sieve for organic matter, the sample fails if organic matter is found.
2. Constant mass will be determined after drying the entire sample a minimum of 24 hours at 110 ± 5 ºC (230 ± 9 ºF).
3. Determine Mass of entire sample.
4. Determine mass of Minus #10 Fraction.
5. Perform AASHTO T-267 to obtain %OC of - #10 Material. Perform new calculation to determine %OC in entire backfill material. %OC of - #10 = T-267 Results %OC (Total Sample) = (%OC of - #10) X (Mass of minus #10 Fraction/ Total mass of Sample). The maximum permissible OC (percent by weight) for the minus #10 fraction of the soil sample from the test method is mathematically adjusted to represent the total sample weight. The sample drying time will be 24 hours.

(F) Rock Reinforced Wall Fill:

Material that is composed primarily of rock fragments (material having less than 25 percent passing a ¾-inch sieve) shall be considered to be a rock backfill. The maximum particle size shall not exceed the limits listed in Table 929-2. Such material shall meet all the other requirements of Subsection 929-3.05(B) and Subsection 929-3.05(E). When such material is used, a very high survivability separation geotextile, meeting the minimum requirements for filtration applications specified in AASHTO M 288 and Subsection 1014-4.04(A), shall encapsulate the rock backfill to within three (3) feet below the wall coping. Adjoining sections of separation fabric shall be overlapped by a minimum of 12 inches. Additionally, the upper three (3) feet of backfill shall contain no stones greater than three (3) inches in their greatest dimension, and shall be composed of material not considered to be rock backfill, as defined herein.

(G) Limits of Reinforced Backfill:

For all walls, except back-to-back walls, the reinforced backfill shall extend to at least one (1) foot beyond the free end of the reinforcement. For back-to-back walls wherein the free ends of the reinforcement of the two walls are spaced apart less than or equal to one-half the design height of the taller wall, reinforced wall fill shall be used for the space between the free ends of the reinforcements as well. The design height of the wall is defined as the difference in elevation between the top of coping and the top of leveling pad. The top of the leveling pad shall always be below the minimum embedment reference line as indicated on the plans for the location under consideration.

929-3.06 Retained Backfill Material:

(A) General:

Backfill behind the limits of the reinforced backfill shall be considered as retained backfill for a distance equal to 50 percent of the design height of the MSE wall at fill locations, and sloped back at a 1:1 slope (1H at the top of fill and 0H at the bottom of fill) at cut locations, except for back-to-back MSE walls as described in Subsection 929-3.05(G) above. The retained backfill shall be free of shale, mica, gypsum, smectite, montmorillonite, or other soft particles of poor durability. The retained backfill shall meet the soundness criteria as described in Subsection 929-3.05(B).

The percent fines (the fraction passing No. 200 sieve) shall be less than 50 as determined in accordance with Arizona Test Method 201, and the Liquid Limit (LL) and the Plasticity Index (PI) shall be less than 40 and 20, respectively, as determined in accordance with AASHTO T-90. The maximum particle size in the retained backfill shall not be greater than 8 inches.

Material that is composed primarily of rock fragments (material having less than 25 percent passing a ¾-inch sieve), shall be considered to be a rock backfill and the requirements of Subsection 929-3.05(F) shall apply.

(B) Internal Friction Angle Requirement:

Unless otherwise noted on the plans, the retained backfill material shall exhibit an effective (drained) angle of internal friction of not less than 32 degrees and as shown in the applicable Geotechnical Report, as determined by AASHTO T 236.

The test shall be run on the portion finer than the No. 10 sieve. The sample shall be compacted at optimum moisture content and to 95 percent of maximum dry density, without rock correction, as determined in accordance with Arizona Test Method 225. The sample shall be tested at the compacted condition without addition of water.

No direct shear testing will be required when 80 percent or more of the material is larger than ¾ inch.

929-3.07 Certificate of Analysis for Reinforced and Retained Backfill Materials:

At least three weeks prior to construction of the MSE wall, the Developer shall furnish the Independent Quality Firm with an 80-pound representative sample of each of the backfill material and a Certificate of Analysis certifying that the backfill materials comply with the requirements specified herein. During construction the reinforced and retained backfill shall be sampled and tested by the Inspector for acceptance and quality control testing in accordance with the requirements stated in Table 929-5 and Table 929-6, respectively. A new sample and Certificate of Analysis shall be provided any time the reinforced and retained backfill material changes as noted in Table 929-5 and 929-6, respectively.

Table 929-5
Sampling Frequency for Reinforced Backfill Material

Test	Frequency
Gradation (Arizona Test Method 201), Plasticity Index (AASHTO T 90)	One per 500 CY At job site
Resistivity, pH, Organic Content, Chlorides, Sulfates (Table 929-3)	One per 500 CY At job site
Internal friction angle (AASHTO T 236) Proctor density and Optimum Moisture by Arizona Test Method 225 Test pad section (Subsection 929-4.06(B))	One per change in USCS Designation, change in source, or change in Rock Content (See Note 2)

Note (1): The gradation and plasticity tests performed at the frequency noted in Table 929-5 shall be used to determine the Unified Soil Classification System (USCS) designation as per ASTM D 2487 and rock content for any given sample. New tests shall be required with each change in USCS designation including change in dual symbol designations (example: SW-SM, SW-SC, etc.). All requirements of Subsection 929-3.05 shall be satisfied. New tests shall also be required for each new source regardless of whether the USCS designation changes or not.

Note (2): Change in rock content (particles greater than ¾-inch) is defined as a deviation of greater than 10 percent from previous sample.

Table 929-6
Sampling Frequency for Retained Backfill Material

Test	Frequency
Gradation (Arizona Test Method 201), Plasticity Index (AASHTO T 90)	One per 500 CY At job site
Internal friction angle (AASHTO T 236) Proctor density and Optimum Moisture by Arizona Test Method 225	One per change in USCS Designation, change in source, or change in Rock Content (See Note 2)

Note (1): The gradation and plasticity tests performed at the frequency noted in Table 929-6 shall be used to determine the Unified Soil Classification System (USCS) designation as per ASTM D 2487 and rock content for any given sample. New tests shall be required with each change in USCS designation including change in dual symbol designations (example: SW-SM, SW-SC, etc.). All requirements of Subsection 929-3.06 shall be satisfied. New tests shall also be required for each new source regardless of whether the USCS designation changes or not. Note (2): Change in rock content (particles greater than ¾-inch) is defined as a deviation of greater than 10 percent from previous sample.

929-3.08 Cast-in-Place Concrete:

Cast-in-place concrete shall conform to the requirements of Sections 601 and 1006. Unless otherwise approved, all cast-in-place concrete shall be Class S with a minimum compressive strength of 4,000 pounds per square inch.

929-3.09 Modular Block (Segmental) Facing Units:

This section covers dry-cast hollow and solid concrete masonry structural retaining wall units, machine made from Portland cement, water, and suitable mineral aggregates. The units are intended for use as facing units in the construction of mortarless, modular block walls (MBW) also known as segmental retaining walls (SRW). Metallic or geosynthetic reinforcement specified in Section 929-3.02 and 929-3.03, respectively, may be used as soil reinforcement in the reinforced (structure) backfill zone.

(A) Casting:

Cementitious material in the modular block facing unit shall be Portland cement conforming to the requirements of ASTM C 150. If fly ash is used it shall not exceed 20% by weight of the total cement content and shall conform to ASTM C 618. Aggregates used in concrete blocks shall conform to ASTM C 33 for normal weight concrete aggregate. Efflorescence control agent shall be used in concrete mix design to prevent efflorescence on the block.

The Developer shall advise the Independent Quality Firm of the starting date for casting at least 14 calendar days prior to beginning the operation if the casting operation is within the State of Arizona, or 21 calendar days if the casting operation is outside the State of Arizona.

(B) Physical Requirements:

At the time of delivery to the work site, the modular block facing units shall conform to the following physical requirements:

1) Minimum required compressive strength of 4,000 psi (average 3 coupons)

2) Minimum required compressive strength of 3,500 psi (individual coupon)

3) Minimum oven dry unit weight of 125 pcf

4) Maximum water absorption of 5 % after 24 hours

5) Maximum number of blocks per lot of 2,000. Tests on blocks shall be submitted at the frequency of one set per lot.

Acceptance of the concrete block, with respect to compressive strength, water absorption and unit weight, will be determined on a lot basis. The lot shall be randomly sampled and tested in accordance with ASTM C 140. Compressive strength test specimens shall be cored or shall conform to the saw-cut coupon provisions of ASTM C 140. Block lots represented by test coupons that do not reach an average compressive strength of 4,000 psi will be rejected.

(C) Freeze-Thaw Durability:

This subsection is not used.

(D) Tolerances for Modular Block Dimensions:

Modular blocks shall be manufactured within the following tolerances:

1) The length and width of each individual block shall be within ± ⅛ inch of the specified dimension. Hollow units shall have a minimum wall thickness of 1¼ inches.

2) The height of each individual block shall be within ± 1/16 inch of the specified dimension.

3) When a broken (split) face finish is required, the dimension of the front face shall be within ± 1.0 inch of the theoretical dimension of the unit.

(E) Finish and Appearance:

Units that indicate imperfect molding, honeycomb or open texture concrete and color variation on front face of block due to excess form oil or other reasons shall be rejected. All units shall be visually efflorescence free. All units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction. Minor cracks (e.g. no greater than 1/50 inch in width and no longer than 25% of the unit height) incidental to the usual method of manufacture or minor chipping resulting from shipment and delivery, are not grounds for rejection.

The exposed faces shall be free of chips, cracks or other imperfections when viewed from a distance of 30 feet under diffused lighting. Up to five (5) percent of a shipment may contain slight cracks or small chips not larger than 1.0 inch.

Color and finish shall be as shown on the plans and shall be erected with a running bond configuration.

(F) Pins:

If pins are required to align modular block facing units, they shall consist of a non-degrading polymer or hot-dipped galvanized steel and be made for the express use with the modular block units supplied. Connecting pins shall be capable of holding the geogrid in the proper design position during backfilling.

(G) Cap Units and Adhesive:

The cap unit connection to the block unit immediately under it shall be of a positive interlocking type and not frictional. Cap units shall be cast to or attached to the top of modular block facing units in strict accordance with the requirements of the manufacturer of the blocks and the adhesive. The surface of the block units under the cap units shall be clear of all debris and standing water before the approved adhesive is placed. The Developer shall provide a written 10-year warranty, acceptable to Owner, that the integrity of the materials used to attach the cap blocks will preclude separation and displacement of the cap blocks for the warranty period.

(H) Unit (Core) Fill:

Unit (core) fill is defined as free-draining, coarse grained material that is placed within the empty cores of the modular block facing units. Unit (core) fill shall be a well graded crushed stone or granular fill meeting the gradation shown in Table 929-7. Gradation for unit fill shall be tested at the frequency of 1 test per 50 yd^3 at the job site and for every change in the material source.

Table 929-7
Gradation for Unit (Core) Fill

U.S. Sieve Size	Percent Passing
1½-inch	100
1-inch	75-100

¾-inch	50-75
No. 4	0-60
No. 40	0-50
No. 200	0-5

(I) Gravel Fill:

A minimum width of 1-ft of gravel fill should be provided behind solid (non-hollow) modular block units. A minimum volume of 1-ft^3/ft^2 of gravel fill shall be provided. Gravel fill shall meet the requirements of the unit (core) fill. A suitable geotextile fabric between the gravel fill and reinforced wall fill shall be used to meet the filtration requirements if the gravel fill does not meet the filtration criteria. The selection of a suitable geotextile fabric for filtration purposes shall be supported by design computations taking in to account the actual gradations of the gravel fill and the reinforced wall fill to be used on the project. Gradation for gravel fill shall be tested at the frequency of 1 test per 50 yd^3 at the job site and for every change in the material source.

929-3.10 Certificate of Analysis for Modular Block Connection

For modular block facing units, a certification shall be provided with detailed calculations according to AASHTO (2012) and the results of laboratory test results performed in accordance with Section A.3 in Appendix A of FHWA NHI-00-043, dated March 2001 ("Mechanically Stabilized Earth Walls and Reinforced Soil Slopes"). Such certification shall demonstrate that all connections, including block-to-reinforcement and block-to-block connections, and all related components meet or exceed the current AASHTO 75 year design life requirements and are capable of resisting 100% of the maximum tension in the soil reinforcements at any level within the wall. Long-term connection testing for extensible reinforcements is also required. The effect of wall batter and normal pressures representative of the full range of wall configurations and heights shall be incorporated in the tests.

929-4 Construction Requirements:

929-4.01 Excavation:

The Developer shall ensure that temporary slopes are safe during the period of wall construction, and shall adhere to all applicable local, state, and federal regulations. During construction of the MSE walls, the Developer shall design, construct, maintain, and when called for, remove temporary excavation support systems (shoring). Temporary excavation support systems may be left in place. The back slope of the excavation shall be benched using a 1 foot horizontal : 1 foot vertical method. Where shoring is required, the Developer shall submit the shoring design, and a plan outlining construction and removal procedures prior to proceeding with the work. Shoring plans shall be prepared and submitted as part of the working drawings, as specified in Subsection 105.03 and shall bear the seal and signature of a licensed Professional Civil or Structural Engineer, registered in the State of Arizona. All shoring design shall include appropriate input and review by a Geotechnical Engineer.

929-4.02 Foundation Preparation:

(A) General:

In the absence of specific ground improvement requirements in the plans, the following applies:

The foundation for the reinforced and retained wall fill shall be graded level for the entire area of the base of such backfills, plus an additional 12 inches on all sides, or to the limits shown in the plans.

If soil reinforcement components are to be positioned on native soil, the top one (1) foot of native soil shall meet the requirements of the reinforced backfill material specified in Subsection 929-3.05.

If soil reinforcement components are to be positioned on native rock mass, the rock mass shall be classified as at least Class II rock mass in accordance with Section 10 of AASHTO (2012). Otherwise the top foot of native rock mass on which the MSE structure is to be constructed shall be scarified and compacted to a dry density not less than 100 percent of maximum dry density as determined in accordance with Arizona Test Method 225.

(B) Proof-Rolling:

The Developer shall perform proof-rolling to evaluate the stability and uniformity of the subgrades on which the MSE structure will be constructed. Proof rolling shall be performed on the entire areas at the following locations:

1. At the bottom of the overexcavation and recompaction zones, if specified on the plans.

2. At the bottom of the overexcavation and replacement zones, if specified on the plans.

3. At the base of all walls.

4. At the top of native soil layers that have been scarified, moisture-conditioned, and recompacted (if different from the bottom of the overexcavation and recompaction zones, or overexcavation and replacement zones).

Proof-rolling shall be done immediately after subgrade compaction while the moisture content of the subgrade soil is near optimum, or at the moisture content that was used to achieve the required compaction.

If proof-rolling is performed after installation of pipe underdrains, the proof-roller shall not be used within 1½ feet of the underdrains.

Proof-rolling shall be performed with a pneumatic-tired tandem axle roller with at least three wheels on each axle, a gross weight of 24 tons (48 kips), a minimum tire pressure of 75 pounds per square inch, and a minimum rolling width of 75 inches. A Caterpillar CW34, Caterpillar PS 300B (or PF 300B), Ingersoll-Rand PT 240R, BOMAG BW24R, Dynapac CP271, or equipment with equivalent capabilities shall be used for proof-rolling. Alternates, as approved by the geotechnical engineer, may include a loaded 10-wheel 4,000 gallon water truck or a 4-wheel 8,000 gallon Caterpiller water pull.

Proof-rolling equipment shall be operated at a speed between 1.5 and 3 miles per hour, or slower to permit measurements of the deformations, ruts and/or pumping.

Proof-rolling shall be carried out in two directions at right angles to each other with no more than 24 inches between tire tracks of adjacent passes. The Developer shall operate the proof-roller in a pattern that readily allows for the recording of deformation data and complete coverage of the subgrade.

The following actions shall be taken based on the results of the proof-rolling activity:

1. Rutting less than ¼-inch – The grade is acceptable.

2. Rutting greater than ¼-inch and less than 1½ inches – The grade shall be scarified and re-compacted.

3. Rutting greater than 1½ inches – The compacted area shall be removed and reconstructed.

4. Pumping (deformation that rebounds, or materials that are squeezed out of a wheel's path) greater than one (1) inch – The area shall be remediated.

The Developer shall be responsible for maintaining the condition of the approved proof-rolled soils throughout the duration of the retaining wall construction. Wall construction shall not commence until the foundation has been accepted by the IQF.

929-4.03 Concrete Leveling Pad:

Leveling pads shall be constructed of unreinforced concrete as shown on the working drawings. Gravel leveling pads shall not be allowed. As a minimum, the concrete for leveling pads shall meet the requirements of Section 922. The allowable elevation tolerances of the top of leveling pad shall be within +0.01-feet (1/8-inch) and -0.02-feet (1/4-inch) from the design elevation when measured by a straightedge over any 10-foot run of the leveling pad.

The leveling pad shall have nominal dimensions of 6-inches thick by 1-foot wide. The centerline of the leveling pad shall be within ½ inch from design location.

Cast-in-place leveling pads shall be cured for a minimum of 12 hours before placement of wall facing units. A geotextile shall be applied over the back of the area of any openings between the facing units and leveling pad steps. The geotextile shall extend a minimum of six (6) inches beyond the edges of the opening. The opening shall be filled with concrete, conforming to Section 1006, or shall be concurrently backfilled on both sides with soil.

929-4.04 Subsurface Drainage:

Prior to wall erection, the Developer shall install a subsurface drainage system as shown on the working drawings.

929-4.05 Wall Erection:

(A) General:

Walls shall be erected in accordance with the Wall Manufacturer's written instructions. The Developer shall be responsible for ensuring that a field representative from the manufacturer is available at the site during construction of the initial 10-foot height of the full length of wall to assist the Developer. All temporary construction aids (e.g., wedges, clamps, etc.) shall be in accordance with the manufacturer's recommendations.

(B) Placement Tolerances for Walls with Rigid (Precast) Facing:

For walls with rigid facing, such as precast concrete panels, the panels shall be placed such that their final position is vertical or battered as shown on the working drawings. As wall fill material is placed, the panels shall be maintained in the correct vertical alignment by means of temporary wedges, clamps, or bracing as recommended by the manufacturer. A minimum of two, but not more than three, rows of panel wedges shall remain in place at all times during wall erection. Wedges shall be removed from lower rows as panel erection progresses, so as to prevent chipping or cracking of concrete panels. The Developer shall repair any damage to erected concrete panels. No external wedges in front of the wall shall remain in place when the wall is complete.

Erection of walls with rigid facing shall be in accordance with the following tolerances:

- Vertical and horizontal alignment of the wall face shall not vary by more than ¾ inch when measured along a 10-foot straightedge.
- The overall vertical tolerance (plumbness) of the finished wall shall not exceed ½ inch per 10 feet of wall height. Negative (outward leaning) batter is not acceptable.
- The maximum permissible out-of-plane offset at any panel joint shall not exceed ⅜ inch.

- The final horizontal and vertical joint gaps between adjacent facing panel units shall be within ⅛-inch and ¼-inch, respectively, of the design final joint opening per the approved calculations required in Subsection 929-3.01(H).

- The final horizontal location of the precast wall facing shall be within ½-inch of its plan location at its interface with other project features. The elevation of the top of wall coping shall be withing ½-inch of its plan elevation.

Wall sections not conforming to these tolerances shall be evaluated by the Wall Manufacturer, Wall Designer and Engineer to determine the cause of the tolerance non-conformity. Based on the outcome of this evaluation, the Wall Manufacturer, Wall Designer and Engineer shall determine if the non-conformity is detrimental to the wall's long-term performance and recommend a construction procedure adjustment, retrofit or reconstruction, as appropriate, for review and approval by the Department.

(C) Placement Tolerances for Permanent Walls with Flexible Facing:

Erection of permanent walls with flexible facing (such as welded wire mesh) shall be in accordance with the following tolerances:

- Vertical and horizontal alignment of the wall face shall not vary by more than two (2) inches when measured along a 10-foot straightedge, or as shown in the plans and specifications.

- The overall vertical tolerance (plumbness) of the wall shall not exceed one (1) inch per 10 feet of wall height. Negative (outward leaning) batter is not acceptable.

- The offset limit between consecutive rows of facing shall not exceed one (1) inch from planned offset.

Wall sections not conforming to these tolerances shall be reconstructed.

(D) Placement Tolerances for Modular Block Units:

Erection of walls with Modular Block Units shall be as per the following requirements:

- Vertical and horizontal alignment of the wall face shall not vary by more than ¾-inch when measured along a 10-feet straightedge.

- Overall vertical tolerance (plumbness) of the wall shall not exceed 1¼-inch per 10-ft of wall height from the final wall batter. Negative (outward leaning) batter is not acceptable.

- The first row of units shall be level from unit-to-unit and from front-to-back. Use the tail of the units for alignment and measurement.

- All units shall be laid snugly together and parallel to the straight or curved line of the wall face.
- Unless otherwise noted, all blocks shall be dry-stacked and placed with each block evenly spanning the joint in the row below (running bond). Shimming or grinding shall control the elevations of any two adjacent blocks within 1/16 inch.
- The top of blocks shall be checked with a minimum length of 3-feet long straight edge bubble level. Any high points identified by the straight edge shall be ground flat. Block front to back tilting shall be checked frequently; however correction by shimming shall be done no later than 3 completed courses.

Wall sections not conforming to these tolerances shall be reconstructed.

(E) Placement of Metallic Reinforcement Elements:

Metallic reinforcement elements shall be placed normal (perpendicular) to the face of the wall, unless otherwise shown on the approved plans. All reinforcement shall be structurally connected to the wall face.

At each level of the soil reinforcement, the reinforced wall fill material shall be roughly leveled and compacted before placing the next layer of reinforcement. The reinforcement shall bear uniformly on the compacted reinforced soil from the connection to the wall to the free end of the reinforcing elements. The reinforcement placement elevation shall be at the connection elevation to two (2) inches higher than the connection elevation.

(F) Placement of Geotextile Fabric:

All joints between precast concrete panels shall be covered with geotextile fabric on the back side of the wall. Adhesive shall be applied to panels only. Adhesive shall not be applied to geotextile fabric or within two (2) inches of a joint. The Developer shall provide geotextile fabric having a minimum width of 12 inches, and shall overlap fabric a minimum of four (4) inches. For modular block walls, the placement of the geotextile fabric shall be in accordance with the working drawings.

(G) Joint Pads and Fillers:

The Developer shall install joint pads and fillers as shown on the working drawings.

(H) Placement of Geosynthetic Reinforcement:

Geosynthetic reinforcement shall be installed in accordance with the manufacturer's site-specific wall erection instructions.

Geosynthetic reinforcement shall be placed in continuous longitudinal rolls in the direction of the main reinforcement. Joints parallel to the wall shall not be permitted, except as shown on the working drawings.

Reinforcement coverage shall be 100 percent of embedment area unless otherwise shown in the working drawings. Adjacent sections of geosynthetic reinforcement need not be overlapped except when exposed in a wrap-around face system, at which time the reinforcement rolls shall be overlapped or mechanically connected per the manufacturer's requirements.

Geosynthetic reinforcement shall be placed to lay flat and pulled tight prior to backfilling. After a layer of geosynthetic reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geosynthetic reinforcement in position until the subsequent soil layer can be placed.

During construction, the surface of the fill shall be kept approximately horizontal. Geosynthetic reinforcement shall be placed directly on the compacted horizontal fill surface. The reinforcement shall bear uniformly on the compacted reinforced soil from the connection to the wall to the free end of the reinforcing elements. The reinforcement placement elevation shall be at the connection elevation to two (2) inches higher than the connection elevation.

929-4.06 Reinforced Wall Fill Placement:

(A) General:

Reinforced wall fill placement shall closely follow erection of each course of facing panels. Backfill shall be placed in such a manner to avoid damage or disturbance of the wall materials, misalignment of facing panels, or damage to soil reinforcement or facing members. The Developer shall place backfill to the level of the connection and in such a manner as to ensure that no voids exist directly beneath reinforcing elements.

For walls with modular block facing units, the backfill shall not be advanced more than the height of a modular block unit until the drainage fill, core fill and all fill in all openings within the blocks at that level have been placed. The filled units shall be swept clean of all debris before installing the next level of units and/or placing the geogrid materials.

For walls with flexible facing with gabion style facing, the rock near the wall face shall be hand-placed in accordance with the recommendations of the wall manufacturer.

The maximum lift thickness before compaction shall not exceed twelve (12) inches. The Developer shall decrease this lift thickness, if necessary, to obtain the specified density.

For geosynthetic reinforcements, the fill shall be spread by moving the machinery parallel to or away from the wall facing and in such a manner that the geogrid remains taut. Construction equipment shall not operate directly on the geogrid. A minimum fill thickness of six (6) inches over the geogrid shall be required prior to operation of vehicles. Sudden braking and sharp turning shall be avoided.

For metallic reinforcements, the fill shall be spread by moving the machinery parallel to or away from the wall facing and in such a manner that the steel reinforcement remains normal to the face of the wall. Construction equipment shall not operate directly on the steel reinforcement. A minimum fill thickness of three (3) inches over the steel reinforcement shall be required prior to operation of rubber-tired vehicles and six (6) inches for tracked equipment. Sudden braking and sharp turning shall be avoided.

Wall materials which are damaged during backfill placement shall be removed and replaced by the Developer. The Developer may submit alternative corrective procedures to the Independent Quality Firm for consideration. Proposed alternative corrective procedures shall have the concurrence of the MSE wall supplier and designer, in writing, prior to submission to the Independent Quality Firm for consideration.

(B) Compaction:

Reinforced wall fill shall be compacted to 95 percent of the maximum dry density as determined in accordance with the requirements of Arizona Test Method 225.

Retained backfill shall be compacted to 95 percent of the maximum dry density as determined in accordance with the requirements of Arizona Test Method 225.

Backfill shall be compacted using a static-weighted or vibratory roller. Sheeps-foot or grid-type rollers shall not be used for compacting material within the limits of the soil reinforcement. The Developer shall take soil density tests, in accordance with Arizona Test Method 235, to ensure compliance with the specified compaction requirements. Soil density tests shall be taken at intervals of not less than one for every 500 cubic yards, with a minimum of one test per lift. Compaction tests shall be taken at locations determined by the Inspector.

The backfill density requirement within three (3) feet of the wall facing shall be 90 percent of maximum dry density as determined by Arizona Test Method 225. No compaction testing within three (3) feet of the wall facing will be required. Compaction within three (3) feet of the wall shall be achieved by a minimum number of passes of a lightweight mechanical tamper or roller system. The minimum number of passes and rolling pattern shall be determined, prior to construction of the wall, by constructing a test pad section. The minimum dimensions of the test pad shall be five (5) feet wide, 15 feet long, and three (3) feet final depth.

Compaction in the test pad section shall be performed as follows:

- Maximum lift thickness before compaction shall be twelve (12) inches.
- Minimum one density test per lift.

Only those methods used to establish compaction compliance in the test pad section shall be used for production work. Any change in the material as per Table 929-5 or the approved equipment shall require the Developer to conduct a new test pad section and obtain re-approval of the minimum number of passes and rolling pattern.

Rock reinforced backfill compaction requirements shall be determined by constructing a trial section in the presence of the Engineer and IQF to determine the appropriate watering, in-situ modification requirements (e.g. grading), lift thickness and number of passes to achieve adequate compaction which will be defined as at least 80 percent of the maximum possible settlement in a lift, without excessively crushing the rock at the surface. Compaction will be determined by measuring the settlement of at least three lifts in a trial section at a minimum of 5 points measured at the center of 1 foot square steel plates that are spaced evenly along the length of the trial section prior to compaction. The minimum number of passes required to achieve the adequate compaction, as defined above, will be recorded for each lift of the trial section and the average number of passes required will be considered the minimum compaction requirement.

(C) Moisture Control:

The moisture content of the backfill material prior to and during compaction shall be uniformly dispersed throughout each layer. Backfill materials shall have a placement moisture content three (3) percent less than or equal to optimum moisture content, as determined in accordance with the requirements of Arizona Test Method 225 for the reinforced wall fill and retained backfill. Backfill material with a placement moisture content in excess of optimum shall be reworked until the moisture content is uniform and acceptable throughout the entire lift.

(D) Protection of the Work:

The Developer shall not allow surface runoff from adjacent areas to enter the wall construction site at any time during construction operations. In addition, at the end of each day's operation, the Developer shall slope the last lift of backfill away from the wall facing so that runoff is directed away from the structure. If the subgrade is damaged due to water or otherwise, such that it does not meet the requirements of Subsection 929-4.02, the Developer shall rework and repair the damaged subgrade. The criteria in Subsection 929-4.02 shall be used to judge the adequacy of the repair. Rework and repair shall extend to a depth where undamaged work is encountered.

SECTION 930 SOIL NAIL RETAINING WALL:

930-1 Description:

The work under this item consists of constructing a permanent soil nail wall at the locations and in accordance with the requirements shown on the project plans and these Project Specifications.

The project plans depict only conceptual details and/or minimum requirements. The information shown on the project plans has not been designed and is not sufficient for construction purposes. The design of the soil nail wall system shall be comparable to the structural characteristics and design requirements shown in the project plans and the requirements of these Project Specifications. The design of the soil nail walls shall be in accordance with the FHWA Geotechnical Engineering Circular No. 7, Soil Nail Walls.

A soil nail wall system shall be chosen to meet the required geometric and load characteristics conforming to the Design Criteria shown on the plans and the requirements of these Project Specifications. The drilling method, grouting pressures, bonded length, unbonded test length and anchor diameter shall be chosen subject to the minimum values shown herein.

The soil nail wall system shall be subject to and conform to the testing requirements also specified herein.

Detailed design calculations, details and installation instructions for the soil nail wall system shall be prepared and sealed by a Professional Engineer registered in the State of Arizona and shall be submitted to the Engineer for review. The soil nail wall contractor and Professional Engineer qualifications shall be included as part of this review. Qualification of the soil nail wall contractor shall include evidence of a minimum of five years of experience constructing permanent soil nail wall systems and the successful completion of at least five similar permanent soil nail wall projects in similar soils completed within the last ten years. Qualification of the soil nail wall Professional Engineer shall include evidence of a minimum of five years of experience designing permanent soil nail wall systems and the successful completion of at least five similar permanent soil nail wall projects completed within the last ten years.

The soil nail wall contractor shall be responsible to review all available geotechnical investigation reports, perform independent geotechnical investigation if they determine it to be required and conduct a site visit as part of the development of the soil nail wall design.

Prior to the start of work, the soil nail wall contractor shall submit a project personnel list identifying the superintendent, drill rig operators and on-site supervisors assigned to the project. The superintendent shall have a minimum of five years of experience and the drill operators and on-site supervisors each shall have a minimum of two years of experience installing soil nails or ground anchors. Shotcrete nozzleman shall be certified to be knowledgeable and to possess previously demonstrated ability in the application of wet mix shotcrete for structural applications, in accordance with the certification procedure presented in Section 506.3R of the ACI Manual of Concrete Practice, latest edition.

All materials and workmanship shall conform to these Specifications and the requirements of the project plans.

The soil nail wall contractor shall verify all existing dimensions, elevations and site conditions before proceeding with the work. The soil nail wall contractor shall be responsible for determining actual locations of all existing utilities, existing bridge foundation elements and underground obstructions that may impact or conflict with the soil nail wall.

The soil nail wall contractor shall be responsible for providing construction site drainage, both behind and in front of the soil nail wall, which is independent of the wall drainage system. The soil nail wall contractor shall be responsible for the condition and maintenance of any pipe or conduit used to control surface water during construction. Surface water control pipes or conduits shall be removed from the site upon substantial completion of the work.

The work shall be done in accordance with these Project Specifications and in reasonably close conformance to the lines and details shown on the plans.

The soil nail wall contractor shall submit plans, working drawings, specifications, supplemental geotechnical analysis and design calculations to the Engineer for review in accordance with the Project Specifications. The soil nail wall contractor's submission shall be sealed by a Professional Engineer registered in the State of Arizona. The submittal shall include, but not be limited to, the following:

1. The design assumptions and design calculations.
2. The working drawings showing vertical views of the nailed walls, typical cross sections, details of nail heads and tables of nail lengths, design loads and bar schedules.
3. Estimated nail capacity.
4. The proposed schedule, excavation and construction sequence.
5. The method of staged excavation and descriptions of the excavation equipment.
6. Grouting procedures and grout pressures.
7. A certified grout mix design.
8. A description of the drilling method and equipment.
9. A certified shotcrete mix design.
10. Certificates of Compliance shall be submitted for the following materials:
    a. Prestressing Steel, strand or bar
    b. Portland Cement
    c. Prestressing Hardware
    d. Bearing Plates
    e. Corrosion Protection Systems
11. A detailed description of the testing procedure and equipment that will be used to meet and satisfy the testing requirements herein.

12. Descriptions of the soil nail testing equipment including jacking frame, bracing and calibration records of jack/pressure gauge system(s).
13. Wall drainage system details

Excavation and construction sequence shall be carried out in accordance with the reviewed working drawings.

The Engineer's review shall be made to verify that the general scope of work is adequate and that the soil nail wall contractor is qualified to perform the work. Review of the soil nail wall contractor's plans and methods of construction by the Engineer shall not be construed to relieve the soil nail wall contractor in any way of his responsibility for the successful and safe performance of the work and the adequacy of design.

All nail testing and excavation work shall be performed after the Independent Quality Firm's review of the submittal.

930-1.01 Design Assumptions:

Preliminary soil properties are provided in Section 4.4 of the Final Geotechnical Investigation Report - Walls, SR 202L South Mountain Freeway, Segment D3, prepared by C202P. It is the responsibility of the soil nail wall contractor to verify conditions at the proposed soil nail wall locations. The preliminary soil properties are subject to modification by the soil nail wall contractor in their judgement and review of the available geotechnical data. The final soil parameters shall be determined by the soil nail wall contractor and reviewed by the Engineer.

930-1.02 Design Criteria:

The soil nail system shall be designed as a permanent wall. The design shall be based on the following design references, the factors of safety (F.S.) noted below and those from Report No. FHWA-IF-03-017 – Geotechnical Engineering Circular No. 7 – Soil Nail Walls (March 2003):

Nail Adhesion F.S. = 2.0 based on the soil parameters presented herein or approved modifications thereto.
Nail Adhesion shall be a minimum F.S. = 1.5 if based on the results of the sacrificial verification nail tests.
General Shear Failure F.S. = 1.5
Reinforcing Steel Yielding F.S. = 1.67

AASHTO LRFD Bridge Design Specifications, 2012, 6th Edition

FHWA Geotechnical Engineering Circular No. 7, Soil Nail Walls, Report No. FHWA-IF-03-017, 2003

Army Corps of Engineers EM 1110-2-2504 – Strip Load Surcharge

Loading Class – HL-93

Walls Under 51st Ave, 59th Ave and 63rd Ave Bridges

The soil nail walls that are located under the 51st Avenue, 59th Avenue and 63rd Avenue bridges, in front of the existing abutments, shall be designed in accordance with the criteria listed in the plans and specified here within. All nails shall be located to avoid conflict with the existing substructures and foundations. The bonded length of the nails shall occur beyond/behind the abutment/drilled shaft cap as illustrated on the plans. The design of the soil nail wall shall take into consideration the surcharge pressures from the total height of the fill behind the abutments above the top of the soil nail wall. These permanent soil nail walls shall be designed to resist the calculated Apparent Earth Pressure (AEP) for Anchored Walls as described in AASHTO (2012) Article 3.11..5.7, except that the active earth pressure coefficient shall be replaced with the applicable at-rest earth pressure coefficient for the applicable type of soils.

Walls Adjacent to 51st Ave, 59th Ave and 63rd Ave Bridges

The walls shall be designed to resist active wall pressures corresponding to the preliminary soil parameters provided within these Specifications. The design shall also consider live load surcharge loads when traffic is in close proximity to these walls.

The design calculations shall consider additional loads on the nails and facing from formwork.

The design calculations shall consider additional loads from construction equipment or other materials stored or possibly present behind the wall.

The minimum auger hole diameter shall be 8 inches.

The minimum shotcrete wall thickness shall be 6 inches. The shear studs and plates that are embedded in the reinforced CIP face wall shall be designed to resist the vertical dead loads associated with the CIP facing.

The software GOLDNAIL or SNAIL is acceptable for the soil nail wall analysis. The nail lengths and spacing shall be based on the analysis and satisfy all the safety factors listed herein. The nail configuration shall be such that the nail spacing in any direction does not exceed 5 ft. The top row of nails shall not be lower than 3 feet from the top of the wall. The bottom row of the nails shall not be higher than 4 feet from the bottom of the wall excavation. The length of any nail in the top row shall not be less than 70% of the height of the wall at that location. Nail lengths in the upper half of the wall shall not be less than the top row of nails.

Detailed horizontal and vertical stress-deformation analyses shall be performed at all critical sections of the walls and slopes. These analyses shall include an evaluation of the deformation of the wall itself and the existing structures behind the wall during all stages of the construction. The soil nail wall contractor shall provide charts detailing the horizontal and vertical deformations with distance behind the soil nail wall with the design calculations.

The soil nail wall contractor shall verify the limits of the slope stabilization and the stability analysis cross sections prior to preparing shop drawings. The soil nail wall contractor shall survey work perform as specified herein.

Soil nails shall be Class I (double-corrosion protected) in accordance with the requirements of the FHWA Geotechnical Engineering Circular No. 7, Soil Nail Walls, Report FHWA-IF-03-017. All connecting hardware and bolts shall also be double corrosion protected. A minimum corrosion life of 75 years shall be demonstrated.

Wire mesh shall have a design life and corrosion protection of at least 75 years.

A surface and subsurface slope stabilization drainage control system shall be designed by the soil nail wall contractor to prevent saturation of slope materials and to relieve hydrostatic pressures.

930-2 Materials:

930-2.01 General:

The soil nail wall contractor shall furnish and install new, free from defect materials for soil nail retaining walls. Defective materials shall not be used and shall be removed from the job site. The soil nail wall contractor shall furnish and install soil nail retaining wall materials that conform to the requirements of the specified AASHTO or ASTM material specifications.

930-2.02 Drainage Network:

The soil nail wall contractor shall furnish and install a drainage network that consists of vertical prefabricated geocomposite drain and fabric, and weep holes in accordance with the details shown on the project plans, and the requirements of the Project Specifications.

One geocomposite drain shall be located between each nail column. The geocomposite drain shall be 12 inches wide and shall be secured to the cut face, with the fabric side against soil, before the shotcrete is installed. Drains shall be continuous from the top of wall to the toe drain.

930-2.03 Nails:

Nail bars shall be continuous, without splices or welds, deformed, and threaded at least 6 inches on the wall anchorage end, Nail bars shall be Grade 60 solid bars conforming to ASTM A615 or Grade 75 threaded bar conforming to ASTM A722. Nail bars shall be double-corrosion protected. All nail bars shall be sized such that the design load does not exceed 60 percent of the yield strength of the steel. All nail bars shall be clean and free of excessive rust and mill scale at the time of installation. Mechanical couplers shall be capable of developing 100 percent of the minimum specified ultimate tensile strength of the bar.

930-2.04 Nail Corrosion Protection:

Soil nails shall be Class I (double-corrosion protected) in accordance with the requirements of the FHWA Geotechnical Engineering Circular No. 7, Soil Nail Walls, Report FHWA-IF-03-017. Corrosion protection may consist of grouted epoxy-coated nails, or grout sheathing and grout-encapsulated nails.

Epoxy coating shall be 16 mils thick, except for the end of the bar, within shotcrete facing, where a range of 7-12 mils epoxy coating shall be used to allow th placement of washer and nut. Epoxy coating shall conform to ASTM A934. Bend test requirements shall be waived. Coating at the wall anchorage end may be omitted over the length required for threading the nut against the bearing plate.

Epoxy coated bars shall be handled and stored in a way that will prevent them from being damaged beyond what is permitted by ASTM 3963. Damaged epoxy coating shall be repaired in accordance with ASTM A934 and the coater's recommendations using an epoxy field repair kit approved by the epoxy manufacturer. Repaired areas shall have a minimum 1/8-in coating thickness.

Encapsulation shall be 40 mil thick (minimum) corrugated HDPE tube conforming to AASHTO M252 or corrugated PVC tube conforming to ASTM D1784, Class 13464-B. Encapsulation shall provide at least 0.4-inches of grout cover over the nail bar and be resistant to ultra violet light degradation, normal handling stresses and grouting pressures. Encapsulation shall be fabricated in the factory.

Encapsulated nails shall not be moved or transported until the encapsulation grout has reached sufficient strength to resist damage during handling. Encapsulated nails shall be handled in a manner that will prevent large deflections, distortions or damage. Encapsulated nails that are damaged or defective shall be repaired or removed from the site.

930-2.05 Centralizers:

Centralizers shall be manufactured from Schedule 80 PVC pipe and shall be securely attached to the nail bar so as not be detrimental to the nail steel. Wood shall not be used. Centralizers shall be sized to position the nail within 1-inch of the center of the drill hole and sized to allow uninhibited grout flow. Centralizers shall be spaced at 7 feet along the nail starting at 2 feet from each end. All soil nail bars shall have a minimum of 2 centralizers per bar. Centralizers shall be attached securely to the nail so the centralizer will not shift during handling or insertion into the drill hole, shall allow grout tremie pipe insertion to the bottom of drill hole and shall allow grout to flow freely up the hole.

The soil nail wall contractor may exclude centralizers when cased or hollow stem auger drilling equipment that does not allow for the centralizers to pass through the casing or auger stem is used provided the neat cement grout pumped through the casing is placed using grout pressures greater than 75 psi or the sand-cement grout placed through the stem of the auger has a slump of 9-inches or less.

930-2.06 Nail Grout:

Nail grout shall be a neat cement or sand-cement mixture with a minimum 3-day compressive strength of 1,500 psi and a minimum 28-day compressive strength of 3,000 psi per ASTM C109 (AASHTO T106).

Additives shall not be used in the grout. Water reducing admixture Pozzolith, MasterGlenium, or approved alternative, Eucon X15, air entraining admixture BASF Micro Air, and hydration control MasterSet DELVO may be used in order to maintain water/cement ratio.

Cement shall conform to ASTM C150 (AASHTO M85) Type II Portland Cement. Fine aggregate for the grout mix shall conform to ASTM C33 (AASHTO M6). Water used shall be potable, clean and free from substances deleterious to concrete and steel, or that which could cause staining.

The soil nail wall contractor shall submit the grout mix design for review.

The Inspector shall test nail grout during construction at a frequency of no less than one test for every 10 cubic yards of grout placed or once per week, whichever occurs first.

930-2.07 Welded Wire Mesh and Waler Steels:

Waler Steels shall conform to the requirements of ASTM A615/AASHTO M31 Grade 60. The minimum bar lap shall be 40 bar diameters.

Welded wire mesh to be used in the shotcrete shall conform to ASTM A1064/AASHTO M55. The minimum bar splice shall be 12-inches.

930-2.08 Shotcrete:

The soil nail wall contractor shall submit the shotcrete mix design for review.

All shotcrete shall comply with the requirements of ACI 506.2-95 except as specified otherwise herein.

All materials for shotcrete shall conform to the following requirements:

1. Cement shall conform to ASTM C150/AASHTO M85, Type I.
2. Fine aggregate shall conform to ASTM C33/AASHTO M6.

3. Coarse aggregate shall conform to AASHTO M80, Class B.
4. Water shall be potable, clean, and free from substances deleterious to concrete and steel, or that would cause staining.
5. Accelerator shall be the fluid type, applied at the nozzle, and meet the requirements herein.
6. Water-reducer and super-plasticizer shall conform to ASTM C494/AASHTO M194, Type A, D, F, or G.
7. Air-entraining agents shall conform to ASTM C260/AASHTO M154.
8. Fly ash shall conform to ASTM C618/AASHTO M295, Type F or G, cement replacement up to 35% by weight of cement.
9. Silica fume shall conform to ASTM C1240, 90% minimum silicon dioxide solids content, not to exceed 12% by weight of cement.
10. Curing compounds shall conform to AASHTO M148, Type ID or Type 2.
11. Film protection for curing shall conform to AASHTO M171 or polyethylene film.

Shotcrete admixtures shall not be used unless approved. Admixtures used to entrain air, to reduce water-cement ratio, to retard or accelerate setting time, or to accelerate the development of strength, shall be thoroughly mixed into the shotcrete at the rate specified by the manufacturer. Accelerating additives shall be compatible with the cement used, be non-corrosive to steel and shall not promote other detrimental effects such as cracking or excessive shrinkage. The maximum allowable chloride ion content of all ingredients shall not exceed 0.10 percent when tested per AASHTO T260.

The soil nail wall contractor shall deliver, store and handle materials in such a manner as to prevent contamination, segregation, corrosion or damage. The soil nail wall contractor shall store liquid admixtures in such a manner as to prevent evaporation and freezing.

Aggregates for shotcrete shall meet the strength and durability requirement of AASHTO M80 and shall meet the following gradation requirements:

Sieve Size	Percent Passing By Weight	Sieve Size	Percent Passing By Weight
½ Inch	100	No. 16	35-55
$^3/_8$ Inch	90-100	No. 30	20-35
No. 4	70-85	No. 50	8-20
No. 8	50-70	No. 100	2-10

Cement content shall be at least 600 pounds per cubic yard. The water/cement ratio shall not be greater than 0.45. For wet-mix shotcrete exposed to freezing and thawing, the air content at the truck shall be between 7 to 10 percent when tested in accordance with ASTM C231/AASHTO T152.

Shotcrete applied to the facing of the nail wall shall be a pumpable mixture and shall be proportioned to attain a minimum compressive strength of 1500 psi in 3 days and 3500 psi in 28 days. The average compressive strength of each set of three cores extracted from test panels or wall face must be equal to or exceed 85%, with no individual core less than

75% of the specified compressive strength in accordance with ACI 506.2. The boiled absorption of shotcrete, when tested in accordance with ASTM C642 at 7 days, shall be less than 8%.

Aggregate and cement may be batched by weight or by volume in accordance with the requirements of ASTM C94/AASHTO M157. Mixing equipment shall be capable of thoroughly mixing the materials in sufficient quantity to maintain placing continuity. Ready-mix shotcrete shall be delivered and placed within 1½ hours of the batch time unless approved otherwise.

930-2.09 Structural Steel:

Structural steel for the anchor plates shall conform to AASHTO M183/ASTM A36 Grade 36.

Washers and nuts shall conform to AASHTO M291/ASTM A563 Grade B.

All headed studs shall conform to ASTM A108. Headed studs shall be "Nelson Studs" by Nelson Division of TRW, Inc. or an approved equal automatically end-welded stud.

930-2.10 Permanent Cast-In-Place Facing:

Reinforcing steel shall conform to the requirements of ASTM A615/AASHTO M31 Grade 60.

Concrete shall be Class 'S' with a minimum 28-day compressive strength of 3,500 psi. Concrete shall conform to the requirements of the Project Specifications.

930-3 Construction Requirements:

930-3.01 General:

The soil nail wall contractor shall conduct operations such that existing facilities and utilities are not damaged or disrupted in any manner. The soil nail wall contractor shall perform whatever means may be necessary to adequately support any excavations and existing facilities or material carrying such facilities.

The soil nail wall contractor shall install soil nails in accordance with the manufacturer's recommendations. In the event of a conflict between the manufacturer's recommendations and these Project Specifications, the Project Specifications shall prevail.

The diameter of the drill hole shall be large enough to provide a minimum of 1-inch grout cover within the bonded length of nail and large enough to remove any large, deleterious material in the soil. Centralizers shall be used within the bonded and unbonded length of the nail.

At each bridge location, the soil nail wall contractor shall drill nail holes to a depth sufficient to provide the required bonded length beyond the backside of the existing abutment drilled shafts. The soil nail wall contractor shall determine the actual bond length necessary to meet the design loading and testing requirements specified herein. The soil nail wall contractor shall inject grout from the lowest point of the hole after the nail holes have been drilled. Grout may be placed using a sacrificial grout tube or conduit. Grout may not be placed before insertion of the nail bar. The quantity of the grout and the grout pressures shall be recorded by the soil nail wall contractor and provided to the Independent Quality Firm for review. The soil nail wall contractor shall select and use a nail anchor installation method sufficient to achieve the required loading.

The soil nail wall contractor is responsible for the stability of the drilled hole. The soil nail wall contractor shall choose and use a drilling method that will maintain stability of the drill hole to the required dimensions and that recognizes the potential for site soil instabilities, vibrations caused by vehicles and other existing site conditions which could result in instability of the hole.

The soil nail wall contractor shall drill holes at the locations and to the length, inclination and diameter shown in the reviewed working drawings and design calculations.

The soil nail wall contractor shall record the following data during the grouting operation and provide this data to the Inspector for review upon completion of the grouting operation:

1. Type of mixer
2. Water/cement ratio
3. Grout pressure
4. Volume of grout placed in bonded and unbonded lengths
5. Test sample strengths.

The anchor shall remain undisturbed after placing initial grout and until the grout has reached a strength sufficient to provide anchorage during testing operations.

930-3.02 Mass Grading:

All pertinent matters of this section shall comply with the terms and conditions of the construction standards for excavations set forth in the OSHA "Safety and Health Regulations for Construction", Chapter XVII of Title 29, CFR, Part 1926. The soil nail wall contractor, as necessary, shall employ a Professional Engineer registered in the State of Arizona to act upon these requirements.

Mass excavation shall have slopes no steeper than 1H:1V. Mass excavation may occur at any time for distances from the shotcrete wall face greater than the current shotcrete wall height or 10 feet, whichever is more. Mass excavation of the drill bench for the next row of soil nails may occur any time of the day after shotcrete operations are complete for the preceding lift, provided such excavation occurs no closer than 5 feet from the face of the shotcrete.

Mass excavation beneath a preceding shotcrete lift closer than 5 feet from the shotcrete wall face shall not occur until:

(1) nail grout and shotcrete on the preceding lift have reached 50% of their specified 28-day compressive strengths; and
(2) installation of connection hardware and nail testing of the preceding lift have been completed and are acceptable to the Inspector.

Mass excavation within 5 feet of the shotcrete face shall be in accordance with the drill berm requirements described below and shown on the plans.

The soil nail wall contractor shall maintain a bench of material to serve as a platform for the drilling equipment and as a stabilizing berm for the wall excavation face (neat line) during excavation of the drill bench for the next row of soil nails. The stabilizing berm may be either

(1) a native berm;
(2) a fill berm; or
(3) neat cut.

In each case, the drill bench shall be established no more than 3-1/2 feet below the row of nails to be installed, and shall extend out from the wall face a minimum distance necessary to provide a safe working bench for the drill equipment and workers.

930-3.03 Face Excavation:

The soil nail wall contractor shall excavate the working berm from the top down in a staged lift sequence.

The soil nail wall contractor is permitted to drill and grout nails through a stabilizing berm of native or fill soils against the excavation face. The stabilizing berm shall extend horizontally from the face of the shotcrete a minimum distance of one foot and shall be cut from that point at a slope determined to be safe by the soil nail wall contractor but not steeper than 1H:1V. The cut surface shall be excavated to final grade after the installation of nails, and cleaned of all loose materials, mud, rebound and other foreign matter which could prevent or reduce shotcrete bond.

Excavation of the soil face to final grade and application of the shotcrete (referred to as closure time) shall be done in the same work shift. The soil nail wall contractor shall demonstrate that the unsupported vertical cut will be stable over the proposed exposure period for each soil unit. Risk of damage to existing structures or structures included in the work shall be borne by the soil nail wall contractor when approval for extended closure time is granted. When extended closure time is allowed, the soil nail wall contractor shall provide and install polyethylene sheets properly anchored to the top and bottom of the excavation to reduce degradation of the cut face caused by changes in soil moisture, unless otherwise directed by the Geotechnical Engineer. Closure time extension may be revoked by the Geotechnical Engineer at any time depending on the performance of the cut face.

The soil nail wall contractor shall ensure installed nails are not damaged during excavation of the stabilizing berm. The soil nail wall contractor shall repair or replace nails damaged or disturbed during excavation of the stabilizing berm. The soil nail wall contractor shall not begin excavation of the stabilizing berm until 24 hours after nail grouting operations have completed. The soil nail wall contractor shall remove hardened nail grout protruding into the shotcrete more than two inches using hand held rock chippers or methods that preclude fracturing the grout at the nail head. The soil nail wall contractor shall not use sledgehammers to remove grout.

The soil nail wall contractor shall not advance excavations until nail installation, reinforced shotcrete placement and nail testing for the preceding lifts are complete. Shotcrete and nail grout on the preceding lift shall have reached 100 percent of the 3-day compressive strength prior to advancing the excavation. Advancing the excavation shall include removal of the stabilizing berm below the shotcrete whether that be by direct excavation or incidental excavation due to nail hole excavation. Exposed materials shall not have an unsupported cut height greater than the vertical nail spacing plus the reinforcing lap required to properly develop shotcrete reinforcement or unless otherwise approved.

Construction sequences other than those described shall be detailed in the working drawings and shall address the requirements described herein.

930-3.04 Protrusions and Voids:

The soil nail wall contractor shall remove all cobbles and boulders that protrude from the soil face more than two inches into the design shotcrete thickness shown in the approved working drawings and shall fill the voids with shotcrete. Shotcrete used to fill voids created by the removal of cobbles and boulders or other obstructions shall be considered included in the cost of the soil nail wall system.

930-3.05 Face Raveling:

The soil nail wall contractor shall bring to the immediate attention of the Inspector any raveling of the face or local instability of the exposed cut due to the presence of perched groundwater, problematic soil conditions, equipment vibration or other causes. Work shall be suspended in these areas until the soil nail wall contractor implements approved remedial measures and the raveling has been successfully arrested. Remedial measures may include lagging, false forming, flash coat application of steel fiber reinforced shotcrete, installation of horizontal PVC drains or a reduction in the width and/or height of the exposed excavation face.

930-3.06 Nail Installation:

(A) Excavation

The soil nail wall contractor shall excavate each nail hole at the locations, lengths and inclinations shown on the approved working drawings. The soil nail wall contractor shall flush cuttings from the nail holes by use of compressed air or other industry acceptable methods. Water shall not be used for flushing. The soil nail wall contractor shall thoroughly clean and make ready for examination the nail hole at final penetration depth and before bar installation or placement of grout.

Allowable tolerances for nail installation shall be as follows:

Nail Position	-	$\pm$1 foot in any direction
Nail Length	-	- 0 feet
Nail Inclination	-	$\pm$3 degrees

Location tolerances are applicable to individual nails and are not accumulative over large wall areas.

Center nail bars within the drill hole and maintain grout cover as specified herein.

Installed soil nails that do not satisfy the specified tolerances, because of the soil nail wall contractor's installation methods, shall be replaced.

(B) Nail Hole Support

The soil nail wall contractor shall provide positive nail hole support as the drilling proceeds to prevent excessive sloughing and caving of the hole prior to grouting. Where caving and sloughing occurs, holes shall be continuously supported and drilled without the loss of ground by use of casing or auger-cast installation methods. Drilling fluids such as bentonite or water shall not be used as a means of nail hole support. All additional installation, material and other costs due to casing of nail holes shall be borne by the soil nail wall contractor.

Casing shall be of steel or fiber construction and shall be of ample strength to withstand handling and installation stresses, grout pressure, and surrounding earth and groundwater pressures. The soil nail wall contractor shall remove casings as the grout is placed. Casing extraction shall be facilitated by the use of a vibratory extractor, if required. Casings shall be continually observed during removal for maintenance of pressure head sufficient to offset the external groundwater and/or soil pressure. Casing seals shall not be broken until the level of grout within the casing provides adequate head to prevent unstable soil or groundwater from contaminating or diluting the grout. The soil nail wall contractor shall maintain at least 5 feet of grout head above the bottom of the casing at all times.

Where casing of the unbonded length of test nails is provided, casing shall be placed in a manner that prevents any reaction between the casing and the grouted zone of the nail and/or the stressing apparatus during testing.

(C) Production Nails

The soil nail wall contractor shall submit the proposed drilling, installation and grouting methods to the Engineer for review prior to drilling and placing production nails. Only installation methods that have been proven through verification testing shall be approved for production nail installation. Installation methods that differ from those used for installation of verification nails shall require additional verification testing at the soil nail wall contractor's expense.

The soil nail wall contractor shall install nails at the locations and to the minimum grouted lengths as shown in the approved working drawings or designated by the Geotechnical Engineer. Nails may be added, eliminated, or relocated to accommodate actual field conditions.

The nail hole shall have a minimum diameter as shown in the approved working drawings to accommodate the required tendon, couplers, corrosion protection and centralizers. Changes to the approved working drawings will require review by the Engineer and may require redesign if the requirements of the verification or proof tests are not satisfied. All redesign costs as a result of reduced drill hole diameter shall be borne by the soil nail wall contractor.

(D) Bar Installation

The soil nail wall contractor shall provide bar sizes and grades for each nail hole as indicated in the approved working drawings. Bars shall be fitted with centralizers as shown in the approved working drawings (at least two centralizers per bar), and inserted into the hole to the required depth without difficulty and in such a manner as to prevent damage to the drillhole. The soil nail wall contractor shall remove bars that cannot be completely inserted and clean or re-drill the hole to permit unobstructed installation. Partially installed bars shall be rejected.

(E) Grouting

Nail holes shall be grouted within 60 minutes of soil nail bar installation. The soil nail wall contractor shall not gravity flow grout into the nail hole. The soil nail wall contractor shall inject grout at the lowest point of each drill hole through a sacrificial grouting conduit and the hole shall be filled in one continuous operation. No cold joint shall be allowed, except as required for proof test nails. Grouting conduit shall be abandoned in the nail hole. The soil nail wall contractor shall provide a sufficient quantity of grout to fill the entire nail hole. Grout shall be available at the site when the first grout is placed in each nail. Grout quantity and the grouting pressures shall be recorded for each soil nail. The soil nail wall contractor shall control grout pressures to prevent excessive ground heave or fracturing.

The soil nail wall contractor shall remove the grout and nail, and install new grout and nail if grouting is suspended for more than 30 minutes or the grout or grouting procedures do not satisfy the requirements of this specification or the approved working drawings.

(F) Test Nail Isolation

The test nail bar shall be isolated from the shotcrete facing and/or the reaction frame used during testing. Isolation of a test nail through the shotcrete facing shall not affect the location of the reinforcing steel under the bearing plate

Test nails to be incorporated into the production nail schedule during shotcrete application shall be isolated in a manner which maintains the tolerances of bearing bars and walers below the bearing plate. Blockouts in the shotcrete that result in no reinforcing below the nail head shall not be allowed. A detail of the method of test nail isolation shall be submitted to the Engineer for review.

930-3.07 Nail Testing

Verification testing of pre-production sacrificial nails and proof testing of production nails shall be required. The soil nail wall contractor shall supply all materials, equipment and labor necessary to perform the tests. The soil nail wall contractor shall measure and record all required data in an acceptable manner and provide the data to the Independent Quality Firm for review.

No testing or stressing of nails shall be performed until nail grout has reached 100 percent of the specified minimum 3-day compressive strength. No testing or stressing of nails shall be performed until shotcrete has reached 100 percent of the specified minimum 3-day compressive strength.

(A) Testing Equipment

Testing equipment shall include dial gauges, dial gauge support, jack and pressure gauge unit, electronic load cell, and a reaction frame. The soil nail wall contractor shall provide a description of the test setup, and jack, pressure gauge and load cell calibration curves.

The soil nail wall contractor shall provide a testing reaction frame that is sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur during testing of the soil nails. If the reaction frame will bear directly on the shotcrete facing, it should be designed to prevent cracking of the shotcrete. The jack shall be independently supported and centered over the nail bar so that the bar does not carry the weight of the testing equipment. The jack, bearing plates, and stressing anchorage shall be aligned with the bar such that unloading and repositioning of the equipment will not be required during the test.

The soil nail wall contractor shall apply and measure the test load with a hydraulic jack and pressure gauge unit. The pressure gauge unit shall be graduated in 75-psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment. The soil nail wall contractor shall monitor the nail load during verification and proof tests with both the pressure gauge and the load cell. The load cell shall be used to maintain constant load during the creep test.

The soil nail wall contractor shall measure the nail head movement with dial gauges capable of measuring to 0.001-in. The dial gauges shall have a travel sufficient to allow the test to be done without having to reset the gauges. The gauges shall be aligned visually to be parallel with the axis of the nail. The gauges shall be supported independently from the jack, wall or reaction frame. A minimum of two dial gauges shall be used.

(B) Verification Testing

The soil nail wall contractor shall perform a minimum of two verification tests for each wall and each soil unit to verify the installation methods, soil conditions and nail adhesion capacity meets the required factor of safety. Verification nails shall be no closer than 40-feet to one another. The soil nail wall contractor shall perform verification tests prior to production nail installation. The soil nail wall contractor shall develop and submit details of the verification testing arrangement, including the method of distributing test load pressures to the excavation surface (reaction frame), nail bar size, grouted hole diameter and reaction plate dimensioning, to the Independent Quality Firm for review. The soil nail wall contractor shall perform all nail testing using the same equipment, methods and hole diameter as approved for the production nails. Changes to the drilling or installation method shall require additional verification testing and shall be provided at the soil nail wall contractor's expense. The nails used for the verification tests shall be sacrificial and shall not be incorporated into the production nail schedule.

Any change in equipment or methods, including but not limited to drill rigs, drill tools, and drilling and grouting sequences, shall be reported and shall require revalidation by installing one additional verification nail in each soil type encountered.

The soil nail wall contractor shall perform verification tests in the presence of the Inspector for the test to be considered valid. The soil nail wall contractor shall notify the Inspector at least 3 working days prior to performing the verification test(s) so that suitable arrangements may be made to observe the test(s).

Verification tests are required for each soil unit encountered and listed in the approved working drawings. The soil nail wall contractor shall select the location of the verification tests and submit the location to the Geotechnical Engineer for review.

Each test nail shall have a bonded and unbonded segment. Only the bonded length of the test nail shall be grouted prior to testing. The soil nail wall contractor shall determine the bonded and unbonded lengths of the test nail and submit the lengths to the Geotechnical Engineer for review. The unbonded length of the test nail shall be at least 3 feet unless otherwise approved by the Geotechnical Engineer. The soil nail wall contractor shall determine the bonded length based on the bar grade, size and installation method such that the allowable bar load is not exceeded. The bonded length shall not be less than 10 feet. The allowable bar load during testing shall not be greater than 80 percent of the ultimate strength of the steel for Grade 150 bars nor greater than 90 percent of the yield strength for Grade 60 and 75 bars.

The maximum verification test bonded length L_{BV} shall not exceed the test allowable bar load divided by 2 times the design adhesion value, as shown in the following equation:

$$L_{BV} = (C*F_y*A_s) / (FS*A_D)$$

Where: L_{BV} = Test Nail Maximum Bond Length (ft)
C = 0.8 for Grade 150 bar and 0.9 for Grade 60 and 75 bar
F_y = Bar Yield Stress (psi)
A_s = Bar Area (sq. in)
FS = Pullout Resistance Factor of Safety = 2
A_D = Design Adhesion (lb/ft)

The design load during testing shall be determined by the following equation:

$$DL = L_B \times A_D$$

Where: DL = Design Load (lb)
L_B = Plan Bond Length (ft)
A_D = Design Adhesion (lb/ft)

Verification test nails shall be incrementally loaded and unloaded in accordance with the following schedule:

Load	**Hold Time**	**Load**	**Hold Time**
AL	1 minute	1.75DL	Until Stable
0.25DL	10 minutes	1.50DL	Until Stable
0.50DI	10 minutes	1.25DL	Until Stable
0.75DL	10 minutes	1.00DL	Until Stable
1.00DL	10 minutes	0.75DL	Until Stable
1.25DL	10 minutes	0.50DL	Until Stable
1.50DL	60 minutes (Creep Test)	0.25DL	Until Stable
1.75DL	10 minutes	AL	Until Stable
2.00DL	10 minutes		

AL = Nail Alignment Load
DL = Nail Design Load

The alignment load (AL) is the minimum load required to align the testing apparatus and should not exceed 0.05DL. Dial gauges shall be zeroed after the alignment load is applied.

Each load increment shall be held for at least 10 minutes. The verification test nail shall be monitored for creep at 1.50 DL load increment. The soil nail wall contractor shall measure and record nail movements during the creep portion of the test at 1, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes. Extended creep measurements may be required and shall be monitored as determined by the Geotechnical Engineer. All load increments shall be maintained within 5 percent of the intended load by use of the load cell. The nail shall be unloaded as indicated with measurements of deflection at each increment. All measurements and movements shall be provided to the Geotechnical Engineer for review.

(C) Proof Testing

The soil nail wall contractor shall perform proof testing on production soil nails to verify the installation methods and the design nail capacity without excessive creep or movement. . The number of proof tested production soil nails shall be a minimum of 10 percent of the total number of production soil nails or a least one nail per row, whichever results in the greater number.. The locations and number of proof tests shall be determined by the Independent Quality Firm.

Each proof test nail shall have a bonded and unbonded segment. Only the bonded length of the test nail shall be grouted prior to testing. The soil nail wall contractor shall determine the bonded and unbonded lengths of the test nail and submit the lengths to the Geotechnical Engineer for review. The unbonded length of the test nail shall be at least 3 feet unless otherwise approved by the Geotechnical Engineer. The soil nail wall contractor shall determine the bonded length based on the bar grade, size and installation method such that the allowable bar load is not exceeded. The bonded length shall not be less than 10 feet. The allowable bar load shall not exceed 80 percent of the ultimate steel strength for Grade 150 bars and 90 percent of the yield strength for Grade 60 and 75 bars.

Proof tests shall be performed by incrementally loading the nail to 130 percent of the design load. The soil nail wall contractor shall determine the design load using the methods used for verification test nails. The soil nail wall contractor shall measure and record nail movement at each load and submit the information to the Geotechnical Engineer for review. The load shall be monitored by a pressure gauge. At load increments other than the maximum test load, the load shall be held long enough to obtain a stable reading. Incremental loading for proof tests shall be in accordance with the following schedule:

Load	**Hold Time**
AL	Until Stable
0.25DL	Until Stable
0.50DL	Until Stable
0.75DL	Until Stable
1.00DL	Until Stable
1.30DL	Until Stable

AL = Nail Alignment Load
DL = Nail Design Load

The alignment load is the minimum load required to align the testing apparatus and should not exceed 0.05DL. Dial gauges shall be zeroed after the alignment load is applied.

All load increments shall be maintained within 5 percent of the intended load. Depending on performance, either 10 minutes or 60 minute creep tests shall be performed at the maximum test load. The soil nail wall contractor shall measure and record nail movements during the creep portion of the test. The creep period shall start as soon as the maximum test load is applied and the nail movement shall be measured and recorded at 1, 2, 3, 5, 6, and 10 minutes. Where nail movement between 1 minute and 10 minutes exceeds 0.04 inches, the maximum load shall be maintained an additional 50 minutes and movements shall be recorded at 20, 30, 50, and 60 minutes. All measurements and movements shall be provided to the Geotechnical Engineer for review.

(D) Test Nail Acceptance

A test nail shall is acceptable when:

1. For verification tests, a creep rate less than 0.08 inches per log cycle of time between the 6 and 60 minute readings is observed during creep testing and the rate is linear or decreasing throughout the load hold.

2. For proof tests less than 0.04 inches of movement is observed between the 1 minute and 10 minute interval during the 10 minute creep test or a creep rate less than 0.08 inches per log cycle of time is observed during the 60 minute creep test and the creep rate is linear or decreasing throughout the load hold period.

3. The total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

4. The maximum test load is sustained without reaching the failure point (pullout). The failure point shall be the point where the movement of the test soil nail continues without an increase in the load. The failure load corresponding to the failure point shall be recorded as part of the test data.

Proof Test nails may be incorporated into the production nail schedule provided:

(1) the unbonded length of the nail hole has not collapsed during testing,
(2) the minimum required hole diameter has been maintained,
(3) corrosion protection is provided and
(4) the test nail length is equal to or greater than the scheduled production nail.

Verification test nails shall not be incorporated into the production nail schedule.

Test nails meeting these requirements shall be completed by grouting the unbonded length. Maintaining the unbonded length for subsequent grouting is the soil nail wall contractor's responsibility. If the unbonded length of production test nails cannot be grouted subsequent to testing due to caving conditions or other reasons, the soil nail wall contractor shall replace the test nail with a similar production nail at the soil nail wall contractor's expense.

(E) Test Nail Rejection:

(1) Verification Test Nails

The Independent Quality Firm shall evaluate the result of each verification test. Installation methods which do not satisfy the nail testing requirements shall be rejected. Installation methods that are substandard on any particular nail or series of nails will require additional tests. The soil nail wall contractor shall propose alternative methods and install replacement verification test nails. Replacement test nails shall be installed and tested.

(2) Proof Test Nails

The Independent Quality Firm may require the soil nail wall contractor to replace some or all of the installed production nails between the failed test and the adjacent passing proof test nail. Alternatively, the Independent Quality Firm may require that additional proof testing be conducted based on the results of the nail tests. Additional or modified production nails shall be provided by and at the expense of the soil nail wall contractor. The soil nail wall contractor may modify the design and/or construction procedures, subject to the Independent Quality Firm's approval. The modifications may include installing additional test or production nails, installing longer production nails, increasing the drill hole diameter or modifying the installation methods.

(F) Redesign:

The soil nail wall contractor shall modify the design or construction procedures when a nail fails during testing and submit the modifications to the Independent Quality Firm for review. These modifications may include increasing the nail diameter, increasing the bond length or changing the type of nail. The soil nail wall contractor shall test, as previously defined, nails that use a modified design, installation method, nail type and/or construction procedure.

930-3.08 Monitoring:

The soil nail wall contractor shall install survey control points on the existing abutment and shall monitor movement of the existing bridge abutments during construction by daily survey of the control points. Survey shall be obtained by a Land Surveyor registered in the State of Arizona. One control point shall be placed at each end and at mid-length of each abutment pile/shaft cap.The soil nail wall contractor shall take regular measurements of vertical and horizontal displacement of the abutments during construction. The soil nail wall contractor shall report any unusual behavior to the immediate attention of the Inspector. Any unusual behavior may result in a halt to the soil nail wall construction. The soil nail wall contractor shall prepare a monitoring plan sealed by the soil nail wall contractor's Professional Engineer and shall submit the plan to the Independent Quality Firm for review prior to construction.

Abutment control points shall be surveyed prior to construction.

The soil nail wall contractor shall install survey points on the top of the shotcrete facing and at a maximum horizontal spacing of 40-feet. Survey of all points shall be obtained by a Land Surveyor registered in the State of Arizona. Survey shall be obtained as the construction advances and the soil nail wall contractor shall monitor all points no less than twice weekly during excavation and twice a month thereafter.

The soil nail wall contractor shall install inclinometers on the shotcrete facing as required by the soil nail wall design plans. The soil nail wall contractor shall read inclinometers once a week during excavation, and then once a month thereafter.

The soil nail wall contractor shall provide to the Independent Quality Firm all monitoring reports from survey points and inclinometers within 24 hours after the data are recorded.

930-3.09 Shotcrete Facing:

(A) General

All shotcrete shall comply with the requirements of ACI 506.2-95 except as specified otherwise herein. The soil nail wall contractor shall contract an independent testing laboratory to core and test shotcrete panels and inspect all shotcrete and steel reinforcement placement in accordance with ACI 506.4R-94.

All workers, including foreman, nozzlemen, finishers and delivery equipment operators, shall be fully qualified to perform the work. Qualification of the nozzlemen shall be based on the results of the test panels as required herein.

The allowable tolerances for shotcrete shall be as follows:
Shotcrete Thickness: -0 inches

(B) Execution of Production Shotcrete Work

The soil nail wall contractor shall provide, as necessary, alignment wires and/or thickness control pins to establish and maintain the minimum shotcrete thickness shown on the plans. The maximum distance between the wires and/or thickness control pins on any surface shall be equal to the vertical nail spacing. The soil nail wall contractor shall ensure that alignment wires are tight, true to line and placed to allow further tightening.

The soil nail wall contractor shall remove all loose materials from the surface of the grout prior to shotcreting the ungrouted zone above the nail grout at the excavation cut face (birds beak). The soil nail wall contractor shall remove all loose materials and loose dried shotcrete from previous placement operations and from all receiving surfaces by acceptable methods. Removals shall be accomplished in such a manner as not to loosen, crack or shatter the surfaces to receive the shotcrete. The soil nail wall contractor shall remove any surface material that is so loosened or damaged and shall remove said material to a sufficient depth to provide a base that is suitable to receive the shotcrete. The soil nail wall contractor shall remove material that loosens as shotcrete is applied. Shotcrete shall not be placed on frozen surfaces.

The soil nail wall contractor shall maintain at all times a clean, dry, oil-free supply of compressed air sufficient for maintaining adequate nozzle velocity for all parts of the work and for simultaneous operation of a blow pipe for cleaning away rebound. The soil nail wall contractor shall furnish and utilize equipment capable of delivering the premixed material accurately, uniformly and continuously through the delivery hose. The soil nail wall contractor shall apply shotcrete from the lower part of the work area upwards to prevent accumulation of rebound on uncovered surfaces. The soil nail wall contractor shall controll the thickness, methods of support, air pressure and rate of placement of shotcrete to prevent sagging or sloughing of freshly applied shotcrete. The soil nail wall contractor shall position the nozzle into the mouth of the drillhole to completely fill the void where shotcrete is used to fill the bird’s beak. Rebound shall not be worked back into the placement nor shall the rebound be salvaged. The soil nail wall contractor shall remove rebound that does not fall clear of the working area. The nozzle shall be held at a distance and at an angle approximately perpendicular to the working face so that rebound will be minimal and compaction will be maximized. The nozzle should be rotated steadily in a small circular pattern. Shotcrete placement shall be by the bench gunning method when the thickness of the shotcrete layer is 6 inches or greater. The gunning method shall consist of building up a thick layer of shotcrete from the bottom of the lift and maintaining the top surface at approximately a 45-degree slope.

A clearly defined pattern of continuous horizontal or vertical ridges or depressions at the reinforcing elements, after they are covered, will be considered indication of insufficient cover of reinforcement or poor application and probability of a void. In this case, the work shall be immediately suspended and the work carefully inspected. The soil nail wall contractor shall implement and complete corrective measures prior to resuming the shotcrete operations. The shotcreting procedure may be corrected by adjusting the nozzle distance and orientation perpendicular to the surface, adjusting the water content of the shotcrete mix or other acceptable means. The soil nail wall contractor shall remove all overspray and rebound from the surface. The soil nail wall contractor shall repair surface defects as soon as possible after initial placement of shotcrete. The soil nail wall contractor shall remove all shotcrete that lacks uniformity, exhibits segregation, sagging, honeycombing, lamination, or contains any voids or sand pockets, and replace the shotcrete with fresh shotcrete.

The soil nail wall contractor shall wet-set bearing plates while the shotcrete is plastic to assure full shotcrete bearing behind the plate. The soil nail wall contractor shall only hand-tighten the retention nut such that full bearing is achieved without excessively squeezing fresh shotcrete out from under the plate.

Construction joints shall be watertight and uniformly tapered toward the excavation face over a minimum distance equal to the thickness of the shotcrete layer. The surface of the joints shall be rough, clean, sound and damp. The soil nail wall contractor shall clean the hardened shotcrete surface of all laitance and foreign substances, wash with clean water and wet thoroughly immediately prior to placement of fresh shotcrete.

930-3.10 Records:

The soil nail wall contractor shall provide the Independent Quality Firm with the following records:

1. Drawings showing the location of the nails, total nail lengths, bonded lengths and unbonded lengths.

2. Steel and grout verifications and/or mill reports.

3. Grouting records indicating the cement type and quantity of grout used.

4. The soil nail wall contractor shall show on the working drawings the type of testing to be performed for each nail.

5. Test results including a letter, sealed by the soil nail wall contractor's Professional Engineer, certifying that the test results conform to these Specifications.

930-3.11 Pre-Construction Meeting:

A soil nail wall pre-construction meeting shall be scheduled following the project pre-construction meeting and prior to commencement of soil nail wall activity and after the initial review is complete. All parties involved with any element of construction of the soil nail walls shall be represented at the soil nail wall pre-construction meeting. No soil nail wall work shall be performed until the soil nail wall contractor's final submittal has been approved by the Engineer and the soil nail wall pre-construction meeting concluded.

SECTION 931 MEDIAN PAVING (DECORATIVE PAVEMENT):

931-1 Description:

The work under this item consists of furnishing all labor, equipment, tools, materials, and performing all work necessary for the installation of decorative pavement at the locations and in accordance with the details shown on the project plans and these Specifications.

931-2 Materials:

Decorative Pavement shall consist of concrete pavers. Paver module sizes shall be 3 7/8" x 7 7/8" x 3 1/8". Edge pavers shall be 3 7/8" x 7 7/8" x 3 1/8.

Average compressive strength of the pavers shall be 8000 psi. Colors shall be approved by the Project Landscape Architect prior to delivery of the pavers to the job site by the Developer.

The Developer shall construct a 4' x 4' square sample of the paver modules for each color for approval. The Project Landscape Architect will then review and approve the samples, which will be used as the criteria for decorative pavement color, uniformity and pattern acceptance. Construction of the decorative pavement shall not begin until the submitted samples have been reviewed and approved.

931-3 Construction Requirements:

Paving work shall be plumb, level and true to line and grade and shall be installed to properly coincide and align with adjacent work. The contractor shall lay paving stones in a perpendicular pattern to the roadway.

The aggregate base shall be placed in accordance with the project plans. The aggregate base shall not vary more than 1/8" ± across the surface. Compaction of the aggregate base will be not less than 95% of the maximum density as determined in accordance with the requirements of Arizona Test Methods 225, 226, and 227.

The first one sq. yard of pavers at each location will be inspected and must be approved by the Inspector for quality of compaction, finish grade of sand and placement of the decorative pavement, before further work may continue at that location.

The maximum thickness of the loose, screeded sand shall be 1 inch. Screed boards shall be used for screeding the sand to a uniform surface. The sand shall not be compacted, walked on or wet down.

After all sand is in place and not more than 2 hours prior to the installation in any one section or panel of the decorative pavement, the sand shall be treated with an approved pre-emergent herbicide.

The decorative pavement shall be installed hand-tight and level on the undisturbed sand laying course.

A Roller Vibrator or Plate Vibrator shall be used to compact the decorative pavement and to vibrate the sand into the joints between the pavement units.

The vibration process shall be performed in two passes 90 degrees to one another. Sand shall be spread over the vibrated pavement approximately ¼ inch in thickness and vibrated again to complete the filling of the joints. Excess sand will be removed from the surface and disposed of.

Any broken units shall be removed. New units shall be inserted and tamped into grade. Joints shall then be filled with sand. Any cutting of the pavement stone shall be accomplished with a saw.

The completed installation shall be washed down and cleaned to provide a clean finished installation.

The concrete retention curbs, edgings, etc., shall be straight and on grade. All edges of decorative pavement shall butt tight against the concrete header edges.

SECTION 932 REMOVE AND RECONSTRUCT (MEDIAN CABLE BARRIER):

932-1 Description:

The work under this item consists of furnishing all labor, equipment, and materials to remove and salvage the existing median cable barrier and associated median cable barrier end terminals. The work shall include de-tensioning of the existing cable barrier system, removal of posts, re-grading median dikes, and reconstructing the salvaged cable barrier as shown on the project plans. This work includes all necessary excavation, backfill and compaction.

The median cable barrier and median cable barrier end terminals shall be reconstructed and the median cable barrier shall be tensioned in accordance with Detail DK, the manufacturer's instructions and these Special Provisions.

932-2 Construction Requirements:

Regrading, backfilling, and compaction shall be in accordance with Section 203 of the Standard Specifications. All final grading requirements shall be completed per plan prior to installing any cable barrier posts and I or end terminals.

All median cable barrier reconstruction shall be in accordance with the requirements as shown on Detail DK.

The existing median cable barrier shall be removed, salvaged, reconstructed and tensioned in accordance with the manufacturer's specifications. To avoid damage to items that are to be re-used, the Developer shall exercise caution when removing and salvaging those items. Items which are to be salvaged or reused in the new construction and are damaged or destroyed as a result of the Developer’s operations shall be repaired or replaced by the Developer in accordance with Subsection 202-3.01 of the Standard Specifications.

The Developer shall submit a detailed Work Plan for installing and initial tensioning of the cable or approval by the Engineer. The Work Plan shall include detailed descriptions of methods, tools and equipment for stringing and tensioning cable, temporary anchorages for cutting cable and installing fittings and accessories, connecting fittings to cable anchors, and other information for completing the installation.

Cable shall be installed in accordance with the approved Work Plan, these Special Provisions and as shown on the project plans. Cables shall be strung through the hook bolts on each line post, drawn taught without sag, and fastened securely as shown on the project plans. Final adjustment of spring compensating devices shall be made in accordance with the Spring Adjustment Table shown on the project plans in the presence of the Engineer. Installation and tensioning of individual cable runs shall be completed in one work day (night).

Thirty calendar days after initial tensioning, the Developer shall retension each cable in accordance with the Spring Adjustment Table shown on the project plans. The purpose of the retensioning is to compensate for initial loss of tension in the cable due to cable stretch and thermal expansion/contraction. Excessive tension loss or sag in the cables at the time of retensioning may require the cutting of cables and reinstallation of fittings to correct the tension loss or sag. All retensioning work shall be performed in the presence of the Engineer and the IQF.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
49430
GREGORY
PATRICK
FLY
Date Signed 8-30-19
ARIZONA U.S.A.
EXPIRES: 3-31-19

SECTION 1001 MATERIAL SOURCES:

1001-1 Description:

The work under this section shall consist of the procuring of borrow, topsoil, subbase and base materials, mineral aggregates for concrete structures, surfacing, and landscape plating, from sources either designated on the project plans or from other sources.

1001-2 General:

The Developer shall determine for itself the type of equipment and work required to produce a material meeting the specifications.

Sites from which material has been removed shall, upon completion of the work, be left in a neat and presentable condition. Where practicable, borrow pits, gravel pits, and quarry sites shall be located so that they will not be visible from the highway.

The Developer shall provide an Environmental Analysis for any source proposed for use outside of the project Right of Way, regardless of whether an approved Environmental Analysis exists for the site.

The Developer may incorporate an existing Environmental Analysis approved after January 1, 1999, provided that the analysis is updated as necessary to be in compliance with current regulations and with the Developer's planned activities.

It shall be the responsibility of the Developer to conduct any necessary investigations, explorations, and research, on-site and otherwise, before and after submitting the bid proposal, to satisfy itself that the specified quantity and/or quality of material exists in any proposed material source.

1001-2.01 Material Sources in Flood Plains:

Any material source located in a flood plain and proposed for use on the project shall be reviewed by the appropriate agency having flood plain management jurisdiction for the area in which the proposed source is located. The Developer shall obtain a letter from the governing flood plain agency addressed to the Independent Quality Firm, certifying that the location of the proposed source conforms to the requirements of the floodplain management agency.

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

Except for surplus material from agency-administered flood control management projects, borrow material shall not be obtained from any area situated in the 100-year flood plain of any stream or watercourse, and located within one mile upstream and two miles downstream of any highway structure or surfaced roadway crossing. Surplus material from agency-administered flood control management projects may be used as borrow material only if the Developer submits written evidence to the Independent Quality Firm that the flood control agency project was fully designed and funded prior to the date of advertisement for bids on the project.

Material sources in flood plains located on Native American Indian Reservations will be considered for use based on an individual analysis. The analysis shall include a review of applicable land use plans, flood plain management plans, environmental plans, applicable laws and regulations pertaining to Indian Reservations, and an engineering analysis of the effects on any highway facility or structure. The Developer shall obtain from the Native American Tribal Council all permits, licenses, and approvals.

1001-2.03 Usage of Materials:

Approval of the use of any source shall be limited to the specific contract and purpose for which the use of the source was obtained.

1001-2.04 Royalty Charges:

If the Independent Quality Firm approves a source for which the Department holds an easement, license, permit, lease, or other right with the landowner or controlling agency that includes requirements for the payment of royalties, the amount of the royalty charges and the name and address of the party to whom royalties are to be paid will be available from the Materials Group, 1221 N. 21st Avenue, Phoenix, Arizona 85009-3740.

The final billing and payment for material extracted from sources under the jurisdiction of the State Land Department will include a small administrative charge based on the total amount of royalties due for materials removed.

Upon receipt of the final billing from the Department of Transportation, the Developer shall mail a check, payable to the State Land Department, addressed as follows:

Arizona Department of Transportation
Field Reports Section
206 South 17th Avenue
Phoenix, Arizona 85007

1001-2.05 Performance Bonds:

If sources are under the jurisdiction of either the State Land Department or the Bureau of Land Management, the Developer shall secure a performance bond. A fully executed copy of the bond shall be furnished to the Engineer along with evidence that a fully executed copy has been sent to the State Land Department or the Bureau of Land Management.

The form of the Performance Bond will be available from the Materials Group, 1221 N. 21st Avenue, Phoenix, Arizona 85009-3740. For pits under the jurisdiction of the Bureau of Land Management, the surety shall be a company listed under "Surety Companies Acceptable on Federal Bonds." This list is published annually as of July 1 in the Federal Register.

Performance bonds shall be conditioned upon the compliance with the requirements of the State Land Department and the Bureau of Land Management and the requirements of the specifications for the clearing of pit sites, the removal of material and the cleaning up of pit sites.

Copies of fully executed performance bonds shall be mailed as follows:

State Land Commission State Land Department 1624 West Adams Street Phoenix, Arizona 85007	Bureau of Land Management Manager, Land Office 222 North Central Avenue Phoenix, Arizona 85004

1001-2.06 Sampling and Testing:

The results of any sampling and testing accomplished by the Department will be available from the Materials Group, 1221 N. 21st Avenue, Phoenix, Arizona 85009-3740.

1001- 2.07 Plan of Operation and Restoration:

The Developer shall determine whether the Department holds an easement, license, permit, lease or other right, for any proposed material source. For such sites, a project-specific Plan of Operation and Restoration will be required. The Developer shall obtain a copy of the related document and the Department’s General Plan of Operation and Restoration for the proposed site from the Materials Group. The Developer shall prepare and submit to the Independent Quality Firm a project-specific Plan of Operation and Restoration which shall follow the format of the Department’s General Plan of Operation and Restoration, and shall take into account the requirements of the Environmental Analysis, as well as any restrictions placed on the use of the source by the landowner or agency.

The proposed source will not be approved without an approved project-specific Plan of Operation and Restoration. Approval of the Developer’s project-specific plan does not constitute approval of the use of the source.

The Developer shall identify and provide a person in charge of the operation. That person shall maintain copies onsite of the Department's General Plan of Operation and Restoration, the Developer's approved project-specific Plan of Operation and Restoration, the current Environmental Analysis, and the license and permits issued to the Department by the landowner or agency.

1001-3 Proposed Source:

1001-3.01 Approval Requirements:

(A) General:

The Developer shall promptly advise the Independent Quality Firm as to the source that it proposes to use.

The Developer acknowledges that all the conditions set forth in this subsection shall be met prior to the source being approved for use.

Other than sampling and testing, the requirements of this subsection shall be completed prior to initiation of any activities that disturb the existing conditions at the proposed source.

The Developer further acknowledges that no additional compensation will be made on account of any delays in preparing or modifying the Environmental Analysis, obtaining approval for the use of a source, or the failure to obtain approval of a source.

Regulatory changes, specification changes, or other reasons may preclude the approval of a materials source. The Developer acknowledges that the Department may refuse to approve a material source even if the Department had approved the source for other projects.

If all of the requirements for approval of a materials source have been accomplished for the project, and the Independent Quality Firm has approved the source for use on the project and, subsequent to that approval, the Environmental Analysis is rescinded, the Developer may request a revision to the contract. In reviewing the Developer's request, the Department will take into account the following factors. Additional factors may be considered.

(1) Whether the Developer was in compliance with the requirements of the Environmental Analysis and, if applicable, the site-specific Plan of Operations and Restoration.

(2) Whether the reasons for rescinding the approval were reasonably foreseeable.

(3) Whether the action taken was the result of regulatory changes.

(4) Whether deficiencies unrelated to the Environmental Analysis may have rendered the source unacceptable.

(5) Whether rescinding the approval was the sole cause of any impact to controlling activities on the project.

(B) Specific Conditions For Approval:

The use of a source will require written approval by the Independent Quality Firm. No approval will be given until the Developer has complied with the following conditions:

(1) The Developer has submitted an Environmental Analysis of the source proposed for use and the Department has reviewed the analysis and satisfied itself that the use of such source will not have an adverse social, economic or environmental impact. The requirements of Subsection 1001-3.01 shall be completed prior to initiation of any activities that disturb the existing conditions at the proposed source, except for exploring test areas.

(2) The Developer has furnished the Independent Quality Firm with evidence that he has secured the rights to the source, including ingress and egress.

(3) The Department has determined that the material from the proposed source not only meets the requirements, but is also compatible with the established project design criteria and the sampling and testing as herein specified has been satisfactorily completed.

(4) The Developer has furnished a fully executed copy of the Performance Bond as specified in Subsection 1001-2.05.

(5) When required, the Developer has submitted the site-specific plan of operations and restoration as specified in Subsection 1001-2.07.

The Developer shall also notify the Arizona Department of Agriculture, in accordance with the Arizona Native Plant Law, at least 30 days prior to any clearing operations of less than 40 acres on private land, 60 days prior to clearing operations of 40 or more acres on private land, and 60 days prior to any clearing of state land, regardless of size.

(C) Historical and Cultural Resources:

If the Department determines that the proposed use will have major adverse impact on cultural or historic resources, the Department will not allow the use of the source.

1001-4 Special Access:

The Developer may make a request to approve special access to a controlled access highway if special access is not shown on the project plans.

The request by the Developer shall be accompanied by an Environmental Analysis and by documents which specify the point(s) of access, the acquisition of right-of-way, the manner in which access will be attained, the traffic control plan, and crossovers, along with all other appropriate data which will allow the Independent Quality Firm to evaluate its request. If the request is approved, a supplemental agreement shall be entered into.

All costs associated with the special access requested by the Developer shall be borne by the Developer, including, but not limited to, cattle guards, fences, gates and restoration work.

When access is not being utilized, gates shall be closed and locked. Upon completion of all operations, the area within the right-of-way that has been disturbed shall be restored to the condition existing prior to the Developer's operations.

1001-5 Operations at Source:

1001-5.01 General Requirements:

The Developer shall conduct its operations in such a manner as to preserve available materials in excess of project requirements.

The Developer shall notify the Inspector in advance of operations at the source. Notice shall be given before and after clearing and grubbing, and before and after cleaning up.

1001-5.02 Clearing and Grubbing:

Clearing and grubbing shall be in accordance with the requirements of Section 201, except that the resulting surface need not be leveled and vegetable matter need not be separated from any overburden. Clearing and grubbing shall be limited to the area expected to be excavated and areas used for processing and stockpiling.

In the disposal of all tree trunks, stumps, brush, limbs, roots, vegetation and other debris removed, the Developer shall comply with the requirements of the Arizona Revised Statutes Title 49 Chapter 3 – Air Quality; and with the Arizona Administrative Code Title 18 Chapter 2 – Department of Environmental Quality – Air Pollution Control.

The Developer shall comply with the requirements of the landowner or agency having jurisdiction over the land.

1001-5.03 Extraction of Materials:

Materials shall be removed from the source in a workmanlike manner and, when required, in accordance with the Developer's project-specific Plan of Operation and Restoration. In order to produce acceptable material in the amount and gradation required, it may be necessary for the Developer to do any or all of the following, along with any other similar operations usually associated with the extraction, processing and production of the particular material being produced:

Move materials from one area to another.
Perform additional screening.
Remove, wash and waste material.
Blend materials.
Revise crushing methods.
Remove deleterious materials such as clay balls, roots and sticks.

If it is determined that the material in a source is stratified, all material except borrow shall be removed for the full depth in such a manner as to produce a uniform blend of the material. Placing the material from different areas and depths into a surge pile and removing material from the surge pile by cutting through the pile will be acceptable provided that a uniformly blended material is obtained.

Material sources located in drainage channels such as washes, riverbeds, etc., may experience seasonal variations in the depth of ground water. In order to produce the quantity of material estimated to be available, the Developer may be required to work below the water table.

1001-6 Fences and Cattle Guards:

Where the haul roads to material sources cross existing fence lines in areas where there is livestock of any kind, temporary cattle guards shall be installed by the Developer at each crossing.

The livestock operator or owner shall be contacted prior to the beginning of any operations and effective measures shall be taken and means provided by the Developer to prevent livestock from straying.

In operations where conditions will exist that are dangerous to livestock of any kind, temporary cattle guards and fence shall be installed around the pit area by the Developer to protect livestock.

Temporary cattle guards and fence installed by the Developer shall be removed and existing fence disturbed shall be replaced or reconstructed and all fence shall be left in as good condition as it was prior to the beginning of work.

1001-7 Cleaning Up:

All overburden and other undesirable materials removed and all piles of waste materials resulting from operations in the source shall be handled in accordance with the requirements of the landowner or agency having jurisdiction over the land, the Environmental Analysis, the project-specific Plan of Operation and Restoration, if applicable, and all laws, rules and regulations. All debris shall be removed and disposed of and, if directed, all open test holes shall be filled. Unless otherwise required, the sides of sources shall be sloped and smoothed so that livestock can enter and leave the excavated area safely. Unless otherwise required, all haul roads shall be obliterated and, as far as practicable, the ground left in as good condition as it was prior to hauling.

SECTION 1002 PAINT:

1002-1 General Requirements:

All paints specified herein shall be ready-mixed at the manufacturer's plant, except for inorganic zinc-rich primer, which shall be mixed by the fabricator or at the project site 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 specifications.

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 for 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 paint the necessary additives for control of sagging, leveling, drying, drier absorption, and skinning.

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, and shall not be added to any paint formulas specified under this section.

The use of halogenated solvents is not permitted.

Paint shall be furnished in new, unopened air-tight containers, which are clearly labeled with the exact title of the paint, Federal Specification number when applicable, name and address of the manufacturer, product code, date of paint manufacture, and the lot or batch number. The containers shall meet U.S. Department of Transportation Hazardous Materials Shipping Regulations. Precautions concerning the handling and the application of the paint shall be shown on the label of the paint containers.

All of the paints of any coating system consisting of individual paints (such as a primer, intermediate coat, and topcoat), shall be made by the same manufacturer, and shall be designed and sold to be used together as a system.

All applicable governmental environmental regulations shall be adhered to during cleanup and for the disposal of unused paint.

1002-2 Paint Types:

1002-2.01 Three-Paint Coating System:

(A) General:

A three-paint coating system shall be for use on metallic surfaces, and shall include a primer (Paint Number 1), intermediate coat (Paint Number 2), and topcoat (Paint Number 3) from the same system. All three paints shall be water-based, 100 percent acrylic (acrylic latex) paints, unless a non water-based primer is specified, in which case, the topcoat and intermediate coat must be a water-based acrylic paint.

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 Developer shall use the checking and calibration procedures found in ASTM D 4212 and verify the paint consistency with the Inspector prior to each application.

Each coating is intended for spray application. Limited application can be made by brushing or rolling.

(B) Paint Number 1 - Primer:

This paint 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:

This paint 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 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.

1002-2.02 Zinc-Rich Primer:

Zinc-rich primer shall be a solvent based, one-part, epoxy ester, zinc-rich coating made to contain no less than 89 percent by weight of zinc dust in the dried film. Zinc-rich primer is suitable for limited use on cuts, welds, or damaged galvanized surfaces, as needed to restore the continuity of cathodic protection. Zinc-rich primer shall be certified by the manufacturer to be compatible with any suitable water-based acrylic finish paint.

Zinc-rich primer shall be used where zinc paint is called for elsewhere in the specifications.

1002-2.03 Inorganic Zinc-Rich Primer:

Inorganic zinc-rich primer shall be a solvent-based three-component, inorganic, ethyl silicate, zinc-rich coating for use on steel surfaces which will be exposed to severely corrosive environments. The primer shall be mixed in accordance with the manufacturer's directions by the fabricator or at the project site just prior to application. Inorganic zinc-rich primer shall be made to contain no less than 80 percent by weight of zinc dust in the dried film, and shall be certified by the manufacturer to form a strong bond to properly cleaned and prepared steel surfaces, either sandblasted or galvanized. This primer shall also be certified by the manufacturer to be compatible with any suitable water-based acrylic finish paint.

1002-2.04 Alkyd Primer:

Alkyd primer shall be solvent-based, and shall be designed for ferrous metal surfaces where there are rusting issues which rule out the use of a water-based primer. Such surfaces may include ornamental iron, tanks, fabricated parts, handrails, and objects referred to as "black steel." Alkyd primer shall be certified by the manufacturer to be compatible with any suitable water-based acrylic finish paint.

1002-2.05 Direct-to-Metal (DTM) Combination Primer and Finish Paint:

This paint shall be a water-based acrylic paint specially designed for use as a direct-to-metal (DTM) primer or combination primer and finish. The product shall be certified by the manufacturer to form a strong bond to properly cleaned and prepared surfaces of structural steel and other metallic products such as metal buildings, tanks, and pipes. It shall also be certified to bond with other properly cleaned and prepared surfaces such as galvanized steel, oil-based paints, and alkyd enamels. When used on ferrous metal surfaces where there are rusting issues, the paint shall be rust-inhibitive. Direct-to-metal combination primer and finish paints shall be designed to be usable as a complete two or three coat system. When used as a primer only, the paint shall be certified by the manufacturer to be compatible with any suitable water-based acrylic finish paint.

1002-2.06 Acrylic Emulsion Paint:

Acrylic emulsion paint shall be used on concrete and masonry surfaces, and shall be a water-based, 100 percent acrylic (acrylic latex) paint.

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 two feet by two feet, or to the surface of the concrete structure to be painted.

1002-3 Sampling and Testing:

(A) General:

Any lot or batch of paint may, at any time, be sampled and tested for conformance to the specifications and the chemical and physical characteristics and properties as declared by the manufacturer on the product data sheets submitted with the original samples used in the evaluation and approval of the product. Also, complete 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) Coating Systems for Structural Steel and Other Metallic Surfaces:

Coating systems composed of the paints specified in Subsections 1002-2.01 through 1002-2.05 will be tested as complete systems applied to steel panels and weathered in accordance with ASTM G 154, and exposure cycle number 4 of ASTM D 4587, in the Q-U-V Accelerated Weathering Tester, utilizing UVB 313 lamps. Each system shall have an evaluation rating of 100 or greater after 2000 hours of weathering. The procedure is 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 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 1000 hours and another at 1500 hours. The last two panels shall be removed at 2000 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. To be acceptable, paint systems shall have an overall score of 100 or higher.

A) Cracking/Flaking: ASTM D 660, ASTM D 661, and ASTM D 772 are used in combination to determine the rating scale. A weighting factor of three will be applied to the results of these tests.

B) Blistering/Flaking: ASTM D 714 and ASTM D 772 are used in combination to determine the rating scale. 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: ASTM D 4214 and ASTM D 662 are used in combination to determine the rating scale. A weighting factor of three will be applied to the results of these tests.

E) Adhesion: Is based on ASTM D 4541 method E with a strength of at least 100 psi being required.

F) Flexibility: ASTM D 522, using a 1-1/4 inch mandrel, is employed to determine flexibility. The degree of cracking observed after bending is used to determine the rating scale. A weighting factor of five will be applied to the results of this test.

(C) Paint for Concrete and Masonry Surfaces:

Paint for concrete and masonry surfaces will be tested in accordance with the following procedures:

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 154, for 2000 hours utilizing UVB-313 lamps, and exposure cycle number 4 of ASTM D 4587. The paint weathered in this manner shall show no appreciable change in color or appearance due to fading, chalking, or material reaction.

2) Adhesion**:**

The paint shall be applied to a concrete or masonry test surface approved by the Independent Quality Firm, in accordance with the application plan specified in Subsection 610-3.03. After a minimum period of 30 days of outdoor exposure, the adhesion of the paint will be measured. Testing will be performed in accordance with the requirements of ASTM D 4541, Method E, with a strength of at least 100 psi being required.

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 the specifications.

Certificates of Compliance shall be submitted for epoxy coated reinforcing bars, as well as uncoated reinforcing bars, wire, and welded wire fabric. In addition, for epoxy coated reinforcing bars, Certificates of Compliance shall be required from the coating manufacturer and Certificates of Analysis shall be required from the coating applicator.

When reinforcing steel is delivered to the site of the work, the Developer shall furnish the Inspector with a copy of all shipping documents. Each shipping document shall show the sizes, lengths and weights of the reinforcing steel separately for each structure.

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 ASTM A 615. Unless otherwise specified, steel bars meeting the requirements of ASTM A 706 may be substituted for ASTM A 615 steel bars. When ASTM A 706 bars are used, tack welding of the reinforcement will be permitted.

Where shown on the plans, the bars shall be Grade 60.

Where Grade 60 is not specified on the plans, Grade 40 shall be used if immediately available. If Grade 40 is not immediately available, Grade 60 may be used exclusively or in combination with Grade 40 provided that the conditions under which the grades are used in combination are acceptable.

1003-3 Wire:

Steel wire used as spirals or ties for reinforcement in concrete shall conform to the requirements of ASTM A 82.

1003-4 Welded Wire Fabric:

Welded wire fabric used as reinforcement in concrete and mortar shall conform to the requirements of AASHTO M 55.

SECTION 1004 STRUCTURAL METALS:

1004-1 General Requirements:

Certificates of Compliance shall be submitted.

1004-2 Structural Steel:

Structural carbon steel shall conform to the requirements of AASHTO M 183 (ASTM A 36).

High strength low-alloy structural columbium vanadium steel shall conform to the requirements of AASHTO M 223.

High strength low-alloy structural steel up to four inches thick with 50,000 pounds per square inch minimum-yield point shall conform to the requirements of AASHTO M 222 (ASTM A 588).

1004-4 Bolts, Nuts and Washers:

High strength structural steel, bolts and washers shall conform to the requirements of Section 604-2.03.

Bolts and nuts other than high strength steel bolts shall conform to the requirements of ASTM A 307, Grade A.

Nonheaded 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). 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 306. The weight of aluminum covers shall not be less that 150 pounds.

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 B, Type E or S, except hydrostatic testing will not be required.

SECTION 1005 BITUMINOUS MATERIALS:

1005-1 General Requirements:

Bituminous materials shall conform, when tested in accordance with the tests hereinafter enumerated, to the following requirements, as applicable, for the types and grades designated and used.

Certificates of Compliance shall be submitted.

1005-2 Sampling of Bituminous Material:

Sampling of bituminous material shall conform to the requirements of Arizona Test Method 103. Samples shall be taken by the Developer and witnessed by the Inspector. The point of sampling and the number of samples will be specified by the Inspector.

The Developer 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 M 320. The pressure aging temperature shall be as specified below:

PG ASPHALT BINDER	***PRESSURE AGING TEMPERATURE***
PG 76-XX or PG 70-XX	110 ºC
PG 64-XX, PG 58-XX, or PG 52-XX	100 ºC

If PG 76-22 TR+ asphalt binder is used, it shall conform to the requirements of Table 1005-1a.

If PG 70-22 TR+ asphalt binder is used, it shall conform to the requirements of Table 1005-1b.

If PG 64-28 TR+ asphalt binder is used, it shall conform to the requirements of Table 1005-1c.

A minimum of seven working days prior to the start of asphaltic concrete production, the Developer shall provide the Independent Quality Firm a one-gallon sample of the proposed asphalt binder and a Certificate of Analysis, showing complete asphalt binder testing.

Laboratory-prepared samples will not be acceptable. Asphaltic concrete production shall not begin until the Inspector 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 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 for asphalt cement will be adjusted by the percentage shown in Table 1005-1. Should the asphalt cement be in reject status, the Developer may, within 15 days of receiving notice of the reject status of the asphalt cement, supply an engineering analysis of the expected performance of the asphaltic concrete in which the asphalt cement is incorporated. The engineering analysis shall detail any proposed corrective action and the anticipated effect of such corrective action on the performance. Within three working days, the Independent Quality Firm will determine whether or not to accept the Developer's proposal. If the proposal is rejected, the asphaltic concrete shall be removed and replaced with asphaltic concrete meeting the requirements of the applicable specifications. If the Developer's proposal is accepted, the asphaltic concrete shall remain in place and any necessary corrective action shall be performed.

1005-3.02 Liquid Asphalt:

Liquid asphalt shall conform to the requirements of AASHTO M 82, Cut-back Asphalt (Medium Curing Type).

Adjustments in the contract unit price, in accordance with the requirements of Table 1005-2, will be made for quantities of material represented by the corresponding test results.

1005-3.03 Emulsified Asphalt:

Emulsified asphalt shall conform to the requirements of Table 1005-3 for Anionic Rapid Set (RS-1, RS-2), Anionic Slow Set (SS-1), Cationic Rapid Set (CRS-1, CRS-2) and Cationic Slow Set (CSS-1).

Polymerized Cationic Rapid Set (CRS-2P) emulsified asphalt shall conform to the requirements of Table 1005-3a.

Polymerized High Float (HFE-150P) and (HFE-300P) emulsified asphalt shall conform to the requirements of Table 1005-3b.

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 delivery.

The contract unit price will be adjusted, to the nearest cent, for quantities of emulsified asphalt which do not meet the specified minimum percent residue. The adjusted contract unit price will be determined by the following:

$$\begin{bmatrix}\text{Adjusted Contract} \\ \text{Unit Price}\end{bmatrix} = \frac{\begin{bmatrix}\text{Percent Residue} \\ \text{From Testing}\end{bmatrix}}{\begin{bmatrix}\text{Specified Minimum} \\ \text{Percent Residue}\end{bmatrix}} \times [\text{Contract Unit Price}]$$

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 water used must be potable. The material shall not be diluted in the field.

TABLE 1005-1: "Creep Stiffness of PAV Binder" in Table 1005-1 of the Standard Specifications is revised to read:

TABLE 1005-1 ASPHALT BINDER ADJUSTMENT TABLE			
Test Property	AASHTO Test Method	Test Result	Percent of Contract Unit Price Allowed
Creep Stiffness of PAV Binder: S, MPa	T 313	≤ 300 301-330 331-450 451-600 > 600	100 95 85 75 65 (1)

TABLE 1005-1b: **PG 70-22 TR+ ASPHALT BINDER** is hereby added to the Standard Specifications:

TABLE 1005-1b PG 70-22 TR+ ASPHALT BINDER

Test Property	Test Method	Requirement	Test Result	Percent of Contract Unit Price Allowed
Solubility in Trichloroethylene, %, minimum	ASTM D 2042	97.5	------	------
Softening Point, °C, minimum	AASHTO T 53	54	≥ 54 51 - 53 < 51	100 85 70 (1)
Elastic Recovery, @ 10 °C, %, Minimum	AASHTO T 301	55	≥ 55 50 - 54 < 50	100 85 70 (1)
Phase Angle (δ), @ 70 °C @ 10 rad/sec, degrees, maximum	AASHTO T 315	75	≤ 75 76 - 83 > 83	100 85 65 (1)
(1) Reject Status: The pay adjustment applies if allowed to remain in place.				

Notes:

PG 70-22 TR+ asphalt binder shall contain a minimum of 8 percent crumb rubber and a minimum of two percent SBS (styrene-butadiene-styrene) polymer.

PG 70-22 TR+ asphalt binder shall conform to the requirements of AASHTO M 320 and, in addition, shall meet the requirements specified above.

Table 1005-1 will also apply for PG 70-22 TR+ asphalt binder.

Should the bituminous material be deficient on more than one of the properties listed in Tables 1005-1 and 1005-1b, the pay adjustment will be the greatest reduction to the contract unit price specified considering individual test results.

The pressure aging temperature for PG 70-22 TR+ asphalt binder shall be 110 °C.

The crumb rubber shall be derived from processing whole scrap tires or shredded tire materials. The tires from which the crumb rubber is produced shall be taken from automobiles, trucks, or other equipment owned and operated in the United States. The processing shall not produce, as a waste product, casings or other round tire material that can hold water when stored or disposed of above ground.

TABLE 1005-1c: PG 64-28 TR+ ASPHALT BINDER is hereby added to the Standard Specifications:

TABLE 1005-1c PG 64-28 TR+ ASPHALT BINDER				
Test Property	Test Method	Requirement	Test Result	Percent of Contract Unit Price Allowed
Solubility in Trichloroethylene, %, minimum	ASTM D 2042	97.5	-----	-----
Softening Point, °C, minimum	AASHTO T 53	50	≥ 50 47 - 49 < 47	100 85 70 (1)
Elastic Recovery, @ 10 °C, %, Minimum	AASHTO T 301	55	≥ 55 50 - 54 < 50	100 85 70 (1)
Phase Angle (δ), @ 64 °C @ 10 rad/sec, degrees, maximum	AASHTO T 315	75	≤ 75 76 - 83 > 83	100 85 65 (1)
(1) Reject Status: The pay adjustment applies if allowed to remain in place.				

Notes:

PG 64-28 TR+ asphalt binder shall contain a minimum of 8% crumb rubber and a minimum of two percent SBS (styrene-butadiene-styrene) polymer.

PG 64-28 TR+ asphalt binder shall conform to the requirements of AASHTO M 320 and, in addition, shall meet the requirements specified above.

Table 1005-1 will also apply for PG 64-28 TR+ asphalt binder.

Should the bituminous material be deficient on more than one of the properties listed in Tables 1005-1 and 1005-1c, the pay adjustment will be the greatest reduction to the contract unit price specified considering individual test results.

The pressure aging temperature for PG 64-28 TR+ asphalt binder shall be 100 °C.

The crumb rubber shall be derived from processing whole scrap tires or shredded tire materials. The tires from which the crumb rubber is produced shall be taken from automobiles, trucks, or other equipment owned and operated in the United States. The processing shall not produce, as a waste product, casings or other round tire material that can hold water when stored or disposed of above ground.

TABLE 1005-3a: "Elastic Recovery by means of Ductilometer" is revised and "Note 2" is added in Table 1005-3a of the Standard Specifications:

TABLE 1005-3a POLYMERIZED CATIONIC RAPID SET (CRS-2P) EMULSIFIED ASPHALT (1)		
Tests on Emulsion:	**Test Method**	**Requirement**
Elastic Recovery by means of Ductilometer, 25 ºC (77 ºF), % minimum	AASHTO T 301 (2)	55
(2) Testing shall be performed on residue by distillation, not on residue by oven evaporation.		

TABLE 1005-3b: "Elastic Recovery by means of Ductilometer" is revised and "Note 3" is added in Table 1005-3b of the Standard Specifications:

TABLE 1005-3b POLYMERIZED HIGH FLOAT EMULSIFIED ASPHALT (1)			
Tests on Emulsion:	**Test Method**	**Requirement**	
		HFE-150P	HFE-300P
Elastic Recovery by means of Ductilometer, 4 ºC (39.2 ºF), % minimum	AASHTO T 301 (3)	25	25
(3) Testing shall be performed on residue by distillation, not on residue by oven evaporation.			

TABLE 1005-6: PG 70-22 TR+ and PG 64-28 TR+ are added to "Paving Asphalt" in Table 1005-6 of the Standard Specifications:

TABLE 1005-6 OTHER REQUIREMENTS

Grade of Asphalt Specification Designation	Range of Temperatures for Application by Spraying, °F (Not applicable for Plant Mixing)	Range of Aggregate Temperatures for Plant Mixing, °F	Basis of Conversion, Average Gallons Per Ton at 60 °F
Paving Asphalt	275 - 400	------	
PG 76-XX			232
PG 70-XX			233
PG 64-XX			235
PG 58-XX			236
PG 52-XX			238
PG 76-22 TR+			229
PG 70-22 TR+			230
PG 64-28 TR+			231

1005-3.05 Recycling Agents:

Recycling agents shall conform to the requirements of Table 1005-4.

1005-3.06 Emulsified Recycling Agents:

Emulsified recycling agents shall conform to the requirements of Table 1005-5.

The contract unit price will be adjusted, to the nearest cent, for quantities of emulsified recycling agent which do not meet the specified minimum percent residue. The adjusted contract unit price will be determined by the following:

$$\begin{bmatrix}\text{Adjusted Contract}\\ \text{Unit Price}\end{bmatrix} = \frac{\begin{bmatrix}\text{Percent Residue}\\ \text{From Testing}\end{bmatrix}}{\begin{bmatrix}\text{Specified Minimum}\\ \text{Percent Residue}\end{bmatrix}} \times \left[\text{Contract Unit Price}\right]$$

1005-3.07 Other Requirements:

Other requirements for bituminous materials shall conform to the requirements of Table 1005-6.

TABLE 1005-1 **ASPHALT BINDER ADJUSTMENT TABLE**

Test Property	AASHTO Test Method	Test Result	Percent of Contract Unit Price Allowed
Dynamic Shear of Original Binder: $G^*/\sin\delta$, kPa	T 315	≥ 1.00 0.90-0.99 0.70-0.89 < 0.70	100 95 85 70 (1)
Dynamic Shear of RTFO Binder: $G^*/\sin\delta$, kPa	T 315	≥ 2.20 2.00-2.19 1.60-1.99 < 1.60	100 95 85 70 (1)
Dynamic Shear of PAV Binder: $G^*\sin\delta$, kPa	T 315	≤ 5000 5001-5500 5501-7000 7001-8000 > 8000	100 95 85 75 65 (1)
Creep Stiffness of PAV Binder: S, Mpa	T 313	≤ 300 301-330 331-450 451-600 > 600	100 95 85 75 65 (1)
m-value at 60 sec.	T 313	≥ 0.300 0.270-0.299 0.230-0.269 < 0.230	100 95 80 65 (1)

(1) Reject Status: The pay adjustment applies if allowed to remain in place.

Notes:

Specified properties in AASHTO M 320 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 pay adjustment will be the greatest reduction to the contract unit price specified considering individual test results.

The information presented in this table does not apply to asphalt cement used for tack coats.

TABLE 1005-1A

PG 76-22 TR+ ASPHALT BINDER				
Test Property	Test Method	Requirement	Test Result	Percent of Contract Unit Price Allowed
Solubility in Trichloroethylene, %, minimum	ASTM D 2042	97.5	-----	-----
Softening Point, ºC, minimum	AASHTO T 53	60	≥ 60 57-59 < 57	100 85 70 (1)
Elastic Recovery, @ 10 ºC, %, minimum	AASHTO T 301	55	≥ 55 50-54 < 50	100 85 70 (1)
Phase Angle (δ), @ 76 ºC @ 10 rad/sec, degrees, maximum	AASHTO T 315	75	≤ 75 76-83 > 83	100 85 65 (1)
(1) Reject Status: The pay adjustment applies if allowed to remain in place.				

Notes:

PG 76-22 TR+ asphalt binder shall contain a minimum of 8 percent crumb rubber and a minimum of two percent SBS (styrene-butadiene-styrene) polymer.

PG 76-22 TR+ asphalt binder shall conform to the requirements of AASHTO M 320 and, in addition, shall meet the requirements specified above.

Table 1005-1 will also apply for PG 76-22 TR+ asphalt binder.

Should the bituminous material be deficient on more than one of the properties listed in Tables 1005-1 and 1005-1a, the pay adjustment will be the greatest reduction to the contract unit price specified considering individual test results.

The pressure aging temperature for PG 76-22 TR+ asphalt binder shall be 110 ºC.

The crumb rubber shall be derived from processing whole scrap tires or shredded tire materials. The tires from which the crumb rubber is produced shall be taken from automobiles, trucks, or other equipment owned and operated in the United States. The processing shall not produce, as a waste product, casings or other round tire material that can hold water when stored or disposed of above ground.

TABLE 1005-2 MC LIQUID ASPHALT PAY ADJUSTMENT TABLE		
Grade	Kinematic Viscosity (AASHTO T 201): Centistokes, Deviations	Percent of Contract Unit Price Allowed
70	70 - 140 63 - 69 or 141 - 154	100 90

	52 - 62 or 155 - 175 Less than 52 or greater than 175	75 60 (1)
250	250 - 500 225 - 249 or 501 - 550 187 - 224 or 551 - 625 Less than 187 or greater than 625	100 90 75 60 (1)
800	800 - 1600 720 - 799 or 1601 - 1760 600 - 719 or 1761 - 2000 Less than 600 or greater than 2000	100 90 75 60 (1)
3000	3000 - 6000 2700 - 2999 or 6001 - 6600 2250 - 2699 or 6601 - 7500 Less than 2250 or greater than 7500	100 90 75 60 (1)
(1) Reject Status: The pay adjustment applies if allowed to remain in place.		
Note: Since volatile solvents utilized in the manufacture of MC Liquid Asphalt may volatilize in varying amounts during normal transporting, handling, and storage operations, whenever such Liquid Asphalts are used for prime coats or curing seals, deviations from the maximum specification limits greater than those listed may be permitted when justified. In such cases, when material is allowed to remain in place, 60% of the contract unit price is allowed.		

TABLE 1005-3
EMULSIFIED ASPHALTS

Tests On Emulsion	Test Method (1)	Requirement					
		RS-1	CRS-1	RS-2	CRS-2	SS-1	CSS-1
Viscosity: Saybolt Furol, seconds, range 77 °F 122 °F	T 59	20-100	20-100	50-400	50-400	20-100	20-100
Settlement: 5 days, %, maximum	T 59	5	5	5	5	5	5
Sieve: Retained on No. 20, %, maximum	T 59(2)	0.10	0.10	0.10		0.10	0.10
Particle Charge	T 59		Pos.		Pos.		Pos. (3)
Demulsiability:							

35 mL, 0.02 N calcium chloride %, minimum	T 59	60		60			
Classification: Uncoated particles, %, minimum	Ariz. 502				55		
Residue: (4) Residue, %, minimum (5)		55	60	63	65	57	57

Notes:

(1) T 59 is AASHTO

(2) Distilled water will be used instead of the two percent sodium oleate solution.

(3) If the Particle Charge Test result is inconclusive, material having a maximum pH value of 6.7 will be acceptable.

(4) Residue will be obtained in accordance with the requirements of Arizona Test Method 504 and shall conform to all the requirements of AASHTO M 320 for PG 64-16, except that for CRS-2 the dynamic shear ($G^*/\sin\delta$) on the original residue shall be a minimum of 1.00 kPa and a maximum of 1.50 kPa.

(5) 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 1005-3A
POLYMERIZED CATIONIC RAPID SET (CRS-2P) EMULSIFIED ASPHALT (1)

Tests on Emulsion:	Test Method	Requirement
Viscosity, Saybolt Furol seconds @ 50 ºC (122 ºF), range	AASHTO T 59	100-400
Storage Stability, 24 hours, % maximum	AASHTO T 59	1
Demulsibilty, 35 mL of 0.8% DSS, % minimum	AASHTO T 59	40
Particle Charge Test	AASHTO T 59	Positive
Sieve Test, retained on 850 μm (No. 20), % maximum	AASHTO T 59	0.10
Residue from Distillation to 176.7 ºC (350 ºF), % minimum	AASHTO T 59	66
Oil Distillate to 176.7 ºC	AASHTO T 59	0.5

(350 ºF), Volume of Emulsion, % maximum		
Tests on Residue from Distillation:		
Penetration, 25 ºC (77 ºF), 100 grams, 5 seconds, range in 0.1 mm	AASHTO T 49	40-100
Ductility, 4 ºC (39.2 ºF), 10 mm/minute, cm, minimum	AASHTO T 51	35
Elastic Recovery by means of Ductilometer, 25 ºC (77 ºF), % minimum	AASHTO T 301	55
(1) The introduction of polymer must occur before emulsification.		

TABLE 1005-3B
POLYMERIZED HIGH FLOAT EMULSIFIED ASPHALT (1)

Tests on Emulsion:	**Test Method**	**Requirement**	
		HFE-150P	HFE-300P
Viscosity, Saybolt Furol seconds @ 50 ºC (122 ºF), range	AASHTO T 59	50-400	50-400
Sieve test, retained on 850 μm (No. 20), % maximum	AASHTO 59 (2)	0.10	0.10
Storage Stability, 24 hours, % maximum	AASHTO T 59	1	1
Residue from Distillation to 204.4 ºC (400 ºF), % minimum	AASHTO T 59	65	65
Oil Distillate to 176.7 ºC (350 ºF), Volume of Emulsion, % maximum	AASHTO T 59	7.0	7.0
Tests on Residue from Distillation:			
Penetration, 25 ºC (77 ºF), 100 grams, 5 seconds, range in 0.1 mm	AASHTO T 49	150-300	300 +
Float Test at 60 ºC (140 ºF), seconds, minimum	AASHTO T 50	1200	1200
Ductility, 25 ºC (77 ºF), 5 cm/minute, cm, minimum	AASHTO T 51	100	N/A
Elastic Recovery by means of Ductilometer,	AASHTO T 301	25	25

4 ºC (39.2 ºF), % minimum			

(1) The introduction of polymer must occur before emulsification.

(2) Distilled water will be used instead of two percent sodium oleate solution.

TABLE 1005-4 RECYCLING AGENTS									
Tests On Recycling Agent	Test Method	Requirement							
		RA-1		RA-5		RA-25		RA-75	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity: 140 °F, centistokes	AASHTO T 201	100	200	200	800	1000	4000	5000	10000
Flash Point: Cleveland Open Cup, °F, minimum	AASHTO T 48	340		375		425		450	
Saturate by weight: %	ASTM D 2007		30		30		30		30
Test on Residue: (1) Weight Change, %			6.5		4		3		2
Viscosity Ratio: (2)			3		3		3		3

Notes:
(1) Residue will be obtained in accordance with the requirements of AASHTO T 240.
(2) Viscosity Ratio:

$$\frac{\text{Viscosity of residue at 140 °F, centistokes}}{\text{Viscosity of recycling agent at 140 °F, centistokes}}$$

TABLE 1005-5 EMULSIFIED RECYCLING AGENTS					
Tests on Emulsified Recycling Agent	AASHTO Test Method Except as Shown	Requirement			
		ERA-1	ERA-5	ERA-25	ERA-75
Viscosity: Saybolt Furol,	T 59	15 - 40	15 - 100	15 - 100	15 - 100

77 °F, seconds range					
Miscibility	T 59	Passes	Passes	Passes	Passes
Sieve Test: %, maximum	T 59 (1)	0.10	0.10	0.10	0.10
Particle Charge	T 59	Positive	Positive	Positive	Positive
Residue: (2) Residue, %, minimum (3)		60	60	60	60

Notes:

(1) Distilled water will be used instead of the two percent sodium oleate solution.

(2) Residue will be obtained in accordance with the requirements of Arizona Test Method 504 and shall conform to all requirements specified in Table 1005-4.

(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 1005-6
OTHER REQUIREMENTS

Grade of Asphalt Specification Designation	Range of Temperatures for Application by Spraying, °F (Not applicable for Plant Mixing)	Range of Aggregate Temperatures for Plant Mixing, °F	Basis of Conversion, Average Gallons Per Ton at 60 °F
Paving Asphalt	275 - 400	------	
PG 76-XX			232
PG 70-XX			233
PG 64-XX			235
PG 58-XX			236
PG 52-XX			238
PG 76-22 TR+			229
Liquid Asphalt			
MC-70	105 - 175	90 - 155	253
MC-250	140 - 225	125 - 200	249
MC-800	175 - 225	160 - 225	245
MC-3000	215 - 290	200 - 260	241
Emulsified Asphalt		-----	240

RS-1 CRS-1 RS-2 CRS-2 CRS-2P SS-1 CSS-1 HFE-150P HFE-300P	70 - 140 125 - 185 125 - 185 125 - 185 125 - 185 (1) 70 - 160 70 - 160 ----- -----		
Emulsified Asphalt (Special Type)	70 - 160	-----	240
Recycling Agent (RA-1, RA-5,	-----	-----	240
Emulsified Recycling Agent (ERA-1, ERA-5, ERA-25, ERA-75)	70 - 160	-----	240
(1) Or as directed by the Independent Quality Firm.			

SECTION 1006 PORTLAND CEMENT CONCRETE:

1006-1 General Requirements:

Portland cement concrete shall consist of a mixture of hydraulic cement, fine aggregate, coarse aggregate, and water. It may also contain air-entraining admixtures, chemical admixtures, and supplementary cementitious materials. Fibrous concrete reinforcement may be used on drainage channels and slope paving as a substitute to reinforcing as shown on plans.

The Developer shall determine the mix proportions and shall furnish concrete which conforms to the requirements of the specifications. All concrete shall be sufficiently workable, at the slump proposed by the Developer 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 Developer to proportion, mix, place, finish, and cure the concrete properly in accordance with the requirements of the 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, III, or V, and shall be low alkali cement containing not more than 0.60 percent total alkali (Na_2O equivalent).

Portland-pozzolan cement shall conform to the requirements of ASTM C 595 for blended hydraulic cement with moderate sulfate resistance, Type IP (MS).

Cementitious material is defined as an inorganic material or a mixture of inorganic materials that sets and develops strength by chemical reaction with water by formation of hydrates and is capable of doing so under water. In this specification, cementitious materials are defined as: hydraulic cement (Portland cement or Portland-pozzolan cement) and supplementary cementitious material (Fly Ash, Natural Pozzolan, or Silica Fume).

Hydraulic cement shall be approved prior to its use in accordance with ADOT Materials Policy and Procedure Directive No. 13, "Certification and Acceptance of Hydraulic Cement, Fly Ash, Natural Pozzolan, Silica Fume, and Lime".

Cement of different types or brands shall not be intermingled or used in the same batch. The Developer 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 Developer elects to weigh the cement into each batch.

1006-2.02 Water:

The water used shall be free of 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 and not more than 1,000 parts per million 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:

Mill tailings or material from mine dumps 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. The Inspector may require that aggregates 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 level and clear of all vegetation. The bottom one-foot layer of aggregate shall not be disturbed or used.

The handling and storage of concrete aggregate for Class P concrete at the job 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 five feet in depth. Aggregate shall not be dumped or spilled over the side of the pile. When a conveyor is used to stockpile aggregate, 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. Aggregate shall be distributed over the stockpile so that the formation of conical piles higher than 10 feet is prevented.

Contamination of concrete aggregate for Class P concrete by contact with the ground at the job site shall be positively prevented. The Developer 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.

The Developer shall maintain at least two full days worth of production of fine and coarse aggregate stockpiled at the batch plant for Class P concrete prior to starting and throughout the duration of Portland cement concrete paving operations. This requirement is waived for the last two days of production.

The following test methods will be used to evaluate the quality of aggregates for concrete:

Sampling	Arizona Test Method 105
Reducing field samples to testing size	AASHTO T 248
Potential for Alkali Silica Reaction (ASR)	ASTM C 1260 & C 1567
Clay lumps and friable particles	AASHTO T 112
Lightweight particles (Specific gravity less than 2.0)	AASHTO T 113 (See Note)
Organic impurities	AASHTO T 21
Aggregate gradation	Arizona Test Method 201
Soundness (Sodium Sulfate)	AASHTO T 104
Mortar Strength	AASHTO T 71(See Note)
Sand equivalent	AASHTO T 176
L.A. abrasion	AASHTO T 96
Fractured Coarse Aggregate Particles	Arizona Test Method 212
Note: AASHTO T 113 and T 71 are modified as specified in Subsections 1006-2.03 (B) and (C).	

(B) Fine Aggregate:

Fine aggregate shall be a natural sand, or other approved inert material with similar characteristics, composed of clean, hard, strong, durable, uncoated particles. The aggregate shall be washed and shall conform to the requirements of AASHTO M 6, with the following exceptions:

The amount of deleterious substances in the washed fine aggregate shall not exceed the following limits by dry weight, when tested in accordance with the following test methods:

Clay lumps and friable particles	AASHTO T 112	0.5%
Lightweight particles (Specific gravity less than 2.0)	AASHTO T 113 (Except that the percent of lightweight particles shall be reported to the nearest 0.01%.)	1.25% (0.25% Max. Coal and Lignite*)
* Only material that is brownish-black, or black, shall be considered coal or lignite.		

The total amount of all deleterious substances listed in the table above shall not exceed 1.25 percent by dry weight.

Fine Aggregate shall meet the following gradation requirements when tested in accordance with Arizona Test Method 201.

Sieve Size	Percent Passing
3/8 in.	100
No. 4	95 - 100
No. 16	45 - 80
No. 50	0 - 30
No. 100	0 - 10
No. 200	0 - 4.0

Fine aggregate shall have a sand equivalent value of not less than 75.

Fine aggregates shall be subjected to testing under AASHTO T 21 for organic impurities. Aggregates producing a color darker than the standard color shall be rejected unless the material passes the mortar strength specified in the following paragraph:

Fine aggregate shall be made into mortar and subjected to testing under AASHTO T 71, except that 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 sand conforming to the requirements of ASTM C 778.

(C) Coarse Aggregate:

Coarse aggregate shall consist of crushed stone, gravel, crushed 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 aggregate gradation, when tested in accordance with Arizona Test Method 201, shall conform to the appropriate size designation of AASHTO M 43, except as shown below.

The amount of deleterious substances in the washed coarse aggregate shall not exceed the following limits by dry weight, when tested in accordance with the following test methods, except as noted:

Clay lumps and friable particles	AASHTO T 112	0.3%
Lightweight particles (Specific gravity less than 2.0)	AASHTO T 113 (Except that the percent of lightweight particles shall be reported to the nearest 0.01%.)	1.25% (0.25% Max. Coal and Lignite*)
Material passing No. 200 sieve	Arizona Test Method 201	1.0%
* Only material that is brownish-black, or black, shall be considered coal or lignite.		

The total amount of all deleterious substances listed in the table above shall not exceed 1.25 percent by dry weight.

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:

Calcium chloride as a separate admixture shall not be acceptable.

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.

Admixtures shall be uniform in properties throughout their use in the work.

If more than one admixture is used, the admixtures shall be compatible with each other so that the desired effects of all admixtures used will be realized.

(B) Air-Entraining Admixtures:

Air-entraining admixtures shall conform to the requirements of ASTM C 260.

Air-entraining admixtures shall be approved prior to their use in accordance with ADOT Materials Policy and Procedure Directive No. 2, "Certification and Acceptance of Chemical and Air-Entraining Admixtures for Portland Cement Concrete".

Only those air-entraining admixtures shown on the Department's Approved Products List (APL) shall be used. Copies of the most current version of the APL are available on the internet from the Arizona Transportation Research Center (ATRC), through its PRIDE program.

Air-entraining admixtures having a chloride concentration of 10,000 parts per million (one percent by mass of the admixture) or less, as determined in accordance with Arizona Test Method 738, are acceptable unless otherwise specified.

(C) Chemical Admixtures:

Chemical admixtures shall conform to the requirements of ASTM C 494.

Chemical admixtures shall be approved prior to their use in accordance with ADOT Materials Policy and Procedure Directive No. 2, "Certification and Acceptance of Chemical and Air-Entraining Admixtures for Portland Cement Concrete".

Only those chemical admixtures shown on the Department's Approved Products List (APL) shall be used. Copies of the most current version of the APL are available on the internet from the Arizona Transportation Research Center (ATRC), through its PRIDE program.

Chemical admixtures having a chloride concentration of 10,000 parts per million (one percent by mass of the admixture) or less, as determined in accordance with Arizona Test Method 738, are acceptable unless otherwise specified.

(D) Supplementary Cementitious Material (Fly Ash, Natural Pozzolan, and Silica Fume):

Supplementary cementitious materials may be used in addition to hydraulic cement. Supplementary cementitious materials shall be approved prior to their use in accordance with ADOT Materials Policy and Procedure Directive No. 13, "Certification and Acceptance of Hydraulic Cement, Fly Ash, Natural Pozzolan, Silica Fume, and Lime".

Fly ash and natural pozzolan shall conform to the requirements of ASTM C 618 for Class C, F, or N mineral admixture, except that the loss on ignition shall not exceed 3.0 percent.

Silica fume shall conform to the requirements of ASTM C 1240.

When a supplementary cementitious material with a calcium oxide content greater than 15 percent is proposed, the hydraulic cement/supplementary cementitious material blend shall be tested for sulfate expansion in accordance with ASTM C 1012. The maximum expansion shall be 0.10 percent at six months.

When either moderate or high sulfate resistant concrete is specified, the proposed hydraulic cement/supplementary cementitious material blend shall be tested for sulfate expansion in accordance with ASTM C 1012. When moderate sulfate resistance is specified, the maximum expansion shall be 0.10 percent at six months. When high sulfate resistance is specified, the maximum expansion shall be 0.05 percent at six months or 0.10 percent at one year.

(E) Fibrous Concrete Reinforcement:

Fiber additive shall conform to the requirements of ASTM C1116 and ASTM D7508.

Fiber additive shall be polymeric, made from 100% virgin materials, non-corrosive, non-magnetic, and 100% alkali free. The specific type, size, and quantity of fiber shall be determined by the mix designer.

All fibrous concrete shall be monitored to ensure it is thoroughly mixed during placement and shall follow fiber manufacturer requirements. Fiber uniformity and consistency within the mix shall conform to the manufacturer's recommendations or approved rates or as determined from field trial batches.

1006-2.05 Concrete Curing Materials:

Liquid membrane forming compound 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.

Acceptance of concrete curing materials shall be as specified in ADOT Materials Policy and Procedure Directive No. 3, "Curing Compounds".

1006-3 Design of Mixtures:

1006-3.01 Design Criteria:

Portland cement concrete shall conform to the requirements specified in Table 1006-A for each of the classes listed therein.

TABLE 1006-A				
Class of Concrete	**Minimum 28-Day Compressive Strength Required: psi** (See Note 1)	**Cementitious Material Content: Lbs per Cu Yd Minimum - Maximum** (See Notes 2, 3, and 4)	**Maximum Water/Cementitious Material Ratio (w/cm): Lb./Lb.**	**Slump Range: Inches**
B	2,500	470 – 658	None	(See Note 6)
S	2,500	520 – 752	0.55	
	3,000 (See Note 5)			
	3,500			
	4,000			
	4,500	564 – 752	0.50	
	Greater than 4,500	564 - 800	0.45	
P	4,000	564 – 658	None	0 – 4.5
H	High performance concrete as specified in project special provisions.			

Note 1: Testing for compressive strength of cylinders for all classes of concrete shall be in accordance with the requirements of Arizona Test Method 314.

Note 2: A supplementary cementitious material (fly ash, natural pozzolan, or silica fume) conforming to the requirements of Subsection 1006-2.04(D) may be used, as specified in paragraphs (a) through (f) below.

(a) When Portland cement is used, a maximum of 25 percent, by weight of the cementitious material, may be an approved fly ash or natural pozzolan, except as specified in paragraphs (d), (e), and (f) below.

(b) When Portland-pozzolan cement [Type IP (MS)] is used, fly ash or natural pozzolan is not allowed, except as specified in paragraphs (d), (e), and (f) below.

(c) When silica fume is used, a maximum of 10 percent, by weight of either Portland cement or Portland-pozzolan cement, may be used.

(d) When a compressive strength greater than 4,500 psi is required, supplementary cementitious material may be added in excess of the maximum cementitious material content. Fly ash or natural pozzolan may exceed 25 percent, by weight of the cementitious material.

(e) When increased sulfate resistance is specified, the required amount of fly ash or natural pozzolan shall be incorporated into the concrete and may exceed 25 percent, by weight of the cementitious material.

(f) For Class S concrete used in bridge decks, a minimum of 20 percent, by weight of the cementitious material, must be an approved Class F fly ash or natural pozzolan.

Note 3: For any concrete mix, other than for precast and/or prestressed bridge members, with a Portland cement content greater than 545 pounds per cubic yard, **one** of the options specified in paragraphs (a) through (e) below for the mitigation of a potential alkali silica reaction (ASR) shall be used:

(a) A minimum of 20 percent Class F fly ash or natural pozzolan, by weight of the cementitious material, shall be used. The Class F fly ash or natural pozzolan shall have a calcium oxide content of 15 percent or less.

(b) Instead of using Portland cement, Type IP (MS) Portland-pozzolan cement with a Class F fly ash or natural pozzolan content of at least 20 percent, by weight of the cementitious material, shall be used. The Class F fly ash or natural pozzolan shall have a calcium oxide content of 15 percent or less.

(c) Limit the total alkali (Na_2O equivalent) to a maximum of 3.00 pounds per cubic yard of concrete, when calculated as follows:

$$\begin{bmatrix}\text{Pounds of total}\\ \text{alkali per cubic}\\ \text{yard of concrete}\end{bmatrix} = \frac{\begin{pmatrix}\text{Pounds of Portland}\\ \text{cement per cubic}\\ \text{yard of concrete}\end{pmatrix} \text{x} \begin{pmatrix}\text{Na}_2\text{O equivalent (\%)}\\ \text{in Portand cement}\end{pmatrix}}{100}$$

(d) Introduce a lithium nitrate admixture, which has been approved, at a minimum dosage of 0.55 gallons of 30 percent lithium nitrate solution per pound of total alkali (Na_2O equivalent) per cubic yard of concrete. The required amount of lithium nitrate is calculated as follows:

$$\begin{bmatrix}\text{Required gallons}\\ \text{of 30 percent}\\ \text{lithium nitrate}\\ \text{solution}\end{bmatrix} = \frac{\begin{pmatrix}\text{Pounds of}\\ \text{Portland cement}\\ \text{per cubic yard}\\ \text{of concrete}\end{pmatrix} \times \begin{pmatrix}Na_2O \text{ equivalent (\%)}\\ \text{in Portand cement}\end{pmatrix}}{100} \times (0.55)$$

(e) The coarse aggregate and the fine aggregate shall be tested separately in accordance with ASTM C 1260 to determine the potential for alkali silica reaction (ASR). When aggregates show the potential for ASR, as indicated by expansions of 0.10% or greater at 16 days after casting, sufficient mitigation for the expansion shall be determined in accordance with ASTM C 1567. The use of fly ash or natural pozzolan may exceed 25 percent, by weight of the cementitious material.

Note 4: Unless otherwise specified, the cementitious material content shall be as shown.

Note 5: Unless otherwise shown on the plans.

Note 6: The proposed slump shall be chosen by the Developer. Concrete at the proposed slump shall be sufficiently workable to allow proper placement without harmful segregation, bleeding, or incomplete consolidation.

Air-entraining admixtures will be required for all classes of concrete placed at an elevation of 3,000 feet or above. The air content of the concrete mixture shall not be less than four percent nor more than seven percent by volume. However, no air-entrainment will be required for minor precast structures, precast pipe, and precast, prestressed structural members supporting a concrete deck slab or impervious overlay. Also, no air-entrainment will be required for any precast items constructed using the dry pack or no-slump method.

For elevations below 3,000 feet, air-entraining admixtures may be used at the option of the Developer. If air-entraining admixtures are used, the air content of the concrete mixture shall not exceed seven percent by volume.

Concrete that fails to conform to the air content requirements listed above for the respective elevation as determined by the Inspector, shall be rejected prior to placement.

The coarse aggregate size designation for Class S or Class B concrete shall be chosen by the Developer 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 one fifth of the narrowest dimension between the sides of adjacent forms, or two thirds of the minimum clear spacing between reinforcing bars, or two thirds of the minimum clear spacing between reinforcing bars and the sides of adjacent forms, or one third of the depth of the slab, whichever is least.

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. The percent of fractured coarse aggregate particles shall be at least 30 when tested in accordance with the requirements of Arizona Test Method 212.

Coarse aggregate for Class P concrete used to construct Portland cement concrete pavement without load transfer dowels shall be separated into two or more stockpiles. 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 size designation No. 467, as specified in AASHTO M 43. The percent of fractured coarse aggregate particles for this coarse aggregate composite shall be at least 30 when tested in accordance with the requirements of Arizona Test Method 212.

Coarse aggregate for Class P concrete used to construct Portland cement concrete pavement with load transfer dowels and adjacent shoulders shall meet the requirements for size designation No. 57, as specified in AASHTO M 43. The percent of fractured coarse aggregate particles shall be at least 30 when tested in accordance with the requirements of Arizona Test Method 212.

Coarse aggregate for Class P concrete placed in pavement ramp tapers not exceeding a width of 10 feet and in pavement gore areas may be size designation No. 57, as specified in AASHTO M 43. The use of size designation No. 57 coarse aggregate may be used in concrete placed in other inaccessible pavement areas.

1006-3.02 Design Procedures:

At least two weeks prior to the appropriate concreting operation, the Developer 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 Developer shall substantiate each mix design by furnishing test data and providing all details of the mixtures proposed for use. Mix designs, for other than precast or prestressed concrete, shall be prepared by or under the direction of, and signed by, a registered professional engineer, a NICET Level III or higher certified technician in the concrete subfield, a NRMCA Level 3 Certified Concrete Technologist, or an ACI certified Concrete Laboratory Testing Technician Level 2 or Grade II. Mix designs for precast or prestressed concrete shall be prepared by or under the direct supervision of, and signed by, either one of the individuals listed above or a PCI

Quality Control Technician/Inspector Level II or higher. Individuals preparing and submitting mix designs shall have experience in the development of mix designs and mix design testing for the respective type of concrete.

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, the water/cementitious material ratio, a product code to identify the mix design, and the intended use of each mix design shall be an integral part of each mix design.

The use of new and previously used mix designs, and the requirements for trial batches, will be as required by ADOT Materials Policy and Procedure Directive No. 15, “Submittal and Approval of Portland Cement Concrete Mix Designs”.

Changes in approved mix designs may be made by the Developer with the approval of the Independent Quality Firm.

In no case shall the approval of a mix design relieve the Developer of the responsibility for the results obtained by the use of such approved mix design.

A new mix design shall be submitted for approval any time the test results of an approved mix design indicate that the concrete does not meet the required compressive strength.

When approved by the Independent Quality Firm, concrete from trial batches may be used in the work at locations where concrete of a lower strength is required and such concrete will meet the requirements of the class of concrete at that location.

1006-4 Concrete Production:

1006-4.01 General Requirements:

The Developer may obtain concrete for each class of concrete and for each strength of Class S concrete from a source approved by the Independent Quality Firm in lieu of establishing a batch plant at the project site.

For each class of concrete and each strength of Class S concrete, except for Class P concrete produced in a batch plant at the site and used exclusively for Class P work, the Developer shall furnish a delivery ticket for each batch of concrete. The minimum information to be shown on each delivery ticket shall be the date, time batched, truck identification number, name or identification of batch plant, name of Developer, name and location of project, the quantity of concrete, the batch weights/volumes or mix design product code, the amount of permissible additional water to meet the design water/cementitious material ratio, and the number of revolutions that the concrete has been mixed at mixing speed in a truck mixer. An authorized representative of the Developer shall be responsible for each delivery ticket and shall sign each delivery ticket accepting the Developer's responsibility for the concrete. The representative shall immediately furnish the delivery ticket to the Inspector.

When requested by the Inspector, the Developer shall supply a separate record for each batch of concrete which shows the batch weight/volume of each individual ingredient.

1006-4.02 Proportioning:

(A) Hydraulic Cement:

A separate scale shall be used to weigh the hydraulic cement. A load indicating device, positioned so as to be easily visible to the Inspector 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.

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 ensure 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 will 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 scales shall be provided by the Developer to weigh each size of aggregate. Load indicating devices for the scales shall be positioned so as to be easily visible to the Inspector and accurate to ± 0.2 percent of scale capacity. The batching accuracy shall be within ± two percent of the target 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 and load indicating devices shall be so graduated and equipped that the weights of materials can be accurately determined. Necessary efforts shall be made 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 concrete production. The estimated percent of free moisture in each of the coarse and fine aggregates shall be determined by the Developer 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 moisture 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 Independent Quality Firm prior to use.

Dry admixtures shall be measured by weight with a separate scale. A load indicating device for the scale shall be positioned so as to be easily visible to the Inspector 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. Admixtures shall be added in accordance with the manufacturer's recommendations and in a manner such that the admixture is incorporated uniformly in the concrete mixture. The amount of liquid admixtures shall not vary from the required amount by more than ± 3.0 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 Independent Quality Firm.

When a supplementary cementitious material (such as fly ash, natural pozzolan, or silica fume) is specified in the mix design, it may be weighed cumulatively with the hydraulic cement on the same scale. If the same scale is used, the hydraulic cement shall be weighed first, then the supplementary cementitious material. If the same scale is not used, a separate scale with a load-indicating device, positioned so as to be easily visible to the Inspecto and accurate to ± 0.2 percent of scale capacity, shall be provided to weigh the supplementary cementitious material.

When the quantity of hydraulic cement exceeds 30 percent of the full capacity of the scale, the batching accuracy of mixtures containing supplementary cementitious material shall be such that the quantity of the hydraulic cement, and the cumulative quantity of the hydraulic cement plus the supplementary cementitious material, is within ± 1.0 percent of the sum of their designated batch weights.

Supplementary cementitious material 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 ensure the complete discharge of the supplementary cementitious material 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 or Class B concrete.

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.

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 un-dispersed cement.

(B) Mixing in a Stationary Mixer:

The volume of concrete mixed per batch shall not exceed the capacity of the mixer as shown on the manufacturer's plate. The mixing time shall be not less than 60 seconds for one cubic yard and shall be increased 15 seconds for each additional cubic yard or fraction thereof for Class S or Class B concrete.

While mixing, the mixer shall be operated at the speed shown on the manufacturer's plate as the mixing speed.

The mixing time shall not be less than 60 seconds per batch on Class P concrete. The mixing time shall be not less than 60 seconds for one cubic yard and shall be increased 15 seconds for each additional cubic yard or fraction thereof for Class S, Class B, and Class E 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 ensure 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 Developer.

Stationary mixers shall be equipped with automatic batch meters for counting the batches for Class P concrete. The Developer shall furnish the batch count daily to the Inspector.

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 otherwise noted in the mix design and approved by the Inspector.

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.

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 rain. When the ambient temperature exceeds 85 degrees F, the concrete shall be covered if it will be exposed to the sun for more than 30 minutes.

(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 Inspector, 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 accurately register 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 otherwise noted in the mix design and approved by the Inspector.

If additional mixing water is required to maintain the mix design water/cementitious material ratio, the concrete shall be mixed by a minimum of 30 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 delivery ticket specified in Subsection 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 or Class B concrete shall be performed in accordance with the requirements of AASHTO M 241.

1006-4.04 Consistency:

The Developer shall furnish Class P Concrete having a slump within the range specified in Table 1006-A.

The Developer shall furnish Class S and Class B concrete having the slump shown on the approved mix design, with a permissible variation of ± one inch when the slump shown on the approved mix design is four inches or less, and a permissible variation of ± 1½ inches when the slump shown on the approved mix design is greater than four inches. However, when an approved high range water reducing chemical admixture (ASTM C 494, Type F or Type G) conforming to the requirements of Subsection 1006-2.04 is used, the permissible variation will be ± two inches, regardless of the slump shown on the approved mix design.

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 Independent Quality Firm 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 Inspector may discontinue sampling from one of the sources; however, the Inspector may take periodic samples from both sources to verify the correlation of test results.

1006-5 Concrete Temperature and Weather Limitations:

1006-5.01 General Requirements:

The temperature of the concrete mixture immediately before placement shall not be less than 50 degrees F nor greater than 95 degrees F. Concrete that fails to conform to this temperature requirement shall be rejected prior to placement.

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 Class P concrete and slabs placed on subgrade for Class S or Class B concrete.

1006-5.02 Hot Weather Concreting:

Forms, subgrade, and reinforcing steel shall be sprinkled with cool water just prior to the placement of concrete.

Mix water may be cooled by refrigeration, liquid nitrogen, or well-crushed ice of a size that will melt completely during the mixing operation. If crushed ice is used, it shall be substituted for part of the mix water on a pound for pound basis.

1006-5.03 Cold Weather Concreting:

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. Immediately prior to placing concrete, the temperature of forms, reinforcing steel, earthen material, or any other material that will come in contact with the freshly placed concrete shall be a minimum temperature of 40 degrees F. If artificial heat is used to adjust the temperature of the items that will come in contact with the freshly mixed concrete, the temperature of these items shall not exceed 10 degrees F greater than that of the concrete being placed.

Concrete operations shall be discontinued when a descending ambient temperature in the shade and away from artificial heat falls below 40 degrees F. Concrete operations shall not be resumed until an ascending ambient temperature in the shade and away from artificial heat exceeds 35 degrees F.

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 ambient temperature drops to 35 degrees F.

Cold Weather is defined as a period when, for more than 3 consecutive days, the following conditions exist: 1) the average daily air temperature is less than 40 degrees F and 2) the air temperature is not greater than 50 degrees F for more than one-half of any 24-hr period. The average daily air temperature is the average of the highest and the lowest temperatures occurring during the period from midnight to midnight. If Cold Weather, as defined herein, is forecast to occur spanning a planned concrete curing operation, the concrete shall be protected in a manner to maintain all concrete surface temperatures at not less than 50 degrees F for a period of 72 hours after placement and at not less than 40 degrees F for an additional 96 hours.

The Developer may use equipment to heat the aggregates or water, or both, prior to mixing. If aggregates are heated, the minimum temperature of the heated aggregate shall be 60 degrees F 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 degrees F unless the water is mixed with the aggregate prior to the addition of cement to the batch. During the heating or mixing process, cement shall not be added to water and aggregate combinations which exceed 100 degrees F.

When weather forecasts indicate a probability that ambient temperatures will fall below 35 degrees F during the placement or curing periods, the Developer shall submit a cold weather concreting plan to the Independent Quality Firm for approval prior to concrete placement. The cold weather concreting plan shall detail methods and equipment which will be used to ensure that the required concrete temperatures are maintained. The Developer shall provide adequate cold weather protection in the form of insulation and/or heated enclosures to protect the concrete after placement. For bridge decks and suspended structures, the cold weather concreting plan shall include protection measures for both the top and bottom surfaces of the concrete. This protection shall maintain concrete surface temperatures as specified above at all locations in the structure. When artificial heating is required, the heating units shall not locally heat or dry the surface of the concrete.

When a cold weather concreting plan is required, the Inspector may require concrete temperatures to be measured and continuously recorded by the use of temperature sensing devices during the entire curing period. The Developer shall provide the temperature sensing devices and recording instruments. The Developer shall install temperature sensing devices near the surface of the concrete at locations and depths designated by the Inspector. When concrete is placed on a bridge deck or suspended structure, both the bottom surface and the top surface shall be monitored with temperature sensing devices. Temperature sensing devices and recording instruments shall be approved by the Inspector. The Developer shall continuously monitor the concrete temperature and provide the recorded data to the Inspector at any time upon request.

If the surface concrete temperature at any location in the structure falls below 35 degrees F during the curing period, the Inspector may direct the Developer to core the areas in question. The Developer shall submit the cores to a petrographer for examination in accordance with ASTM C 856. Concrete damaged by frost, as determined by the petrographer, shall be removed and replaced. All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Developer regardless of the outcome of the petrographic examination.

The placing of concrete will not be permitted until the Inspector 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 curing period in such a manner that will permit a gradual drop in the concrete temperatures.

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 if 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 covered with a curing medium or sprinkling of the surface is permitted. 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.

If a curing medium is used, the concrete shall be kept continuously wet by sprinkling with water for the entire curing period. Burlap, rugs, carpets, or earth or sand blankets may be used as a curing medium to retain the moisture during the 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 waterproof 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 one gallon per 100 square feet.

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 a rate sufficient to assure uniform coverage.

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.

(E) Curing Bridge Decks, Approach Slabs, and Anchor Slabs:

The top surface of bridge decks, approach slabs, and anchor slabs 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 one gallon per 100 square feet. The curing compound shall form a continuous unbroken surface.

Water curing shall be applied not later than four hours after the completion of the surface finishing operations and shall be applied as specified herein.

The top surface of bridge decks, approach slabs, and anchor slabs that will be covered with a special riding surface or waterproofing 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 Developer 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 degrees F, steam shall be applied during the presteaming period to hold the air surrounding the precast item at a temperature between 50 and 90 degrees F.

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 degrees F per hour. The average curing temperature throughout the enclosure shall not exceed 160 degrees F 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 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 degrees F 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 of continuous bed length will be required for checking temperature.

In the event the side forms are removed before the precast unit has attained 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. A temperature sensing device shall be placed two ± 1/2 inches 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 Inspector may allow 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 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, and additionally in the case of Class P concrete, on the measured thickness of concrete pavement in place according to Section 401. 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 (when required) as well as for fabrication of test cylinders for compressive strength determination at 28 days will be taken at random at the specified sampling frequency 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 as follows:

(1) Concrete for Class S or Class B shall be sampled only once during discharge in the middle portion of the batch. At the discretion of the Inspector, a sample may be obtained at the beginning of the discharge if, in the Inspector's opinion, the properties of the concrete do not appear to be within the specification limits for slump or temperature.

(2) Concrete for Class P shall be sampled immediately before going into the paver or forms.

If concrete is pumped to facilitate placement, 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 Inspector, 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 made, cured, handled, protected, and transported 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.

For Class S concrete with a compressive strength requirement less than 4000 psi, or Class B concrete, a strength test will consist of the average strength of two test cylinders. However, if the compressive strengths of the two test cylinders differ by more than 10 percent from the average of the two, the strength test result shall be the cylinder with the highest compressive strength.

For Class S concrete with a compressive strength requirement equal to or greater than 4000 psi, or Class P concrete, the compressive strength of each sample shall be determined by averaging the results of the three test cylinders fabricated as specified in Subsection 1006-7.03. However, if the compressive strength of any one of the three test cylinders differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cylinders. Should the individual compressive strength of any two of the three test cylinders differ by more than 10 percent from the average of the three, the results of both will be discarded and the compressive strength shall be the strength of the remaining cylinder.

If approved by the Independent Quality Firm, and unless otherwise specified, Arizona Test Method 318 may be used to estimate concrete strength by the maturity method. The maturity method shall not substitute for compressive strength acceptance testing (28-day test cylinder breaks). The Developer shall submit a written request to the Independent Quality Firm prior to using the maturity method. If its use is approved by the Independent Quality Firm, the Developer shall be responsible to develop the strength-maturity relationship and shall also be responsible to provide the maturity meter(s) and digital data loggers necessary, as well as performing all required testing.

1006-7.03 Sampling Frequency for Cast-In-place Concrete:

See Developer's Guide Schedule for sampling frequency.

1006-7.04 Sampling Frequency for Precast Concrete:

See Developer's Guide Schedule for sampling frequency.

1006-7.05 Testing for Minor Precast Concrete Structures:

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. Testing for compressive strength of cylinders shall be in accordance with the requirements of Arizona Test Method 314.

1006-7.06 Acceptance for Compressive Strength:

(A) Class P Concrete:

Class P concrete will be accepted for compressive strength in accordance with the provisions of Section 401. All concrete failing to meet the compressive strength requirement or otherwise rejected in accordance with Section 401 or Subsection 1006-7.01, shall be replaced with concrete meeting the requirements of these specifications.

If the Developer chooses to contest the compressive strength results of any sample for purposes of acceptability, the Developer may elect to rely on the results of compressive strengths of cores. Three cores shall be obtained, at the approximate location where the contested test cylinders were obtained. Such cores shall be obtained and tested in accordance with Arizona Test Method 317. Cores must be obtained under the observation of an Inspector and delivered to the Independent Quality Firm in time to allow complete testing within 48 days of placement. Testing shall be performed by the Independent Quality Firm. The Developer may elect to have a representative present during testing. Compressive strength shall be the average of the results of the three cores. However, if the compressive strength of any one of the three cores differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cores. Should the individual compressive strength of any two of the three cores differ by more than 10 percent from the average of the three, the results of both shall be discarded and the compressive strength shall be the result of the remaining core. Results of the core testing will be binding and will replace the results of the test cylinders for that sample.

(B) Class S and Class B Concrete:

Class S and Class B concrete will be accepted for compressive strength unless:
Concrete failing to meet at least 85 percent of the 28-day compressive strength for specified strengths of 3,000 pounds per square inch and below, 90 percent for a specified strength of 3,500 pounds per square inch, or 95 percent for specified strengths of 4,000 pounds per square inch and above, or any concrete failing to meet the other requirements of Subsection 1006-7.01, will be rejected and removed and replaced with concrete which meets the specified requirements, unless the Developer can submit evidence that will indicate to the Independent Quality Firm that the strength and quality of the concrete is such that the concrete should be considered acceptable and be allowed to remain in place.

If such evidence consists of cores, the Developer shall obtain three cores from the concrete represented by the failing cylinder strength test. The cores shall be obtained under the observation of an Inspector, and delivered to the Independent Quality Firm in time to allow complete testing of such cores within 48 days after the placement of the concrete. All cores shall be obtained and tested in accordance with the requirements of Arizona Test Method 317. Testing shall be performed by the Independent Quality Firm. The Developer may elect to have a representative present during testing. The concrete represented by the cores will be considered for acceptance, in accordance with the requirements of the table above. If the average compressive strength does not meet the specified requirement, all concrete so represented shall be removed unless permitted to remain in place. Results of the core testing will be binding and will replace the results of the test cylinders for that sample.

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, except for self-supporting products having a Class V backing, such as roll-up signs and some types of traffic cone collars. Sheeting shall conform to criteria listed in the most current version of ASTM D 4956 for the applicable type and class, unless otherwise specified.

Only those retroreflective sheeting, inks, and film products that are currently shown in the Department's Approved Products List (APL) shall be used. Copies of the APL are available on the internet from the Arizona Transportation Research Center (ATRC), through its PRIDE program.

A Certificate of Compliance shall be submitted. The Certificate of Compliance shall identify the retroreflective sheeting type, backing class, make of sheeting, inks, and film intended for use in all manufactured devices, including signs, channeling devices, mileposts, object markers, guard rail markers, delineators and reference markers. The Inspectorr may accept all materials based on the certification or may require the Developer to furnish additional information or laboratory test results. Additionally, the Inspector may perform measurements on materials to determine their compliance with these specifications. Signs and other devices that have sheeting, inks or films that do not meet these requirements shall be rejected and shall be replaced.

1007-2 Material Types:

Sheeting for permanent warning signs, regulatory signs, and overhead-mounted guide signs, including all sign legends and borders, shall be ASTM Type XI.

Sheeting for all warning signs with yellow backgrounds shall be Type XI fluorescent retroreflective yellow.

Sheeting for information signs, ground-mounted guide signs, and marker signs, including all sign legends and borders, shall be ASTM Type IX or XI.

Sheeting for permanent object markers and delineators on a rigid substrate with yellow backgrounds, including guardrail end treatments, guardrail markers, rigid delineators, and impact attenuators, shall be Type XI fluorescent retroreflective yellow.

Sheeting for permanent object markers and delineators on a rigid substrate in colors other than yellow, including guardrail end treatments, guardrail markers, rigid delineators, and impact attenuators, shall be ASTM Type IX or XI.

Sheeting for object markers and delineators on a flexible or plastic substrate, including flexible delineators and sand barrels, shall be ASTM Type VIII, IX or XI.

For temporary regulatory and guide signs on a rigid substrate with fluorescent retroreflective orange sheeting, ASTM sheeting Types VIII, IX, or XI shall be used.

For temporary regulatory and guide signs on a rigid substrate in colors other than fluorescent retroreflective orange, ASTM sheeting Types IV, VIII, IX, or XI shall be used.

For retroreflective orange temporary signs on a flexible or roll-up substrate, ASTM Type VI sheeting shall be used.

All temporary signs (rigid, flexible, or roll-up) with orange backgrounds shall use fluorescent retroreflective orange sheeting, except that non-reflective sign materials may be used for temporary signs where the signs will be clearly visible under available natural light.

For barricades and other temporary channelizing devices, ASTM sheeting Types IV, VIII, IX, or XI shall be used.

Sheeting for Adopt-A-Highway signs shall be ASTM Type I, IV, or XI.

Logo signs shall be ASTM Type I, IX, or XI.

When more than one sheeting type is allowed, the Developer may use any of the types listed, provided that materials used for a particular application shall be of the same ASTM type, manufacturer, and product for all signs of the same type in the project.

Opaque films used with sheeting shall be acrylic type films.

Direct-applied and demountable black characters shall be non-reflective.

1007-3 Visual Appearance, Luminance and Color Requirements:

Except as specified herein, the color of the sheeting, ink or film shall conform to the ADOT Manual of Approved Signs, the Manual on Uniform Traffic Control Devices (MUTCD), and the plans.

All sheeting, inks and film used shall be uniformly colored so there is no visual variation in their appearance on the same sign or from sign to sign of the same colors.

Standard colors specified for sheeting, processing inks, and films shall, as applicable, match visually and be within the color tolerance limits required by Highway Tolerance Charts issued by the Federal Highway Administration. Additionally, for the retroreflective sheeting, unless otherwise noted, the Luminance Factor (Daytime Luminance) and Color Specification Limits (Daytime) shall conform to the applicable requirements of ASTM D 4956.

In addition to the luminance and color requirements, fluorescent orange sheeting and fluorescent yellow sheeting shall have the capacity to effectively fluoresce outdoors under low light conditions. For all applications requiring fluorescent orange sheeting or fluorescent yellow sheeting, the Developer shall provide a letter to the Independent Quality Firm from the manufacturer certifying that the sheeting to be used is fluorescent.

1007-4 Coefficient of Retroreflection:

The coefficient of retroreflection shall meet the minimum requirements of ASTM D 4956 for the type of retroreflective sheeting specified.

All black opaque films shall have a maximum coefficient of retroreflection of 1.0 or less at an observation angle of 0.2 degrees and entrance angle of -4.0 degrees.

1007-5 Color Processing:

Transparent and opaque inks used for post or pre-screen printing of signs shall be of a type and quality specified by the sheeting manufacturer, and shall conform to the applicable requirements of the MUTCD and the Federal Highway Administration for traffic signs. The inks shall be applied in a manner, and with equipment, that is consistent with the ink manufacturer's recommendations. Additionally, the signs produced shall have a uniform legend of consistent stroke width and sharply defined edges, without blemishes that would negatively impact appearance, color or required retroreflectivity.

For sheeting applications using black ink, the maximum coefficient of retroreflection shall be 1.0 or less at an observation angle of 0.2 degrees and entrance angle of -4.0 degrees.

1007-6 Adhesive:

Reflective sheeting and film adhesives shall be Class I as specified in ASTM D 4956 and as modified herein.

Pressure sensitive adhesive shall be an aggressive tack type that requires no heat, solvent or other pre-application preparation of the sheeting or film for its adhesion to clean aluminum, plywood, or reflective sheeting surfaces. Pretreatment of plastic surfaces shall be done as recommended by the sheeting manufacturer.

The adhesive shall form a tight weatherproof durable bond that shall endure under all weather conditions for the required time of durability for that material. During this period the material shall remain bonded to its surface without discoloration, cracking, crazing, peeling, blistering, dimensional change or alignment change.

1007-7 Weather Testing:

For the evaluation of sign sheeting products the Department has adopted a desert environment, 45 degree, south-facing outdoor acceleration test method. Sheeting will be tested for the time periods specified in Subsection 1007-8. The Department's test method will be considered to produce a two to one time-acceleration ratio for equivalent vertical exposure.

1007-8 Durability Requirements:

Sheeting stability will be determined using a durability rating which shall be equal to twice the testing periods listed below. Sheeting must be warranted by the manufacturer against the defects listed below for a period equal to the specified durability rating for each type of sheeting product. Only those sheeting products which provide the specified warranty will be acceptable.

Sheeting shall be weather-tested as specified above in Subsection 1007-7. Sheeting weather-testing periods and durability ratings shall be as specified in Table 1007-8. In all cases, the related inks and films shall be tested along with the respective sheeting, and shall be subject to the same durability requirements as the sheeting.

TABLE 1007-8

ASTM Sheeting Type	Color	Weather-testing period, months	Durability rating, years
XI	Fluorescent yellow	42	7
XI	Fluorescent orange	18	3
XI	All other colors	60	10
IX	Fluorescent orange	18	3
IX	All other colors	60	10
VIII	Fluorescent orange	18	3
VIII	All other colors	30	5
VI	Fluorescent orange	18	3
IV	All colors	30	5
I	All colors	30	5

After weather testing for the periods specified above, sheeting and related inks and films shall show no significant degradation or reduced performance. Unacceptable degrees of degradation and reduced performance are as listed below:

(1) Bubbles, wrinkles, cracks or breaks on any portion of the applied materials greater than three inches in length that result in a negative appearance or concerns of additional degradation.

(2) Significant shrinkage that causes the material to curl or to pull away from the background.

(3) Significant delaminating of any material or layer (sheeting to substrate, sheeting to sheeting, sheeting to film, ink to sheeting, film to sheeting, or film to film).

(4) Significant visible discoloration, including clouding or chalking.

(5) A loss of transparency of any transparent sheeting, ink or film.

(6) A loss in opaqueness of any opaque ink or film.

(7) Significant cracking, blistering, ripping, flaking, curling or chipping of any sheeting, ink or film.

(8) A loss of nighttime retroreflectivity as observed at night under normal conditions, or as defined and measured with a portable retroreflectometer at an observation angle of 0.2 degrees and entrance angle of -4.0 degrees. The measured coefficient of retroreflection shall be consistent with what would be expected of the type of material being measured, normal manufacturing variations, the time that the material has been in the field, and FHWA requirements.

Those sheeting products which have been evaluated for the time periods specified above using the Department's own testing and evaluation program, and that have been shown to meet the durability requirements listed herein, are included on the Approved Products List.

Manufacturer's guarantees or warranties on all traffic sign material shall be transferred to the Department upon completion and acceptance of the project.

1007-9 Application:

The sheeting, inks, clear coats (if required), and films shall be applied as specified by the manufacturer. The applied sheeting or film shall not have bubbles, wrinkles or foreign materials beneath the reflective sheeting, ink or film.

SECTION 1008 PRISMATIC REFLECTORS:

1008-1 General Requirements:

The Developer shall furnish a Certificate of Compliance. 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.

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.

1008-2 Delineator and Object Marker Retroreflectors:

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. 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 five inches gauge for five minutes. Restore atmospheric pressure and leave samples submerged for five 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 3003-H-14 or similar aluminum, or of cold rolled, hot dip, galvanized steel, having a thickness of 0.064 inches. 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 that removal is not 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 five inches gauge (water) for five 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 four hours in a circulating air oven at 175 ± five degrees F. 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
(Candelas per Footcandle per Square Inch)
Minimum Specific Intensity Per Unit Area (SIA):

Reflector Units						
Observation Angle: (Degrees)	Entrance Angle: (Degrees)	Delineators & Object Markers				Cutout Letters, Symbols & Access.
		*White	Yellow	Green	Red	Colorless
0.1	0	17.7	6.5	4.6	4.6	14.0
0.1	20	6.9	3.8	1.8	1.8	5.6
0.33	0	-	-	-	-	10.0
0.33	20	-	-	-	-	4.0
0.17	0	-	-	-	-	7.0
0.17	20	-	-	-	-	2.8

* 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. Asphalt-rubber material is also referred to as crumb rubber asphalt (CRA).

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) Crumb Rubber:

Crumb rubber shall be ambient ground and shall meet the following gradation requirements when tested in accordance with Arizona Test Method 714.

TABLE 1009-1		
Sieve Size	Percent Passing	
	Type A	Type B
No. 8	100	
No. 10	95 – 100	100
No. 16	0 – 10	75 - 95
No. 30		30 - 60
No. 50		5 - 30
No. 200		0 - 5

The crumb 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 crumb rubber shall contain not more than 0.1 percent fabric and Type B crumb rubber shall contain not more than 0.5 percent fabric. Calcium carbonate, up to four percent by weight of the crumb rubber, may be added to prevent the particles from sticking together.

Certificates of Compliance 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 material that can hold water when stored or disposed of above ground.

1009-2.02 Asphalt-Rubber Proportions:

The asphalt-rubber shall contain a minimum of 20 percent crumb rubber by the weight of the asphalt cement.

1009-2.03 Asphalt-Rubber Properties:

Asphalt-rubber shall conform to the following:

TABLE 1009-2			
Property	**Requirement**		
	CRA Type 1	**CRA Type 2**	**CRA Type 3**
Grade of base asphalt cement	PG 64-16	PG 58-22	PG 52-28
Rotational Viscosity: 177 °C (350 °F); (ASTM D 7741); Pascal·seconds	1.5 - 4.0	1.5 - 4.0	1.5 - 4.0
Penetration: 4 °C (39.2 °F), 200 g, 60 sec. (ASTM D 5); 0.1 mm, minimum	10	15	25
Softening Point: (AASHTO T 53); °C, minimum	57	54	52
Resilience: 25 °C (77 °F) (ASTM D 5329); %, minimum	30	25	20

If, during production, it is determined by testing that asphalt-rubber fails to meet the above requirements for the specified type, the material in which the asphalt-rubber is incorporated and represented by the corresponding test results shall be evaluated for acceptance. Should the material in which the asphalt-rubber is incorporated be allowed to remain in place, the contract unit price for asphalt-rubber will be adjusted by the percentage shown in Table 1009-3. Should the asphalt-rubber be in reject status, the Developer may, within 15 days of receiving notice of the reject status of the asphalt-rubber, supply an engineering analysis of the expected performance of the material in which the asphalt-rubber is incorporated. The engineering analysis shall detail any proposed corrective action, and the anticipated effect of such corrective action on the performance. Within three working days, the Independent Quality Firm will determine whether or not to accept the Developer's proposal. If the proposal is rejected, the material in which the asphalt-rubber is incorporated shall be removed and replaced with material meeting the requirements of the applicable specifications. If the Developer's proposal is accepted, the material in which the asphalt-rubber is incorporated shall remain in place at the applicable percent of contract unit price allowed, and any necessary corrective action shall be performed.

TABLE 1009-3 ASPHALT-RUBBER PAY ADUSTMENT TABLE						
Test Property	CRA Type 1		CRA Type 2		CRA Type 3	
	Test Value	Percent of Contract Unit Price	Test Value	Percent of Contract Unit Price	Test Value	Percent of Contract Unit Price
Penetration	≥ 10 8-9 < 8	100 85 70*	≥ 15 13-14 < 13	100 85 70*	≥ 25 23-24 < 23	100 85 70*
Softening Point	≥ 57 55-56 < 55	100 85 70*	≥ 54 52-53 < 52	100 85 70*	≥ 52 50-51 < 50	100 85 70*
Resilience	≥ 30 24-29 18-23 < 18	100 85 70 50*	≥ 25 20-24 15-19 < 15	100 85 70 50*	≥ 20 15-19 10-14 < 10	100 85 70 50*
*Reject Status: The pay adjustment applies if allowed to remain in place.						
Should the asphalt-rubber be deficient on more than one property, the pay adjustment will be the greatest reduction to the contract unit price specified considering individual test results.						

1009-2.04 Asphalt-Rubber Design:

At least two weeks prior to the use of asphalt-rubber, the Developer shall submit an asphalt-rubber design prepared by an approved laboratory. The design shall be formulated using asphalt cement and crumb rubber that are representative of the materials to be utilized in production, and 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 crumb rubber used. In addition, the asphalt-rubber design shall include verification of the PG binder grade of the base asphalt; however, in lieu of the design including this information, a Certificate of Analysis from an accredited laboratory or the supplier of the PG base asphalt will be acceptable.

If changes are made in the type or source of asphalt cement or in the type or source of crumb rubber, a new asphalt-rubber design will be required.

The Developer may propose the use of an asphalt-rubber design that has been developed for a previous project. The proposed design shall meet the requirements of the specifications. The Developer shall provide evidence that the type and source of asphalt cement and the type and source of crumb rubber have not changed since the formulation of the previous design. The Independent Quality Firm will determine if the previously used design is suitable for the intended use and if the previous use of the asphalt-rubber design was satisfactory. The Independent Quality Firm will either approve or disapprove the proposed design. Should the Independent Quality Firm disapprove the use of the previously used design, the Developer shall prepare and submit a new asphalt-rubber design proposal in accordance with the requirements of the specifications.

A previously used asphalt-rubber design more than two years old shall not be allowed for use. Once approved for use on a project, an asphalt-rubber design may be used for the duration of the project.

1009-3 Construction Requirements:

During production of asphalt-rubber, the Developer shall combine materials in conformance with the asphalt-rubber design.

1009-3.01 Mixing of Asphalt-Rubber:

The temperature of the asphalt cement shall be between 350 and 400 degrees F at the time of addition of the crumb rubber. No agglomerations of crumb rubber particles in excess of two inches shall be allowed in the mixing chamber. The Developer shall document that the amount of crumb rubber used does not deviate more than plus or minus 1.0% from the percentage specified in the accepted asphalt-rubber mix design. The temperature of the asphalt-rubber immediately after the initial dispersion of the crumb rubber into the asphalt cement shall be between 325 and 375 degrees F. The Developer shall ensure that the crumb rubber and asphalt cement for a particular batch have been thoroughly mixed and placed in the reaction tank prior to the beginning of the reaction period. The reaction period shall be a minimum of sixty minutes, during which time the asphalt-rubber is continuously agitated while a temperature between 325 and 375 degrees F is maintained. At any time, if the temperature falls below 325 degrees F, the reaction period shall begin anew when the temperature reaches 325 degrees F. The reaction period shall be completed before the asphalt-rubber is used. The Developer shall demonstrate that the crumb rubber particles have been uniformly incorporated into the mixture and that they have been "wetted". The occurrence of crumb rubber floating on the surface or agglomerations of crumb rubber particles shall be evidence of insufficient mixing.

The Developer shall test the viscosity of the asphalt-rubber in each batch by the use of a rotational viscometer, in accordance with ASTM D 7741. The rotational viscometer shall be furnished by the Developer or supplier. Prior to the use of each batch of asphalt-rubber, the results of the rotational viscosity testing shall meet the requirements given in Table 1009-2.

1009-3.02 Handling of Asphalt-Rubber:

Once the asphalt-rubber has been mixed, it shall be kept thoroughly agitated to prevent settling of the crumb rubber particles. The temperature of the asphalt-rubber shall be maintained between 325 and 375 degrees F.

If in the first ten hours after the completion of the reaction period the temperature of the asphalt-rubber drops below 325 degrees F, it may be reheated to a temperature between 325 and 375 degrees F.

In no case shall the asphalt-rubber be held at a temperature between 325 to 375 degrees F for more than 10 hours after the completion of the reaction period. Asphalt-rubber held for more than 10 hours shall be allowed to cool and gradually reheated to a temperature between 325 and 375 degrees F before use.

The reheating of asphalt-rubber that has cooled below 325 degrees F shall not be allowed more than one time.

Asphalt-rubber shall not be held at temperatures above 250 degrees F for more than four days after the completion of the reaction period.

For each load or batch of asphalt-rubber, the Developer shall provide the Independent Quality Firm with the following documentation:

(1) The source, grade, amount and temperature of the asphalt cement prior to the addition of crumb rubber.

(2) The source and amount of crumb rubber and the crumb rubber content expressed as percent by the weight of the asphalt cement.

(3) Times and dates of the crumb rubber additions and resultant viscosity test.

(4) 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 crumb rubber and continue until the load or batch is completely used. Readings and recordings shall be made at every temperature change in excess of 20 degrees F, and as needed to document other events which are significant to batch use and quality.

1009-4 Supplier Quality Control:

The Supplier shall perform the quality control measures described in Subsection 106.04(C) of the ADOT Standard Specifications for road and Bridge Construction, 2008.

The Supplier shall obtain samples and perform the tests specified in Table 1009-4.

TABLE 1009-4
SUPPLIER QUALITY CONTROL TESTING REQUIREMENTS

TYPE OF TEST	TEST METHOD	SAMPLING POINT	MINIMUM TESTING FREQUENCY
Crumb Rubber for Asphalt-Rubber			
Gradation	Arizona Test Method 714	Hot Plant	One sample per 40,000 lbs.
Asphalt-Rubber Material			
Softening Point	AASHTO T 53	Circulation Line Recommended (Point of sampling specified by the Inspector.)	One sample per day
Resilience: 25 °C (77 °F)	ASTM D 5329		
Rotational Viscosity	ASTM D 7741		One sample per batch.

SECTION 1010 DRAINAGE PIPE:

1010-1 General Requirements:

Certificates of Compliance shall be furnished.

1010-2 Metal Pipe:

1010-2.01 Corrugated Metal Pipe:

Type 1A pipe, as specified in AASHTO M 36, Section 4.1.2, may be used if the shell thickness meets or exceeds the thickness specified on the plans for Type 1 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, except as otherwise noted herein.

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.

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 245 and M 196, except that the use of bands with projections (dimples) will be limited to connection of new pipe to existing in-place pipe. 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 or ASTM B 766. Components of bolted assemblies shall be galvanized in accordance with ASTM A 153 separately before assembly.

Special sections, such as elbows and prefabricated end sections, shall conform to the applicable requirements of AASHTO M 36, M 190, M 196 and M 245.

Gaskets for all water-resistant joints shall be a continuous band or strip, at least seven inches wide and one half inch thick. Rubber for the gaskets shall conform to the requirements of ASTM D 1056 for the "2A" closed cell expanded grades.

Watertight joints shall use "O"-ring gaskets. The “O”-ring gasket shall conform to the diameter dimensions specified in AASHTO M 36, Section 9.3, and conform to the technical requirements of AASHTO M 198. Watertight joints may be used when water-resistant joints are specified.

1010-3 Slotted Pipe:

Slotted pipe shall conform to the applicable requirements of AASHTO M 36. 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 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 the grate. The grate must be continuous and full depth. The grate shall be welded continuously to the pipe with a 3/16 inch 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 material shall be an extruded strip or bead compounded from a nondrying, nontoxic, synthetic resin base with butyl rubber and inorganic extenders and 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 degrees F nor become brittle, crack or lose adhesion at temperatures as low as -30 degrees F 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 inch by one inch strips or in one inch diameter beads on one inch 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 Independent Quality Firm.

Grout shall consist of Portland cement, aggregate, and water. It may also contain supplementary cementitious material. Portland cement, aggregate, water, and supplementary cementitious material shall conform to the requirements of Section 1006. Chemical admixtures may be used. Chemical admixtures shall conform to the requirements of Subsection 1006-2.04, except no admixtures containing chlorides or nitrates shall be used. Air-entraining admixtures, conforming to the requirements of Subsection 1006-2.04, will be required for grout placed at elevations of 3000 feet or above.

The grout shall meet the requirements given in the table below.

Minimum Cementitious Material Content: Lbs per CY (See Note 1)	**Maximum Water/Cementitious Material Ratio (w/cm): Lb./Lb.**	**Slump: Inches** (See Note 2)	**Air Content: Percent** (See Note 3)
850	0.60	9 ± 2	0 – 8
Note 1: A maximum of 25 percent of the cementitious material, by weight, may consist of an approved Class F fly ash, conforming to the requirements of ASTM C 618.			
Note 2: The consistency of the grout shall be as approved by the Independent Quality Firm.			
Note 3: For placement of grout at elevations of 3000 feet or above, the air content shall be a minimum of 4 percent and a maximum of 8 percent.			

The aggregate shall consist of fine aggregate; however, at the option of the Developer, No. 8 coarse aggregate may be used in the grout. If No. 8 coarse aggregate is used, the volume shall be a maximum of 35 percent of the total aggregate volume.

For plant-mixed grout, the proportioning, mixing, and placing shall be in accordance with the applicable requirements in Section 1006.

For on-site mixing, grout that has been mixed more than one hour shall not be used.

Re-tempering of grout will not be permitted.

1010-4 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.

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, 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 1004, as applicable.

1010-6 Reinforced Concrete Pipe:

Reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 242 for the D-load specified.

Reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 170 for the class of pipe specified.

Reinforced concrete pipe (elliptical) shall conform to the requirements of AASHTO M 207 for the class of pipe specified.

Reinforced concrete pipe (arch) shall conform to the requirements of AASHTO M 206 for the class of pipe specified.

The Developer shall furnish the Independent Quality Firm 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 of the flared end section shall be at least equal to the minimum steel requirement for the reinforcement in that portion of the flared end section which abuts the pipe.

Gaskets for reinforced concrete pipe (circular) joints 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 replacement for any cement.

1010-7 Nonreinforced Concrete Pipe:

Nonreinforced concrete pipe shall conform to the requirements of AASHTO M 86 for the class of pipe specified.

Gaskets and mortar used to join nonreinforced concrete pipe shall conform to the requirements hereinbefore specified under Subsection 1010-6.

1010-8 Corrugated High Density Polyethylene Plastic Pipe, Steel Reinforced High Density Thermoplastic Ribbed Pipe, and Corrugated Polypropylene Plastic Pipe:

See Section 508-2 and 508-3 for material requirements.

Tracer wire, which is to be placed in the trench with the corrugated high density polyethylene plastic pipe, steel reinforced high density thermoplastic ribbed pipe, or corrugated polypropylene plastic pipe as an aid in location after burial, shall conform to the requirements of Subsection 104.15(B).

1010-9 Metal Safety End Sections:

Metal safety end sections shall conform to the applicable requirements of AASHTO M 36.

Bolts and nuts shall be steel conforming to the requirements of ASTM A 307 and shall be galvanized in accordance with the requirements of ASTM A 153.

Safety and longitudinal bars shall be fabricated using schedule 40 galvanized pipe. All bars shall be galvanized after fabrication in accordance with the requirements of ASTM A 123. Components of bolted assemblies shall be galvanized after fabrication in accordance with the requirements of ASTM A 153 separately before assembly.

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 Developer.

The waterstops shall be formed with an integral cross section which shall be uniform within ± 1/8 inch in width and the web thickness or bulb diameter within + 1/16 and - 1/32 inch. 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 splices 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, at the option of the Developer. All finished splices shall have a tensile strength of not less than 50 percent of the unspliced material.

Certificates of Compliance 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), psi	Minimum 3,500
Elongation at Breaking (ASTM D 412), percent	Minimum 550
Unit Stresses:	
At 300 percent Elongation, psi	Minimum 1,100
At 500 percent Elongation, psi	Minimum 2,800
Shore Durometer (Hardness) (ASTM D 2240)	55 to 65
Tensile Strength and Elongation at Breaking (ASTM D 572), after 7 days in air at 158 ± 2 ^{o}F or after 48 hours in oxygen at 158 ± 2 ^{o}F and 300 psi = 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), psi	Minimum 2,500
Elongation at Breaking (ASTM D 412), percent	Minimum 425
Shore Durometer (Hardness) (ASTM D 2240)	50 to 70
Tensile Strength and Elongation at Breaking (ASTM D 572), after 7 days in air at 158 ± 2 °F or after 48 hours in oxygen at 158 ± 2 °F and 300 psi = percent of original	Minimum 65

1011-2 Polyvinyl Chloride (PVC) Waterstops:

Polyvinyl chloride waterstops shall be manufactured from virgin polyvinyl chloride conforming to the requirements of the Corps of Engineers Specification Number CRD-C572.

Certificates of Compliance shall be submitted stating that the requirements specified under paragraph six 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-Applied):

Joint sealant material, other than asphalt-rubber sealant, shall be a hot-applied type, conforming to the requirements of ASTM D 3406 or ASTM D 7116, as appropriate. Joint sealant shall not contain any coal-tar materials.

Asphalt-rubber joint sealant material shall be a hot-applied type, conforming to the requirements of ASTM D 6690, Type I or Type II.

The following requirement shall be added to the "Packaging and Package Marking" requirements of ASTM D 3406, ASTM D 7116, and ASTM D 6690:

> The minimum ambient temperature during application and ambient temperatures under various storage conditions shall be clearly marked on the container.

Certificates of Compliance shall be submitted.

1011-4 Joint Sealant (Cold-Application):

Joint sealant shall be cold-application, mastic, single- or multiple-component type.

Certificates of Compliance 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 longer than required by the plans and the additional length will be removed by the Inspector and used for testing by Independent Quality Firm.

Certificates of Compliance shall be submitted.

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 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 three inches with commercial quality open cell polyurethane foam or closed by other means.

The seal element shall be installed in strict accordance with the manufacturer's recommendations 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 seals 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.

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 degrees F to 120 degrees F.

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 instructions 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 preformed 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 will not be permitted.

The elastomer for strip seal elements shall conform to the requirements of ASTM D 3542 modified as follows:

(a) Recovery testing is excluded.

(b) TABLE 1 of ASTM D 3542 is revised as follows:

TABLE NO. 1
PHYSICAL PROPERTIES FOR PREFORMED ELASTOMER STRIP SEALS

Property	Require-ment	ASTM Test Method
Tensile strength, minimum psi	2000	D 412
Elongation at break, min. %	250	D 412
Hardness, Type A durometer, points	60 ± 5	D 2240 (Modified) (1, 3)
Oven aging, 70 hr at 212 ^{o}F Tensile strength, loss, max. % Elongation, loss, max. % Hardness, Type A durometer, points change	 20 20 0 to + 10	D 573 D 2240 (Modified) (1, 3)
Oil swell, ASTM Oil No. 3, 70 hr at 212 ^{o}F, weight change, max. %	45	D 471
Ozone resistance, 20 % strain, 300 pphm in air, 70 hr at 104 ^{o}F	No Cracks	D 1149 (Modified) (2)
Low temperature stiffening 7 days at 14 ^{o}F; Hardness, Type A durometer, points change	0 to +15	D 2240 (Modified) (1, 3)
Compression set, 70 hr at 212 ^{o}F, maximum %	40	D 395 Method B (Modified) (1)
(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.

Certificates of Compliance shall be submitted.

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 its recommendations.

Certificates of Compliance shall be submitted.

1011-8 Silicone Joint Sealant:

1011-8.01 General Requirements:

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 conform to the requirements of ASTM D 5893, except as specified herein.

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 sealant, 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 bond test method in conformance with ASTM D5893. The sealant may be recertified for a period not exceeding six months from the date of retesting.

1011-8.03 Field Performance:

The manufacturer of the joint sealant shall demonstrate satisfactory field performance in Arizona of less than one percent 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 Acceptance:

Only those sealants shown on the Department’s Approved Products List (APL) shall be used. Copies of the most current version of the APL are available on the internet from the Arizona Transportation Research Center (ATRC), through its PRIDE program. In addition, a Certificate of Analysis shall accompany each lot or batch of sealant.

SECTION 1012 GUARDRAIL MATERIALS:

1012-1 General Requirements:

Certificates of Compliance shall be submitted.

References to ARTBA in this section shall hereinafter refer to AASHTO-AGC-ARTBA "A GUIDE TO STANDARDIZED HIGHWAY BARRIER HARDWARE", 1995 edition.

1012-2 Fasteners, Rail Elements, Posts and Blocks:

Guardrail fasteners, rail elements, posts, blocks, and other components shall conform to the requirements of ARTBA. Rail elements shall be galvanized after fabrication, with fabrication to include forming, cutting, shearing, punching, drilling, bending, welding, and riveting. Unless otherwise specified, all surfaces of guardrail 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 strap shall be 10-penny common, galvanized.

The metal used to manufacture reflector tabs shall be either 3003-H14 aluminum strip 0.063 ± 0.004 inches thick, or steel strip 0.078 ± 0.008 inches 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. Adhesive for sheeting attachment to the metal tab shall be of the type and quality recommended by the sheeting manufacturer.

Nuts, bolts, and washers to be used in installations for which the details are not shown on the plans nor in the ARTBA publication shall conform to the requirements of ASTM F 568 or A 307; 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.

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 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 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.

Where galvanizing has been damaged, the coating shall be repaired by painting with two coats of zinc paint, in accordance with Section 1002.

1012-4 Timber Guardrail, Posts and Blocks:

Timber for posts and blocks shall be rough sawn (unplaned) 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 or better, and the stress grade shall be as follows:

6 inch by 8 inch Post and Block	1,200 psi
8 inch by 8 inch Post and Block	900 psi
10 inch by 10 inch Post and Block	900 psi

When the plans show guardrail systems using eight-inch by eight-inch timber posts and blocks, the Developer may use 8-1/4 inch by 8-1/4 inch nominal size posts and blocks with a stress grade of 825 pounds per square inch.

At the time of installation, the dimensions of timber posts and blocks shall vary no more than ± 1/2 inch 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. Only one type of post and block shall be used for any one continuous length of guardrail.

All timber shall have a preservative treatment in accordance with the requirements of AASHTO M 133.

SECTION 1013 BEARING PADS:

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 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, shall be an elastomer with 130 pounds per square inch 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 be not 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, signified by a larger grade number, may be substituted for a lower one.

The elastomer compound shall meet the minimum requirements of Table 1013-1. 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 1013-1. Laminated bearings shall have a shear modulus not greater than 200 pounds per square inch. When test specimens are cut from the finished product, the physical properties shall be permitted to vary by 10 percent from those specified in Table 1013-1. All material tests shall be carried out at 73 ± 4 degrees F, unless otherwise noted. Shear modulus tests shall be carried out using the apparatus and procedures described in Annex A1 of ASTM D 4014.

Table 1013-1
ELASTOMERIC COMPOUND REQUIREMENTS

Note 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.

Physical Properties				
D 2240	Hardness: Shore A Durometer	45 to 75		
		50 ±5	60 ±5	70 ±5
D 412	Ultimate Elongation: min. %	400	350	300
	Tensile Strength: min. psi	2250		
Heat Resistance				
D 573: 70 hrs at 212 °F	Change in Durometer Hardness: maximum points	15		
	Change in Tensile Strength: maximum %	- 15		
	Change in Ultimate Elongation: maximum %	- 40		
Compression Set				
D 395, Method B	22 hr at 212 °F: maximum %	35		
Ozone				
D 1149	100 pphm ozone in air by vol., 20 % strain, 100 ± 2 °F, 100 hr, mounting IAW ASTM D 518 (Procedure A)	No Cracks		
Low Temperature Brittleness				
D 746 Procedure B	Grade 0: No Test Required Grade 2: No Test Required Grade 3: Brittleness at - 40 °F	- - No Failure		
Instantaneous Low Temperature Thermal Stiffening				
D 1043	Grade 0: Tested at - 25 °F Grade 2: Tested at - 25 °F Grade 3: Tested at - 40 °F	(1) (1) (1)		
Low Temperature Crystallization				
Quad Shear Test As Described	Grade 0: No Test Required Grade 2: 7 Days at 0 °F	(2) (2)		

	Grade 3: 14 Days at - 15 ^oF	(2)

(1) Stiffness at test temperature shall not exceed four times the stiffness measured at 73 ^oF.
(2) Stiffness at test time and temperature shall not exceed four times the stiffness measured at 73 ^oF 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 ± 25 % 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 Elastomeric Bearing Pads:

Pads less than or equal to 1/2 inch in thickness shall be all elastomer.

Pads of all-elastomer 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 areas, and to cause as little damage to the material as possible.

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.

1013-2.04 Steel Reinforced Elastomeric Bearing Pads:

Steel-reinforced elastomeric bearing pads shall conform to the requirements for steel-laminated elastomeric bearings as specified in ASTM 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 in inches shown on the project plans divided by 1/2 inch. The steel laminates shall be 14 gage and shall be spaced every 1/2 inch, center-to-center. The top and bottom steel laminates shall have 1/4 inch 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. 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, ASTM A 1011, or ASTM A 1008, Grade 40. Holes in plates 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 plates (sole plates) shall be protected from rusting by the manufacturer, 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 inch of width.

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	**Tolerances**	
	Minus	**Plus**
1. Overall Height:		
Design Thickness 1-1/4 inch or less	-0	+1/8 inch
Design Thickness over 1-1/4 inch	-0	+1/4 inch
2. Overall Horizontal Dimensions:		
36 inches or Less	-0	+1/4 inch
Over 36 inches	-0	+1/2 inch
3. Thickness of Individual Layers of Elastomer at any Point Within the Bearing	± 20 % of Design Value but no more than ± 1/8 inch	
4. Parallelism with Opposite Face:		
Top and Bottom	0.005 Radians	
Sides	0.02 Radians	
5. Position of Exposed Connection Members, Holes, Slots, or Inserts	± 1/8 inch	
6. Edge Cover: Embedded Laminates or Connection Members	-0	+1/8 inch
7. Thickness: Top and Bottom Cover Layer	-0	+1/8 inch

(if required)		
8. Size: Holes, Slots, or Inserts	± 1/8 inch	

1013-3 Certification and Testing:

1013-3.01 General Requirements:

(A) General:

A lot shall consist of a single type of bearing of the same design, material and thickness, delivered to the project site at the same time. Unless otherwise specified on the plans, certification and testing shall be as described in Subsections 1013-3.01(B) and (C).

(B) Testing by Manufacturer:

The Developer shall furnish the Certificates of Analysis from the manufacturer certifying that the bearings to be furnished conform to all specified requirements.

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. The marking shall be on the face that is visible after erection of the bridge.

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 within the preceding year on identical formulations. Certificates of Analysis from the manufacturer shall be provided for each lot of reinforcement.

All three low temperature tests described in Subsection 1013-3.02(C) shall be conducted on Grade 3 material used in each lot of bearings, with the following exception. In lieu of the low temperature crystallization tests on each lot of bearings to be used, the manufacturer may choose to provide Certificates of Analysis from low-temperature crystallization tests performed within the preceding year on identical Grade 3 material.

Instantaneous thermal stiffening tests shall be conducted on material of Grades 0 and 2. Low temperature brittleness and crystallization tests are not required for Grade 0 or 2 materials.

Every finished bearing shall be visually inspected in accordance with Subsection 1013-3.02(D).

Every steel reinforced bearing shall be subjected to the short-term load test described in Subsection 1013-3.02(E).

(C) Testing by Developer:

A minimum of two sample pads from every 100 pads furnished, or portion thereof, will be selected at random by the Inspector at the project site for testing. A minimum of one sample pad will be selected from each lot. Bearing pads marked or otherwise presented as being test pads shall not be tested. Samples shall consist of complete pads as detailed on the project plans and as specified herein. The Developer 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 Developer shall have the sample elastomeric bearing pads tested by a testing laboratory. The testing laboratory shall be approved by the Independent Quality Firm, shall be not affiliated with the bearing pad manufacturer, and shall be under the supervision of a registered professional engineer. The Developer shall furnish the Certificates of Analysis from the approved testing laboratory certifying that the bearings tested conform to the specified requirements for dimensional tolerances and material properties. The following tests shall be performed as appropriate and be supported with Certificates of Analysis:

(1) Ambient temperature test
(2) Heat resistance test
(3) Low temperature test
(4) Visual inspection
(5) Shear modulus test
(6) Bond and peel strength tests

The heat resistance tests shall be performed in accordance with Subsection 1013-3.02(B).

Shear stiffness tests shall be performed on material from a random sample of the finished bearings in accordance with Subsection 1013-3.02(G).

Cold bonding of individual laminated pads and peel strength tests shall be performed in accordance with Subsection 1013-3.02(H).

1013-3.02 Testing Requirements:

(A) Ambient Temperature Tests on the Elastomer:

The elastomer used shall satisfy the limits prescribed in Table 1013-1 for durometer hardness, tensile strength, and ultimate elongation. The bond to the reinforcement, if any, shall also satisfy the bond requirements in Subsection 1013-2.03 or 1013-2.04 and shall be tested in accordance with ASTM D 429, Method B. The shear modulus of the material shall be tested at 73 degrees F using the apparatus and procedure described in Annex A1 of ASTM D 4014. It shall fall within 15 percent of the specified value.

(B) Heat Resistance Tests on the Elastomer:

The elastomer shall satisfy the limits prescribed in Table 1013-1 for the change in durometer hardness, change in tensile strength, and change in ultimate elongation, as well as for compression set and ozone.

(C) Low Temperature Tests on the Elastomer:

Grade 3 elastomer shall be subjected to low temperature brittleness tests (ASTM D 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 1013-1, and the compound shall satisfy all limits for its grade.

(D) 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.

(E) Short-Duration Compression Tests on Bearings:

The bearing shall be loaded in compression to 1.5 times its maximum design load. That load shall be held constant for five minutes, removed, and reapplied for another five minutes. The bearing shall be examined visually while under the second loading. If the bulging pattern suggests layer thickness or parallelism outside the specified tolerances or a poor laminate bond, the bearing shall be rejected. If there are three or more separate surface cracks greater than 0.08 inches wide and 0.08 inches deep, the bearing shall be rejected.

(F) 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 layer thickness or parallelism outside the specified tolerances or a poor laminate bond, the bearing shall be rejected. If there are three or more separate surface cracks greater than 0.08 inches wide and 0.08 inches deep, the bearing shall be rejected.

(G) 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 procedures described in Annex A1 of ASTM D 4014, or 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 account of the influence on shear stiffness of bearing geometry and compressive load.

(H) Bond and Peel Strength Tests:

Cold bonding between individual laminated pads, if used, shall be tested in accordance with the requirements of California Test 663.

The peel strength test shall be performed in accordance with ASTM D 429, Method B, for steel reinforced pads.

1013-4 Installation:

Bearings shall be placed on surfaces that are plane to within 1/16 inch and horizontal to within 0.01 radians. Exterior plates of the bearing shall not be welded unless at least 1-1/2 inches 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 degrees F.

SECTION 1014 GEOSYNTHETICS:

1014-1 General Requirements:

Certificates of Compliance shall be submitted by the Developer 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 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 Independent Quality Firm before the materials may be incorporated in the work.

Certificates of Analysis may be submitted, along with a representative sample of appropriate size for testing, by the supplier or manufacturer of any geosynthetic material to the Independent Quality Firm 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 sheets, installation procedures and recommendations, recommended use, and project references shall also be submitted by the supplier or 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 materials will be in a manner to prevent damage, contamination, or deterioration of the materials.

Samples of geosynthetic materials shall be submitted for testing. No samples shall be taken within five feet of either end of a roll. Samples shall be a minimum of six feet long by the full roll width.

1014-2 Pavement Fabric:

Pavement fabric shall be a geotextile fabric material, constructed of nonwoven 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	Requirement	Test Method
Weight: oz./sq. yd.	4.0 - 6.0	ASTM D 3776
Grab tensile strength: lbs.	80 minimum*	ASTM D 4632

Elongation at break: percent	50 minimum*	ASTM D 4632
Fabric thickness: mils	25 to 100	ASTM D 461
Melting point: degrees F	300 or greater	ASTM D 276
Asphalt Retention: gal./sq. yd.	0.2 minimum	ASTM D 6140
* 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.

1014-3 Geogrid:

Geogrid reinforcement material for roadway base applications shall be a bi-axial polymer grid structure, specifically fabricated for use as a base reinforcement. The geogrid shall be one of the following structure types:

(A) A structure comprised of punched and drawn polypropylene or high density polyethylene sheet to form a grid.

(B) 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	Requirement	Test Method
Average Aperture Size: inch MD, Note (2) XD, Note (3)	 0.8 - 2.0 0.8 - 2.0	I.D. Calipered, (1)
Open Area: %	70 min., (4)	COE Method, (5)
Weight: oz./yd.	5.5 min.	ASTM D 3776
Thickness: mils At Rib At Junction	 30 min. 60 min.	ASTM D 1777
Wide Width Strip Tensile Strength: lb./ft.		ASTM D 4595

At 2% Strain At 5% Strain At 15% Strain or Ultimate	275 min. 550 min. 800 min.	
Flexural Rigidity: mg-cm	250,000 min.	ASTM D 1388
Junction Strength: %	80 min.	ASTM D 638 Mod,(6)

(1) Maximum inside dimension in each principal direction measured by calipers.
(2) MD-Machine direction which is along roll length.
(3) XD-Cross machine direction which is across the roll width.
(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 minimum values listed when sampled according to ASTM D 4354 and tested according to the test method specified above.
(5) Percent open area measured without magnification by the Corps of Engineers Method as specified in CW 02215, Civil Works Construction Guide, November 1977.
(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 a "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 two inches per minute at a temperature of 68 degrees F.

The width of the geogrid shall normally be approximately 13 feet or as appropriate for the proposed construction.

1014-4 Separation Geotextile Fabric:

Separation geotextile fabric shall be a 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 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 as shown on the project plans. Physical requirements for nonwoven or woven fabrics 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) Nonwoven:

Low survivability, nonwoven separation fabric shall meet the following physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Grab Tensile Strength: lbs.	90 min.	ASTM D 4632
Grab Elongation at Break: %	45 min., 115 max. (2)	ASTM D 4632
Puncture Strength: lbs.	30 min.	ASTM D 4833
Burst Strength: psi	130 min.	ASTM D 3786
Trapezoidal Tear: lbs.	30 min.	ASTM D 4533
Permittivity: $second^{-1}$	0.07 min.	ASTM D 4491
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Ultraviolet Stability: %	70 min.	ASTM D 4355
(1) 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. (2) 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, nonwoven separation fabric shall meet the following physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Grab Tensile Strength: lbs.	140 min.	ASTM D 4632
Grab Elongation at Break: %	45 min., 115 max. (2)	ASTM D 4632
Puncture Strength: lbs.	50 min.	ASTM D 4833
Burst Strength: psi	210 min.	ASTM D 3786
Trapezoidal Tear: lbs.	40 min.	ASTM D 4533

Permittivity: second^{-1}	0.07 min.	ASTM D 4491
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Ultraviolet Stability: %	70 min.	ASTM D 4355

(1) 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.

(2) 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:

(A) Nonwoven:

High survivability, nonwoven separation fabric shall meet the following physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Grab Tensile Strength: lbs.	200 min.	ASTM D 4632
Grab Elongation at Break: %	45 min., 115 max. (2)	ASTM D 4632
Puncture Strength: lbs.	75 min.	ASTM D 4833
Burst Strength: psi	320 min.	ASTM D 3786
Trapezoidal Tear: lbs.	50 min.	ASTM D 4533
Permittivity: second^{-1}	0.07 min.	ASTM D 4491
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Ultraviolet Stability: %	70 min.	ASTM D 4355

(1) 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.

(2) 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:

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) Nonwoven:

Very high survivability, nonwoven separation fabric shall meet the following physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Grab Tensile Strength: lbs.	270 min.	ASTM D 4632
Grab Elongation at Break: %	45 min., 115 max. (2)	ASTM D 4632
Puncture Strength: lbs.	110 min.	ASTM D 4833
Burst Strength: psi	430 min.	ASTM D 3786
Trapezoidal Tear: lbs.	75 min.	ASTM D 4533
Permittivity: second^{-1}	0.07 min.	ASTM D 4491
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Ultraviolet Stability: %	70 min.	ASTM D 4355

(1) 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.

(2) 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 physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Grab Tensile Strength: lbs.	340 min.	ASTM D 4632
Grab Elongation at Break: %	13 Min., 115 Max. (2)	ASTM D 4632
Puncture Strength: lbs.	130 min.	ASTM D 4833
Burst Strength: psi	500 min.	ASTM D 3786
Trapezoidal Tear: lbs.	90 min.	ASTM D 4533
Permittivity: $second^{-1}$	0.07 min.	ASTM D 4491
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Ultraviolet Stability: %	70 min.	ASTM D 4355

(1) 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.

(2) 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 nonwoven 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 physical requirements for the bank protection fabric shall be as specified in Subsection 1014-4.03(A) except that the grab elongation at break, percent, shall be 15 minimum, 115 maximum, and the permittivity shall be 0.50 minimum.

1014-6 Geocomposite Wall Drain System:

The Geocomposite Wall Drain 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 drainage core shall provide support for and shall be bonded to the geotextile filter fabric at intervals not exceeding 1-1/8 inches 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 per square foot of flat area in contact with the geotextile fabric to support the fabric. The core material shall additionally conform to the following minimum physical requirements:

Property	Requirement	Test Method
Thickness with Fabric: inch	0.23 (1)	ASTM D 1777
Compressive Strength: psf	6,000	ASTM D 1621
Transmissivity; Gradient = 1.0, Normal Stress = 3000 psf, gal./min./ft.	4.0	ASTM D 4716
(1) Minimum average roll value, i.e., the average test result for a lot shall meet or exceed the minimum value listed when sampled and tested according to the specified 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 physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Weight: oz./sq. yd.	4.0 min.	ASTM D 3776
Grab Tensile Strength: lbs.	90 min.	ASTM D 4632
Grab Elongation at Break: %	35 min.,115 max. (2)	ASTM D 4632
Mullen Burst Strength: psi	140 min.	ASTM D 3786
Trapezoidal Tear: lbs.	30 min.	ASTM D 4533
Puncture Strength: lbs.	30 min.	ASTM D 4833
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Permittivity: second^{-1}	0.50 min.	ASTM D 4491
Ultraviolet Stability: %	70 min.	ASTM D 4355

(1) 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.
(2) 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 three-inch 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 which 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. The core shall have at least 14 square inches of flat area in contact with the geotextile fabric to support the fabric per square foot. The core material shall additionally conform to the following minimum physical requirements:

Property	Requirement	Test Method
Thickness Wrapped with Fabric: inch	0.75 (1)	ASTM D 1777
Compressive Strength: psf	4,000	ASTM D 1621
Transmissivity; Fabric Wrapped Core, Gradient = 0.1, Normal Stress = 1500 psf, gal./min./ft.	4.0	ASTM D 4716, (2)
Width: ft.	1.0 (3)	Measured
Notes: (1) Minimum average roll value, i.e., the average test result for a lot		

	shall meet or exceed the minimum value listed when sampled and tested according to the specified 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 physical requirements:

Property	Requirement (Average Roll Value) (1)	Test Method
Weight: oz./sq. yd.	4.0 min.	ASTM D 3776
Grab Tensile Strength: lbs.	90 min.	ASTM D 4632
Grab Elongation at Break: %	35 min., 115 max. (2)	ASTM D 4632
Mullen Burst Strength: psi	140 min.	ASTM D 3786
Trapezoidal Tear: lbs.	30 min.	ASTM D 4533
Puncture Strength: lbs.	30 min.	ASTM D 4833
Apparent Opening Size: U.S. Standard sieve size	30 – 140	ASTM D 4751
Permittivity: second^{-1}	0.50 min.	ASTM D 4491
Ultraviolet Stability: %	70 min.	ASTM D 4355

(1) 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.

(2) 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.

1014-7.03 Outlet Pipes:

The pipe for the edge drain outlet lateral shall be rigid, four-inch 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.

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.

1014-9 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 second^{-1}.

SECTION 1015 EPOXY MATERIALS:

1015-1 General Requirements:

Certificates of Compliance shall be submitted by the Developer for any epoxy materials used on a specific project. The epoxy material must be on the current ADOT Approved Products List (APL) prior to submittal for use on an ADOT project. Copies of the most current version of the APL are available on the internet from the Arizona Transportation Research Center (ATRC), through its PRIDE program. The epoxy material must be approved for the use or application for which it is intended.

The Developer shall submit product literature and Safety Data Sheets (SDS). 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 degrees F. 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 Directions for Use:

Use of epoxy materials shall be in accordance with the manufacturer's recommendations. Use of epoxy materials shall be allowed for only those uses as shown on the ADOT Approved Products List.

At the time of mixing, the two components of the epoxy material shall be at a temperature between 60 and 85 degrees F, unless otherwise specified or approved by the Inspector. 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 13,200 pounds 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 C 881, 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 C 882 and shall provide a slant shear compressive strength of 1,000 pounds per square inch at two days and 1,500 pounds per square inch at 14 days. The compressive strength shall be determined in accordance with ASTM C 109 for two-inch 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 seven days shall be 8,000 pounds per square inch for Type I epoxy and 10,000 pounds per square inch 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 1,500 pounds per square inch at 14 days. The compressive strength shall be determined in accordance with ASTM C 109 for two-inch 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 seven days shall be 5,000 pounds per square inch for Type II epoxy and 8,000 pounds per square inch 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 1,000 pounds per square inch at two days and 1,500 pounds per square inch 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 two-inch 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 seven days shall be 8,000 pounds per square inch for Type I epoxy and 10,000 pounds per square inch 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 utilized to thin the material.

SECTION 1016 PACKAGED DRY CONCRETE AND MORTAR MATERIALS:

1016-1 General Requirements:

Certificates of Compliance shall be submitted by the Developer 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 ADOT Approved Products List 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 Developer 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 directions 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. Use of packaged dry concrete or mortar materials shall be allowed for only those uses as shown on the ADOT Approved Products List.

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. 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. An 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 three days shall be a minimum of 2,500 pounds per square inch. The compressive strength at seven days shall be a minimum of 3,500 pounds per square inch.

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 two inches, 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 seven days shall be a minimum of 2,500 pounds per square inch. The compressive strength at 28 days shall be a minimum of 3,500 pounds per square inch.

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 two inches 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 seven days shall be a minimum of 3,000 pounds per square inch. The compressive strength at 28 days shall be a minimum of 5,000 pounds per square.

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 three hours shall be a minimum of 500 pounds per square inch. The compressive strength at one day shall be a minimum of 2,000 pounds per square inch and at seven days the compressive strength shall not be less than 4,000 pounds per square inch. The strength at 28 days shall not be less than the strength at seven 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 1,000 pounds per square inch at one day and 1,500 pounds per square inch at seven 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 three-inch prisms at three 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 three inches 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 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 very rapid-hardening concrete material at three hours shall be a minimum of 1,000 pounds per square inch. The compressive strength at one day shall be a minimum of 3,000 pounds per square inch and at seven days the compressive strength shall not be less than 4,000 pounds per square inch. The strength at 28 days shall not be less than the strength at seven 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 1,000 pounds per square inch at one day and 1,500 pounds per square inch at seven 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 three-inch prisms at three 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 three inches at five 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 one-inch prisms, and the consistency at 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 one-inch prisms, and the consistency at five minutes after mixing will be a mortar flow of 100 percent, minimum.

SECTION 1017 NONSHRINK GROUT MATERIALS:

1017-1 General Requirements:

Certificates of Compliance shall be submitted by the Developer for any nonshrink grout materials. The nonshrink grout material must be on the current ADOT Approved Products List prior to submittal for use. The nonshrink grout material must be approved for the use or 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 Developer 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, also called "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. Use of nonshrink grout materials shall be allowed for only those uses as shown on the ADOT Approved Products List.

At the time of mixing, the nonshrink grout materials shall be at a temperature within the range allowed according to the manufacturer's recommendations. 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 1,000 pounds per square inch at seven days and 1,500 pounds per square inch 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 eight 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 seven days shall be 2,500 pounds per square inch and the minimum compressive strength at 28 days shall be 5,000 pounds per square inch. Nonshrink grouts with high early strength development as stated by the manufacturer will be tested for conformance 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 zero.