

SPECIFICATION 701 – HYDRAULIC CEMENT

701-1 PORTLAND CEMENT AND MASONRY CEMENT

701-1.01 Cement shall conform to the requirements of the following cited specifications for the type specified or permitted:

<u>Type</u>	<u>Specification</u>
Portland Cement.....	AASHTO M 85 or ASTM C 150
Masonry Cement.....	AASHTO M 150 (ASTM C 91)

701-1.02 Type IP Portland-Pozzolan cements meeting the requirements of AASHTO M 240 may be substituted for Portland Cement (AASHTO M 85) whenever the latter is specified.

701-1.03 Unless otherwise permitted by the Engineer, the product of only one mill of any one brand and type of portland cement shall be used on any one structure.

701-1.04 The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which, for any reason, has become partially set or which contains lumps or caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

701-1.05 The Contractor, at his option may substitute fly ash or up to a maximum of 15 percent of the required portland cement by weight in any concrete mixture subject to the following conditions:

- a. The fly ash to be used shall meet the requirements specified in Article 711-4 of Specification 711 - Concrete Curing Materials and Admixtures, and shall be submitted to the Authority for approval prior to its use.
- b. The proportioning of the concrete and the design mix required by Specifications 601 - Structural Concrete and 501

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- Portland Cement Concrete Pavement shall take into account the type and amount of fly ash to be used and the concrete mix shall meet the specified strength and other requirements of these specifications.

c. Fly ash may not be substituted for:

1. Type IP blended cements
2. Portland cement in high early strength concretes.

SPECIFICATION 702 – BITUMINOUS MATERIALS

702-1 ASPHALT CEMENT

702-1.01 Asphalt cements shall conform to the requirements of AASHTO M 226 for the viscosity grade specified, modified and supplemented as follows:

a. The asphalt cements shall conform to the requirements of Table 1 of AASHTO M 226 to which another viscosity grade AC-30 meeting the following requirements, is added:

- Viscosity, 60C (140F), poises.....	3,000 ± 600
- Viscosity, 135C (275F), Cs-minimum.....	250
- Penetration, 25C (77F), 100 g., 5 sec. – Minimum.....	30
- Flash Point, COC, C (f), minimum.....	232 (450)
- Solubility in trichloroethylene, % - minimum.....	99.0
- Test on residue from Thin-Film Oven Test:.....	
Viscosity, 60C (140F), poises - maximum.....	12,000
Ductility, 25C (77F), 5 cm. per minute, cm-minimum.....	14

702-2 CUTBACK ASPHALTS

702-2.01 Cut-back asphalts shall conform to the requirements of the following specifications:

Rapid-Curing Type.....	AASHTO M 81
Medium-Curing Type.....	AASHTO M 82

702-3 EMULSIFIED ASPHALTS

702-3.01 Emulsified asphalts shall conform to the requirements of the following specifications:

Anionic Emulsified Asphalts.....	AASHTO M 140
Cationic Emulsified Asphalts.....	AASHTO M 208

SPECIFICATION 702 – BITUMINOUS MATERIALS

702-4 APPLICATION TEMPERATURES

702-4.01 Bituminous materials for the several applications indicated in the specifications shall be applied within the temperature ranges indicated in Table 702-1 unless otherwise specified.

TABLE 702-1

APPLICATION TEMPERATURE FOR BITUMINOUS MATERIALS

Type and Grade of Material	Application Temperature Range (°F)	
	SPRAY (Min. - Max.)	MIX (Min. – Max.)
<u>Cut-backs</u>		
MC-30	70 - 145	60 - 105
RC or MC-70	105 - 185	155 - 190
RC or MC-250	140 - 225	125 - 200
RC or MC-800	175 - 265	160 - 225
RC or MC-3000	215 - 290	200 - 260
<u>Emulsions</u>		
All grades	50 - 160	50 - 160
<u>Asphalt Cements</u>		
All grades	275 - 325	See Note 1
1. As determined from the applicable temperature/viscosity chart. See Specification 401.		

SPECIFICATION 703 – AGGREGATES

703-1 FINE AGGREGATE FOR PORTLAND CEMENT CONCRETE

703-1.01 Fine aggregate for Portland cement concrete shall conform to the requirements of AASHTO M 6 but subject to the following:

- a. The requirements for soundness do not apply.
- b. The gradings given in Table 703-1 are suggested and not mandatory.

703-1.02 Manufactured sands shall not be used in Portland cement concrete mixes for pavements, bridge decks or any other concrete structure which will serve as the travel surface for vehicular traffic.

**TABLE 703-1
SUGGESTED GRADING OF FINE AGGREGATE
FOR PORTLAND CEMENT CONCRETE
(AASHTO T-27)**

Sieve Designation	Percentage by Weight Passing	
	Grading A	Grading B
3/8"	100	-
No. 4	95 - 100	100
No. 8	-	90 - 100
No. 16	45 - 80	80 - 100
No. 50	10 - 30	10 - 45
No. 100	2 - 10	2 - 10

703-2 COARSE AGGREGATE FOR PORTLAND CEMENT CONCRETE

703-2.01 Coarse aggregate for Portland cement concrete shall consist of crushed stone or crushed gravel conforming to the requirements of AASHTO M 80 but subject to the following:

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- a. The maximum percentage of wear when tested as per AASHTO T 96 shall not exceed 40.
- b. Suggested gradings are shown in Table 703-2.
- c. Deleterious substances shall not exceed the limits of Class Designation B (Table 1 in M 80) for all uses. The soundness requirements do not apply.
- d. The coarse aggregate in Portland cement concrete mixes for pavements, bridge decks and any other concrete that will serve as a surface for vehicular traffic shall have a minimum polishing value of 48% as determined by ASTM D 3319.

TABLE 703-2**SUGGESTED GRADATION FOR COARSE AGGREGATE FOR PORTLAND CEMENT
CONCRETE**

Designated Size	Percentage by Weight Passing Square Mesh Sieves (AASHTO T-27)									
	3 inch	2-1/2 inch	2 inch	1-1/2 inch	1 inch	3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8
1/2" to No.4	-	-	-	-	-	100	90-100	40-70	0-15	0-5
3/4" to No. 4	-	-	-	-	100	90-100	-	20-55	0-10	0-5
1" to No. 4	-	-	-	100	90-100	-	25-60	-	0-10	0-5
1-1/2" to No. 4	-	-	100	95-100	-	35-70	-	10-30	0- 5	-
2" to No. 4	-	100	95-100	-	35-70	-	10-30	-	0- 5	-
2-1/2" to No. 4	100	95-100	-	35-70	-	10-30	-	-	0- 5	-
1-1/2"to ¾"	-	-	100	90-100	20-55	0-15	-	0-5	-	-
2" to 1"	-	100	90-100	35-70	0-15	-	0-5	-	-	-

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703-3 AGGREGATES FOR HOT PLANT-MIX BITUMINOUS PAVEMENT

703-3.01 Aggregates for hot plant-mix bituminous pavements shall conform to the grading requirements shown in Table 703-3 for each specified mix.

703-3.02 Coarse aggregate (not passing the No. 8 sieve) shall be crushed stone or crushed gravel meeting the following requirements:

- a. It shall be free from soft and disintegrated pieces, clay, organic or other deleterious matter.
- b. The maximum percentage of wear when tested as per AASHTO T 96 shall not exceed 40.
- c. Aggregate for surface courses shall have a minimum polishing value of 48% as determined by ASTM D 3319.
- d. The coarse aggregate shall have the following minimum percentages of fractured faces:

Fractured Faces	Course Designation		
	<u>Surface</u>	<u>Leveling</u>	<u>Base</u>
One Face	75	50	50

- e. Maximum number of pieces with elongated faces shall not exceed 15%. An elongated face is one where the ratio of the longest dimension to the shortest dimension exceeds 5.
- f. The grading of the coarse aggregate shall be such that when it is combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required by the composition of the particular mix specified in the contract.

TABLE 703-3**AGGREGATE GRADINGS FOR HOT PLANT-MIX BITUMINOUS PAVEMENTS**

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves (AASHTO T-27)					
	Base Courses		Leveling Courses		Surface Course	
	B-1	B-2	L-1	L-2	S-1	S-2
1-1/2"	100	-	100	-	-	-
1"	80-100	-	80-100	-	-	-
3/4"	70-90	100	70-90	100	100	100
1/2"	-	80-100	-	80-100	85-100	85-100
3/8"	55-75	70-90	55-75	70-90	70-90	75-92
No. 4	45-62	50-70	45-62	50-70	50-70	45-75
No. 8	35-50	35-50	35-50	35-50	35-50	40-55
No. 30	19-30	18-29	19-30	18-29	18-29	18-29
No. 50	13-23	13-23	13-23	13-23	13-23	13-23
No. 100	7-15	8-16	7-15	8-16	8-16	8-16
No. 200	0-83	4-10	0-8	4-10	4-10	4-10
Recommended Range in Compacted Depth in Centimeters for each Individual Course						
	7.5 – 10.0	3.8 – 7.5	7.5 – 10.0	2.5 – 5.0	3.8 - 6.3	2.5 - 3.8

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703-3.03 Fine aggregate (passing the No. 8 sieve) shall consist of natural sand, stone screenings, or a combination thereof and shall conform to the quality requirements of AASHTO M 29 except that the soundness test is not required. It shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation requirements of the particular mix specified in the contract.

703-3.04 Mineral filler for bituminous paving mixtures shall conform to the requirements of AASHTO M 17.

703-4 AGGREGATE FOR BASE COURSE

703-4.01 Aggregate for untreated aggregate base course shall consist of hard durable particles or fragments of crushed stone or crushed or natural gravel conforming to the grading requirements shown in Table 703-4 for the grading class specified in the contract and meeting the following requirements:

- a. Material shall be free from lumps of clay, vegetable matter or other objectionable matter.
- b. The coarse aggregate not passing the No. 8 sieve shall have a percentage of wear, when tested by AASHTO T 96, of not more than 45.
- c. Maximum number of pieces with elongated faces shall not exceed 15%. Elongated faces are defined in paragraph 703-3.02e.
- d. The fraction passing the No. 200 sieve shall not be greater than two-thirds ($2/3$) of the fraction passing the No. 40 sieve.
- e. The fraction passing the No. 40 sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6.

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- f. When crushed aggregate is specified, not less than 50 percent by weight of the particles retained in the No. 4 sieve shall have at least one fractured face.

TABLE 703-4

**GRADINGS FOR AGGREGATE BASE COURSE
(Percentage by Weight Passing Square Mesh Sieve)**

Sieve Designation	Grading Class			
	A	B	C	D
2"	100	-	-	100
1 1/2"	-	100	-	-
1"	50 - 80	-	100	50 - 80
1/2"	-	40 - 75	-	-
No. 4	20 - 50	30 - 60	40 - 75	20 - 50
No. 10	-	-	25 - 60	-
No. 200	5 - 12	5 - 12	5 - 12	0 - 5

703-5 BED COURSE MATERIAL

703-5.01 Bed course material for sidewalks, curbing, and paved waterways shall consist of sand, gravel, crushed stone or other approved material of such gradation that all particles will pass through a sieve having 1/2 inch square openings and not more than 12 percent shall pass a No. 200 sieve.

703-5.02 Bed course material for slope paving shall be a porous material consisting of sand, gravel, crushed stone or other approved free-draining material. This material shall be uniformly graded and of such size that 100 percent of the material will pass through a sieve having 1 1/2 inch square openings.

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703-6 AGGREGATES FOR BITUMINOUS SURFACE TREATMENTS

703-6.01 Aggregates for bituminous surface treatments, including seal coats, shall consist of crushed stone on crushed gravel conforming to the grading requirements shown on Table 703-5 for each specified grading class.

703-6.02 The coarse portion of the aggregate not passing the No. 8 sieve shall meet the following requirements:

- a. It shall be free from soft and disintegrated pieces, clay, organic material and other deleterious material.
- b. A minimum of 75 percent of the material shall have at least one fractured face.
- c. The maximum number of pieces with elongated faces shall not exceed 15%. Elongated faces are defined in paragraph 703-3.02e.
- d. The maximum percentage of wear when tested as per AASHTO T 96 shall not exceed 40.
- e. Aggregate for seal coats and for the top layer of other bituminous surface treatments shall have a minimum polishing value of 48% as determined by ASTM D 3319.
- f. The aggregate shall have a retained bituminous film cover of no less than 95 percent when tested for coating and stripping under AASHTO T 182. Subject to approval by the Authority, a chemical additive may be used to aid in meeting this requirement.

703-6.03 Sand and fine screenings shall consist of natural sand, stone screenings, or a combination thereof and shall conform to the quality requirements of AASHTO M 29 except that the soundness test is not required. It shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the

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resultant mixture will meet the gradation requirements of the particular class specified in the contract.

703-7 BLOTTER MATERIAL

703-7.01 Blotter material shall be non-plastic rock screening or sand conforming to the gradation requirements of Size No. 10 of AASHTO M 43, and free from organic matter, clay or other deleterious material.

TABLE 703-5

**AGGREGATE GRADINGS FOR BITUMINOUS SURFACE
TREATMENTS
(Percentage by Weight Passing Square Mesh Sieve)**

Sieve Designation	Grading Class			
	A	B	C	D
1"	100	-	-	-
3/4"	90-100	100	-	-
1/2"	0- 35	90-100	100	-
3/8"	0- 12	0- 35	85-100	100
No. 4	-	0- 12	0- 35	85-100
No. 8	-	-	0- 8	0- 20
No. 200	0- 1	0- 1	0- 1	0- 1

SPECIFICATION 705 – JOINT MATERIALS

705-1 CONCRETE JOINT FILLERS

705-1.01 Poured joint sealants shall be of the types called for in the contract documents and shall conform to the following requirements:

- a. Hot poured elastic type shall conform to the requirements of AASHTO M 173.
- b. Hot-poured, one-component, elastomeric type shall conform to AASHTO M 282.
- c. Silicone joint sealant shall be furnished in a one part silicone formulation meeting the requirements specified in Table 705-1. Acid cure sealants are not acceptable. If required by the manufacturer, a primer for bonding the sealant to the concrete shall be used.
- d. The Contractor shall submit certified test reports from the manufacturer for each lot of sealant material furnished to a project. These reports shall indicate the results of tests performed as required by this specification and shall include a certification that the material conforms with this specification.

705-1.02 Preformed expansion joint fillers shall be of the types called for in the contract documents and shall conform to the following requirements:

- a. Bituminous type shall conform to AASHTO M 33 (ASTM D 994).
- b. Sponge rubber and cork types shall conform to AASHTO M 153 (ASTM D 1752).
- c. Non extruding resilient types shall conform to AASHTO M 213 (ASTM D 1751).

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d. Elastic joint seals of the elastomeric open-cell compression type shall conform to AASHTO M 220.

e. The filler for each joint shall be furnished in a single piece for the full depth and width required unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening method satisfactory to the Engineer. The filler shall be punched to admit dowels where called for on the plans.

705-2 PIPE JOINT MORTAR

705-2.01 Pipe joint mortar shall consist of one part portland cement and two parts approved sand with water added as necessary to obtain the required consistency. The mortar shall be used within 30 minutes after its preparation.

**TABLE 705-1
PHYSICAL REQUIREMENTS FOR SILICONE SEALANT**

<u>TEST</u>	<u>TEST METHOD</u>	<u>REQUIREMENT</u>
Tensile Stress (7-day cure at 77°F ± 3° and 45%-55% R.H.)	ASTM D-412, Die C	45 psi max. (at 150% elongation)
Extrusion Rate (100° to 40°F)	MIL S-8802	75-250 grams/minute
Specific Gravity	ASTM D-792 (Method A)	1.010 – 1.515
Tack Free Time (at 77°F ± 3° and 45%-55% R.H.)	MIL S-8802	20-75 minutes

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<u>TEST</u>	<u>TEST METHOD</u>	<u>REQUIREMENT</u>
Flow	MIL S-8802	0.3 inches max.
Durometer Hardness, Shore A (7-day cure at 77°F ± 3° and 45%-55% R.H.)	ASTM D-2240	10-25
Elongation (7-day cure at 77°F ± 3° and 45%-55% R.H.)	ASTM D-412, Die C	1,200% minimum
Bond to Concrete Mortar Briquets (air cured 7 days at 77% ± 3°)	Note 1	50 psi minimum
Ozone and Ultraviolet Resistance	ASTM C-793	No chalking, cracking or bond loss after 5,000 hours

Note 1 - Three briquets molded in accordance with AASHTO T-132 and moisture cured for at least 28 days shall be sawed in half, cleaned and oven dried to a constant weight in an oven at 110°C ± 5°. After cooling, they shall be bonded with approximately 10 mils of silicone sealant and tested using clips in accordance with AASHTO T-132. They shall be tested in tension at a loading rate of 0.3 inch/minute.

705-3 PIPE GASKETS

705-3.01 Ring gaskets for rigid pipe shall conform to the requirements of AASHTO M-198.

SPECIFICATION 705 – JOINT MATERIALS

705-4 MASONRY MORTAR

705-4.01 Unless otherwise shown on the plans, masonry mortar shall consist of one part portland cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight.

705-5 COPPER WATER STOPS OR FLASHING

705-5.01 Sheet copper for water stops or flashing shall meet the requirements of AASHTO M 138 (ASTM B 152) for type ETP, light cold-rolled, soft anneal, unless otherwise specified in the contract documents.

705-6 RUBBER AND NEOPRENE WATER STOPS

705-6.01 Neoprene or natural rubber water stops shall be of the type and dimensions shown on the plans. An equivalent standard shape may be furnished if approved by the Engineer.

705-6.02 Natural rubber shall conform to the requirements for virgin natural polyisoprene and neoprene shall conform to the requirements for virgin chloroprene included in Specification 717 - Elastomeric Bearing Pads, with the following additional requirements:

- a. Maximum water absorption determined as per ASTM D 471 - 10%.
- b. Maximum strength loss determined as per ASTM D 573 - 15%.

705-7 PLASTIC SEALING COMPOUND

705-7.01 Preformed plastic sealing compound for concrete pipe joints shall meet the requirements of Federal Specification SS - S - 210.

SPECIFICATION 706 – CONCRETE AND PLASTIC PIPE

706-1 REINFORCED CONCRETE PIPE

706-1.01 Reinforced concrete pipe shall conform to the requirements of AASHTO M 170 (ASTM C 76) for the specified diameters and strength classes called for in the contract documents.

706-1.02 When the contract documents call for reinforced concrete pipe designed for specific D-loads, the pipe shall conform to the requirements of AASHTO M 242 (ASTM C 655).

706-1.03 Reinforced concrete arch culvert pipe shall conform to the requirements of AASHTO M 206 (ASTM C 506), for the specified size and strength classes.

706-1.04 Reinforced concrete elliptical pipe shall conform to the requirements of AASHTO M 207 (ASTM C 507) for the specified size and strength classes.

706-1.05 Precast reinforced concrete end sections shall conform to the requirements of the respective pipe specification, to the extent to which they apply.

706-1.06 Acceptance of all reinforced concrete classes and sizes of pipe shall be on the basis of plant load bearing tests, material tests and inspection of the manufactured and delivered pipe at the project for conformance with prescribed design and its freedom from defects and imperfections.

706-2 PERFORATED CONCRETE PIPE

706-2.01 Perforated concrete pipe for underdrains shall conform to the requirements of AASHTO M 175 (ASTM C 444) for the size and type specified, and for the strength class specified as per AASHTO M 86. When no type is specified in the contract documents, either Type 1 or Type 2 may be furnished. When no strength class is specified in the contract documents, Class 2 pipe shall be furnished.

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706-3 PRECAST REINFORCED CONCRETE BOX SECTIONS

706-3.01 Precast reinforced concrete box sections for culverts, storm drains and sewers shall conform to the requirements of AASHTO M 259 M, M 259M, M 273, or M 273M, for the type, size and load conditions specified in the contract documents.

706-4 POLYVINYL CHLORIDE (PVC) PIPE

706-4.01 PVC pipe shall conform to the requirements of AASHTO M 267 and the respective ASTM standard specification for the class and type specified in the contract documents.

706-4.02 Perforated PVC pipe for use in underdrains shall conform to the requirements of ASTM D 3033 and the perforation shall meet the requirements of ASTM C 508.

706-5 CORRUGATED POLYETHYLENE PIPE

706-5.01 Perforated corrugated polyethylene pipe for underdrains shall conform to the requirements of AASHTO M 252.

SPECIFICATION 707 – METAL PIPE

707-1 BITUMINOUS COATED CORRUGATED STEEL PIPE

707-1.01 Bituminous coated galvanized corrugated steel circular pipe (Type I) and pipe arches (Type II) for culverts and storm drains shall conform to the requirements of AASHTO M 36 and M 218 for the specified types, sectional dimensions, corrugations and thicknesses. Lap joint seams may be riveted or welded unless otherwise specified in the contract documents.

707-1.02 In addition, the bituminous coating shall conform to the requirements of AASHTO M 190 for the coating type and invert paving specified in the contract documents. When no type is specified, Type C shall be furnished.

707-1.03 Unperforated helically corrugated pipe with continuous lock or welded seams shall be fabricated to the sizes shown on the plans in conformance with the applicable requirements of AASHTO M 36 and M 218.

707-1.04 Galvanized coupling bands for field joints shall conform to the requirements of AASHTO M 36 and M 218. Projection type coupling bands (dimpled bands) shall not be used on pipes 12 inches in diameter or larger.

707-1.05 Prefabricated flared end sections, elbows and other special sections shall be of the same metal thickness, or thicker, than the pipe to which they are joined and shall conform to all applicable requirements of AASHTO M 36 and M 218.

707-1.06 Coupling bands, prefabricated flared end sections, elbows and other special sections shall be bituminous coated under the same requirements as for the pipes to which they are joined.

707-1.07 When asbestos bonded bituminous coating is specified, in addition to these requirements, the special process of embedding asbestos fiber in the molten metallic bonding medium shall be used to bond the bituminous coating. Asbestos-bonded corrugated metal pipe shall be fabricated in accordance with

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AASHTO M 36 using asbestos-bonded sheets of base metal. Both sides of the metal sheets shall be coated with a layer of asbestos fibers pressed into the molten zinc bonding medium. Immediately after the metallic bond has solidified, the asbestos fibers shall be thoroughly impregnated with a bituminous saturant. The finished sheets shall be uniformly coated and free from blisters. After fabrication, the culvert sections shall be bituminous coated and the culvert paved, as per AASHTO M 190, as specified in the contract documents.

707-2 BITUMINOUS COATED CORRUGATED STEEL PIPE FOR UNDERDRAINS

707-2.01 Bituminous coated galvanized steel pipe for underdrains shall conform to the requirements of AASHTO M 36 and M 218 for Type III, perforated pipe. The perforations shall conform to the requirements for Class 1 unless otherwise specified on the plans. Pipes shall be fully bituminous coated in accordance with the requirements for Type A coating, AASHTO M 190, except that the minimum coating thickness required is 0.03 inch. Coupling bands shall be fully coated. The specified nominal diameter of perforations shall apply after coating.

707-3 SLOTTED CORRUGATED STEEL PIPE

707-3.01 Slotted corrugated steel pipe consists of galvanized corrugated steel pipe of the specified size and gage with a grate slot at the top as shown on the plans. The pipe shall be bituminous coated galvanized steel pipe conforming to the requirements of AASHTO M 36, M 218 and M 190. Unless otherwise indicated on the plans, Type A bituminous coating shall be applied. Grate assemblies for the grate slot drain shall conform to ASTM A 36 or A 576 steel and shall be hot dip galvanized in accordance with AASHTO M 111. Bolts and nuts shall conform to the provisions of ASTM A 307 and shall be galvanized in accordance with AASHTO M 111. The grate assemblies shall be bituminous coated in accordance with AASHTO M 190, Type I, after fabrication.

SPECIFICATION 708 – PAINTS FOR STEEL STRUCTURES

708-1 GENERAL REQUIREMENTS FOR ALL PAINTS

708-1.01 Paint shall conform to the following general requirements and the applicable Subsections for the paint system shown on the plans or specified in the contract.

- a. All paint shall be shipped to the project completely mixed and ready to be used without additional oil or thinner. It shall be furnished in strong, tightly sealed containers, plainly marked with the name, weight, and volume of paint content, together with the color, formula, lot number, date of manufacture, and the name and address of the manufacturer. Five gallon containers shall be used unless otherwise approved by the Engineer.
- b. The paint shall not show excessive settling in a freshly-opened full can, and shall easily be redispersed with a paddle to a smooth, homogeneous state free of curdling, livering, caking, color separation, lumps, and skins. The paint shall not skin within 48 hours in a three-quarters filled closed container.
- c. When it is specified that the paint shall be tinted, the tinting material shall be thoroughly and uniformly incorporated with the paint to form a uniform and even shade.
- d. The paint shall have a good spreading quality and when brushed or sprayed on a clean, smooth, vertical metal surface, shall air dry to a smooth uniform finish, free from roughness, grit, unevenness, separation, running, streaking, sagging or other surface imperfections.
- e. The paints shall show no thickening, curdling, gelling, or hard caking after six months storage in full tightly covered containers at a temperature of 85°F.
- f. The Contractor shall submit certified reports from the paint manufacturer covering the composition of the paint and

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its compliance with this specification and other applicable specifications. However, the Authority reserves the right to sample all shipments of paint at the destination and to withhold acceptance of the paint until an analysis of the samples has been made. Failure of the samples to meet all the requirements of the specifications will be cause for rejection of the paint represented by such failing samples.

g. The SSPC specifications mentioned in the following articles refer to those issued by the Steel Structures Painting Council located at Mellon Institute, 4400 Fifth Avenue, Pittsburgh, PA 15213.

708-2 VINYL PAINT SYSTEM

708-2.01 Vinyl wash primer shall conform to Military Specification MIL-P-15328.

708-2.02 Vinyl intermediate second, third and fourth coats shall conform to MIL-P-15928, MIL-P-15930, SSPC Paint 8 or SSPC Paint 9.

708-2.03 Finish coat shall be the same as intermediate coats, SSPC Paint 8 or SSPC Paint 9 to obtain the desired finish color.

708-3 ALKYD-OIL BASIC LEAD SILICO-CHROMATE SYSTEM

708-3.01 Prime coat shall be a dull orange primer conforming to AASHTO M 229-Type II.

708-3.02 The second coat shall conform to AASHTO M 229, Types II or V, but shall be tinted maroon to contrast with both the prime coat and the third coat.

708-3.03 The third coat shall conform to AASHTO M 229, Type V, but shall be tinted to contrast with both the second and finish coats.

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708-3.04 The finish coat shall conform to SSPC-104 or Federal Specification TT-E-489 and shall be tinted to the color specified in the contract documents conforming to Federal Standard 595 A.

SPECIFICATION 709 – REINFORCING STEEL AND PRESTRESSING STEEL

709-1 REINFORCING STEEL

709-1.01 Reinforcing steel shall conform to the requirements of the following AASHTO specifications:

Deformed Billet-Steel Bars for Concrete Reinforcement.....	AASHTO M 31 (ASTM A 615)
Cold-Drawn Steel Wire for Concrete Reinforcement.....	AASHTO M 32 (ASTM A 82)
Deformed Steel Wire for Concrete Reinforcement.....	AASHTO M 225 (ASTM A 496)
Fabricated Steel Bar or Rod Mats for Concrete Reinforcement.....	AASHTO M 54 (ASTM A 184)
Welded Steel Wire Fabric for Concrete Reinforcement.....	AASHTO M 55 (ASTM A 185)
Welded Deformed Steel Wire Fabric for Concrete Reinforcement.....	AASHTO M 221 (ASTM A 497)
Corrosion Resistant Coated Dowel Bars.....	AASHTO M 254

709-1.02 Bar reinforcement for concrete structures, except No. 2 bars, shall be deformed in accordance with AASHTO M 31.

709-1.03 Dowel and tie bars shall conform to the requirements of AASTHO M 31. Tie bars shall be deformed bars. Dowel bars shall be plain round bars, free from burring or other deformation restricting slippage in the concrete. Dowel bar shall be corrosion resistant as per AASHTO M 254 when so specified in the contract documents.

SPECIFICATION 709 – REINFORCING STEEL AND PRESTRESSING STEEL

709-1.04 The sleeves of dowel bars shall be of metal and of an approved design to cover 5 centimeters (2”) plus or minus 0.6 centimeters (1/4”) of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 25 mm from the end of the dowel bar. Sleeves shall be of such design that they do not collapse during construction.

709-1.05 Structural shapes used as reinforcement shall conform to the requirements for structural steel as provided in the specification for Structural Steel, AASHTO M 183 (ASTM A 36).

709-2 PRESTRESSING STEEL

709-2.01 High-strength wire shall conform to AASHTO M 204 (ASTM A 421) - Uncoated Stress-Relieved Wire for Prestressed Concrete.

709-2.02 High-strength, seven-wire strand shall conform to AASHTO M 203 (ASTM A 416) - Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete.

709-2.03 High-strength alloy bars shall conform to AASHTO M 275 (ASTM A 722) - Uncoated High-Strength Steel Bar for Prestressing Concrete.

709-3 EPOXY COATED REINFORCING STEEL

709-3.01 Epoxy coated reinforcing bars shall conform to the requirements of AASHTO M 284 (ASTM D 3963) but acceptable coating shall be limited to epoxy applied by the electrostatic spray method.

SPECIFICATION 710 – FENCE AND GUARD RAIL

710-1 BARBED WIRE

710-1.01 Barbed wire shall conform to the requirements of AASHTO M-280 (ASTM A 121) and shall be 12 1/2 gage with Class 2 coating and 4-point round barbs.

710-2 CHAIN-LINK FENCE

710-2.01 Galvanized chain-link fabric and the required fittings and hardware for Types A and B chain-link fences shall conform to the requirements of Type I, AASHTO M 181. Fabric shall be 2" mesh of Gage 9 wire with Class B coating, unless otherwise specified in the contract documents.

710-2.02 Vinyl coated chain-link fabric, fittings and hardware for Type C chain-link fence shall conform to the requirements of Type IV, AASHTO M 181, but the uncoated fabric shall be of Gage 9 galvanized wire meeting the requirement of Paragraph 710-2.01 above.

710-3 TENSION WIRE

710-3.01 The tension wire for Type A chain-link fence shall be 1 x 7 - 3/8" galvanized steel wire rope, with Class C coating, conforming to the requirements of AASHTO M 30, unless otherwise specified in the contract documents.

710-4 FENCE POSTS, RAILS, FRAMES AND EXPANSION SLEEVES

710-4.01 Reinforced concrete posts for barbed wire fences, Type A, shall be made of Class A concrete conforming to Specification 601 and shall contain steel reinforcement conforming to Specification 602.

710-4.02 Wood posts for barbed wire fence, Type B, shall conform to the details and dimensions indicated on the plans. All wood posts shall be of sound, seasoned, peeled wood of the species indicated on the plans. The posts shall be straight, with ends cut as

SPECIFICATION 710 – FENCE AND GUARD RAIL

indicated, and all knots trimmed flush with the surface. When treated posts are called for, the kind and type of treatment shall conform to that indicated on the plans.

710-4.03 Steel posts and hardware for barbed wire fence shall be of the sizes and shapes indicated on the plans, shall conform to AASHTO M 281, and shall be galvanized in accordance with AASHTO M 111 (ASTM A 123).

710-4.04 Galvanized steel posts, rails, braces and expansion sleeves for chain-link fences shall conform to the sizes and shapes shown on the plans and shall meet the requirements of AASHTO M 181.

710-5 CHAIN LINK GATES

710-5.01 Gate frames shall be composed of tubing braced with rods, bars or angles and filled with chain-link fabric, all meeting the requirements of the specifications for the type of fencing with which the gate is to be used and the appropriate requirements of AASHTO M 181.

710-6 CORRUGATED GALVANIZED STEEL BEAM GUARD RAIL

710-6.01 Corrugated galvanized steel beam guardrail and hardware shall conform to the requirements of Class A, Type 2, of AASHTO Specification M 180. The same requirements applies to other guardrail appurtenances such as transition, end and buffer sections.

710-7 GUARD RAIL POSTS

710-7.01 Guard rail posts, offset blocks, plates and anchoring units shall be fabricated of structural steel conforming to AASHTO M 183 (ASTM A 36). These shall be galvanized in accordance with the requirements of AASHTO M 111 (ASTM A 123).

SPECIFICATION 711 – CONCRETE CURING MATERIALS AND ADMIXTURES

711-1 CURING MATERIALS

711-1.01 Curing materials shall conform to the following requirements as specified.

<u>Material</u>	<u>Specification</u>
Burlap Cloth, Any class.....	AASHTO M 182
Sheet Materials.....	AASHTO M 171
Liquid Membrane Forming Compound.....	AASHTO M 148 Type 2, Class A

711-2 AIR ENTRAINING ADMIXTURES

711-2.01 Air entraining admixtures shall conform to the requirements of AASHTO M 154.

711-3 CHEMICAL ADMIXTURES

711-3.01 Water reducing, set-retarding and set accelerating or combinations thereof, as may be specified in the contract documents or permitted, shall conform to the requirements of AASHTO M 194 (ASTM C 494) for the type specified.

711-4 FLY ASH

711-4.01 Fly ash for use with portland cement shall conform to the requirements of ASTM C 618, either Class F or Class C except that the maximum loss at ignition of either class shall be 5 percent. In addition, the optional chemical requirements of Table 1A shall apply in all cases.

711-4.02 The Contractor shall provide certification and test results substantiating that the fly ash proposed for use conforms to the above requirements.

SPECIFICATION 712 – MISCELLANEOUS MATERIALS

712-1 WATER

712-1.01 Water used in mixing or curing concrete shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substance injurious to the finished product. Water will be tested in accordance with and shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without testing. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass or other deleterious substances.

712-2 CALCIUM CHLORIDE

712-2.01 Calcium chloride shall conform to the requirements of AASHTO M 144.

712-3 HYDRATED LIME

712-3.01 Hydrated lime shall conform to the requirements of ASTM C 207, Type N.

712-4 PRECAST CONCRETE CURBING

712-4.01 Precast concrete curbing shall consist of precast portland cement concrete curb units constructed to the lengths, shapes, and other details shown on the plans. These units shall be constructed of the class of concrete indicated on the plans and conforming to the requirements of Specification 601 - Structural Concrete.

712-4.02 The curbing units shall be reinforced as shown on the plans with reinforcing steel conforming to the requirements of Specification 602 - Reinforcing Steel.

712-4.03 When required for driveways, crossings, closures, or for other reasons, and a depressed or modified section of curb is indicated on the plans or ordered by the Engineer, the Contractor shall furnish curbing with the required modification.

SPECIFICATION 712 – MISCELLANEOUS MATERIALS

712-5 PRECAST CONCRETE UNIT

712-5.01 Precast portland cement concrete units shall be constructed to the shapes, dimensions and other details shown on the plans, and shall be cast in substantial permanent steel forms unless otherwise authorized by the Engineer.

712-5.02 The portland cement concrete shall be of the class indicated on the plans and shall be manufactured, handled, cast, finished and cured in conformance with the applicable provisions of Specification 601 - Structural Concrete and Specification 602 - Reinforcing Steel. Precast prestressed concrete units shall conform to the applicable requirements of Specification 630 - Prestressed Concrete Structures.

712-5.03 A sufficient number of cylinders shall be cast from each batch, or truck mixer load, of concrete to permit compression tests at 7, 14 and 28 days, and to allow for at least three cylinders for each test. If the strength requirement is met at 7 or 14 days, the units will be certified for use 14 days from the date of casting. If the strength requirement is not met at 28 days, all units made from that batch or load will be rejected unless they are determined to be acceptable by the Authority on the basis of further testing and structural analysis.

712-5.04 Cracks in units, honeycombed or patched areas in excess of 200 sq. cms. and failure to meet strength requirements will be causes for rejection.

712-5.05 Precast reinforced concrete manhole base sections, riser sections and tops shall conform to the requirements of AASHTO M 199 except as may be modified by details on the plans.

712-6 FRAMES, GRATES, COVERS, AND LADDER RUNGS

712-6.01 Metal units shall conform to the plan dimensions and details, and to the following specification requirements for the designated materials:

SPECIFICATION 712 – MISCELLANEOUS MATERIALS

- a. Gray iron castings shall conform to the requirements of AASHTO M 105 (ASTM A 48). Strength class shall be optional unless otherwise specified in the plans.
- b. Carbon-steel castings shall conform to the requirements of AASHTO M 103 (ASTM A 27). Grade shall be optional unless otherwise specified in the plans.
- c. Structural steel shall conform to the requirements of AASHTO M 183 (ASTM A 36).
- d. Galvanizing, where specified for the above units, shall conform to the requirements of AASHTO M 111.
- e. Malleable iron castings shall conform to the requirements of ASTM A 47. Grade will be optional unless otherwise specified.
- f. Aluminum alloy ladder rung material shall conform to the requirements of ASTM B 221, alloy 6061-T6 or 6005-T5.
- g. Aluminum castings shall conform to ASTM B 26, alloy 356 - T6.

712-6.02 Metal grates and covers which are to rest on frames shall bear on them evenly. They shall be assembled and tested before shipment and so marked that the same pieces may be reassembled readily in the same position when installed. Inaccuracy of bearings shall be corrected by machining, if necessary.

712-7 GEOTEXTILES – STABILIZATION AND FILTER FABRICS

712-7.01 Geotextiles shall be woven or nonwoven fabrics as specified and shall consist of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other. These

SPECIFICATION 712 – MISCELLANEOUS MATERIALS

fabrics shall be resistant to deterioration due to ultraviolet exposure, ambient temperatures, acid and alkaline conditions, oils, microorganisms and insects. During shipment and storage, the rolls of fabric shall be protected from exposure to the sun, heat, dirt and other detrimental conditions. Except for fabrics designed for slope stabilization and soil erosion control work, the geotextiles shall not be exposed to ultraviolet radiation for more than seven days.

712-7.02 The following definitions apply to geotextiles:

- a. Machine Direction - the long (or warp) direction of the geotextile. The cross-machine (or fill) direction is perpendicular to the machine direction.
- b. Mean Roll Values - The mean roll value of any specific geotextile property is the average of the test results from any roll within a lot.
- c. Nonwoven Geotextile - A textile produced by bonding or interlocking of fibers, or both, accomplished by mechanical, heat, or chemical means.
- d. Seam Allowance - The minimum distance from the edge of a geotextile to the stitch line nearest to that edge.
- e. Seam Type - A designation relating to the essential characteristics of geotextile positioning and rows of stitching in a specified sewn seam, as shown on the plans.
- f. Selvage - The finished edge of a geotextile parallel to the machine direction.
- g. Stitch type - A designation relating to the essential characteristics of the interlacing of sewing thread(s) in a specified seam, as shown on the plans.
- h. Woven Geotextile - A textile comprising two or more sets of filaments or yarns interlaced in such a way that they result in a uniform pattern.

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712-7.03 Where factory seams are made, the sheets of geotextile shall be sewn together using a lock-type stitch. The seams shall be sewn with polymeric thread, consisting of polyolphins, polyester, or polyamides, and shall be as resistant to deterioration as the geotextile being sewn. Nylon threads will not be allowed. The strength of the seam shall be at least equal to required tensile strengths for the intended application of the geotextile.

712-7.04 Strength requirements specified in the following sections are applicable to both machine and cross-machine directions.

712-7.05 Geotextile filter fabrics for use in subsurface drainage installations such as edge of pavement drains, interceptor drains and wall drains shall be designed to allow the passage of water while retaining in situ soil without clogging. The fabric shall be either woven or nonwoven conforming to the physical requirements specified in Table 712-1. Slit film or slit tape fabrics are not permitted.

TABLE 712-1

REQUIREMENTS FOR GEOTEXTILES FOR SUBSURFACE DRAINAGE INSTALLATIONS

Property	Class A ²	Drainage ¹	Test Method
		Class B ³	
Tensile Strength, lbs.	180 min.	80 min.	TF-25 #1
Elongation, percent	N/A	N/A	TF-25 #1
Seam Strength, lbs. ⁴	160 min.	70 min.	TF-25 #1
Puncture Strength, lbs.	80 min.	25 min.	TF-25 #4
Burst Strength, psi	290 min.	130 min.	TF-25 #3
Trapezoid Tear, lbs.	50 min.	25 min.	ASTM D 4533

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Property	Drainage ¹		<u>Test Method</u>
	<u>Class A</u> ²	<u>Class B</u> ³	
Apparent Opening Size- U.S. Std. Sieve	1. Soil with 50% or less particles #200 Sieve, AOS greater than #30 Sieve. 2. Soil with more than 50% particles by weight passing #200 sieve, AOS greater than #50 Sieve.		TF-25 #1
Permeability, cm/sec ⁵	K fabric greater than K for soil, all classes		ASTM D 4491-85
Ultraviolet Degradation At 150 hours	70% Strength Retained – all classes		ASTM D 4355

1. Minimum - Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table). Stated values are for non-critical, non-severe applications. Lots sampled according to ASTM D 4354.

2. Class A Drainage applications for fabrics are where installation stresses are more severe than Class B applications, i.e., very coarse sharp angular aggregate is used, a heavy degree of compaction (95% AASHTO T 99 or greater) is specified or depth of trench is greater than 10 feet.

3. Class B Drainage applications are those where fabric is used with smooth graded surfaces having no sharp angular projections, no sharp angular aggregate is used; compaction requirements are light, (less than

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95% AASHTO T 99), and trenches are less than 10 feet in depth.

4. Values apply to both field and manufactured seams.

5. A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.

712-7.06 Geotextile fabrics for use in roadbed stabilization work shall be woven or nonwoven conforming to the requirements specified in Table 712-1 for Class A drainage installations except that they shall provide for a 15% minimum elongation when tested by TF-25 #1.

712-7.07 Geotextiles for use in erosion control applications such as cut and fill slopes protection behind gabions, protection of small drainage structures and ditches, wave protection for causeways and shore line roadway embankments, and scour protection for bridge piers and abutments. The fabric shall be either woven or nonwoven fabric conforming to the requirements specified in Table 712-2. Slit film or slit tape fabrics are not permitted.

TABLE 712-2

REQUIREMENTS FOR EROSION CONTROL GEOTEXTILES

Property	Erosion Control ¹		
	<u>Class A</u> ²	<u>Class B</u> ³	<u>Test Method</u>
Tensile Strength (lbs)	200	90	TF-25 #1
Elongation (%) (min)	15	15	TF-25 #1
Seam Strength (lbs) ⁴	180	80	TF-25 #1

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Property	Erosion Control ¹		<u>Test Method</u>
	<u>Class A</u> ²	<u>Class B</u> ³	
Puncture Strength (lbs)	80	40	TF-25 #1
Burst Strength (psi)	320	140	TF-25 #1
Trapezoid Tear (lbs)	50	30	ASTM D 4533
Apparent Opening Size US Std. Sieve	1. Soil with 50% or less particles by weight passing #200 Sieve, AOS greater than #30 Sieve. 2. Soil with more than 50% particles by weight passing #200 Sieve, AOS greater than #50 Sieve.		TF-25 #1
Permeability ⁵	K fabric greater than k for soil, all classes		ASTM D 4491-85
Ultraviolet Degradation	70% strength retained for all classes at 150 hrs. when buried and 90% at 500 hrs. when exposed to sunlight.		ASTM D 4355

1. Minimum - Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the table). Stated values are for non-critical, non severe conditions. Lot sampled according to ASTM D 4354.

2. Class A Erosion Control applications are those where fabrics are used under conditions where installation stresses are more severe than Class B, i.e.,

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stone placement height should be less than 3 feet and stone weights should not exceed 250 pounds.

3. Class B Erosion Control applications are those where fabric is used in structures or under conditions where the fabric is protected by a sand cushion or by “zero drop height” placement of stone.

4. Values apply to both field and manufactured seams.

5. A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.

712-7.08 Paving fabrics for use between pavement layers shall be nonwoven geotextiles conforming to the requirements specified in Table 712-3.

TABLE 712-3

REQUIREMENTS FOR PAVING FABRICS

<u>Property</u>	<u>Requirements</u>	<u>Test Method</u>
Tensile Strength, lbs.	*80 min.	TF-25 #1
Elongation-at-Break, percent	50 min.	TF-25 #1
Asphalt Retention, gal/sq. yd.	0.20 min.	TF-25 #8
Melting Point, degrees F	300 min.	ASTM D 276

* Minimum - Value in weaker principal direction. All numerical values represent minimum average roll values (i.e. any roll in lot shall meet or exceed the minimum values in the table).

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712-7.09 Geotextiles for use as temporary silt barrier fences shall be composed of at least 85% by weight polyolefins, polyesters or polyamides. The fabric shall conform to the requirements specified in Table 712-4.

TABLE 712-4

REQUIREMENTS FOR TEMPORARY SILT FENCE GEOTEXTILES

<u>Property</u>	<u>Wire Fence Supported</u>	<u>Self Supported</u>	<u>Test Method</u>
Tensile Strength, lbs.	90 min ¹	90 min ¹	TF-25 #1
Elongation at 45 lbs. tensile strength	N/A	50 max.	TF-25 #1
Permittivity ² , sec. -1	0.01 min.	0.01 min.	ASTM D 4491
Apparent Opening ² Size (AOS) (min)	0.84 max.	0.84 max.	TF-25 #6
Ultraviolet Degradation Min. strength retained	70%	70%	ASTM D 4355

1. Minimum - Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the table). Stated values are for non-critical, non-severe conditions. Lot sampled according to ASTM D 4354.

2. Permittivity & AOS do not relate directly to filtration performance of silt fence fabrics. Values presented reflect minimum criteria of products currently used. Performance tests such as VTM-51

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(from Virginia Highway Research Council) may be used to evaluate silt fence performance if deemed necessary by the Engineer.

3. Strength retained after 500 hours of ultraviolet exposure when tested according to ASTM D 4355. This method specifies tensile testing by 2-inch strip (or ravelled strip) for both control and exposed samples.

712-7.10 Sampling, testing, certification and acceptance shall conform to the following requirements:

a. Acceptance of geotextile material shall be based on Task Force 25 Acceptance/Rejection Guidelines.

b. Tests shall be performed by the manufacturer in accordance with TF-25 methods to determine geotextile properties specified herein for the intended application(s).

c. The Contractor shall furnish the geotextile manufacturer's certified test results attesting that the geotextile and all factory seams meet the requirements stated in these specifications for the intended application. The certification shall state that all the rolls being furnished of the named product conform to the Authority's requirements.

1. The certification shall give the name and address of the manufacturer and the testing agency and the date of tests; and shall set forth the means of identification which will permit field determination of the product delivered to the project as being the product covered by the certification.

2. The certification shall be in duplicate and shall be sent with the shipment of the covered product to the Engineer.

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- d. The Authority will not be responsible for costs of certification or for costs of the sampling and testing of products in connection therewith.
- e. The Authority reserves the right to require samples and to test products for compliance with pertinent requirements irrespective of prior certification of the products by the manufacturer thereof.

712-8 PLASTIC LINER

712-8.01 Plastic liner shall be either polyvinyl chloride plastic film conforming to ASTM D 1593, Type II, or polyethylene plastic film conforming to ASTM D 2103, Type 02000. Film thickness shall be 8 mils unless otherwise specified in the contract documents. The film shall be delivered in rolls of such width and length as to minimize the necessity of field seams. The latter, when required, shall be made in accordance with the manufacturer's recommendations unless otherwise specified in the contract documents.

SPECIFICATION 713 – ROADSIDE IMPROVEMENT MATERIALS

713-1 LOAMY TOPSOIL

713-1.01 Loamy topsoil shall come from the surface layer of soil and shall consist of loose, friable, sandy loam, free of admixture of subsoil, clay-lump, refuse, stumps, roots, rocks, brush, weeds or other material which would be detrimental to plant growth.

713-1.02 Loamy topsoil shall contain a minimum of 3 percent and a maximum of 20 percent of organic matter as determined by the loss on ignition method of AASHTO T-267.

713-1.03 The pH of the topsoil shall be between 5 and 8 as determined by ASTM E-70.

713-1.04 The gradation of the topsoil shall conform to the following:

Sieve Designation	Percent by Weight Passing Square Mesh Sieve
1 inch	90-100
1/4 inch	80-100
No. 10	70-100
No. 200	15-80

713-1.05 Prior to stripping, loamy topsoil shall have demonstrated by the occurrence upon it of healthy crops, grass, or other plant growth, that it is of good quality and reasonably free draining.

713-1.06 Samples of the topsoil will be taken by the Authority for testing prior to its use. Topsoil containing detrimental material may be rejected by the Engineer on the basis of a visual examination prior to testing. Acceptance of the topsoil will be based on the Authority's test results unless otherwise specified. Failure to comply with the above requirements will be cause for the rejection of the material.

SPECIFICATION 713 – ROADSIDE IMPROVEMENT MATERIALS

713-2 AGRICULTURAL LIME

713-2.01 Agricultural lime shall be a calcic or dolomitic ground limestone containing not less than 85 percent of total calcium and magnesium carbonates. Limestone shall comply with all applicable Commonwealth and Federal regulations.

713-2.02 The lime shall have a minimum of 90% passing the No. 10 sieve and 50% passing the No. 100 sieve.

713-2.03 Agricultural lime shall be packed in the manufacturer's standard sealed containers which shall each carry a label with the name of the material, the name of the manufacturer, the net weight of the contents and the guaranteed chemical analysis of the material. Bulk shipments shall be accompanied by a certificate providing the names, weight and analysis as specified for packaged material.

713-3 FERTILIZER

713-3.01 Fertilizers shall be either fluid or dry formulations of standard commercial grade fertilizers conforming to all Commonwealth and Federal regulations. Commercial fertilizer shall provide the minimum percentage of available nutrients as specified.

713-3.02 Fertilizers shall be packed in the standard manufacturer's sealed containers which shall each carry a label with the name of the material, the name of the manufacturer, the net weight of fertilizers of the contents, and the guaranteed analysis of the fertilizer.

713-3.03 The Contractor shall furnish a certified analysis from the vendor, or from an independent laboratory, as to the available nutrients contained in the fertilizer furnished. The Engineer may, at his discretion, take such samples as he deems necessary for testing by the Authority.

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713-3.04 Any fertilizer that has become caked or otherwise damaged will be rejected, at the Engineer's discretion, if considered unsuitable for use.

713-4 SEEDS

713-4.01 Types of seeds or seed mixtures shall be as shown on the plans or other contract documents. The common and scientific names of grasses, legumes and cereals used in the contract documents correspond to the Standardized Plant Names used in horticultural nomenclature. Grass seed shall be fresh stock, live, hulled seed. Weed seeds in the seed mix shall not exceed 1% of gross weight.

713-4.02 Seed stock provided shall have a minimum 85% purity and 80% germination. To determine the gross amount of a particular seed stock required to meet the specified application rate of live seed, divide the specified rate by the purity percentage and then divide the result by the germination percentage.

713-4.03 The contents of each seed in a seed mixture shall be within +/-10% of the specified amounts by weight.

713-4.04 The seeds shall be furnished separately or in mixture in standard sealed containers each clearly labeled to show the seed name, lot number, net weight, percentages of purity and of germination and hard seed, and percentage of maximum weed seed content.

713-4.05 The Contractor shall furnish the Engineer duplicate signed copies of a statement by the vendor certifying that each lot of seed has been tested by a laboratory qualified for seed testing within six months of the date of delivery of the seed. The statement shall include the name and address of the laboratory, the date of test, the lot number for each kind of seed, and the results of the test. The test results shall contain the name, percentages of purity and of germination, and percentage of weed content for each kind of seed

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furnished, and, in case of a mixture the proportion of each kind of seed.

713-5 SOD

713-5.01 Sod shall be of the grass type called for in the contract documents. If no specific type is called for, the Contractor may, at his option, place Zoysia, Bermuda, St. Augustine or Centipede grass. However, only one type of grass will be permitted to be used in the project.

713-5.02 Sod shall be a living vigorous growth of at least 80% of the grass specified and having a dense root system contained in a suitable sod mat which shall be reasonably free from noxious weed and grasses. The sod mat shall be of sufficient thickness to withstand all necessary handling but not less than 2.5 centimeters.

713-5.03 The sod, when delivered to the project site, shall be sufficiently moist so that the soil will adhere firmly to the roots when it is handled. The height of the grass shall not exceed 7.5 centimeters when the sod is cut.

713-5.04 Sod will be inspected by the Engineer at the source and none shall be cut without his prior approval.

713-6 MULCH

713-6.01 Mulch shall consist of “cachaza”, wood cellulose fiber, peat moss, hay or other approved material.

713-6.02 “Cachaza” - Shall be cane sugar factory refuse which shall have been aerated for not less than one (1) year.

713-6.03 Wood Cellulose Fiber - Shall be natural or cooked wood cellulose fiber specially prepared for dispersing readily in water and shall have no toxic effect when combined with seed or other materials. The homogeneous slurry or mixture shall be capable of application with power spray equipment. A green dye which is

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noninjurious to plant growth shall be added to the mulch for visually determining the rate of spread. Wood cellulose fiber shall be packaged in new labeled containers in an air-dry condition and have a pH range of 3.5 to 5.0.

713-6.04 Peat Moss - Peat moss shall be a granulated sphagnum peat moss nearly free from woody substances, consisting of at least 75 percent of partially decomposed stems and leaves of sphagnum and essentially brown in color. The texture may vary from porous fibrous to spongy fibrous and shall be free of sticks, stones, and mineral matter. Peat moss shall be in an air-dry condition, shall show an acid reaction of 3.5 pH to 5.5 pH, and shall otherwise conform to Commonwealth and Federal regulations. The peat moss shall be furnished in bales.

713-6.05 Hay - Hay mulch shall be of approved herbaceous mowings, such as pangola, bermuda or other acceptable local grass. It shall be free from noxious weeds, mold or other objectionable material. The hay shall be delivered in an air-dry condition and be suitable for placing with mulch blower equipment.

713-7 PLANT MATERIALS

713-7.01 Plant Names

- a. All scientific and common plant names of the items specified shall conform with the edition of “Standardized Plant Names”, as adopted by the American Joint Committee on Horticultural Nomenclature that is in effect at the time of the invitation for bids.
- b. All plants delivered shall be true to name and legibly tagged with the names and sizes of materials. Should it be necessary to substitute a plant or plants of a different variety than the plant material specified, it will be necessary for the Contractor to secure approval in writing from the Engineer for the proposed substitution prior to digging the plants.

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713-7.02 Quality of Plant Material

- a. All plants shall be first-class representatives of their normal species or varieties unless otherwise specified as “street-tree”, “extra heavy”, “clump”, and other of like import, according to the particular exception. All plants shall be free from plant diseases and insect pests.
- b. Unless otherwise specified, all plants shall be nursery grown stock that has been transplanted or root-trimmed two or more times, according to the kind and size of plants. The branch system shall be of normal development and free from disfiguring knots, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements.
- c. Trees shall have reasonably straight stems and shall be well branched and symmetrical in accordance with their natural habits of growth.
- d. All plants shall have a well-branched vigorous and balanced root and top growth and shall be of standard No. 1 grade or equal in accordance with the “Horticultural Standards”.
- e. All plants shall be free of mechanical injury from sun and shall show no evidence of insect attack or disease. Any plant material arriving at the point of delivery or at the site of planting with dried-out or otherwise damaged top or root systems or with mildewed tops, and any thin, weak plants of poor form or abnormal leaf color will be rejected.

713-7.03 Grading Standards - Grading of plants shall conform to the “American Standard for Nursery Stock”, as approved by the American Association of Nurserymen, in effect at the time of invitation for bids, and to any further requirements that may appear in the contract documents.

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713-7.04 Balled and Burlapped Plants - Balled and burlapped plants shall be dug so as to retain as many fibrous roots as possible, and shall come from soil which will form a firm ball. The soil in the ball shall be the original and undisturbed soil in which the plant has been grown. The plant shall be dug, wrapped, transported and handled in such manner that the soil in the ball will not be so loosened that it would cause striping of the small and fine feeding roots or cause the soil to drop away from such roots.

713-7.05 Container Grown Material - Shall be as specified on the plans. The container shall be sufficiently rigid to hold the shape and protect the root ball during handling and shipping. Container grown plants shall have been grown in the container long enough for the new fibrous roots to have developed so that the root ball is firm and will retain its shape and hold together when removed from the container.

713-7.06 Inspection - All plant materials shall be subject to inspection by the Engineer at any time during the life of the contract before or during planting operations; however, such inspection shall not be construed as final acceptance of the plants involved.

713-8 JUTE MESH

713-8.01 Jute mesh shall be of a uniform, plain weave with warp and weft yarns of approximately the same size. It shall be made of new material, clean, sound and free of rips or tears, and shall comply with the following physical requirements:

- a. Width - 45 to 48 inches.
- b. 78 warp ends per width.
- c. 40 weft ends per linear yard.
- d. Weight - 1.5 lbs. average per running yard.

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713-9 MISCELLANEOUS PLANTING MATERIALS

713-9.01 Water - Water used in the planting or care of vegetation shall be free from oils, acids, alkalis, salts or any substance injurious to plant life. Water from streams, lakes, ponds or similar sources shall not be used unless approved by the Engineer.

713-9.02 Stakes for Bracing and Anchoring - Stakes for bracing or supporting trees shall be of rough approved wood free from knots, rot, cross grain or other defects that would impair the strength of the stake for which it is to be used. Stakes shall be a minimum of 5 cm. by 5 cm. squares, or 5.5 cm. diameter, in cross section and of adequate length. Anchor stakes shall conform to the same size and quality requirements as for bracing stakes. Where deadmen are to be used to anchor trees, the quality requirements for other stakes shall apply. The diameter and length of deadmen shall be as shown on the plans.

713-9.03 Wire - Wire used to guy trees shall be new soft annealed galvanized steel wire or aluminum wire, No. 9 gage unless otherwise specified.

713-9.04 Hose - Hose to be used with wire for bracing and guying trees shall be at least 3/4 inch in outside diameter. All hose shall be new garden or steam hose (rubber and fabric).

713-9.05 Wrapping Material - Wrapping material for trees shall be water-proof paper 30-30-30 krinklecraft in four-inch wide rolls, or a standard weave burlap in six-inch wide rolls and weighing 6 to 8 ounces per square yard.

713-9.06 Twine - Twine used for tying wrapping on trees shall be of approved quality. Two-ply twine shall be used for trees three inches and less in diameter and three-ply twine for trees over three inches in diameter.

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713-9.07 Antidessicant - Antidessicant shall be an approved emulsion which will provide a film over plant surfaces permeable enough to permit transpiration. Antidesiccant shall be used only after approval by the Engineer.

713-9.08 Soil Stabilizer - Material for stabilizing soils shall be one of the following:

- a. Type SS-1 Emulsified Asphalt meeting the requirements of AASHTO M-140 and diluted in water to 50% of its normal strength.
- b. An approved elastomeric polymer emulsion manufactured as a concentrate and suitable for the purpose intended.

713-9.09 Stakes for Pegging Sod and Jute Mesh - Shall be of sound wood, roughly square or round, with a cross sectional area of approximately 6.25 square centimeters and at least 20 centimeters in length.

713-9.10 Chemical Mulch Binders - Shall be approved non-staining commercially available products that are specifically formulated for the purpose of anchoring or stacking hay or straw mulches. The material shall be furnished in the manufacturer's standard containers with the name of the material, the manufacturer's name, and the instructions for mixing and application appearing on each container.

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714-1 ALUMINUM LIGHTING STANDARDS

714-1.01 Aluminum lighting standards include the shaft, the bracket arms and the base. However, for payment purposes the lighting standard includes all the items required for a complete installation as specified in paragraph 612-4.02 a of Specification 612 - Highway Lighting System.

714-1.02 The complete lighting standard assembly shall be designed in accordance with the requirements of the “Standard Specifications for Structural Supports for Highways Signs, Luminaires and Traffic Signals”, published by AASHTO, and with the “Guide to Standardized Highway Lighting Pole Hardware” of AASHTO - ARTBA - AGC, (ARTBA Technical Bulletin No. 270), as modified and supplemented by this specification and the contract documents.

714-1.03 The lighting standard shall be designed for 90 mph wind loads with a gust speed factor of 1.3 and shall provide for a luminaire mounting height of 40 feet unless otherwise shown on the plans. Ice load need not be considered. Shop drawings and structural design computations for the proposed lighting standards shall be submitted for review and approval by the Authority prior to purchase.

714-1.04 The aluminum shaft shall be a one-piece, seamless, round tapered tube made of Alloy 6063 heat treated for its full length to produce a T6 temper after the anchor base is welded on to the bottom of the shaft, or Alloy 6005 having a T5 temper after fabrication, and having the following additional characteristics:

- a. Shall provide for a luminaire mounting height of 40 feet unless otherwise shown on the plans.
- b. For 40' mounting heights the shaft shall be dimensioned as per the structural design but shall have a minimum diameter of 10 inches at the bottom and 6 inches at the top and minimum wall thicknesses as follows:

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<u>Bracket Arms Type and Length</u>	<u>Minimum Shaft Wall Thickness (inches)</u>	
	<u>Alloy 6063</u>	<u>Alloy 6005</u>
Single Tapered – 4 or 8 ft.....	0.156	0.156
Double Tapered – 4 or 8 ft.....	0.219	0.156
Single Truss – 12 ft.....	0.188	0.156
Single Truss – 15 ft.....	0.188	0.156
Double Truss – 12 ft.....	0.250	0.170
Double Truss – 15 ft.....	0.312	0.188

c. Shafts to be mounted without a transformer base shall be equipped with a 4" x 6" oval shaped reinforced handhole, as per the ARTBA Technical

Bull. 270 centered 14" to 18" above the base of the shaft and located 90 degrees measured clockwise from the plane of the bracket arm as viewed from the top. Each handhole shall have an aluminum cover with stainless steel attachment screws to secure the cover. A grounding nut to accommodate a 1/2" threaded bolt shall be provided inside the shaft opposite the handhole.

d. A removable ornamental cast aluminum cap with three stainless steel (AISI 302) set screws to hold it in place shall be provided with each shaft.

e. A 1 1/2" diameter hole shall be included near the top of each shaft to provide a cable entrance from the shaft into the bracket area. This opening shall have a rubber or metal grommet to provide a smooth cable guide for pulling the electrical cables through.

f. The shaft anchor base shall be a one piece casting of 356-T6 aluminum alloy and shall be shop welded to the shaft.

714-1.05 Aluminum breakaway transformer bases shall be one-piece castings of 356-T6 aluminum alloy (ASTM B 26) or ASTM B 108 Alloy, of the dimensions shown on the plans and meeting

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structural requirements and breakaway criteria specified in the AASHTO standard specifications for structural supports cited in Article 714-1.02. Any of the transformer bases included in the FHWA list of tested and approved breakaway bases may be used. Bases shall be equipped as follows:

- a. With a removable aluminum, trapezoidal shaped door, approximately 13" high, 7" wide at the top and 9" wide at the bottom. Door shall be secured to the base with stainless steel screws.
- b. For attachment to shaft anchor base, each transformer base shall be supplied with four (4) loose bearing plates or other acceptable bearing surfaces and four (4) 1" diameter by 3 3/4" long, or longer, hot-dip galvanized hexhead machine bolts.
- c. With a grounding connection to accommodate a 1/2" threaded bolt or nut.
- d. A template print giving complete information for setting the anchor bolts in the foundation.

714-1.06 Anchorage in the foundation shall consist of four 1" diameter hot rolled steel rods meeting the requirements of AASHTO M 255 (ASTM A 675) Grade 90, 36-inch long with a 4-inch long right angle leg. The threaded end shall be hot-dip galvanized for a minimum length of 8 inches. Hot-dip galvanized steel hex nuts, flat washers and lock washers shall be provided for each anchor bolt.

714-1.07 Aluminum bracket arms shall be of upsweep design with slip fit end, of the type, shape and dimensions shown on the plans, and having the following additional characteristics:

- a. Arms shall be proportioned to provide a 40-foot clearance or other specified clearance, from the center of the luminaire to ground level.

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b. Single member type arms shall be fabricated from 6063 T6 aluminum alloy tube. They shall be 4 or 8 feet in length, shall be tapered in outside diameter from 3 1/2" to 2 3/8" at the luminaire end, and shall have a nominal wall thickness of 0.125 inch.

c. Truss type arms shall conform to the following:

1. They shall be fabricated from aluminum alloy 6061-T6 pipe or 6063-T6 tube.

2. The upper member shall be tapered to a circular shape of 2 3/8" outside diameter at the luminaire end.

3. Dimensions of upper and lower members shall be as follows:

<u>Arm Length (Feet)</u>	<u>Member</u>	<u>Nominal Diameter Alloy 6063 Tubing</u>	<u>x Wall Thickness (inches) Alloy 6061 Pipe</u>
12	Upper	3.5 x 0.125	2.5 x 0.203
	Lower	1.5 x 0.145	2 x 0.218
15	Upper	4 x 0.125	2.5 x 0.203
	Lower	1.5 x 0.145	2.5 x 0.203

(4) The arm shall be braced with one or two vertical struts depending on the arm length. The struts shall be fabricated of the same type aluminum alloy as the other members.

(5) The arm shall have welded to it bolted type or clamp type attachments, as shown on the plans, to secure the arm to the shaft. Bolts, washers and nuts shall be American Iron and Steel Institute (AISI) Type 302 stainless steel. Bolts shall be 1/2"-13 UNC of the required length.

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714-2 CONCRETE LIGHTING STANDARDS

714-2.01 Precast reinforced concrete poles shall be of the design shown on the plans, manufactured of 5000 psi concrete in accordance with the requirements of Specification 601 - Structural Concrete, and meeting the following additional requirements:

- a. Concrete coarse aggregate shall be of size 1/2" to No. 4 as per Table 703-2 of Specification 703 - Aggregates.
- b. Poles shall be hollow, provided with smooth, beveled top and bottom entrance openings, and conforming to the details specified in P. R. Electric Power Authority (PREPA) Drawing STL-1, Concrete Pole Details.
- c. Pole reinforcement and fabrication shall be in accordance with PREPA Public Lighting Standards.
- d. Each pole shall be provided with a small metal plate, to be located at approximately 1.75 meters from the bottom of the pole, indicating the pole manufacturer's trade name, the type of pole and the date when it was cast.
- e. Contractor shall submit certification that the concrete poles furnished comply with the specification requirements.

714-2.02 Aluminum bracket arms shall be of the type, shape and dimensions shown on the plans, and meet the requirements included in Article 714-1.07 above except that:

- a. Mounting height for luminaire shall be as shown on the plans.
- b. Bracket arm shall have welded to it a clamp type attachment.

714-2.03 Galvanized steel bracket arms shall be of the type, shape and dimensions shown on the plans, fabricated from 2" diameter Schedule 40 steel pipe conforming to ASTM A-501 or A-

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53, Grade B, and galvanized after fabrication in accordance with AASHTO M 111 (ASTM A 123). Arms shall be equipped with two-piece clamps to attach arm to pole. Clamp bolts, nuts and washers shall be galvanized in accordance with ASTM A 153 unless stainless steel is specified. Luminaire end shall be of the slip fit type.

714-3 WOOD LIGHTING STANDARDS

714-3.01 Wood poles shall comply with the specifications and dimensions for creosoted wood poles of PREPA, except as otherwise shown on the plans.

714-3.02 Bracket arms for use with wood poles shall be of the type, shape and dimensions shown on the plans and shall conform to the requirements included in Article 714-2.02 for aluminum arms and Article 714-2.03 for galvanized steel arms.

714-4 LUMINAIRES

714-4.01 Luminaires shall be of the fully enclosed, full-cutoff type, designed for use with high pressure sodium lamps and shall be of the standard mount type or wall mounted type for use in tunnels and underpasses. They shall be capable of producing the ANSI/IES light distribution patterns specified in the contract documents.

714-4.02 Standard mount high-pressure sodium luminaires shall be of the enclosed type suitable for a horizontal burning 200W lamp and conforming to the following requirements:

- a. Equipped with built-in cooper low loss output, high power factor type ballast for 120/240V operation, prewired and connected for 240V, unless otherwise shown on the plans, and suitable for use on multiple circuits as per Article 714-6.
- b. With or without a photo-electric cell, as called for on the plans, meeting the approval of PREPA.

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c. Equipped with locking type mounting receptacle in accordance with NEMA standards.

d. The housing shall be fabricated from aluminum by either die casting or forming and shall have a refractor holder hinged on the pole side and with a spring-loaded automatic latch on the other side. The housing shall also include:

1. A detachable snap-in aluminum reflector polished to a highly specular surface and protected by an electrically applied anodized finish or a chemically applied silicate film. The reflector shall be shaped so that a minimum of light is reflected through the arc tube of the lamp.

2. A refractor of high quality, high transmission, heat impact, discoloration and ultraviolet rays resistant tempered glass such as borosilicate or pyrex glass, acrylic material will be considered as an alternate. An accurately molded system of light controlling prisms shall provide the proper lateral spread and vertical elevation to the concentrated beams of light from the reflector. It shall not be rigidly held so as to compensate for thermal and/or mechanical stress.

3. An adjustable porcelain lamp socket of the enclosed mogul-multiple type, with vertical and axial adjustments to allow field distribution, and with integral lamp grips that assure electrical contact under conditions of normal vibration. The socket shall permit the presetting of a variety of specified light patterns. It shall be rated for 1,000 watts.

4. The system consisting of the reflector, refractor, lamp socket and lamp shall be in a sealed chamber. Sealing shall be provided by silicone-rubber gaskets between the reflector and refractor and between the reflector and lamp socket. The chamber

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shall have a provision for filtered flow of air in and out of the chamber due to lamp heat. Filtering shall be accomplished by either a separate filter or a filtering gasket.

e. Field wires connected to the luminaire shall terminate on a barrier type terminal block secured to the housing. The terminal screws shall be captive and equipped with wire grips for conductors up to No. 6. Each terminal position shall be clearly identified.

f. The luminaire housing shall be provided with a variable slip fitter capable of mounting on the slip fit end of the bracket arm without rearrangement of mounting parts and of being adjusted ± 5 degrees from the axis of the tenon.

714-4.03 Tunnel and underpass luminaires shall be of the wall mounted type meeting the following requirements:

a. Luminaire shall consist of a weatherproof die-cast aluminum housing including a prismatic thermal high light transmission and shock resistant polycarbonate refractor, a specular anodized aluminum reflector, an integral ballast, a lamp socket and a photo control if shown on the plans.

b. The refractor shall be mounted on the door frame which shall be hinged, gasketed and secured to the body by at least two stainless steel pressure latches.

c. Luminaires shall be prewired and designed to mount directly on a wall for surface wiring or over a recessed outlet box.

d. Beam position shall be 60° or 70° as indicated on the plans.

e. Luminaires for underpasses shall be for 100 watt HPS lamps and for tunnels shall be for 100, 150 or 250 watt HPS lamps as indicated on the plans.

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- f. The lighting controls for on/off operation shall be as indicated on the plans.

714-5 LAMPS

714-5.01 High pressure sodium lamps for standard mounts shall be of the wattage indicated on the plans, suitable for horizontal mounting, and shall have a minimum average rated life of 24,000 hours. Lamps shall comply with the ANSI code designations and light output indicated in Article 714-5.03.

714-5.02 High pressure sodium lamps for wall mounts shall be of the types shown on the plans and shall have a minimum average rated life of 24,000 hours.

714-5.03 Lamps of various wattages shall be as follows:

<u>Lamp Wattage</u>	<u>ANSI Code No.</u>	<u>Lumens</u>
70	S-62 ME-70	5,800
100	S-54 SB-100	9,500
150	S-55 SC-150	16,000
200	S-66 MN-200	22,000
250	S-50 VA-250	27,500

714-6 LAMP BALLASTS

714-6.01 General ballasts for high pressure sodium lamps shall be designed for the type, characteristics and wattage of the lamp it is to operate, and it shall provide the proper starting and operating wave forms, voltage and current. In addition:

- a. Unless otherwise indicated on the plans, the ballast shall be an integral part of the luminaire unit. It shall be built-in and pre-wired to the lamp socket and terminal board, fused, and requiring only connection of the power supply leads to the ballast primary terminals.

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- b. Voltage rating shall be as shown in the contract documents.
- c. Efficiency of the ballast shall be at least 85 percent and the power factor shall be at least 95 percent.
- d. Ballast shall, over the full range of allowable voltage variation, control lamp watts within the prescribed limits of operation throughout the rated life of the lamp, as defined by the ANSI “Trapezoid” specification for HPS lamps.

714-6.02 Lamp ballasts for pole mounted 200W luminaires shall be of the isolated two-winding, constant wattage type, cooper low-loss reactor ballast. They shall provide regulation within plus or minus one percent variation in lamp watts with a primary voltage variation of plus or minus one percent and allowable line voltage variation of $\pm 5\%$. In addition, the ballast shall provide sufficient voltage at the lamp so that the lamp will not be extinguished even with a line voltage drop of as much as 60 to 30% below the nominal value.

714-6.03 Ballasts for underpass and tunnel luminaires shall be of the high power factor, reactor type.

714-6.04 Ballasts for use with concrete lighting standards shall be Type H-1 for direct burial, suitable for underground installation.

714-7 SUBSTATIONS

714-7.01 Substations shall consist of distribution transformers and related equipment for multiple connection of highway and street lighting as shown on the plans and as described below.

- a. Distribution transformers shall be of the outdoor distribution type, oil immersed, self cooled, of the ratings and primary voltages shown on the plans, 120/240 volt secondary, with four 2-1/2% taps as indicated on the plans, in accordance with the latest applicable EEI-NEMA standards, and meeting the approval of PREPA.

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b. When required for pole installation, the transformer shall be suitable for cross arm or direct pole mounting.

c. Transformers shall be furnished complete with oil for continuous operation, with NEMA Class 185°C insulation system, with 115°C rise. For 37 1/2 KVA and 50 KVA transformers, NEMA Class 220°C insulation shall be provided.

d. The transformer bushings shall be oil proof, removable, stud type, pocket mounted, clamped in position with weather-tight joints by means of cork or equal gaskets and provided with terminal connections suitable for either copper or aluminum conductors. The secondary connector shall be universal and suitable for aluminum or copper conductors. High voltage taps shall be brought out to a terminal block located under cover.

e. Secondary voltage shall be 120/240 suitable for multiple, three wire service and shall have 4 high voltage taps of 2-1/2% below and none above in the range of 5 to 50 KVA.

f. Fuse cut-outs shall be of the following ratings:

<u>System</u>	<u>Rating</u>
2400/4160	27KV, 100 or 200 amp with 14,000 amp interrupting capacity.
4800/8320	27KV, 100 or 200 amp with 10,000 amp interrupting capacity.
7620/13200	27KV, 200 amp with 8,500 amp interrupting capacity.

g. Pad mounted substations shall include disconnecting type power fuses of 15KV, 200 amp, with 25,000 amp interrupting capacity.

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714-7.02 Lightning arresters shall be suitable for use on a three-phase, four-wire system or valve type. The arresters shall be furnished with line lead, ground stud, and supporting bracket. The ratings shall be:

3 KV for 2,400 and 2,400/4160 Y Grd Neutral

6 KV for 4160 delta, 4800 and 4800/8320 Y Grd Neutral and 4160/7200 Y Grd Neutral

10 KV for 7620/13200 Y Grd Neutral

714-7.03 Insulators shall be of the pin type and shall conform with EEI - NEMA Standards for Insulators:

<u>Line KV</u>	<u>4.16 KV</u>	<u>8.32 KV</u>	<u>7620/13200 Y</u>
EEI NEMA Class	55-2	55-5	55-5
Dry Flash Over KV	50	75	85
Wet Flash Over KV	30	50	45
Mechanical Strength (lbs)	2500	3000	3000

714-8 LIGHTING CONTROLS

714-8.01 Lighting controls for centralized systems shall consist of a photoelectric unit located in a top mounting adaptor on the service equipment cabinet.

a. The cabinet shall include contactors, lighting load breakers or fuses, and entrance condulets for conductors from the substation 120/240 secondary system. Lighting controls shall comply with PREPA standard STL-14.

b. The contactors shall be actuated by the photoelectric control rated as required on the plans. The photoelectric control shall automatically turn the highway or street lighting

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on and off at predetermined light levels. It shall have a minimum incandescent rating of up to 1,000 watts and shall be controlled by a cadmium sulphide photoconductive cell or its equivalent. The unit housing shall be weather proof and raintight.

c. The photoelectric control shall be solid state, and shall be capable of being faced in any direction. Normal installation is facing towards the northeast.

d. The controller shall have two relays, each with a capacity of 3,600 watts.

714-8.02 For individual systems, the control on each luminaire shall consist of a photocell switch in the integrated photoelectric receptacle of the luminaire.

714-8.03 Type and location of lighting controls for underpass luminaires shall be as indicated on the plans.

714-9 GALVANIZED STEEL CONDUIT

714-9.01 Galvanized steel electrical conduit and fittings shall conform to all requirements of the NEC. Each conduit length shall bear the UL label. Exterior and interior surfaces, including threads (except field cuts) of all conduit and fittings shall be uniformly zinc coated by the hot-dip galvanizing process meeting the requirements of ASTM A 239. Where conduit expansion joints are called for on the plans, they shall be of the "XJ" type.

714-9.02 All condulets shall be corrosion resistant with a zinc coating and lacquer dip finish. Covers for condulets shall be installed with a moisture-proof gasket.

714-10 RIGID PLASTIC CONDUIT

714-10.01 Plastic conduit shall be UL approved non-sparking polyvinyl chloride (PVC) conduit Schedule 40 designed for direct

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burial in the ground. Solvent cement for joining conduits and fittings shall meet the requirements of ASTM D 2564.

714-11 JUNCTION BOXES

714-11.01 Metal Junction Boxes

- a. Metallic junction boxes located one mile or further from the sea shall be constructed of cast iron or of 1/8-inch minimum thickness welded sheet steel. Cast iron shall conform to Specification 715 - Metallic Materials for Bridges and Structures. Sheet steel construction shall conform to ASTM A 415. All metallic boxes and covers shall be hot-dip galvanized accordance with AASHTO M 111 after fabrication. Each box shall have a gasketed cover that will, with cover in place, form a watertight fit. Covers shall be provided with brass, Allen head screws. Screw heads shall be recessed in the cover.
- b. Metallic junction boxes located within one mile of the sea shall be constructed of AISI stainless steel.

714-11.02 Concrete Junction Boxes - Concrete junction boxes shall be precast concrete, water meter type, with cast iron cover held down by brass bolts and hexagonal head nuts recessed in the cover, and meeting the requirements of PREPA.

714-12 SERVICE PEDESTALS

714-12.01 Service pedestals shall be suitable for direct burial in the ground and shall conform to PREPA Standard URD 26. They shall consist of a bituminized enclosure with a polyethylene dome, cast iron cover (green finish), earth anchor, compression lock and universal service tap. It shall withstand a 7,500 weight on the cover and an axial crushing force of 30,000 pounds. The dome shall be a polyethylene bell jar made of 1/8 inch thick high density polyethylene. The universal service tap shall be made of aluminum alloy with four (4) outlets filled with “penetrox” for copper or aluminum conductors in the range of No. 6 stranded to 4/0 stranded.

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714-13 CONDUCTORS

714-13.01 Individual conductors of the sizes called for on the plans, shall be round, uncoated, stranded copper wire conforming to the requirements of ASTM B 3, latest revision, except as specified herein. All cable and wire shall be rated 600 volts, unless otherwise specified, and shall be in accordance with the applicable ASTM and IPCEA specifications and NEMA Standards. The number and size of conductors shall be as shown on the plans. If the plans and specifications are silent on the number and size of the conductor, such conductors shall be sized according to requirements of the NEC and the total number of conductors needed to service the electrical device shall be placed by the Contractor.

714-13.02 Secondary conductors of the sizes specified on the plans shall be copper, 600V and 90°C rated, with cross linked polyethylene (XLP) or ethylene propylene (EPR) insulation, and shall conform to the current PREPA regulations and standards.

714-13.03 Single phase primary line conductors shall be 90 °C and 15KV rated as indicated on the plans. They shall be cross linked polyethylene (XLP) insulated, shield PVC jacketed, single conductor cables, and designed with 100 percent installation level in accordance with the current PREPA regulation and standards.

714-14 GROUNDING MATERIALS

714-14.01 Grounding equipment conductor shall have a current rating in accordance with the overcurrent device ahead of the equipment as per Table 250-122 NEC, and TW insulation.

714-14.02 Ground Electrode Wire - Unless otherwise specified, the ground wire shall be bare copper rated as per Table 250-66 NEC.

714-14.03 Ground Rods - Shall be made of steel with heavy molten welded, rust proof, copper coating. Rods shall be 3/4 inch diameter and five (5) feet long for poles, and 3/4 inch diameter by 10

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feet long, or 5/8 inch diameter by 8 feet long, for substations, as indicated on the plans. The point shall be conical and the top tinned.

714-14.04 Ground Rod Clamps - Shall be suitable for making the connection between the copper grounding electrode conductor and ground rod. The clamp shall be of the safety set screw type. Hexagonal safety wrenches shall be used for tightening the connection.

714-15 PULL BOXES

714-15.01 Pull boxes shall be suitable for direct burial in the ground and shall conform to PREPA standard STL-9B. It shall consist of a polymer concrete with highly interlaced fiberglass and withstand a design load of 15,000 pounds. The cover shall be the same material as the pull box, 3/4 inch thickness and shall be bolted with four (4) 3/8 in-16 NC stainless steel hexagonal screws with washers.

SPECIFICATION 715 – STRUCTURAL METALS

715-1 STRUCTURAL STEEL

715-1.01 Structural steel shall conform to the requirements included in the contract documents and shall be furnished in accordance with the following specifications. Unless otherwise specified, structural carbon steel shall be furnished.

- a. Carbon Steel - Unless otherwise specified, structural carbon steel for bolted or welded construction shall conform to Structural Steel, AASHTO M 183 (ASTM A36).
- b. Eye Bars - Steel for eye bars shall be a weldable grade which includes:
 - 1. Structural Steel AASHTO M 183 (ASTM A36).
 - 2. High-Strength Low Alloy Structural Steel, AASHTO M 222.
- c. High-Strength Low-Alloy Structural Steel for bolted construction shall conform to:
 - 1. High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, AASHTO M 223, Grade 50 unless otherwise specified.
 - 2. High-Strength Low-Alloy Structural Steel with 50,000 psi Minimum Yield Point to 4-in. thick, AASHTO M 222.
- d. High-Strength Low-Alloy Structural Steel for Welding - shall conform to the requirements in Article 715-1c above but the supplementary requirements S2 of AASHTO M 223 and S1 of AASHTO M 222 are mandatory.
- e. High-Yield-Strength, Quenched and Tempered Alloy Steel Plate - shall conform to:

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1. High-Yield-Strength, Quenched and Tempered Alloy Steel Plate Suitable for Welding, AASHTO M 244 (ASTM A 514).
 2. High-Strength Alloy Steel Plates, Quenched and Tempered for Pressure Vessels, ASTM A 517.
 3. Quenched and tempered alloy steel structural shapes and seamless mechanical tubing, meeting all of the mechanical and chemical requirements of A 514/A 517 steel, except that the specified maximum tensile strength may be 140,000 psi for structural shapes and 145,000 psi for seamless mechanical tubing, shall be considered as A 514/A 517 steel.
- f. When copper bearing steel is specified, the steel shall contain not less than 0.2 percent copper.

715-2 HIGH-STRENGTH BOLTS

715-2.01 High-strength bolts for structural steel, including suitable nuts and washers shall conform to either of the following specifications as called for in the contract documents.

- a. High-Strength Bolts for Structural Steel Joints, AASHTO M 164 (ASTM A 325). When Type 3 bolts are specified they, along with suitable nuts and washers, shall have an atmospheric corrosion resistance of approximately two times that of carbon steel with copper.
- b. Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints, AASHTO M 253 (ASTM A 490).

715-2.02 Bolts and nuts manufactured to AASHTO M 164 (ASTM A 325) shall be identified by proper markings, as specified in M 164, on the top of the bolt heads and one face of the nuts for the three different types.

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715-2.03 Bolts manufactured to AASHTO M 253 (ASTM A 490) shall be identified, as specified in M 253, with the symbol A 490 or M 253 on the top of the heads. The nuts shall be marked on face with the legend “2H” or “DH” as applicable.

715-2.04 Bolts and nuts shall conform to the dimensions given in Table 715-1 and to the requirements for Heavy Hexagon Structural Bolts and Heavy Semi-Finished Hexagon Nuts given in ANSI Standards B18.2.1 and B18.2.2 respectively.

TABLE 715-1
STEEL BOLT AND NUTS DIMENSIONS
(All dimensions in inches)

Heavy Hexagon Structural Bolts				Heavy Semi-Finished Hexagon Nuts	
Nominal Bolt Size D	Width of Head Across Flats F	Height of Head H	Thread Length T	Width Across Flats W	Height H
1/2	7/8	5/16	1	7/8	31/64
5/8	1 1/16	15/64	1 1/4	1 1/16	39/64
3/4	1 1/4	15/32	1 3/8	1 1/4	47/64
7/8	1 7/16	35/64	1 1/2	1 7/16	55/64
1	1 5/8	39/64	1 3/4	1 5/8	63/64
1 1/8	1 13/16	11/16	2	1 13/16	1 7/64
1 1/4	2	25/32	2	2	1 7/32
1 3/8	2 3/16	27/32	2 1/4	2 3/16	1 11/32
1 1/2	2 3/8	15/16	2 1/4	2 3/8	1 15/32

715-2.05 Circular washers shall be flat and smooth and their nominal dimensions shall conform to the dimensions given in Table

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715-2, except that for lock pin and collar fasteners, flat washers need not be used, unless slotted or over size holes are specified.

715-2.06 Beveled washers for American Standard Beams and Channels shall be square or rectangular, shall taper in thickness, and shall conform to the dimensions given in Table 715-2.

715-2.07 Where necessary, washers may be clipped on one side to a point not closer than 7/8 of the bolt diameter from the center of the washer.

715-3 PINS, ROLLERS AND EXPANSION ROCKERS

715-3.01 Steel for pins, rollers and expansion rockers shall be as follows unless otherwise specified in the contract documents.

- a. For pins 4" or less in diameter - Steel Bars, Carbon, Cold Finished, Standard Quality - AASHTO M 169 (ASTM A 108).
- b. For pins, rollers and rockers up to 20 inches in diameter - Steel Forgings, Carbon and Alloy, for General Use - AASHTO M 102 (ASTM A 668) - Class C, D or G as specified.
- c. For pins, rollers and rockers up to 10 inches in diameter - AASHTO M 102 (ASTM A 668) - Class F.
- d. Expansion rollers shall be not less than 4 inches in diameter.

**TABLE 715-2
WASHER DIMENSIONS**

C I R C U L A R W A S H E R S					S Q U A R E O R R E C T A N G U L A R B E V E L E D W A S H E R S		
Bolt Size Diam.	Nominal Outside Diam (a)	Nominal Hole Diam.	T h i c k n e s s		Minimum Side Dimension	Mean Thickness	Slope of Taper
			Min.	Max.			
1/2	1 1/16	17/32	0.097	0.177	1 3/4	5/16	1:6
5/8	1 5/16	21/32	0.122	0.177	1 3/4	5/16	1:6
3/4	1 15/32	13/16	0.122	0.177	1 3/4	5/16	1:6
7/8	1 3/4	15/16	0.136	0.177	1 3/4	5/16	1:6
1	2	1 1/16	0.136	0.177	1 3/4	5/16	1:6
1 1/8	2 1/4	1 1/4	0.136	0.177	2 1/4	5/16	1:6
1 1/4	2 1/2	1 3/8	0.136	0.177	2 1/4	5/16	1:6
1 3/8	2 3/4	1 1/2	0.136	0.177	2 1/4	5/16	1:6
1 1/2	3	1 5/8	0.136	0.177	2 1/4	5/16	1:6

C I R C U L A R W A S H E R S					S Q U A R E O R R E C T A N G U L A R B E V E L E D W A S H E R S		
Bolt Size Diam.	Nominal Outside Diam (a)	Nominal Hole Diam.	T h i c k n e s s		Minimum Side Dimension	Mean Thickness	Slope of Taper
			Min.	Max.			
1 3/4	3 3/8	1 7/8	0.178 (b)	0.280	-	-	-
2	3 3/4	2 1/8	0.178	(b)	-	-	-
Over 2 t 4 Inc.	2D-1/2	D + 1/8	0.240 (c)	0.280 0.340 (c)	-	-	-
(a) May be exceeded by 1/4 inch.			(b) 3/16 inch nominal.		(c) 1/4 inch nominal.		

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715-4 WELDED STUD SHEAR CONNECTORS

715-4.01 Shear connector studs shall conform to the requirements of Cold Finished Carbon Steel Bars and Shafting, AASHTO M 169 (ASTM A 108), cold-drawn bars, grades 1015, 1018, or 1020, either semi or fully-killed. If flux retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with Cold Rolled Carbon Steel Strip, ASTM A 109.

715-4.02 The studs shall conform to the dimensions given in Table 715-3 unless otherwise specified.

715-4.03 Tensile properties as determined by tests of bar stock after drawing or of finished studs shall conform to requirements as follows:

Tensile Strength – minimum.....	60,000 psi
Yield Strength as determined by 0.2% offset method – minimum.....	50,000 psi
Elongation – minimum.....	20% in 2 inches
Reduction in Area – minimum.....	50%

715-4.04 Tensile properties shall be determined in accordance with the applicable sections of ASTM A 370, Mechanical Testing of Steel Products. Tensile tests of finished studs shall be made by the manufacturer on studs welded to test plates using a test fixture with dimensions similar to those shown in Table 715-3. If fracture occurs outside of the middle half of the gauge length, the test shall be repeated.

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TABLE 715-3

WELDED STUD SHEAR CONNECTORS Standard Dimensions and Tolerances - Inches

S H A N K		H E A D	
Diameter (C)	Length (L)*	Diameter (H)	Thickness (T)
$\frac{3}{4} + 0.000$ - 0.015	$4 - 0.062$ - 0.125	$1 \frac{1}{4} \pm \frac{1}{64}$	3/8 min.
$\frac{7}{8} + 0.000$ - 0.015	$4 + 0.062$ - 0.125	$1 \frac{3}{8} \pm \frac{1}{64}$	3/8 min.

* Length includes thickness of head.

715-4.05 Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends or other injurious defects. Finish shall be as produced by cold drawing, cold rolling or machining.

715-4.06 The Contractor shall provide the manufacturer's certification that the studs as delivered are in accordance with the material requirements of this specification. Certified copies of manufacturer's in-plant quality control test reports shall be furnished to the Engineer.

715-4.07 The Engineer may select, at the Contractor's expense, studs of each type and size under the contract, as necessary for checking the requirements specified herein.

715-5 CASTINGS

715-5.01 Cast steel shall conform to Steel Castings for Highway Bridges, AASHTO M 192 (ASTM A 486), or Mild-to Medium-Strength Carbon-Steel Castings for General Application,

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AASHTO M 103 (ASTM A 27). For M 192 steel castings, Class 70 shall be furnished and for M 103 steel castings Grade 70-36 shall be furnished, unless otherwise specified.

715-5.02 Chromium alloy steel castings shall conform to Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel Based Alloy Castings for General Application, AASHTO M 163 (ASTM A 743). Grade CA-15 shall be furnished unless otherwise specified.

715-5.03 Iron castings shall conform to Gray Iron Castings, AASHTO M 105 (ASTM A 48). Class No. 30 shall be furnished unless otherwise specified.

a. Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect.

b. All iron castings must be sandblasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean, and uniform surface.

715-5.04 Ductile iron castings shall conform to Ductile Iron Castings, ASTM A 536, Grade 60-40-18 unless otherwise specified. The requirements for workmanship, finishing and cleaning shall be the same as specified in paragraphs 715-5.03a. and b. above.

715-5.05 Malleable iron castings shall conform to Malleable Iron Castings, ASTM A 47, Grade 35018 unless otherwise specified. The requirements for workmanship, finishing and cleaning shall be the same as specified in paragraphs 715-5.03a and b above.

715-5.06 Bronze castings shall conform to Bronze Castings for Bridges and Turntables, AASHTO M 107 (ASTM B 22), Alloys C 913 or C 911.

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715-6 STEEL FORGINGS AND STEEL SHAFTING

715-6.01 Steel forgings shall conform to Steel Forgings, Carbon and Alloy, for General Use, AASHTO M 102 (ASTM A 668), Classes C, D, F, or G, unless otherwise specified.

715-6.02 Cold-finished carbon steel shafting shall conform to Steel Bars, Carbon, Cold Finished, Standard Quality, AASHTO M 169 (ASTM A 108). Grades 1016-1030, inclusive, shall be furnished unless otherwise specified.

715-7 STAINLESS STEEL

715-7.01 Stainless steel shall be a chromium-nickel steel alloy conforming to the composition and mechanical properties of the AISI 300 series for the specific type called for in the plans, and meeting the applicable requirements of ASTM A 480.

715-7.02 Unless otherwise shown on the plans, AISI stainless steel type 321 or 347 shall be used when the stainless steel is to be subject to welding.

715-8 COPPER-ALLOY PLATES

715-8.01 Copper alloy plates shall conform to Rolled Copper-Alloy Bearing and Expansion Plates and Sheets for Bridge and other Industrial Uses, AASHTO M 108 (ASTM B 100)

715-9 SHEET ZINC

715-9.01 Sheet zinc shall conform to the requirements for Type II of the Specification for Rolled Zinc, ASTM B 69.

715-10 SHEET LEAD

715-10.01 Sheet lead shall conform to the requirements for Common Desilverized Lead of the Specification for Pig Lead, ASTM B 29.

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715-11 GALVANIZING

715-11.01 When galvanizing is specified in the contract documents, ferrous metal products shall be galvanized in accordance with the Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip, AASHTO M 111 (ASTM A 123).

715-12 WELDING ELECTRODES AND FLUXES

715-12.01 All welding electrodes and fluxes shall conform to the requirements of the American Welding Society (AWG) as modified by the AASHTO Standard Specification for Welding of Structural Steel Highway Bridges.

- a. Shielded metal-arc welding electrodes shall conform to AWS Specifications for Mild Steel Covered Arc-Welding Electrodes.
- b. Submerged-arc welding electrodes and flux shall conform to AWS Specifications for Bare Mild Steel Electrodes and Fluxes for Submerged-Arc Welding.
- c. Gas metal-arc welding electrodes shall conform to AWS Specification for Mild Steel Electrodes for Gas Metal-Arc Welding.
- d. Flux-cored arc welding electrodes shall conform to AWS Specification for Mild Steel Electrodes for Flux-Cored Arc Welding.
- e. Electrodes for welding chromium-nickel stainless steel shall correspond to the AISI number of the stainless steel to be welded. Covered electrodes AISI, Type 347 shall be used for welding AISI Types 321 and 347 stainless steels.

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716-1 PAVEMENT MARKING PAINT

716-1.01 Pavement marking paint, white or yellow, shall conform to the requirements of AASHTO M 248 as modified and supplemented herein.

716-1.02 All paint shall be furnished in strong, substantial and properly sealed containers. Five-gallon steel or plastic pails shall have a full diameter hub cover, wire bail and handle. Large containers, of 50 to 55 gallon capacity, shall be open-end drums equipped with a ring and lock closure, multi-seal reusable sponge gasket and removable lid which can be readily resealed after partial use of its contents. All containers shall meet current specifications of the U. S. Department of Transportation for transporting flammable liquids.

716-1.03 Drying Time - Unless otherwise specified in the contract documents, Type “N” traffic paint shall be furnished. It shall set to touch in not more than 15 minutes and shall dry hard so that there is no tracking under traffic in 30 minutes. At the Contractors’ option a Type “F” paint, with a drying time of 3 to 5 minutes when heated in the applicator, may be used.

716-1.04 Hiding Power - The traffic paint when applied at the rate of 10 mils wet film thickness, using a suitable doctor blade (Bird Film Applicator or equivalent) shall show complete hiding over Morest Black and White Hiding Power Chart, Form 03-B (supplied by the Morest Company, 211 Center Street, New York 13, New York). If there should be questions on the complete hiding as determined visually on this chart, then hiding may be measured by use of the Hunter Multi-Purpose Reflectometer. By use of this instrument, the reflectance over the white and black surfaces is determined. A minimum contrast ratio of 0.98 shall represent complete hiding. The contrast ratio is calculated by dividing the reflectance over black by reflectance over white.

716-1.05 Flexibility - The paint, as evidence of its flexibility, shall show no cracking or flaking when submitted to the following

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test conducted in accordance with the method of test of Federal Specification TT-P-115 a, with the exception that the film is to be applied with a doctor blade in lieu of a brush.

- a. The tin panels used in this test shall be cut from bright tin plate weighing not more than 25 grams and not less than 19 grams per square decimeter (0.51 to 0.39 pounds per square foot). The panels shall be about 7.5 by 13.0 centimeters (3" x 5") and shall be lightly buffed with steel wool and thoroughly cleaned with benzol immediately before using.
- b. The paint shall be applied in a uniform manner on duplicate tin panels using a Bradley blade or similar doctor blade which will produce a wet film thickness of 0.0025".
- c. The applied paint shall be let to dry in a horizontal position at room temperature (70° - 90°F) for 18 hours and then the panels shall be placed in an oven heated to 105° - 110°C and baked for 5 hours after which, the panels shall be removed and let to cool for 15 minutes to 25°C.
- d. The panels shall be placed with the painted side uppermost over a 1/2" diameter rod held firmly by suitable supports and bent double rapidly, then examined for cracks with the naked eye. No cracks shall appear on either panel or the paint shall be considered to have failed the test.

716-1.06 Water Resistance - The paint will be tested for water resistance in accordance with Federal Specification TT-P-115 a except that:

- a. The paint shall be applied to 8" x 8" glass panels, which have been previously cleaned with benzol, with an 0.003" Bradley or similar doctor blade. Application shall be started within approximately one (1) inch from the top of the panel.

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- b. The coated glass panels shall be allowed to air dry at room temperature (70° - 90°) for ninety hours. The top of the panel where application was started shall be immersed to a depth of four (4) inches in distilled water. After eighteen (18) hours, the panels shall be removed and allowed to dry for two (2) hours and examined. The immersed paint film shall show good adhesion to the glass panel and shall show no wrinkling, blistering, or other forms of deterioration.

716-1.07 Dilution - The paint shall be tested for dilution in accordance with Test 4203 of Federal Test Method, Standard No. 141. To about 120 milliliters of paint in a small beaker, there shall be added 15 milliliters of ordinary white gasoline (boiling range not less than 10% above 60°C and not more than 10% above 170°C) slowly, with constant stirring. The thinned paint shall be uniform, and shall show no separation, curdling or precipitation.

716-1.08 Gasoline Resistance - The paint when subjected to the following test shall show no blistering or wrinkling immediately upon removal of the panel from the gasoline:

- a. The paint shall be applied at a wet film thickness of six thousandths of an inch (.006”) to tin panels of the same size and prepared in the same manner as described above under subparagraph 716-1.04, “Flexibility”.
- b. The coated panels shall be air dried for ninety (90) hours and subsequently immersed in gasoline conforming to Federal Specification VV-G-101a to a depth of approximately three (3”) inches in a container covered with a watch glass and allowed to remain in the gasoline at room temperature (70°F – 90°F) for eighteen (18) hours. At the end of the 18 hours the coated panels shall be removed, allowed to dry, and examined.
- c. Any softening effect that may remain two hours after removal from the gasoline shall have disappeared after air drying for twenty-four hours.

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716-1.09 Bleeding - The paint shall show no perceptible bleeding over bituminous surfaces when tested in accordance with ASTM Standard D 969.

716-1.10 Weight - The paint shall weigh no less than 11.0 pounds per gallon.

716-1.11 Samples - For testing purposes the Contractor shall submit three (3) gallons each of white and/or yellow traffic paint not later than 90 calendar days prior to the date for starting pavement marking operations. These samples shall be submitted in separate one-gallon cans.

716-2 GLASS BEADS FOR REFLECTORIZED PAVEMENT MARKINGS

716-2.01 The glass beads for use in reflectorized pavement markings shall conform to the requirements of AASHTO M 247 as modified and supplemented herein. Type I, standard gradation shall be used unless otherwise specified in the contract documents.

716-2.02 Atmospheric Test - The glass beads shall be subjected to either one of the following tests:

a. Accelerated Test - Place 100 milliliters of distilled water in a 300 ml beaker, cover beaker and place in a hot plate or oven previously warmed to 180°F. Allow the water to warm to 180°F, place a small glass dish floating in the beaker and place 10 grams of the glass beads on the dish. Again cover the beaker and place it in the oven or hot plate and allow it to stay at 180°F for 8 hours. At the end of the 8 hours remove the beaker from the oven or hot plate and examine the glass beads. If the beads are still clear they will be considered to have passed the test. If they are cloudy they will be rejected.

b. Standard Test - Place 5 centimeters of water in the bottom of a glass desiccator and keep at an ambient

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temperature of 72°F. Place 10 grams of the glass beads in a glass dish in the desiccator and replace the desiccator cover. The glass beads shall stay in the desiccator for seven (7) days. Once every 24 hours the cover of the desiccator shall be removed for 30 minutes and then replaced. After the seventh day the glass beads shall be removed from the desiccator and examined. If the beads are still clear they shall be considered to have passed the test. If they are cloudy they will be rejected.

716-2.03 Certification - Four copies of certified test results showing that the glass beads meet the above specifications shall be submitted to the Engineer by the Contractor.

716-3 REFLECTORIZED PAVEMENT MARKING PAINTS

716-3.01 The reflectorized pavement marking paints shall comply with the weathering, abrasion and reflectance tests specified below. A sufficient number of sample panels shall be prepared to permit making these various tests.

716-3.02 Panel Preparation - The traffic paint shall be applied on suitably cured concrete panels at a wet film thickness of 0.015" using a Bradley or other suitable doctor blade. Glass beads of correct gradation shall be uniformly distributed into the wet film in the ratio of 6 pounds of glass beads to one gallon of paint. The beads shall be dropped immediately after the paint is applied.

716-3.03 Accelerated Weathering Test - The prepared panels shall be subjected to an accelerated weathering test equivalent to 12 months of exterior exposure. The samples so exposed shall show no excessive discoloration and not more than 20% loss of reflecting power at the end of the test period. To accomplish this test, either one of the following methods may be used. Six hundred (600) hours of exposure in either one of the two tests shall be considered equivalent to 12 months of exterior exposure.

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- a. Exposure in National Carbon Apparatus - The test shall be conducted in accordance with Method 6151 of the Federal Test Method Standard No. 141. The samples shall be exposed for 600 hours in the National Carbon Arc Type DMC-R accelerated weathering machine using Sunshine Carbon Arcs enclosed in Corex D Filters, and sprayed with water every two (2) hours.
- b. Exposure in Atlas Twin - Arc Apparatus. The test shall be conducted in accordance with Method 6152 of the Federal Test Method Standard No. 141. The samples shall be exposed for 600 hours in the Atlas Twin-Arc Type accelerated weathering machine. The Atlas cycle shall provide 3 minutes of water spray out of each 20 minute period. Ambient temperature at the specimen shall be 130°F plus or minus 5 degrees.

716-3.04 Accelerated Abrasion Test - Upon completion of the accelerated weathering test, three panels of sample material shall be subjected to an accelerated abrasion test. The cured concrete panels shall be removed from the Weatherometer and conditioned at room temperature for 72 hours. After this conditioning period, the panels shall be placed on the periphery of a modified Hickson type, vertical abrasion machine, using a 10 pound brake load, 5° angle of shear and 80 pound loading. The panels shall withstand not less than 500,000 revolutions (impacts) before losing 75% of the paint film or 80% of the glass spheres. If at least two panels meet these requirements, the material shall be accepted as meeting abrasion tests satisfactorily.

716-3.05 Directional Reflectance Test - The directional reflectance of a surface for the given incidence and divergence angles is defined as the reflecting power of the test surface expressed in comparison with the reflecting power of a completely reflecting, perfectly diffusing surface for the same angles. For incidence and divergence angles specified herein a panel of white casein paint will closely duplicate the reflective properties of the ideal, completely reflecting, perfectly diffusing surface. The materials furnished under

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these specifications shall have direction reflectance values at least equal to the following:

<u>Incidence Angle</u>	<u>Divergence Angle</u>	<u>Minimum Directional Reflectance</u>
75°	1°20'	3
88°	1°20'	10

716-3.06 Laboratory Equipment - The supplier of the materials for reflectorized pavement marking paints shall have available the laboratory equipment necessary to perform all the required tests.

716-3.07 Certification - Four copies of certified test results showing that the reflectorized pavement marking paint meets the above specifications shall be submitted to the Engineer by the Contractor.

716-4 REFLECTORIZED THERMOPLASTIC PAVEMENT MARKING MATERIALS

716-4.01 Reflectorized Extruded Thermoplastic Pavement Marking Material - This type shall conform to the requirements of AASHTO M 249.

716-4.02 Reflectorized Thermoplastic Pavement Marking Material, Flame-Spray Powder - This type shall conform to the requirements of AASHTO M 250.

716-5 REFLECTIVE PREFORMED PLASTIC PAVEMENT MARKING FILM

716-5.01 Reflective preformed plastic pavement marking film shall consist of a mixture of high quality polymeric materials, pigments and glass beads uniformly distributed throughout its base cross-section area, with a reflective layer of protruding glass beads

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bonded to the top surface. The film shall comply with the following requirements.

716-5.02 The composition of the film shall be as follows:

Resins and Plasticizers, Minimum.....	20%
Pigments, Minimum.....	30%
Glass Beads, Minimum.....	33%

716-5.03 The preformed markings shall consist of white or yellow films with pigments selected and blended to conform to standard FHWA highway colors through the expected life of the film. Glass beads shall be incorporated to provide immediate and continuing retroreflection. The markings shall be readily visible when viewed with automobile headlights at night.

716-5.04 The glass beads shall conform to AASHTO M 247 and their size, quality and refractive index shall be such that the performance requirements for the markings shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.

716-5.05 The film shall have glass bead retention qualities such that when a 2" x 6" sample is bent over a 1/2" diameter mandrel, with the 2" dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

716-5.06 The preformed markings shall be capable of being adhered to asphalt concrete or portland cement by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. The preformed marking film shall mold itself to pavement contours by the action of application on new, dense and open graded asphalt concrete wearing courses during the paving operation in accordance with the manufacturer's instructions. After application, the markings shall identify be immediately ready for traffic. The Contractor and his supplier shall identify proper solvents and/or primers (where necessary) to be applied at the time of

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application, all equipment necessary for proper application, and recommendations for application that will assure the materials shall be suitable for use for one year after the date of receipt.

716-5.07 Tensile Strength and Elongation - The film shall have a minimum tensile strength of 150 pounds per square inch of cross section at maximum load, when tested according to ASTM D 638-76. A sample 6 inches by 1 inch by 0.06 inch shall be tested at a temperature between 70° and 80°F using a jaw speed of 10 to 12 inches per minute. The sample shall have a minimum elongation of 75% at break when tested by this method.

716-5.08 Skid Resistance - The surface of the film shall provide an initial minimum skid resistance value of 45 BPN when tested according to ASTM E 303-74.

716-5.09 Thickness - The film, less adhesive, shall be a standard thickness of 0.06 inch (60 mils).

716-5.10 The film shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use. It shall be capable of use for patching worn out areas of the same type film in accordance with manufacturer's instructions.

716-5.11 The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The pliant polymer shall provide a cushioned, resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and, through normal traffic wear, shall show no fading, lifting or shrinkage which will significantly impair the intended usage of the marking throughout its useful life, and shall show no significant tearing, roll back or other signs of poor adhesion.

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716-5.12 Certification - Four copies of certified test results showing that the marking film meets the above specification shall be submitted to the Engineer by the Contractor.

716-6 NON-REFLECTIVE RAISED PAVEMENT MARKERS – CERAMIC TYPE

716-6.01 Non-reflective ceramic raised pavement markers shall consist of a heat-fired, white, vitreous, ceramic base and a heat-fired, opaque, white or yellow glazed surface, as indicated on the plans. The bottoms of the markers shall be free from gloss or glaze and shall have a number of integrally formed protrusions of approximately 0.05-inch projecting from the surface in a uniform pattern of parallel rows. The markers shall be free from defects which affect appearance or service-ability.

716-6.02 The top surface of the marker shall be convex and the radius of curvature shall be between 3 1/2 inches and 6 inches except that the radius of the 1/2 inch nearest the edge may be less. Any change in curvature shall be gradual. Each marker shall be $4'' \pm 0.1''$ in diameter at the base. Height of the marker shall be $1\frac{1}{16}'' \pm \frac{1}{16}''$ or $\frac{7}{16}'' \pm \frac{1}{16}''$ or as shown on plans. The base of the marker shall not deviate from a flat plane by more than $\frac{1}{16}''$. The glazed surface shall have a mean thickness not less than .005 inch when measured not closer than 1/4" from the edge of the marker to the nearest 0.001 inch by a calibrate scale microscope.

716-6.03 Markers shall be bonded to the pavement surface by the use of an epoxy resin adhesive meeting the requirements of AASHTO Specifications M 234 and M 237. Class II, Type III or III-M adhesive (Standard Setting) shall be used on new construction where the markers will be protected from the traffic for at least six hours, unless otherwise provided in the contract documents. Where the pavement has to be quickly exposed to traffic, as on existing roads, a Rapid Setting Type I or I-M adhesive shall be used.

SPECIFICATION 716 – PAVEMENT MARKING MATERIALS

716-7 REFLECTIVE RAISED PAVEMENT MARKERS

716-7.01 Reflective raised pavement markers shall be of the prismatic reflector type consisting of an acrylic plastic shell filled with a mixture of an inert thermosetting compound and filler material. The shell shall be molded of methyl methacrylate conforming to Federal Specification L-P-380 a, Type I, Class 3. The exterior surface of the shell shall be smooth and contain one or two methyl methacrylate prismatic reflector faces of the color specified.

716-7.02 Markers shall be monodirectional or bidirectional to incident light as specified on the plans. The reflective lens shall not contain any voids or air space and the back of the lens shall be metallized.

716-7.03 The markers shall be in the shape of a shallow frustrum of a pyramid with the base 4" x 4" and a height of 0.75". The base of the marker shall be flat and the bottom rough textured and free from gloss or any substance that may reduce its bond to the adhesive.

716-7.04 Markers shall be bonded to the pavement surface as provided in paragraph 716-6.03 of this specification.

SPECIFICATION 717 – ELASTOMERIC BEARINGS

717-1.01 Elastomeric bearings shall include plain bearings, consisting of elastomer only, and laminated bearings consisting of layers of elastomer restrained at their interfaces by bonded laminates.

717-1.02 The elastomer portion of the elastomeric compound shall be 100 percent virgin natural polyisoprene (natural rubber) or 100 percent virgin chloroprene (neoprene), meeting the requirements of Table 717-1 as specified by the Engineer. Compounds of nominal hardness between the values shown may be used and the test requirements interpolated. When test specimens are cut from the finished product a 10 percent variation in “Physical Properties” will be allowed.

717-1.03 Laminates shall be rolled mild steel sheets conforming to ASTM A 570, Grade D, or ASTM A 611, Grade D, unless otherwise specified by the Engineer.

717-1.04 Plain bearings may be molded individually, cut from previously molded strip or slabs, or extruded and cut to length. Cut edges shall be at least as smooth as ANSI 250 finish. Unless otherwise shown on the plans, all components of a laminated bearing shall be molded together into an integral unit, and all edges of the non-elastic laminations shall be covered by a minimum of 1/8 inch of elastomer except at laminate restraining devices and around holes that will be entirely closed on the finished structure.

717-1.05 Flash tolerance, finish, and appearance shall meet the requirements of the latest edition of the Rubber Handbook as published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for moulded bearings and RMA F2 for extruded bearings.

717-1.06 For both plain and laminated bearings the permissible variation from the dimensions and configuration required by the plans and these specifications shall be as follows:

a. Overall Vertical Dimensions

Average Total Thickness 1 1/4 in. or less	-0, +1/8 in.
Average Total Thickness over 1 1/4 in.	-0, +1/4 in.

SPECIFICATION 717 – ELASTOMERIC BEARINGS

- b. Overall Horizontal Dimension
 - 36 in. and less -0, +1/4 in.
 - Over 36 in. -0, +1/4 in.
- c. Thickness of Individual Layers of Elastomer
 - (Laminated Bearing Only) $\pm 1/8$ in.
- d. Variation from a Plane Parallel to the Theoretical Surface (as determined by measurements at the edges of the bearings)
 - Top 1/8 in.
 - Sides 1/4 in.
 - Individual Nonelastic Laminates 1/8 in.
- e. Position of Exposed Connection
 - Members 1/8 in.
- f. Edge Cover of Embedded Laminates or Connection Members
 - 0, $\pm 1/8$ in.
- g. Size of Holes, Slots, or Inserts $\pm 1/8$ in.
- h. Position of holes, Slots or Inserts $\pm 1/8$ in.

717-1.07 Bearing pads will be accepted upon certification from the manufacturer, submitted to the Engineer by the Contractor that all components of the pads furnished conform to the applicable requirements of the contract documents and this specification. The certification shall be supported by a certified copy of the tests performed upon components representative of those actually used on the pads furnished.

SPECIFICATION 717 – ELASTOMERIC BEARINGS

717-1.08 The Authority may perform such additional tests on samples of the full size bearing pads as may be necessary to ascertain their compliance with these specifications.

TABLE 717-1
REQUIREMENTS FOR NATURAL RUBBER AND NEOPRENE

ASTM Standard	Property	Natural Rubber			Neoprene		
		50 Duro	60 Duro	70 Duro	50 Duro	60 Duro	70 Duro
	PHYSICAL PROPERTIES						
D 2240	Hardness	50±5	60±5	70±5	50±5	60±5	70±5
D 412	Tensile Strength, Min. psi	2,500	2,500	2,500	2,500	2,500	2,500
	Ultimate Elongation Min. %	450	400	300	400	350	300
	HEAT RESISTANCE						
D 573	70 hrs. at 158°F (rubber) and 212°F (neoprene)						
	Hardness, max. pts. Change	±10	±10	±10	±15	±15	±15
	Tensile strength, Max. change	-25%	-25%	-25%	-15%	-15%	-15%
	Ultimate elongation Max. change	-25%	-25%	-25%	-40%	-40%	-40%

ASTM Standard	Property	<u>Natural Rubber</u>			<u>Neoprene</u>		
		50 Duro	60 Duro	70 Duro	50 Duro	60 Duro	70 Duro
	COMPRESSION SET						
D 395	Max. %, 22hrs. at 158°F	25	25	25			
Method B	Max. % 22hrs. at 212°F				35	35	35
	OZONE						
D 1149	25pphm (rubber) and 100 pphm (neoprene) – ozone in air by vol., 20% strain 100°F \pm 2F, 48 hrs. (rubber) and 100 hrs. (neoprene) – mounting procedure D 518, Proc. A.	No Cracks			No Cracks		
	ADHESION						
D 429, B	Bond made during Vulcanization, Lbs. per inch	40	40	40	40	40	40

SPECIFICATION 718 – STONE REVETMENT MATERIALS

718-1 FILTER MATERIAL

718-1.01 General - Filter material shall consist of sand and gravel or crushed stone obtained from excavation, quarry waste, or from any other source approved by the Engineer. All filter material shall be sound, durable, hard, free from laminations, weak cleavages and undesirable weathering, and of such character that it will not disintegrate from the action of air, water, or the conditions to be met in handling and placing. All material shall be clean and free from earth, clay and adherent coatings. The stone shall have the longest dimension not greater than three times the least dimension.

718-1.02 Quality - The filter material shall conform to the following physical requirements:

Apparent Specific Gravity as per AASHTO T 85..... 2.20 Min.

Abrasion Loss as per AASHTO T 96 and ASTM

C 535 45% Max.

718-1.03 Gradation - The filter material shall be well graded between the limits specified in Table 718-1 for each type. All points on individual grading curves obtained from representative samples of filter material shall be between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes or other irregularities which would be detrimental to the proper functioning of the filter. All material shall be made to the required grading at the source and individual loads as delivered to the project shall meet the required grading.

SPECIFICATION 718 – STONE REVETMENT MATERIALS

TABLE 718-1

FILTER MATERIAL - GRADATION REQUIREMENTS

Average Diameter or Sieve Size	Percent by Weight Passing Filter Material Type				
	A	B	C	D	E
18"					100
12"				100	
9"			100		80-95
6"		100		75-95	
4"	100				
3"			65-95	60-80	60-75
2"		60-90			
1 1/2"	55-85				
1"			40-65		
3/4"		35-65		35-65	35-50
No. 4	15-40	15-40	15-40	15-35	20-35
No. 40	0-25	0-10	0-10	0-10	0-10
No. 200	0-10				

718-2 STONE FOR REVETMENT

718-2.01 General - The stone for revetment shall be angular quarried rock. It shall be sound, durable, hard, free from laminations, weak cleavages and undesirable weathering, and of such character that it will not disintegrate from the action of air, water or the conditions to be met in handling and placing. The material shall be clean and free from earth, slag and adherent coatings. Each stone shall have the longest dimensions not greater than three times the least dimension.

718-2.02 Quality - The stone shall conform to the following physical requirements:

SPECIFICATION 718 – STONE REVETMENT MATERIALS

Apparent Specific Gravity as per AASHTO T 85..... 2.60 Min.

Abrasion Loss as per ASTM C 535..... 45% Max.

718-2.03 Size Distribution - The stone shall be well distributed between the weight distribution requirements in Table 718-2 for the type specified.

TABLE 718-2

REVETMENT STONE - SIZE DISTRIBUTION

Rock Size Lbs.	Percent Smaller by Weight Stone Type						
	I	II	III	IV	V	VI	VII
16,000							100
8,000						100	25-50
4,000					100	25-50	
2,000				100	25-50		0-10
1,000			100	25-50		0-10	
500		100	25-50		0-10		
200	100	25-50		0-10			
75	25-50		0-10				
5	0-10	0-10					

SPECIFICATION 719 – BITUMINOUS PAVEMENTS, MEASUREMENT OF REDUCTION IN MARSHALL STABILITY CAUSED BY IMMERSION IN WATER

719-1 SCOPE

719-1.01 This test method is intended to measure the reduction in Marshall stability resulting from the action of water on compacted bituminous mixtures containing viscosity grade asphalt cement. A numerical index of reduced stability is obtained by comparing the stability of specimens determined in accordance with usual Marshall procedures with the stability of specimens that have been immersed in water for a prescribed period. This test procedure is also applicable to core specimens obtained from compacted hot plant mix bituminous pavement courses.

719-2 APPARATUS

719-2.01 A water bath at least 6 inches deep provided with mechanical water agitator, heating elements, and thermostatic controls capable of maintaining the bath water at temperatures ranging from 100° to 140° F. The bath shall have a perforated false bottom or be equipped with a shelf of supporting specimens 2 inches above the bottom of the bath.

719-2.02 Balance and water container with accessory equipment for weighing the test specimens in air and water.

719-2.03 Transfer plates, flat, of glass or metal. One of these plates shall be kept under each test specimen during immersion and subsequent handling, except when weighing and testing, in order to prevent breakage or distortion of the specimens.

719-3 SPECIMENS

719-3.01 A minimum of six standard Marshall test specimens, 4 in. in diameter and 2 1/2 inches \pm 1/8 in. in thickness, shall be prepared for each test in accordance with the procedures described in AASHTO T 245. The compaction effort used shall be 50 or 75 blows on each end of the specimen as required by the specific mix being tested. When core specimens with thickness other than 2 1/2

**SPECIFICATION 719 – BITUMINOUS PAVEMENTS,
MEASUREMENT OF REDUCTION IN MARSHALL
STABILITY CAUSED BY IMMERSION IN WATER**

inches are used, the measured stability of the specimens shall be corrected by using the correlation ratios included in Table 1 of AASHTO T 245.

719-4 PROCEDURE

719-4.01 Weigh each test specimen in air and in water.

719-4.02 Calculate the specific gravity of each test specimen as follows:

$$\text{Specific Gravity} = \frac{A}{A - B}$$

Where A = weight of specimen in air
 B = weight of specimen in water

719-4.03 Sort the test specimens into two groups so that the average specific gravity of the specimens in group 1 is essentially the same as that of group 2.

719-4.04 Place the group 1 specimen in the water bath at $140^{\circ} \pm 1^{\circ}\text{F}$ for 30 to 40 minutes. Immediately upon removal from the water, test the specimen for Marshall stability and flow as per AASHTO T 245.

719-4.05 Place the group 2 specimens in the water both at $140 \pm 1^{\circ}\text{F}$ for 24 hours. Immediately upon removal from the water, weigh the specimens and test for Marshall stability and flow as per AASHTO T 245.

719-5 CALCULATION

719-5.01 Calculate the water absorption of each group 2 immersed-in-water specimens as follows:

**SPECIFICATION 719 – BITUMINOUS PAVEMENTS,
MEASUREMENT OF REDUCTION IN MARSHALL
STABILITY CAUSED BY IMMERSION IN WATER**

$$\text{Water Absorption (Percent)} = \frac{(B - A)100}{A}$$

Where A = Weight in grams of specimen before
24 hour immersion.

B = Weight in grams of specimen after 24 hour immersion.

719-5.02 Calculate the numerical index of resistance of bituminous mixtures to the detrimental effect of water, expressed as a percentage of the original stability, as follows:

$$\text{Index of Retained Stability (Percent)} = \frac{S_2 \times 100}{S_1}$$

Where S_1 = Marshall stability of group 1 (average)
 S_2 = Marshall stability of group 2 (average)

719-6 REPORT

719-6.01 The test report shall include the following values:

- a. Specific gravity for group 1 and 2 specimens.
- b. Average unit weights (lbs./cu. ft.) for group 1 and 2 specimens.
- c. Average Marshall stability (lbs.) and flow value (0.01 in.) for group 1 and 2 specimens.
- d. Average water absorption in percent.
- e. Retained stability in percent.

SPECIFICATION 722 – MEASUREMENT OF FLUIDITY OF GROUT MIXTURES

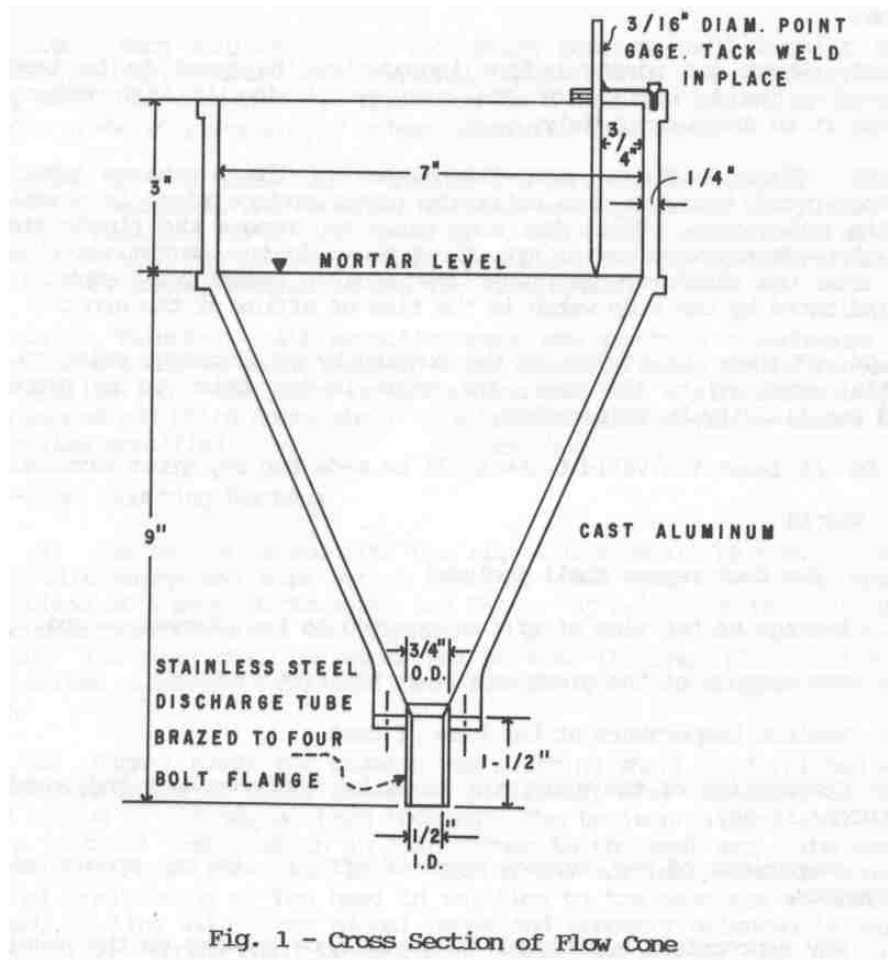
722-1 SCOPE

722-1.01 This test covers the procedure to be used for determining the fluidity of grout mixtures by measuring the time of efflux of a specified volume of grout from a standard flow cone. It has been adopted from the U.S. Corps of Engineers test method CRD - C 611.

722-2 APPARATUS

722-2.01 A flow cone conforming to the dimensions and other requirements shown in Figure 722-1

SPECIFICATION 722 – MEASUREMENT OF FLUIDITY OF GROUT MIXTURES



722-2.02 A stop watch or other accurate timer graduated in divisions of one second or less.

722-3 SAMPLE

722-3.01 Each test sample shall consist of $1725 \pm$ cubic centimeters of grout.

SPECIFICATION 722 – MEASUREMENT OF FLUIDITY OF GROUT MIXTURES

722-4 PROCEDURE

722-4.01 The flow cone shall be mounted firmly in such manner that the top will be level and the cone free of vibration. The cone shall be calibrated by introducing 1725 ± 1 cc of water while holding the outlet end closed and adjusting the point gage to touch the level of the water surface.

722-4.02 About one minute before introducing the grout to be tested, moisten the inside surface of the cone by filling it with water and allowing it to drain completely.

722-4.03 Place a finger over the outlet of the discharge tube and introduce grout into the cone until the grout surface rises into contact with the point gage. Start the stop watch and remove the finger simultaneously. Stop the watch at the first break in the continuous flow of grout from the discharge tube when the cone is essentially empty. The time indicated by the stop watch is the time of efflux of the grout.

722-4.04 If there is a break in the continuity of discharge prior to the essential emptying of the cone, the grout is too thick to be properly tested for fluidity by this method.

722-4.05 At least two valid tests shall be made for any grout mixture.

722-5 REPORT

722-5.01 The test report shall include:

- a. Average of the time of efflux computed to the nearest second.
- b. Temperature of the grout sample at the time of test.
- c. Ambient temperature at the time of test.

**SPECIFICATION 722 – MEASUREMENT OF FLUIDITY OF
GROUT MIXTURES**

- d. Composition of the grout mix including water content and chemical admixtures, if any.
- e. Comparison of the average time of efflux with the specification requirements.
- f. Any appropriate additional information on remarks on the physical characteristics of the sample.

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

723-1 STANDARD TRAFFIC SIGNAL HEADS

723-1.01 All the components of standard traffic signal heads shall conform to the latest edition of “A Standard for Adjustable Face Vehicular Traffic Control Signal Heads”, published by the Institute of Transportation Engineers (ITE) as modified and supplemented by the plans and these specifications.

723-1.02 Each vehicle signal face shall be made up of the number of separate signal indication sections of the nominal sizes, (8”, 12”, 18” or 4”), and in the arrangement required by the plans. They shall be of the adjustable type permitting rotation of 360 degrees about a vertical axis.

723-1.03 Each vehicle signal indication section shall consist of the housing, visor, louvers when required, optical unit and necessary wiring. They shall be designed for operation on a nominal 120 volt, 60 Hertz, single phase AC power supply unless otherwise indicated.

723-1.04 Signal heads shall include the slip-fitter adapter, trunions, brackets, backplate and mounting hardware as required by the plans. They shall be designed for a wind speed of 90 mph with a gust factor of 1.3 in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

723-1.05 Painting - All metallic heads and mounting attachments shall have three coats of paint each of which shall be baked at the factory after application. The first or prime coat shall be a zinc chromate paint. The second and third coats shall be flat black enamel unless otherwise specified.

723-1.06 Mounting Hardware

- a. For span wire mounting the signal head shall be provided with a span wire clamp and wire outlet fitting. The span wire clamp shall be comprised of a shoe, lockbar and two “U” or “J” bolts. A 12 or 18 circuit disconnect hanger shall be supplied if specified in the contract documents. The

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

head shall be assembled so that it hangs plumb. A hot-dip galvanized extension pipe shall be provided for double span wire mounting.

b. Signal heads for midmast arm mounting shall be furnished with a mount consisting of upper and lower horizontal arms attaching to the top and bottom of the signal head housing. The horizontal arms shall attach to a vertical member which in turn clamps to the mast arm. The mast arm mount shall have provision for adjusting the vertical, angular and rotational positioning of the head in relation to the mast arm so that it is plumb, in line with other signal heads and properly oriented in relation to traffic. Wiring shall be concealed within the mount.

c. Signal heads to be mounted at the end of mast arms shall be provided with an aluminum spring loaded hanger of the design shown on the plans or an alternate design approved by the Engineer. However, when the mast arm exceeds 40 feet in length the end mounting will be of a free swinging design.

d. Post top mounted signal heads shall be furnished with a post top type slipfitter mounting.

e. Vertical pole bracket mount signal heads shall be equipped with upper and lower horizontal brackets equipped with pole plates for attachment to the pole with stainless steel bands.

f. Unless otherwise specified, all bolts, washers and nuts shall be of chromium-nickel stainless steel alloy.

723-1.07 Housing

a. Traffic signal head housings shall be made of die cast aluminum or of structural plastic as specified in the contract documents. When not specified, aluminum housings shall be provided.

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

b. Aluminum housings shall conform to the following requirements.

1. Aluminum die castings shall be made of ingots in accordance with ASTM B85 - Alloys SC84A, SC84B, SG100A, SG100B, or S12B.

2. Each signal section shall be a one-piece casting with front, sides, top and bottom integrally cast. They shall be clean, smooth and free from flaws, cracks, blow holes and other imperfections.

3. The housing for each face shall be of unitized sectional construction and shall consist of as many sections as necessary to provide the indications shown on the plan. All sections shall be rigidly and securely fastened together into one weather-tight signal face.

4. Each housing shall be arranged with openings in the top and bottom so that it may be rotated about a vertical axis between waterproof supporting brackets or trunnions and shall be capable of being securely fastened at increments of not more than 7 degrees of rotation. The top and bottom of each housing shall have integrally cast locking rings or other provisions to provide positive interlocking and indexing.

5. The top and bottom of each housing shall be provided with tees or crosses equipped with pipeplug knobs or caps which can be removed to assist in wiring.

6. Flat arms or spiders will be accepted as an alternative for use on the bottom of adjustable signals. One-section adjustable beacons may be supplied without bottom bracket arms.

7. Each housing shall be so designed that additional sections may be added. The construction

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

shall permit the assembly of 12 inch signal sections with 8 inch sections of the same manufacturer. The assembly shall permit the joining of 12 inch sections either above or below the 8 inch sections.

8. The door shall be of cast aluminum alloy and shall provide mounting for the lens and visor. Neoprene gasketing shall be provided between the body of the housing and the doors. The doors shall be suitably hinged and shall be forced tightly against the gasket and the housing by simple stainless steel locking devices. All other exterior hardware such as hinge pins, lens clips, etc. shall be of stainless steel. The locking device shall be capable of being operated without the use of tools. Hinges shall be arranged to allow convenient relamping. On the outside of the door, there shall be a rim encircling the lens opening to prevent any light leakage between optical systems.

9. The visors shall be separate and removable from the doors, held in place by stainless steel fastenings attached to the door in such a manner as to prevent the possibility of any light leakage between the door and hood which might be discernible from the side. Visors shall be of sheet aluminum, not less than 0.05 inches, and shall be equipped with bayonet slots or other provision to permit firm attachment and rotation of the visor.

10. Visors shall be the tunnel type. The insides of visors and the entire surface of louvers or fins used in front of signal lenses shall be painted a flat black to minimize light reflection to the sides of the signals. Visors shall tilt down from the horizontal a minimum of 3 1/2" and shall be a minimum of 9-1/2 inches in length for 12 inch diameter lenses and 7 inches in length for 8 inch diameter lenses.

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

c. Structural plastic housings shall conform to the following requirements:

1. The signal sections shall be molded in one piece from a polycarbonate material having ultraviolet stability and remaining unaffected by the heat of the lamps used such as G.E. Lexan or approved equal. The sections may be fabricated from two or more pieces if joined into a single piece using thermal, chemical or ultrasonic bonding.
2. The unit shall be molded in a homogeneous color, Federal highway yellow, unless otherwise specified.
3. Signal housing and door elements shall be nominally 0.100 inch thick, but shall not exceed 0.125 inch. Stiffening webs and gussets may be 0.060 inch thick up to 0.100 inch maximum.
4. The housing of each signal section shall be designed to permit access to the section for relamping without the use of tools. The door shall be secured by a method that will hold the door closed when the section is subjected to the wind load test specified. Metal door hardware, including hinge pins, shall be made from Type 304 or 305 Stainless Steel.
5. Each signal section in a face shall, in addition to the fastening through the housing opening, be joined to the adjacent section with at least 2 stainless steel carriage bolts placed through holes near the front of the 2 housings. Each bolt shall be provided with 2 stainless steel washers, lockwasher and nut.
6. The supporting section of each signal face supported solely at the top or bottom shall be provided with 2 aluminum reinforcing plates. One plate shall be placed inside the housing, the other plate shall be

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

placed outside. Three stainless steel carriage bolts shall be installed through holes in each of the plates and matching holes in the housing. Each bolt shall have a lock washer and a nut. Each plate shall be a minimum of 0.125 inch thick and shall be painted to match the housing. Each plate shall have a hole in line with the mounting hole in the housing; the hole in the outside plate shall be large enough to avoid interference with locking serrations.

7. Tunnel visors shall be thermal formed polycarbonate .060 inch thick in Federal highway yellow but the inside of the visors shall be painted flat black. Visors shall meet the same dimensional requirements given for metal visors in paragraph 723-1.07b(10) above.

723-1.08 Directional Louvers - Directional louvers shall be installed in signal visors when called for in the plans. The cylinder and vanes shall be constructed of aluminum alloy of the dimensions and arrangement shown on the plans.

723-1.09 Backplates

a. Backplates shall be furnished and installed on signal heads when shown on the plans. Dimensions, materials and installation details shall be as indicated below unless otherwise specified.

b. Metallic backplates shall be made of flat sheet aluminum with a minimum thickness of 0.06 inches and provided with a dull black paint finish. They shall be designed to be attached to the signal head without interfering with the opening and closing of the housing doors. Where a metal backplate consists of 2 or more sections, the sections shall be fastened with aluminum rivets or with aluminum bolts peened after assembly to prevent loosening.

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

c. Plastic backplates shall be either formed from sheet plastic or assembled from extruded, molded or cast sections. Sections shall be joined using appropriate solvent cement or with aluminum rivets and washers. Backplates shall be of black homogeneous colored material with a lusterless finish. Each plastic backplate shall be secured to the plastic signal face in a manner that will prevent its removal or permanent deformation.

d. All backplates for signal heads mounted in mast arms 40 feet or longer shall be of the louvered type. For shorter mast arms and for span wire mountings, the use of louvered backplates is optional.

e. Backplates shall extend 5 inches on each side of the signal face and 4 inches on the top and bottom unless otherwise shown on the plans.

723-1.10 Connection Blocks - Each signal face shall be equipped with a 5-point heat resistant terminal block. It shall have five terminals with connectors for receptacle leads and screw terminals for field wires. The individual connection blocks in the separate faces of a signal head shall be interconnected.

723-1.11 Optical Units

a. The optical unit of each vehicle signal indication shall consist of a glass lens, a reflector, a lamp receptacle and a clear traffic signal lamp. The unit shall be properly gasketed to exclude dust and dirt from the reflecting surface of the reflector and the inner surface of the lens. Plastic lenses are not acceptable.

b. Lenses shall be red, yellow, or green glass and shall conform to the ITE standards requirements. Except for reversible lane control signals and pedestrian signals, all lenses shall be circular in shape with nominal diameters of either 8 inches or 12 inches. Each 12 inch lens shall be standard wide angle and be clearly marked as such.

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

c. Reflectors shall be parabolic and mathematically designed to put the filament of the appropriate lamp at the focal point of the reflector. The reflector material will be .036" min. reflector aluminum with a bright specular Alzak finish on the reflecting surface. The reflector shall be hinged with simple holding devices (catches or friction fits) and, when opened, shall expose the rear of the lamp receptacle and the wiring terminal block.

d. The lamp receptacle shall be so mounted that it can be rotated to various positions to permit proper orientation of the lamp filament. The receptacle positioning shall be maintained by the friction of a retaining spring.

e. Traffic signal lamps for 8-inch lenses shall be clear, 120 volts AC, 665 rated initial lumens output, with a rated average life of 8000 hours. Traffic signal lamps for 12-inch lenses shall be clear, 120 volts AC, 1950 rated initial lumens output, with a rated life of 8000 hours. Lamps and the intensity and distribution of light from each illuminated signal lens shall conform to the requirements of the ITE "Standards for Traffic Signal Lamps".

723-2 OPTICALLY PROGRAMMED SIGNAL HEADS

723-2.01 Optically programmed signal heads shall meet all the applicable requirements for standard signal heads included in Section 723-1 above except for the optical units and other requirements which shall be as specified below.

723-2.02 Housing - The signal head housing shall be constructed of die cast aluminum meeting the requirements of paragraph 723-1.07b.

723-2.03 Optical Units - Each optical unit shall consist of a lamp, lamp collar, optical limiter-diffuser and an objective lens:

a. The lamp shall be nominal 150 watt, 120 volt AC, three prongs, sealed beam having an integral reflector with

SPECIFICATION 723 – TRAFFIC SIGNAL MATERIALS

stippled cover and an average rated life of at least 6000 hours. An equivalent 75 watt lamp shall be used with pedestrian indications. The lamp shall be coupled to the diffusing element with a collar including a specular inner surface. The diffusing element may be discrete or integral with the convex surface of the optical limiter.

b. The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 300 to 400 meters distant, and permit an effective veiling mask to be variously applied as determined by the desired visibility zone. The optical limiter shall be provided with positive indexing means and be composed of heat resistant glass.

c. The objective lens shall be a high resolution planar incremental lens hermetically sealed within a flat laminant of weather-resistant acrylic or approved equal. The lens shall be symmetrical in outline and may be rotated to any 90° orientation about the optical axis without displacing the primary image.

d. The optical system shall accommodate projection of diverse, selected indicia to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer. The projected indication shall conform to ITE transmittance and chromaticity standards.

723-2.04 Mounting

a. The signal head shall mount to standard 1-1/2 inch fittings as a single section, as a multiple section face, or in combination with other signals. Each signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connection shall permit external adjustment about the mounting axis in 5 degree increments. The signal shall be constructed such that it can be installed with ordinary tools and serviced with no tools.

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- b. Attachments such as visors, backplates or adapters shall conform and readily fasten to existing mounting surfaces without affecting the light intensity and field of vision of the signal.
- c. The programmed signal head shall be arranged for rigid mounting to either a mast arm, post top or a dual span wire assembly.

723-2.05 Electrical - Lamp fixture shall comprise a separately accessible housing and integral lamp support, indexed ceramic socket and self-aligning, quick-release lamp retainer. Electrical connection between case and lamp housing shall be accomplished with an interlock assembly which disconnects lamp housing when opened. Each signal section shall include a covered terminal block for clip or screw attachment of field wires. Concealed No. 18 AWG, stranded and coded wires shall interconnect all sections to permit field connection within any section.

723-3 PEDESTRIAN SIGNAL HEADS

723-3.01 All the components and indications of pedestrian signal heads shall conform to the requirements of the ITE “Standard for Adjustable Face. Pedestrian Signal Heads” as modified and supplemented by the plans and these specifications.

723-3.02 Housing

- a. The pedestrian signal head housing shall be constructed of die cast aluminum or of structural plastic as specified in the contract documents. When not specified, aluminum housing shall be provided.
- b. Aluminum housings shall conform to the applicable requirements of paragraph 723-1.07b. Painting shall be as specified in paragraph 723-1.05.
- c. Structural plastic housing shall conform to the applicable requirements of paragraph 723-1.07c.

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723-3.03 Lenses shall be made of vandal resistant polycarbonate or acrylic plastic, square in shape, 9” or 12” on a side, as called for in the plans. Each lens shall be opaque except for the specified word message or symbol and shall comply with the ITE standards. The message or symbol shall be as indicated on the plans.

723-3.04 Lamps shall be clear traffic signal lamps. For 9” lenses the lamps shall be 120 volts AC, 665 rated initial lumens and with a rated average life of 8,000 hours. For 12” lenses the lamps shall be 120 volts AC, 1950 rated initial lumens and with a rated average life of 8,000 hours.

723-3.05 Each signal lens shall be equipped with a visor which encloses the top and both sides of the lens.

723-4 TRAFFIC SIGNAL SUPPORTS

723-4.01 Traffic signal supports include the following types:

- a. Post Top Mount - Aluminum pole for mounting the signal head directly on its top.
- b. Bracket Mount - Signal heads and other items bracketed from or attached to the side of an aluminum or concrete pole.
- c. Mast Arm - Consist of an aluminum vertical shaft to which a mast arm is attached for mounting signal heads and overhead traffic signs.
- d. Overhead Bridge - Consist of a galvanized steel structure made of two vertical tubular poles and a horizontal tubular cross beam to which are attached signal heads and overhead signs.
- e. Span Wire Assembly - Self-supporting standard reinforced concrete or prestressed concrete poles supporting steel cable or cables span to which are attached signal heads and overhead signs.

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- f. Pedestrian Push Button Post - Galvanized steel pipe support for pedestrian push button signal activator and sign.

723-4.02 The traffic signal support structure of each type shall comprise all the necessary items to provide a complete installation including poles, mast arms, brackets, cables, bases, foundations, hardware, fittings, internal wiring and all other required appurtenances, as per Specification 654 and the contract documents, except for signal heads, signs and pedestrian push button units which are separate units.

723-4.03 Each complete signal support assembly shall be fabricated of the materials called for in the contract documents and shall be designed in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signs (hereinafter referred to as the AASHTO Signal Support Specification), the details shown on the plans, and the requirements of these specifications. Each assembly, including the signal heads, signs and other mounted equipment shall be designed to withstand 90mph wind loads, with a gust speed factor of 1.3, without permanent deformation, rupture, or other structural failure. Ice loads need not be considered.

723-4.04 Shop drawings and structural design computations for each traffic signal support structure shall be submitted for review and approval by the Authority prior to purchase.

723-4.05 Aluminum for the various components of signal support structures shall conform to the applicable ASTM specifications and Aluminum Association designations for aluminum alloys identified as acceptable in the AASHTO Signal Supports Specification.

723-4.06 Aluminum mast arm and pole assemblies shall comply with the following requirements:

- a. The mast arm and pole assemblies shall be designed to support clevis or rigid mounted traffic signals suspended from a structural assembly similar in appearance and

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construction to that shown on the plans and as specified herein.

b. The pole shaft shall be designed for mounting with or without a transformer base, as called for in the plans, and shall be made of ASTM Specification B221, aluminum alloy 6063, seamless tubing of sufficient diameter and wall thickness to properly withstand full design loads. The shaft shall be fabricated of tubing with a wall thickness of not less than 0.188" and the top and bottom of the shaft shall be a constant diameter to provide vertical adjustability of the arm and proper fitting of the base as required. After welding, the shaft shall be artificially aged to a T6 temper by means of heat treatment. It shall be free of longitudinal welds and shall be rotary sand finished and wrapped for protection during handling and shipping. The shaft shall be designed to support the mast arm in such a way that, when a traffic signal head is mounted at the end of the mast arm, the bottom of the signal head shall be 17 to 19 feet above the pavement. In addition:

1. Shafts to be mounted without a transformer base shall be equipped with a 4" x 6" oval shaped reinforced handhole as per ARTBA Technical Bulletin 270, centered 14" to 18" above the base of the shaft and located 90 degrees measured clockwise from the plane of the bracket arm as viewed from the top. Each handhole shall have an aluminum cover with stainless steel attachment screws to secure the cover. A grounding nut to accommodate a 1/2" threaded bolt shall be provided inside the shaft opposite the handhole.
2. A removable ornamental cast aluminum cap with three stainless steel (AISI 302) set screws to hold it in place shall be provided with each shaft.
3. A 1 1/2" diameter hole shall be drilled near the top of each shaft where the mast arm clamp is to be attached to provide for the signal wiring. This

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opening shall have a rubber or metal grommet to provide a smooth cable guide for pulling the electrical cables through.

4. The shaft anchor base shall be a one piece casting of 356-T6 aluminum alloy and shall be shop welded to the shaft.

c. Aluminum transformer bases, when called for in the plans, shall be one-piece castings of 456-T6 aluminum alloy (ASTM B 26) of the dimensions shown on the plans and meeting the structural requirements specified in the AASHTO Signal Support Specifications. Bases shall be equipped as follows:

1. With a removable aluminum, trapezoidal shaped door, approximately 12” high, 9” wide at the top and 11” wide at the bottom. Door shall be secured to the base with stainless steel screws.

2. For attachment to shaft anchor base, each transformer base shall be supplied with four (4) loose bearing plates or other acceptable bearing surfaces and four (4) hot-dip galvanized high strength steel (ASTM A 325 - Type 3) hexhead machine bolts of the size needed to meet the structural design requirements but not less than 1 1/4” diameter.

3. With a grounding connection to accommodate a 1/2” threaded bolt or nut.

4. A template print giving complete information for setting the anchor bolts in the foundation.

d. Anchorage in the foundation shall consist of four hot rolled steel rods meeting the requirements of AASHTO M 255 (ASTM A 675) Grade 90. The threaded end shall be hot-dip galvanized for a minimum length of 12 inches. Hot-dip galvanized steel hex nuts, flat washers and lock washers shall

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be provided for each anchor bolt. Anchor rods shall be of the size and length required to meet the structural design requirements but not less than 1 1/4" diameter and 36" long.

e. The mast arm shall be a one piece welded assembly manufactured of 6063-T6 aluminum tubing and consisting of top and bottom members joined by vertical braces.

1. The mast arm assembly shall conform to the space and dimensions shown on the plans.

2. Clamps made of 6063-T6 or 6061-T6 aluminum shall be provided at the inboard end of the arm for attachment to the support pole.

3. Mast arms 40 feet or less in length shall be provided with a 2" slipfitter at the free-end for a fixed traffic signal head installation.

4. Mast arms longer than 40 feet shall have a signal hanger strap welded at the outboard or free end for the installation of a free swinging traffic signal head. The upper arm member with the welded signal hanger shall have a 1 1/2" diameter hole lined with a rubber grommet forward of the hanger strap and the arm clamps at the inboard end shall have a smooth 1 1/2" diameter hole to allow the use of the mast arm as an internal raceway for the traffic signal wiring. The lower arm member shall have a safety chain lug for the traffic signal welded at the outboard end but inward of the hanger.

5. The outboard end of both the upper and lower arm members of a free swing installation (over 40 foot arms) shall be cupped. On fixed signal installations, the arm member not used for the signal mounting shall be capped.

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6. Extruded aluminum clamps of alloys 6063-T6 or 6061-T6 shall be provided for attaching the mast arm to the shaft as shown on the plans. Clamp bolts, washers and nuts shall be of AISI Type 302 stainless steel of the required diameter to meet the structural design requirements.

f. Aluminum poles and mast arms shall be furnished with a polished surface finish and shall be wrapped with heavy water resistant paper by the fabricator for protection during shipping, storage and erection.

723-4.07 Aluminum poles for post top mounted traffic signal heads shall meet all the applicable requirements of paragraphs a, b, c, d and f of Article 723-4.06 above. In addition the pole shall be round in cross section with a uniform diameter of approximately 4 1/2" from butt to tip.

723-4.08 Steel overhead bridge structures shall comply with the following requirements:

a. Steel for the end poles and the cross beam shall be Grade 60 high-strength low alloy structural steel meeting the requirements of paragraph c. and d. of Article 715-1.01 of Specification 715 – Structural Metals. All steel shall be galvanized after fabrication in accordance with the requirements of AASHTO M 111.

b. Steel bolts, washers and nuts shall be high-strength and hot-dipped galvanized meeting the requirements of AASHTO M 164 and M 111, and Article 715-2 of Specification 715.

c. End poles shall be either continuous or sectionalized. They shall be round in cross section and evenly cambered from one end to the other. Each pole shall include a removable pole top, and J-hook wire support welded inside near the top and one pinned joint assembly to match the butt end of the crossbeam. A reinforced handhole assembly,

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curved on the front to follow the contour of the pole, shall be welded into the shaft near the base of the pole which contains the controller. The handhole frame and cover shall be of gauge 11 steel having the same properties as the pole steel. The handhole reinforcing frame shall have a tapped hole to accommodate a grounding lug and the cover shall be secured to the frame by at least two stainless steel screws and a stainless steel captive chain. Each pole shall have a one piece anchor base welded to the butt end. This base shall be designed to secure the pole assembly to a concrete foundation by means of four L-bent anchor bolts, and shall be fitted with removable anchor bolt covers.

d. The crossbeam shall be a flexible member with a beam splice at the midpoint and connected to the upright end poles by pinned joints which shall not transmit any bending moments. Crossbeams shall be round in cross-section and shall be cambered to minimize sag. The entire assembly shall be constructed so that all wiring can be concealed internally. The crossbeam shall be connected to the upright poles at a height necessary to provide the specified clearance between the attached signal heads and/or signs and the highest elevation of the traveled roadway.

723-4.09 Self-supporting concrete poles for span wire assemblies shall conform to the design and details shown on the plans.

a. Concrete shall conform to the requirements of Specification 601 - Structural Concrete for the class indicated in the contract documents. When the concrete class is not specified, Class D concrete (5,000 psi) shall be provided.

b. Prestressed concrete poles shall conform to the requirement of Specification 630 - Prestressed Concrete Structure.

c. Reinforcing steel shall conform to Specification 602.

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723-4.10 Steel cable for span wire assemblies shall be either of the following, at the Contractor's option, unless otherwise specified in the contract documents.

a. Zinc-coated steel wire strand or cable conforming to the requirements of ASTM A 475 and, unless otherwise specified, meeting the requirements for the use listed below.

1. Strand for use as tie cables shall be seven wire "Common" grade with a Type "I" zinc coating.

2. Strand for use as span wire, messengers and guy wire shall be 3/8 inch diameter, seven wire, "High-Strength" grade cable with a Class "A" zinc coating.

3. Strand for use as traffic signal tie wire shall be 1/4 inch diameter, seven wire "Siemens-Martin" grade cable with a Class "A" zinc coating.

b. Aluminum-coated steel wire strand or cable shall conform to the requirements of ASTM A 474 and unless otherwise specified shall meet the strength grade requirements above.

723-4.11 The support post for pedestrian push button units shall be fabricated from 4-inch outside diameters, hot-dipped galvanized steel pipe meeting the requirements of ASTM A 120. The pipe shall have a nominal wall thickness of no less than 0.203 inch. It shall be furnished with a cap and the necessary openings to attach the push button detector and to permit the wiring.

723-5 INDUCTIVE LOOP VEHICLE DETECTOR SYSTEMS

723-5.01 An inductive loop vehicle detector system consists of:

a. Sensor Loop - An electrical conductor wire loop or group of loops embedded in the roadway.

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- b. Lead-In Cable - The electrical cable which connects the sensor loop(s) to the loop detector unit. See article 723-12.02.
- c. Loop Detector Unit - An electronic device with its power supply installed in a traffic signal controller cabinet or an independent cabinet that energizes and monitors the sensor loop(s).

723-5.02 The wire for the sensor loop shall be No. 14 RHW, cross-linked polyethylene insulated, stranded copper wire, rated at 600 volts and conforming to Specification 51-3 of the International Municipal Signal Association (IMSA). The loop shall be formed of five turns of continuous, unspliced wire unless otherwise indicated on the plans.

723-5.03 Sealer for loop slot shall be silicon joint sealant conforming to the requirements of Article 705-1.01 of Specification 705.

723-5.04 The lead-in cable shall meet the requirements of par. 723-12.02 of this specification.

723-5.05 The loop detector unit for an inductive loop detector system shall be a solid state electronic device capable of providing closure and amplification of an output circuit when a vehicle stands or passes over a loop, or one of several loops, connected to its input circuitry. The unit shall meet the performance and design requirements for Inductive Loop Detectors with Delay and Extension Timing included in the NEMA Standards Publication for Traffic Control Systems, TS-1, latest edition, and the following requirements:

- a. The detector unit shall be of the NEMA shelf mounted type and as required by the controller with which it will be used. It shall be of the 4-channel type with NEMA connectors and output relay. Rack mounted units are not acceptable.

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- b. Each unit shall be housed in a dust proof sheet aluminum enclosure with a durable protective finish. The enclosure shall be easily removed to permit access to the solid state circuitry. All controls, indicator lights, meters and connectors shall be mounted on the front panel.
- c. The unit shall be provided with an integral 120 volts nominal, AC power supply and shall function normally over a power voltage range of 100 to 130 volts. Input power shall be provided with overcurrent protection.
- d. All solid state components shall be amply derated with respect to heat dissipating capacity and rated voltage. Shortening of component life or shift in values shall not occur at maximum operating temperature and voltage. The design life under continuous duty operation shall not be less than five years. All solid state components shall be individually replaceable and shall be readily available from any industrial electronics supply house.
- e. The solid state components used in the designed of the sensor unit shall be mounted on printed circuit (PC) boards. Intercomponent circuit traces shall be copper track, with a minimum weight of two ounces per square foot and shall be of adequate cross-sectional area to carry the designed current. All holes in the PC board utilizing intercomponent circuit traces on two sides shall be copper plated. All components mounted and soldered to the PC board shall be easily removed and replaced without causing damage to the board or tracks.
- f. The output relay shall be of the plug-in type and shall be normally energized to provide fail-safe operation in the event of power failure. It shall also provide that when two sensor units are operated into one phase of a signal controller, almost simultaneous actuations from the two sensor units shall be separated to provide maximum detection accuracy.

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g. The detector unit shall be capable of self tuning to loop inductances within a range of 50 to 700 microhenries. It shall provide output closures for each vehicle passing through the response area of the detector loop at speeds from 5 to 80 mph.

h. Each detector unit channel shall be capable of providing a minimum of two modes of operation. The Pulse or Presence mode shall be switch selective in the front panel.

1. Pulse Mode - The detector amplifier shall produce an output pulse of between 75 and 150 milliseconds duration for each vehicle entering the detection zone. Any vehicle stopped on the loop for 2 seconds or more shall be automatically tuned into the resonant circuit so that any unused portion of the loop may detect passing vehicles.

2. Presence Mode - The unit shall provide a detection output for as long as a vehicle remains in the detection area or for at least three minutes after which it shall be incorporated in the background inductance so that any unused portion of the loop may detect passing vehicles.

723-6 PEDESTRIAN PUSH BUTTON DETECTORS

723-6.01 A pedestrian push button detector assembly shall consist of the housing, the electrical contacts unit, the push button, and sign. The complete assembly shall be capable of completing an electrical circuit to the traffic controller to which it will be connected.

723-6.02 The housing shall be of cast aluminum, tamper proof, weather proof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. In addition:

a. It shall have two outlet taps for one-half inch pipe for wiring.

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- b. When intended for mounting on top of a post support, it shall be provided with a slip-fitter fitting and screws for securing rigidly to the post.
- c. When intended for mounting attached to a pole it shall be of a design, or be provided with adaptors, to facilitate mounting securely on poles of different diameters. Saddles shall be provided to make a neat fit when required.
- d. The housing shall be finished with three coats of paint which shall be baked at the factory after application. The first or prime coat shall be zinc chromate paint. The second and third coats shall be Federal highway yellow enamel unless otherwise specified.

723-6.03 The contacts unit shall be entirely enclosed within, but insulated from, the housing. The contacts shall be open in normal position, closing only when the push button is depressed and returning to the open position upon release.

723-6.04 The push button shall be a direct push type sealed with a rubber membrane. The exposed exterior of the button shall be made of brass or other non-rusting alloy, or other durable material acceptable to the Engineer.

723-6.05 The sign may be either reflectorized or non-reflectorized with a legend and of the size shown on the plans, and in accordance with the DTPW's manual of uniform traffic control devices. It shall include the necessary mounting hardware.

723-7 LOCAL TRAFFIC SIGNAL CONTROLLER ASSEMBLY

723-7.01 Description - A local traffic signal controller assembly shall consist of a complete electrical mechanism for controlling the operation of traffic control signals, including the controller unit and all necessary auxiliary equipment, mounted in a cabinet. All the equipment required to provide the operation shown

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on the plans and described herein shall be provided in a complete assembly.

723-7.02 General Requirements - The controller assembly shall be modular, microprocessor controlled, fully traffic actuated, solid state in design and shall conform to the interface, physical and functional standards for two-phase through eight-phase solid state traffic signal controller units included in the NEMA Standards Publication for Traffic Control Systems, TS-1, latest edition, as supplemented and modified by these specifications.

- a. Controller assemblies shall be furnished in 8 phase chassis with a full complement of 8 phase modules, unless otherwise specified in the plans.
- b. Only one type of controller unit, all from the same manufacturer, shall be supplied to an individual contract.
- c. The type and make of controller assemblies to be supplied shall have an experience record of satisfactory field operations for at least two years. The manufacturer shall submit data indicating locations and owners of previous installations to support the experience record.
- d. All controller equipment and accessories to be supplied for an interconnected system shall be designed to insure full compatibility and interface of the master and secondary controller assemblies in the system.
- e. Details of operation for the controller assembly shall be in accordance with the traffic phases, preferential phase sequence and concurrence, signal indications, signal indication sequence, detection requirements and other details specified in the contract documents.
- f. Shop drawings and manufacturer's specifications on all the controller assembly equipment shall be submitted by the Contractor to the Authority for review and approval prior to purchase.

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g. The Contractor shall submit to the Authority with each controller assembly three copies of each of the following documents which shall be furnished by the equipment manufacturer:

1. Dimensional, schematic and wiring diagrams.
2. Parts list.
3. Engineering data and operations and maintenance instructions.

723-7.03 Controller Environmental Standards - The controller shall perform satisfactorily within the environmental and operating conditions specified in NEMA TS-1. The Contractor shall submit certification by the equipment manufacturer that the controller units comply with this requirement. In addition, the Authority may require the submittal of reports on TS-1 tests performed by the manufacturer on sample units.

723-7.04 Controller Unit Interface Requirements - The controller shall comply with the interface standards specified in NEMA TS-1, including all the requirements on input-output electrical characteristics. Each unit shall be provided with the number of input/output terminals and pin connections specified for 8-phase controllers including the terminations indicated as reserved for future use and spares. Identification of pin connector terminations shall be as specified in NEMA TS-1.

723-7.05 Controller Unit Physical Standards - The controller shall comply with the physical standards on modular design, printed circuit assemblies, connectors and frame sizes specified in NEMA TS-1 and the following additional requirements:

- a. All active devices used for logic, timing or control functions shall be solid state in design, and shall be sufficiently derated to insure no material shortening of life under conditions of maximum power dissipation at maximum ambient temperatures.

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- b. Individual components shall be grouped and soldered to the epoxy glass printed circuit boards with two ounce or better copper track, forming modular plug-in assemblies, internal to the controller. These assemblies when collectively grouped shall have a mean-time-to-failure of not less than three years. The design life of individual components under 24 hours per day operation in the circuit application shall not be less than five years.
- c. All vehicle and/or pedestrian control elements shall be directly interchangeable between controllers. Each element shall have a part number, serial number and function description permanently attached.
- d. The use of such components as paper encased condensers, electro-lytic condensers (except of computer grade); selenium rectifiers and vitreous resistors are not acceptable.
- e. The controller shall be designed with slide-ways and positive locking devices to insure proper pin alignment and pin contact area.
- f. All solid state equipment shall be designed to prevent dust or dirt from entering the enclosed solid state components.

723-7.06 Controller Functional Standards - The controller shall comply with the functional standards applicable to basic 8-phase units which are included in NEMA TS-1 including the capability to provide all the specified features per phase, per ring and per unit.

- a. Each phase shall have identical control capability, features, and options. The options and features for each phase may be exercised independently of the options and features exercised on other phases.

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b. During time of the respective intervals the phase that is timing, the interval that is timing and the interval time remaining shall be displayed in alphanumeric readouts on the front panel. The time shall be displayed in seconds and tenths of seconds to be compatible with the interval assigned increment.

c. Each traffic signal phase shall have available the options indicated below which shall be selectable by keyboard on the front panel of the controller.

Vehicle Recall	Non-lock Detector Memory
Pedestrian Recall	Recall to Maximum

d. The timing intervals and phase options shall be selectable and settable by a direct reading front panel assembly. These timing parameters shall be entered through a keyboard and additional phase, interval and time select switches. The keys shall have interval designations imprinted on them or shall be defined by a displayed menu. The method of setting the length of each interval shall be direct and discrete for that interval.

e. The front panel shall provide display the information going into the controller. Pilot lights shall be illuminated indicating presence of vehicle calls and of pedestrian calls for each phase. Additional indicators shall be provided showing which phase the controller is in, and which phase the controller will go to next. A display shall also be provided indicating the interval in which the controller is operating at the moment. All displays shall have a minimum design life of 20,000 hours at rated voltage.

723-7.07 Microcomputer System - The controller's timing, decision making and control elements shall be run by a microcomputer system which will store the computer programs and data necessary to operate the unit, a clock generator that provides computer system real-time clock that provides traffic system timing, flexible input/output circuitry that provides interface to traffic

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sensors and signal lights. The microprocessor shall provide eight bit parallel processing and an eight bit data bus, a 16 bit address line and be capable of addressing 65K bytes of memory. The processor shall have a complete instruction set.

723-7.08 Cabinet Construction - The controller assembly shall be housed in a weatherproof cabinet mounted on a concrete pedestal base and conforming to the following requirements:

- a. Cabinet shall be fabricated from sheets of aluminum alloy, ASTM 6061-T6, 0.125 inch thick, adequately reinforced to provide a sturdy structure. It shall have the following minimum inside dimensions unless otherwise shown on the plans:

Width – 38” Height – 54” Depth – 24”

- b. The cabinet exterior shall be primed with two coats of resin base paint and finished with two coats of enamel paint of Federal yellow color matching Federal Standard 595. The cabinet interior shall be primed with one coat of resin base paint and finished with two coats of white enamel paint.

- c. The main door of the cabinet shall substantially cover the full area of the front of the cabinet. This door shall be right hand hinged and permit complete access to the cabinet interior.

1. A weatherproof and dustproof seal shall be provided between the door and cabinet using neoprene sponge or other approved gasket material.
2. A door stop shall be provided for base mounted cabinets which securely holds the door at open positions of 90 and 135 degrees.
3. The door hinge pins shall be made of stainless steel.

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4. The door shall be equipped with a keyed tumbler lock and two keys shall be provided.
 5. An auxiliary police access, weatherproof design shall be provided on the front of the main door equipped with a standard police lock furnished with two keys.
- d. The cabinet shall contain a minimum of two removable shelves securely fastened to the side walls. The height and position of the shelves shall be easily changed.
- e. The cabinet shall be provided with a ventilation system as follows:
1. A thermostatically controlled, ducted fan unit with a minimum rating of 100 CFM in free air installed in the cabinet to provide forced air ventilation through the cabinet. The fan unit shall be mounted to the inside top of the cabinet and shall be easily removed and replaced without having to dismantle any part of the cabinet or exhaust duct systems.
 2. The fan shall be manually adjustable to turn on between 90°F and 150°F. The fan circuit shall be fused at 125% of the capacity of the fan motor.
 3. The fan shall intake air through filtered vents located near the bottom of the cabinet or cabinet door and exhaust it through a screened duct located near the top of the cabinet. Filter shall be of the permanent aluminum mesh type.
 4. The fan shall be separately fused and wired after the main AC circuit breaker.
- f. The cabinet shall be furnished with all of the hardware necessary for assembly and installation. The hardware shall

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include anchor bolts, anchor bolt template, and all nuts, bolts and washers necessary to assemble and install the cabinet as specified in the plans. A pliable seal, composed of non-hardening silicone sealant, shall be placed between the controller cabinet and the concrete base.

g. A heavy-duty clear plastic envelope, securely attached to the inside wall of the cabinet or cabinet door, shall be provided for stowing cabinet electrical prints. Minimum dimensions shall be 9" wide x 11" deep.

723-7.09 Cabinet Electrical Design

a. The controller and all auxiliary equipment housed within the cabinet shall be designed to operate from nominal 115V, 60 Hertz AC, single-phase power supply. Distribution of the electrical current throughout the cabinet shall not occur until it has first passed through the power protection devices specified herein.

b. Power Protection Devices - Shall include the main power circuit breakers, radio interference suppressors, lightning and surge protectors, and auxiliary equipment circuit breaker. These devices shall be in addition to any protection devices furnished with the controller and auxiliary equipment housed within the cabinet. The protection devices shall be mounted in a power distribution panel that is securely fastened to an interior wall of the cabinet.

1. The power service shall be connected directly to a main circuit breaker. This circuit breaker shall be a single pole, nonadjustable, magnetic breaker rated for 115V operation with a minimum rating of 60 amps. It shall be equipped with a solderless connector suitable for terminating No. 6 AWG wire. The circuit breaker shall be capable of manual operation and shall be clearly marked to indicate the "ON" and "OFF" positions.

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2. Radio interference suppressors (RIS), adequate in number to handle the power requirements for the cabinet, shall be wired in series with and after the main circuit breaker. The RIS shall be designed to minimize interference in all broadcast, transmission and aircraft frequency bands.
 3. As a minimum requirement, the lightning and voltage surge protectors shall be a combination of gas-type thyrectors, rated for 350 volts operation, and metal oxide varistors, rated for 150 volts. The combination shall be wired in advance of the main circuit breaker and shall provide a direct path to ground. Additional protection shall be provided on all loop detector input terminals.
 4. Auxiliary equipment circuit breaker shall be rated at 15 amperes.
- c. The power distribution panel shall also include:
1. A copper equipment grounding bus bar which shall be grounded to the cabinet and shall provide a minimum of 14 terminals.
 2. A neutral bus bar isolated from cabinet ground and providing a minimum of 18 terminals.
 3. A 60 amp mercury contactor power relay which shall be normally closed but capable of switching 60 amperes at 120 volts AC.
- d. The regulated portion of the power supply shall furnish a voltage of sufficient amplitude to provide an adequate DC NOISE MARGIN to prevent transient voltage spiked from triggering components, internal to the controller, into conduction.

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e. Cabinet Wiring - All cabinet wiring shall be neat, firm and routed to minimize cross talk and electrical interference. Printed circuit other boards may be used to eliminate or reduce cabinet wiring.

1. Wiring shall be attached to interior panels using non-conductive clamps or tie-wraps. Wiring containing AC shall be routed and bundled separately by function, from all low voltage control circuits.

2. All conductors and live terminals or parts which could be hazardous to maintenance personnel shall be covered with insulating material with a minimum rating of 600 volts.

3. The cabinet shall be wired for the maximum operation of the control unit including overlap and pedestrian phases. It shall only be necessary to add plug-in cabinet accessories (i.e. load switches, flash transfer relays, etc.) to obtain future operation.

f. Terminal Block Facilities - Molded composition barrier type terminal blocks shall be used for termination of the incoming and outgoing signals within the cabinet assembly. Each terminal block shall be one-piece construction with a minimum of twelve terminals. Each terminal shall have a threaded contact plate with a binderhead screw. The terminal blocks shall have minimum rating of 600 volts.

1. All terminals shall be identified and labeled in accordance with the cabinet wiring diagram.

2. The terminal block facilities shall be arranged in function groupings and mounted to either panels or brackets fastened to the interior walls of the cabinet. Each terminal block shall be retained using either machine or self-tapping screws and shall be easily removed and replaced.

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3. Terminals shall be provided for the vehicle and pedestrian signal circuits for each phase. These terminal blocks shall be of the barrier type using No. 8 or larger binderhead screws. These terminal blocks shall be located near the bottom of the cabinet, a minimum of six inches above the bottom surface for base mounted cabinets and two inches for pole mounted cabinets. A minimum number of two additional terminal blocks shall be provided for future expanded operation.
 4. Terminals shall be provided and connected for all of the controller input and output circuits including those circuits which are not to be used on the project. These terminal blocks shall utilize No. 6 or larger binderhead screws.
 5. A special panel shall be provided with terminal blocks for terminating all circuitry associated with vehicle detectors and pedestrian push buttons. These circuits shall be wired to their respective termination points within the cabinet and shall be operational. These terminal blocks shall use No. 8 binderhead screws. Terminals shall be provided for each vehicle detector including AC+, AC neutral, relay common, relay closure, and the loops or probes from the field. Solid state lightning protection devices shall be provided for each loop input from the field. A minimum number of two additional terminal blocks shall be provided for future expanded detection. Terminals shall be provided for each pedestrian pushbutton circuit from the field.
- g. Detector Connecting Cables - The cabinet shall be furnished with loop amplifier connecting cables for controller phases as required by each controller as per NEMA TS-1 standards.

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h. Polarity of Electrical Circuits - The outgoing signal indication conductors shall be of the same polarity as the line (+) side of the AC field service to the cabinet. The incoming signal indication conductors shall be common and of the same polarity as the neutral (-) side of the AC field service. The neutral (-) side of the AC field shall be connected to the cabinet in an approved manner usually to the copper ground bus. The cabinet shall, in turn, be connected to an earth ground through a ground rod.

i. Maintenance Panel - On the inside of the main door, accessible only when the main door is open, there shall be mounted a maintenance panel containing the following:

1. A stop time switch which shall be a three position toggle switch labeled ON, OFF and AUTO. In the ON position, stop timing power shall be applied to the controller. In the OFF position stop timing shall be removed from the controller if it has been applied by the conflict monitor or other auxiliary device. The AUTO position shall be the normal operating position and allow auxiliary devices to apply stop timing inputs to the controller.

2. A signals switch which shall be a two position toggle switch labeled ON and OFF. In the OFF position all signal displays shall be turned off and the controller allowed to run, subject to the position of other cabinet switches.

3. A controller test switch which shall allow the controller to be turned on for test purposes when the "AUTO-FLASH" switch on the Police panel has been placed in the "FLASH" position. The switch shall be labeled "CONTROLLER", "TEST", "NORMAL".

4. Detector test switches which shall be used to manually place calls into the controller during actuated operation. These switches, one for each

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vehicle and pedestrian phase, shall be in parallel with the vehicle detector relay closure and pedestrian pushbutton circuits.

j. Convenience Outlet - A 3-wire ground fault type receptacle shall be provided at an easily accessible location. It shall be separately fused and wired in advance of the main AC circuit breaker.

k. Cabinet Illumination - An incandescent lamp, 60 watts, shall be provided near the top of the cabinet interior with a manual switch mounted on the maintenance panel.

723-7.10 Other Cabinet Auxiliary Equipment

a. Conflict Monitor - A self-contained solid state signal conflict and voltage monitor, meeting the standards included in NEMA TS-1, and capable of handling an 8-phase controller.

1. The unit shall monitor the green, amber, and walk of each phase, and be fully programmable to designate the conflicting phases. All monitoring shall be done on the field side of the cabinet field wiring terminals.

2. When the monitor is triggered as a result of sensing conflicting indications, it shall place the intersection into emergency flash and store and display the conflicting indications at the moment of conflict on the front of the unit. The monitor shall retain these operations until reset by a front panel push-button.

3. When the monitor is triggered as a result of sensing a supply voltage error, it shall place the intersection in emergency flash and retain this operation until reset by the front panel pushbutton or restoration of proper power.

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b. Solid State Load Switches - The interface between the controller and the vehicle and pedestrian signals shall be accomplished with triple-signal solid state load switches which shall meet the requirements specified in NEMA TS-1. The controller cabinet shall be provided with twelve load switches wired to provide eight vehicle phases and four pedestrian phases. Each load switch pack shall have a dust proof metal cover enclosing all electrical parts and provided with a handle for easy removal.

c. Solid State Flasher - The cabinet shall be furnished with a dual circuit solid state flasher conforming to the standards included in NEMA TS-1. It shall be used for the alternate opening and closing of connections between the applied power and the signal lamps required for flashing operation. The unit shall commence flashing operation when AC power is applied to the input terminals. It shall be rated for 10 amperes unless otherwise specified.

d. Power and Flash Transfer Relay Assembly - The controller assembly shall contain electromechanical relays used to manually transfer AC power and operation from the controller and load switches to the solid state flasher. This transfer relay assembly shall be controlled by either the "AUTO-FLASH" mode switch located on the Police Panel or the conflict monitor. The flasher shall remain operational with the controller removed from the cabinet.

1. The cabinet shall be wired to flash amber for the main street and red for the cross streets. The red-yellow-flash indications shall be easily changed with simple tools such as a screwdriver.

2. The plug-in transfer relays shall be enclosed in a transparent case for protection against dust and for visual observance of operations. They shall be insulated or so located that electrically live parts are not readily exposed.

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3. All contact points which make, break and carry current to the signal lamps shall be of silver-cadmium, coin silver or equivalent materials. Contacts shall be capable of making, breaking, and carrying a current of 10 amperes, 120 volts, without undue pitting. Relay coils shall be designed for continuous duty.

4. The transfer relay shall withstand a potential of 1500 volts at 60 Hertz between insulated parts, and between current carrying parts and grounded and noncurrent carrying parts. Each relay shall have a one cycle surge rating of 175 amperes RMS (247.5 amperes peak) and shall be unaffected by electrical noise having a rise time of up to 200 volts per microsecond or by the 500 volt power noise transient test.

5. The transfer relay shall be provided with a connector Cinch-Jones Type #P-408-SB, or equivalent, and intermate with Cinch-Jones Type #S-408-SB, or equivalent. Socket assignments shall be as follows:

PIN	FUNCTION	PIN	FUNCTION
1	Relay Coil	5	Relay Common Ckt. #1
2	Relay Coil	6	Relay Common Ckt. #2
3	NC Ckt. #1	7	No Ckt. #1
4	NC Ckt. #2	8	No Ckt. #1

e. Secondary Coordination Unit - When the local controller is to function as a secondary controller under the supervision of a master controller, a solid state secondary coordination unit shall be incorporated into the local controller assembly cabinet as called for in the plans, unless the secondary coordination function is provided as a built-in feature of the local controller unit.

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f. Telemetry Module - When the local controller is to function under the supervision of a master controller, a telemetry module shall be included in the local controller assembly for two way communication with the master controller.

1. This telemetry module shall be capable of transmitting, as a minimum, the following information:

- | | | |
|--------------|-----------------------|--------------------|
| 1. Cycle 1 | 6. Off-set 3 | 11. Split 2 |
| 2. Cycle 2 | 7. Sampling Detectors | 12. Split 3 |
| 3. Cycle 3 | 8. Sampling Detectors | 13. Flashing |
| 4. Off-set 1 | 9. Sampling Detectors | 14. Free Operation |
| 5. Off-set 2 | 10. Split 1 | |

2. The telemetry tone transmitter and receiver unit shall be designed so that all communications among system's intersections and the master controller can be accomplished over no more than two pairs of wire interconnect. Dedicated pairs from the master to each local controller are not permitted. To accomplish that, the telemetry module shall be capable of transmitting and receiving on a time-sharing multiplex frequency shift keying basis.

723-8 TRAFFIC SIGNAL SYSTEM MASTER CONTROLLER ASSEMBLY

723-8.01 Description - A master controller assembly is a solid state electronic unit for providing supervision to a systems of secondary local controller assemblies. The master controller may be an independent remote unit or a local controller which is also designed and built to provide a supervisory function (secondary

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coordination unit) over other local controllers in addition to operating traffic signals.

723-8.02 Functional Requirements - The master controller unit shall:

- a. Receive all timing and operating parameters for the intersections under its control and down load to the intersections. It shall also be capable of uploading and displaying all timing and operational parameters from all intersections under its control and of displaying the operational status of all controllers including real time intersection operations.
- b. Receive and process data from lane detectors to determine volume and occupancy at strategic points within a coordinated network. It shall also compare the processed volume and occupancy against a number of sets of volume and/or occupancy data stored in memory and shall identify the set that most closely matches the actual traffic at the comparison time.
- c. Be capable of selecting parameters not only by the traffic responsive method, but also by time-of-day, day-of-week, or by manual selection.
- d. Provide the necessary interface circuitry to force the termination of any phase as determined by the programmed background coordinating scheme, if the local controller is operating at or near its maximum limits and if there is demand on any other phase.
- e. Be equipped with the necessary failsafe features to prevent the controller from terminating a phase when the phase timing is operating on the minimum green or pedestrian intervals, thus preventing abnormally short green or pedestrian periods while maintaining full traffic responsive control.

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723-8.03 Design Requirements - The master controller shall meet the following design requirements:

- a. The master or secondary coordination units shall be self contained in their own separate housing and shall be capable of producing programmed coordination schemes at a minimum of three cycle lengths, three separate signal splits, and three off-set timing relationships per cycle.
- b. The program information shall be easily changed by trained personnel without shutting down the local intersection controller.
- c. The secondary local controller shall never be forced to go to any phase where there is no demand.
- d. The secondary coordination units and local controllers shall be connected to the master unit by means of a multiconductor cable of the number of conductors and gauge of wire as per plans for the master to local communications format to be employed, such as master to local through a coordination unit interface, master to coordination unit to local, or any variations thereof. All conductors of this connecting cable shall be fused before their connection to the secondary units.
- e. All connections from local controllers to master coordination unit shall be done in a separate electric terminal panel, and then routed into the master controller unit by the use of a multipin electric harness.
- f. The master controller shall be mounted in one of the housings specified below as called for in the contract documents.
 1. In its own metal cabinet and concrete pedestal base which shall comply with the requirements for controller cabinets specified in Article 723-7.09 except that the dimensions shall be as required to

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accommodate the master controller assembly but with the equipment occupying not more than 60% of the internal volume of the cabinet.

2. In a separate concrete building erected in accordance with the plan details and the requirements of Specification 655 - Traffic Signals Master Controller Building.

g. All communications from master to local secondary coordination unit and controller shall be accomplished thru the installation of a DC low voltage communication system. System coordination and program changes, as well as any other system's function as delineated in the design drawings, shall be carried out thru the above described type of communication. A telemetry module shall be included in each local controller for two way communications with the master controller.

723-8.04 Weekly Program Unit Time Switch - This consists of a weekly program unit time switch installed in the controller cabinet which contains the master coordination unit. It shall be supplied by the traffic con-troller manufacturer and shall be completely compatible with the local controller and coordination equipment. It may be provided internal to the master controller or local controller.

a. The time-clock supplied shall be capable of changing a minimum of twelve times daily over a seven day time period, and shall have a minimum of 10 hours of reserve power capabilities. It shall be solid state with a quartz mechanism with an accuracy within plus or minus sixty seconds per month.

b. The program unit shall activate the proper programmed coordination scheme as specified in the plans. The exact time period shall be determined by the Engineer.

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723-9 RIGID PLASTIC CONDUIT

723-9.01 Plastic conduit, couplings and fittings shall be UL approved non-sparking polyvinyl chloride (PVC) conduit DB-120 designed for direct burial in the ground or PVC Schedule 40; however, the use of PVC Schedule 40 conduit at exposed locations is mandatory. Solvent cement for joining conduits and fittings shall meet the requirements of ASTM D 2564. Conduit size shall be a minimum of 2 inches in diameter unless otherwise specified in the plans.

723-10 GALVANIZED STEEL CONDUIT

723-10.01 Galvanized steel electrical conduit and fittings shall conform to all requirements of the NEC and the details on the plans. Each conduit length shall bear the UL label. Exterior and interior surfaces, including threads (except field cuts) of all conduit and fittings shall be uniformly zinc coated by the hot-dip galvanizing process meeting the requirements of ASTM A 239. Where conduit expansion joints are called for on the plans, they shall be of the “XJ” type.

723-11 PULL BOXES AND JUNCTION BOXES

723-11.01 Concrete Pull Boxes - Shall be precast or cast-in-place meeting the requirements of Class A Concrete, Specification 601 - Structural Concrete, and built in conformance with the details and dimensions shown on the plans.

- a. The cast iron frame and cover shall conform to the approximate dimensions and weights shown on the plans and shall conform to the Specifications for Gray Iron Castings, ASTM A 48.
- b. Reinforcing steel shall be in accordance with the requirements of Specification 602 - Reinforcing Steel.

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- c. The aggregate drain in the bottom of the pull box shall be filled with aggregate conforming to the requirements of paragraph 209-2.01 of Specification 209 - Sheathing.
- d. Conduit and fittings within the limits of the pull box shall comply with the same specification used for similar materials placed outside.
- e. Cable hooks shall be provided and shall be either fabricated of bent reinforcement imbedded in the wall of the pull box or standard cleat type cable hangers used for racking cable.
- f. The conduit bell shall be any non-metallic funnel shaped item.

723-11.02 Metallic Pull and Junction Boxes - May be cast iron or cast aluminum unless otherwise specified in the plans.

- a. Cast iron box shall be of the dimensions specified and shall conform to paragraph 715-5.03 of Specification 715 - Structural Metals. The cover shall be cast steel conforming to AASHTO M 103 (ASTM A27), Grade 60-30, or ductile iron casting conforming to paragraph 715-5.04 of Specification 715. The box and cover shall be hot-dipped galvanized in accordance with AASHTO M 111 (ASTM A 123) after fabrication.
- b. Cast aluminum box shall meet the requirements of ASTM B 26 for Aluminum Alloy Sand Castings, Grade CS 43A with a normal tensile strength of 25,000 psi and a yield strength of 12-15,000 psi.
- c. Box and cover shall be neatly finished. The thicknesses as given shall be uniform throughout. Completed assembly shall be as approved by the Engineer.

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- d. All nuts, bolts and screws shall be recessed and of stainless steel meeting the requirements of AISI 300 Series Commercial Grade.
- e. The box cover shall be gasketed so that when the cover is in place it shall have a watertight fit.

723-12 ELECTRICAL CONDUCTORS

723-12.01 Traffic Signal Cable - Electrical conductors for use as traffic signal cable in underground conduits and overhead messenger supported installations shall be of the size and number of conductors specified in the plans.

- a. Individual conductors shall be stranded copper wire polyethylene insulated, polyethylene jacketed, UL listed and labeled, rated for 600-volt operation, and conforming to the requirements of the International Municipal Signal Association (IMSA) Specification 20-1, latest edition.
- b. When the conductor sizes are not specified in the plans, the Contractor shall furnish conductors of adequate size to meet NEC requirements and the total number of conductors required to service the signals installation.
- c. Each shipping length of cable shall show the name of the manufacturer, the year of manufacture and the IMSA specification number. The above information shall be applied every two feet or less to the outer surface of the jacket by indent printing.
- d. The cable shall be factory tested for each conductor insulation resistance and also for continuity of conductors. The Manufacturer shall furnish a certified report of compliance with the IMSA specifications and shall include the factory test results for conductor insulation resistance and continuity. This report shall be submitted by the Contractor in advance of shipment of the cable together with a sample of the cable covered by this report.

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723-12.02 Detector Lead-In Cable - The loop detector lead-in cables to the controllers shall be stranded tinned copper conductors, polyethylene insulated, polyethylene jacketed cable conforming to the latest edition of IMSA Specification 50-2. The cable shall be AWG No. 14, two conductor, twisted pair, shielded wire, unless otherwise shown on the plans.

- a. Each shipping length of cable shall show the name of the manufacturer, the year of manufacture, and the IMSA specification number on a tape under the outer jacket.
- b. The Contractor shall, when requested by the Authority, furnish a certified report of the tests made on the cable to show compliance with the IMSA specifications.

723-12.03 Electrical Service Cable - Conductors and cable for the electrical connections to the PREPA system shall comply with the PREPA standards and regulations.

723-13 TELECOMMUNICATION CABLE

723-13.01 The cable used for the low voltage telecommunication interconnect system shall conform to the requirements of REA Specification PE-22 for polyethylene insulated, polyethylene jacketed communication cable with corrugated aluminum electrical shielding tape. The conductors size shall be AWG-19 and the number of pairs shall be 12 unless otherwise specified in the plans.

723-13.02 The conductor insulation shall be colored so as to identify (1) the wire and mate conductor of each pair and (2) each pair in the completed cable. Each conductor shall consist of stranded copper wire.

723-13.03 The cable shall be factory tested for each conductor insulation resistance and also for continuity of conductors. The manufacturer shall furnish a certified report on the cable to show compliance with the specifications. This report shall be submitted by the Contractor in advance of shipment of the cable together with a sample of the cable covered by this report.