

700 MATERIAL DETAILS

Materials shall conform to the stated requirements and/or the requirements of the referenced specifications, including modifications as noted.

701 HYDRAULIC CEMENT

Acceptance. Cements meeting the requirements of 701.01, 701.04, 701.05 and 701.08 may be accepted for shipment to and immediate use in construction projects by cement manufacturer's certification, at the option of the City in lieu of sampling by inspectors at manufacturing plants, when requested by a cement manufacturer and agreed to by both the requesting cement manufacturer and the City.

701.01 Air-entraining Portland Cement. ASTM C 150, Type 1A. The Gillmore time of set and the air-permeability (fineness) test shall govern.

701.04 Portland Cement. ASTM C 150, Type 1. The Gillmore time of set and the air-permeability (fineness) tests shall govern. This cement may be used provided 705.10 admixture is added at the mixer.

701.05 High-early-strength Portland Cement. ASTM C 150, Type III. The Gillmore time of set shall govern. This cement may be used provided 705.10 admixture is added at the mixer.

701.07 Masonry Cement. ASTM C 91.

701.08 Expansive Hydraulic Cement. ASTM C 845, Type K.

701.11 Non-shrink Grout. ASTM C 827.

702 ASPHALT MATERIAL

Acceptance. Asphalt binders, 702.01 and liquid asphalts 702.02, 702.03, and 702.04 may be acceptable for shipment to and immediate use in construction projects. The Contractor has the option of using the manufacturer's certification, when requested by an asphalt manufacturer and agreed to by both the requesting asphalt manufacturer and the City. Acceptance procedure is according to ODOT Supplement 1032.

702.00 Application Temperatures. Apply asphalt materials, according to the temperature ranges specified in Table 702.00-1.

Table 702.00-1

Type and Grade of Material	Application Temperature Range °F (C)	
	Spray	Mix
RC-70	75 to 150 (24 to 66)	---
RC-250	100 to 175 (38 to 79)	80 to 150 (27 to 66)
RC-800	66 to 107 (150 to 225)	66 to 93 (150 to 200)
RC-3000	200 to 275 (93 to 135)	175 to 225 (79 to 107)
MC-30	50 to 120 (10 to 49)	---
MC-70	75 to 150 (24 to 66)	---
MC-250	100 to 225 (38 to 107)	100 to 225 (38 to 107)
MC-800	150 to 250 (66 to 121)	150 to 225 (66 to 107)
MC-3000	225 to 275 (107 to 135)	200 to 250 (93 to 121)
All Emulsions	50 to 160 (10 to 71)	50 to 140 (10 to 60)
Asphalt Primer for Waterproofing	50 to 80 (10 to 27)	---
Asphalt for Waterproofing	300 to 350 (149 to 177)	---
CBAE 350, CBAE 350 Special	100 to 150 (38 to 66)	100 to 150 (38 to 66)
CBAE 800, CBAE 800 Special	125 to 175 (52 to 79)	125 to 175 (52 to 79)
Primer 20	60 to 120 (16 to 49)	---
Primer 100	75 to 125 (24 to 52)	---
Asphalt Binders	350 (177) Max.	325 (163) Max.
Asphalt Binders-Polymer modified with SB, SBR, or SBS	---	350 (170) Max.

702.01 Asphalt Binders.

General. According to AASHTO M 320-03 except as follows.

PG Binders with the suffix “M” (e.g., PG 70-22M, PG 76-22M) will meet the requirements of Table 702.01-1. When a PG 64-28 is made thru modification ensure it meets the requirements of Table 702.01-1.

An independent laboratory will not be owned or operated, in whole or part, by the binder supplier, Contractor, or affiliates of either.

Materials and Manufacture. Replace the requirements of AASHTO M 320-03 Section 5 “Materials and Manufacture” Section with the following:

5.1 Supply PG Binder from the refining of crude petroleum, or combination of asphalt binders from the refining of crude petroleum, or asphalt binders and suitable liquid from the refining of crude petroleum, and possible organic modifiers for performance enhancement. Material from the crude refining stream is considered neat. Liquid from crude refining may be used for adjustments, but do not use liquid from crude refining for the purpose of substitution of crude refined asphalt binder in a PG Binder. In the event of a failure investigation where asphalt binders exhibit unusual properties a supplier may be requested by the Laboratory to supply information about the makeup of a PG Binder. Failure to cooperate will mean removal from Supplement 1032 certification.

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5.2 A modifier may be any organic material of suitable manufacture that is proven compatible with asphalt binder (does not separate appreciably in routine storage), and that is dissolved, dispersed or reacted in asphalt binder to improve its performance. Performance enhancement is defined as a decrease in the temperature susceptibility of the asphalt binder while maintaining or improving desirable properties in a neat asphalt binder such as coatability, adhesiveness and cohesiveness. Limit modifiers to no more than 6.0 percent by PG Binder weight.

5.3 The use of previously used materials in a PG Binder must be approved by the Department. Since no standard test procedures exist for reprocessed materials (and original tests were not developed with the use of such materials in mind), appropriate test methods may be chosen by the Department for review. Department approval does not relieve the binder supplier from full responsibility for content and use of any previously used material in a PG Binder nor guarantee suitable performance enhancement as defined above. The detected presence in a PG Binder sample of any unapproved previously used material will mean immediate removal from Supplement 1032 certification. Limit approved reprocessed materials to 6.0 percent by PG Binder weight.

5.4 Ensure the PG Binder is homogeneous, free from water and deleterious materials, and does not foam when heated to 350° F (175° C). Prove the asphalt binder (before modification or after modification if liquid modifier used) is fully compatible with a negative result by means of the Spot Test per AASHTO T 102 using standard naphtha solvent. If standard naphtha shows a positive result, a retest using reagent grade 35 percent Xylene/ 65 percent Heptane (volume) may be used.

5.5 Ensure the PG Binder is at least 99.0 percent soluble as determined by ASTM D 5546 or D 2042. Ensure any insoluble component is substantially free of fibers and have discrete particles less than 75 µm.

5.6 Ensure flash point is 500° F (260° C) minimum. Ensure mass loss on RTFO of the final PG Binder grade is 0.5 percent maximum.

5.7 Ensure that PG 58-28 has a minimum Viscosity (ASTM D2171 @ 60° C) of 800 poise and that PG 64-22 has a Penetration (ASTM D5) between 55 and 75.

5.8 Direct Tension testing is not required, unless otherwise required in this specification.

Requirements for PG Modified Binder. Furnish PG Modified Binder according to the requirements of Table 702.01-1 by modifying a non-oxidized, non-air blown, neat asphalt binder by using a styrene butadiene latex rubber compound (SBR polymer) or a styrene butadiene styrene polymer block copolymer (SBS polymer). The polymer supplier will certify to the refiner and Contractor that the polymer used meets a minimum 68 percent by weight butadiene content. Perform SBS polymer

modification prior to shipment to the asphalt concrete mixing plant (preblend).
 Perform SBR polymer modification at the asphalt concrete mixing plant (postblend)
 or prior to shipment to the asphalt concrete mixing plant (preblend).

For each project, the PG Modified Binder supplier will give the Contractor a handling guide specifying temperature, circulation, shelf life, and other requirements for assuring the PG Modified Binder will perform as desired. Give this handling guide to the Testing Lab and place a copy in the plant control room and plant laboratory.

If PG Modified Binder is retained at the asphalt concrete mixing plant for more than two weeks before use or beyond the supplier recommended shelf life, whichever is less, a top and bottom sample test (material property difference between samples taken from the top and bottom of the storage tank) will be performed by the Laboratory on samples retrieved by the Contractor at the City's direction. Do not use material on hand until approved.

Table 702.01-1Material Requirements for PG Modified Binder					
Test / Requirement	SBR Polymer		SBS Polymer		Notes
Final PG Binder Grade	70-22M (a, b)	64-28 (a,b)	70-22M (a)	76-22M (a)	c
Final PG Binder Grade			64-28 (a)		
Actual Pass Temperatures	Report		Report		i
RTFO Mass Loss, percent max	0.5		0.5	0.5	d
Phase Angle, max	76		80	76	d
Elastic Recovery, min			65	75	e
Toughness, in lb	118	105			f, d
Tenacity, in lb	70	80			f, d
Elongation, in, min	20	20			f, d
Ductility, in, min	28	28			j, d
Separation, F max	10		10		g
Homogeneity			None Visible		h, d

- a. Preblended Binder with a base binder of at least -22 grade or stiffer for 70-22M.
- b. Post blended Binder made from ODOT Supplement 1032 certified or preapproved standard PG Binder grade and rubber solids amount equal to or above 3.5 percent by weight of total binder to achieve the PG Binder grade.
- c. Without Direct Tension, graded with actual pass temperatures
- d. PG Modified Binder
- e. ASTM D 6084, 10cm @ 25° C, hold 5 min. before cutting, on RTFO material
- f. ASTM D 5801, 50cm/min @ 25° C

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g. Softening point difference of top and bottom of tube sample conditioned at 340° F for 48 hours. Compatibility of polymer and neat binder is sole responsibility of supplier. Formulate PG Modified Binder to retain dispersion for 3 days minimum.

h. Heat a minimum 400 gram sample at 177° C for 2.5-3 hours. Pour entire sample over a hot No 50 (300 µm) sieve at 340° F. Look for retained polymer lumps.

i. Actual high and low temperature achieved by PG Modified Binder beyond required grade, but will not grade out to the next standard PG Binder grade for low temperature.

j. ASTM D 113, @ 4° C, 1 cm/min

702.02 Cut-Back Asphalt. Provide rapid curing cut-back asphalt according to AASHTO M 81 and medium curing cut-back asphalt according to AASHTO M 82. Instead of viscosity on the residue, the penetration in note 3 (AASHTO M 81) or note 4 (AASHTO M 82) shall govern.

702.03 Cut-Back Asphalt Emulsions. Prepare emulsions by compounding a suitable volatile solvent and water with 702.01 asphalt to produce emulsions according to Table 702.03-1.

Table 702.03-1

	CBAE-350	CBAE-350 Special	CBAE-800	CBAE-800 Special	Primer 20	Primer 100
Kinematic Viscosity at 60 C, Centistokes	350-700	350-700	800-1600	800-1600	20-40	100-200
Water Content ^[1] , %	4-12	4-12	4-12	4-12	3-8	3-8
Volatile Solvent ^[1] , %	12-25	12-25	10-20	10-20		
Asphalt Content ^[1] , %	67+	67+	72+	72-	45+	60-
Adhesion Test ^[1]	[2]	[2]	[2]	[2]		
Wet Stone Coating Test ^[1]		[2]		[2]	[2]	[2]
Stripping Test ^[1]		[2]		[2]		
Tests on Residue From Distillation						
Penetration at 25 C	80-150	80-150	80-150	80-150	100-200	100-200
Ductility at 25 C, in cm	100+	100+	100+	100+	100+	100+
Total Binder (Sol. in CSx), %	99+	99+	99+	99+	99+	99+
[1] Perform tests according to Supplement 1014.						
[2] Meets.						

702.04 Emulsified Asphalts. Provide emulsified asphalts according to AASHTO M 140 or AASHTO M 208.

702.05 Asphalt Primer for Waterproofing. Provide asphalt primer for waterproofing according to ASTM D 41.

702.06 Asphalt for Waterproofing. Provide asphalt for waterproofing according to ASTM D 312, Type III.

702.07 Asphalt Emulsion MWS. Prepare asphalt emulsion MWS from a base material according to 702.01, except vary the penetration to meet the float test and penetration specified below. Ensure that the emulsion coats the aggregate readily, thoroughly, and uniformly. Ensure that the specified characteristics do not change during transportation or normal storage and that the emulsion is according to the following when tested according to AASHTO T 59:

Saybolt furol viscosity at 77° F (25° C), seconds	50+ [1]
Asphalt residue, percent	68+
Settlement, 7 days, percent	5-
Sieve test	0.1-
Coating test	[2]
Oil distillate, percent	7-
Withstand freezing to	-10° F (-23° C) [3]
Particle charge	Negative
Penetration, 77 °F (25 °C) [6]	[4]
Float test at 140 °F (60 °C), seconds [6]	1200+ [5]
Total bitumen soluble CS ₂ [6]	97.5+
Ash content, percent [6]	2.0-

[1]Pumpable.

[2]Use aggregates to test the emulsion that are from sources standardized by the Laboratory. Use aggregates consisting of 100 percent passing a 3/8 inch (9.5 mm) sieve and 0 percent passing a 1/4 inch (6.3 mm) sieve. Wash the standard reference aggregates with distilled water until free of dust, and dry them.

Weigh 3.280 ounces (93 grams) of the dry graded reference aggregate into a suitable container. Weigh 0.247 ounces (7 grams) of the emulsion onto the aggregate in the container, and vigorously mix the contents for 5 minutes. After mixing, thoroughly coat the stone. Completely immerse the mixture in tap water, and immediately pour off the tap water. Ensure that the aggregate surface area is at least 90 percent coated.

[3]When shipped after October 1 and before April 15, except if the emulsion is stored and mixed at temperatures of emulsion, aggregate, and atmosphere above 40° F (5° C).

[4]Select the penetration within the following ranges of the designation specified:

Designation	Penetration at 77° F (25° C)
MWS 300	300+
MWS 150	150 to 300
MWS 90	90 to 150
MWS 60	60 to 90

[5]AASHTO T 50, except immediately pour residue from distillation into the float collar at 500° F (260° C); or if the residue has been allowed to cool, heat it again to 500° F (260° C) and pour it into the float collar.

[6]Test on residue from distillation.

702.13

702.13 Rubberized Asphalt Emulsion. Provide material consisting of asphalt emulsion SS-1 or SS-1h, according to 702.04, blended with rubber compound, according to 702.14, to produce a residual mixture of asphalt and rubber solids having a composition of 95 0.3 percent asphalt and 5 0.3 percent rubber solids by weight.

Furnish a certification to the Laboratory showing the following:

- A. The weight of rubber compound blended with the emulsion.
- B. The weight of SS-1 or SS-1h emulsion blended with the rubber compound.
- C. The Laboratory Report Number and/or the approved Notice of Shipment Number of the SS-1 or SS-1h emulsion.
- D. The certified lot or batch number of the rubber compound.
- E. The percent of asphalt in the emulsion residue by distillation.
- F. The percent of rubber solids in rubber compound.
- G. The percent of rubber solids in the mixture of asphalt residue by distillation and rubber solids.

Determine the weight of the rubber compound to be added to a designated weight of SS-1 or SS-1h emulsion to provide the percent of rubber solids in the mixture of asphalt residue by distillation and rubber solids specified herein using the following formula:

$$X = \frac{0.0526 B x W}{A}$$

where:

X =pounds (kilograms) of rubber compound

A =percent of rubber solids in the rubber compound

B =percent of asphalt residue by distillation of SS-1 or SS-1h emulsion

W =pounds (kilograms) of SS-1 or SS-1h emulsion

702.14 Rubber Compound. Provide a dispersible rubber compound.. consisting of unvulcanized virgin synthetic rubber in the liquid latex form. The manufacturer of the rubber compound will furnish a written certification of the total rubber solids content of the rubber compound and provide written certification containing actual test results showing compliance with the requirements of these Specifications.

Provide a rubber compound according to the following:

- A. Rubber compound:

Total rubber solids, % by weight (Certification).....49+
 Ash, % of total rubber solids (ASTM D 297).....3.5-

B. Combination of rubber compound with reference asphalt, mixed according to Supplement 1012.02:

Flow, cm	5-
Softening point, °C raise from reference asphalt, ASTM D 36	12+
Penetration @ 25 °C., 100 g, 5 sec., mm/10 drop from reference asphalt, ASTM D 5	10+
Viscosity, Brookfield units, Model RVF, spindle No. 7 @ 10 RPM @ 94 °C *	175,000+
Toughness inch-pounds (Nm)	150+ (17+)
Tenacity, inch-pounds (Nm)	90+ (10+)
Peak load, pounds (N)	65+ (289+)
Elongation, inches (mm)	20+ (500+)
Ductility @ 4 °C, 1 cm/min, ASTM D 113	150+

*Take the reading 60 seconds after spindle is actuated.

C. Mixture of the rubber compound with the reference asphalt and reference aggregate:

Dispersion of rubber, number
of remaining black rubbery
particles visible to the naked eye..... None

Resistance to flexure fatigue,
number of flexural units1500+

Perform the testing according to Supplement 1012

702.16 Polymer Emulsified Binder

Emulsion (ASTM D 244)	Type A	Type B (j)
Saybolt Furol Viscosity	75-400 (50° C)	20-100 (25° C)
Storage stability, 24 hrs., % difference, max (a)	1	1
Demulsibility, 35 ml of 0.8% Dioctyl Sodium Sulf., min	40 (b)	60
Demulsibility, 35 ml of 0.02N, CaCl ₂ , %, min (c)	40	60
Sieve test, (distilled water), %, max	0.1	0.05
Distillation to 190 °C or (h), residue % solids (d) symbol	68	63
Oil distillate, %, max	2	2
Distillation Residue		
Penetration, 100g, 5 sec @ 25°C ASTM D 5	75-115	90-150

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Float Test, sec, min ASTM D 139	1200 (g)	
Softening point, ° C, min ASTM D 36	60	
Solubility in TCE, %, min ASTM D 2042 or D 5546	97.5	97.5
Elastic Recovery, 10° C, %, minASTM D 113, (e),(j)	70	58
Force Ductility, 4° C, 40 cm, lb/ sq in ASTM D 113, (j)	report	report
Toughness/Tenacity, 25° C, 50 cm/min, Nm ASTM D 5801 (f), (j)	report 16.0/ 9.0	
25°C, 50 cm/min, Nm ASTM D 5801 (i)		
Ductility, 4 ° C,1cm/min, min ASTM D 113, (i)	70	

Notes:

- (a) After standing undisturbed for 24 hours, the surface will show no white, milky colored substance, but will be a smooth homogeneous color throughout.
- (b)CRS-2P, test within 20 days of shipment.
- (c)HFRS-2P, test within 20 days of shipment.
- (d)Maximum of 190 °C held for 15 minutes. (e)Straight molds. Hold at test temperature for 90 minutes. Place in ductilometer and elongate 10 cm at 5 cm/min. Hold for 5 minutes and cut. After 1 hour retract the broken ends to touch and note elongation in cm (X). Percent Recovery = ((10-X)/10) x 100.
- (f)Report on JMF. Not part of normal QC testing. Run when requested for investigation.
- (g)HFRS-2P
- (h)California Test 331, Residue by Evaporation
- (i)SBR
- (j)SBS, SB

702.17 Crack Sealant

A.Type I Crack Sealant. Conform to 705.04

B.Type II Crack Sealant.Provide a mixture of PG 64-22 certified binder (Supplement 1032) and polyester fibers (recycled fibers not permitted) according to the following requirements:

- Denier; ASTM D 1577*3.0 to 6.0
- Length0.25 0.02 inch (6.35" 0.51mm)
- Crimps; ASTM D 3937 None
- Tensile str, min. ASTM D2256* 70,000 psi (483 Mpa)
- Specific gravity 1.32 to 1.40
- Minimum melting temperature..... 475° F (256° C)
- Ignition temperature 1000° F (538° C) min.

*This data must be obtained prior to cutting the fibers.

Combine materials so the fibers are a minimum of 5.0 percent by total weight of the asphalt binder. Ensure combined materials are according to the following properties:

Strength (at break)	
at 72° F (22° C)	350 psi (2.4 MPa) min.
at 0° F (-18° C).....	500 psi (3.5 MPa) min.
Elongation (at break)	
at 72° F (22° C)	50 percent min.
at 0° F (-18° C)	20 percent min.

The option for using premixed and prepackaged Type II crack sealant is permitted provided (1) the fibers and the fiber binder are according to the requirements as shown and, (2) the fiber binder is according to the manufacturer's specifications. Furnish certified test data from the fiber binder manufacturer annually to the Laboratory, and when requested ~~of~~ by the Laboratory. Furnish a ~~A~~ letter of certification with each shipment stating that the material complies with specification requirements.

C. Type III Crack Sealant. Provide a mixture of PG 64-22 certified binder (Supplement 1032) and polypropylene fibers (recycled fibers not permitted) according to the following requirements:

Denier; ASTM D 1577*	15 " 3
Length,	0.390.08 inch (9.91" 2.0 mm)
Crimps; ASTM D 3937	None
Tensile strength, min, ASTM D 2256*	40,000 psi (276 MPa)
Specific gravity	0.910.04
Minimum melting point	320° F (160° C)

*This data must be obtained prior to cutting the fibers.

Combine materials so the fibers are a minimum of 7.0 percent by total weight of the asphalt binder. Ensure combined materials are according to the following properties:

Strength (at break)	
at 72° F (22° C)	350 psi (2.4 MPa) min.
at 0° F (-18° C).....	500 psi (3.5 MPa) min.
Elongation (at break)	
at 72° F (22° C)	50 percent min.
at 0° F (-18° C)	20 percent min.

D. Type IV Crack Sealant. Provide a prepackaged, preapproved mixture of modified binder according to the following properties and minimum 2.0 percent

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polyester fibers (recycled fibers not permitted) according to the following properties. Place sealant with a manufacturer's representative for the fiber binder on site to ensure proper application and conditions.

Modified binder:

Cone penetration, 77° F(25° C).....	50-90
Flow, 140° F (60° C).....	1.0 cm max
Resilience, 77° F (25° C)	25-60 percent
Ductility, 77° F (25° C).....	40 cm min
Bond, 0° F (-18° C), 100 percent ext.Pass	5 cycles
Impact, 0° F (-18° C).....	Pass
Compression recovery.....	0.40 min
Recommended pour temperature.....	380° F (193° C)
Safe heating temperature.....	410° F (210° C)

Polyester fiber properties and fiber approval: Same as for Type II crack sealant.

Fiber binder properties:

Safe heating temperature.....	400° F (204° C)
Softening point.....	190° F (88° C)
Viscosity, 400° F(225° C).....	3000 cp min
Cone penetration, 77° F(25° C).....	25-45
WorkabilityCapable of being melted and applied through a pressure feed, indirect heated and agitated melter	
Flexibility*	Pass

* 1 inch (25mm) sample at -20° F(-30° C), 90 degree bend, 10 sec

Crack sealant approval: Submit 10 pounds (4.5 kg) of base modified binder and 10 pounds (4.5 kg) of fiber binder from the same batch to the Laboratory. Submit samples for approval annually. Before shipment to the project the fiber binder must be approved by the Laboratory. Additional testing or submission of samples may be required by the Laboratory.

703 AGGREGATE

703.01 General. Soundness. When the major portion of the unsound material in a coarse aggregate acquires a mud-like condition when tested for soundness, the maximum loss shall be five percent for all uses.

Stock Piles. Stockpiling and loading methods shall be such as to permit ready identification of the aggregates and to minimize segregation. Sites for stock piles shall be clean prior to storing materials. No material which has become mixed with foreign matter or other sizes or grades of aggregates shall be used.

Aggregates shall be handled in such a manner that the moisture content will be reasonably uniform for each day's run. If necessary, in order to secure uniformity of moisture content of the aggregate, stockpiling will be required.

Open-hearth and Basic-oxygen Furnace Slags. All open-hearth and basic-oxygen furnace slags shall be furnished to a size meeting the specified grading requirements of the use item to which it will be incorporated, and stockpiled for a period of not less than 6 months prior to use. New material shall not be added to the stockpile during the 6 month aging period, or prior to or during delivery from the stockpile to the project. Any addition of new material to a stockpile will require initiation of a new aging period before any material from that stockpile may be used. Prior or during the stockpiling operation, these materials shall have water added to provide a uniform moisture content not less than their absorbed moisture and the stockpile shall be maintained in a moist condition during the required stockpiling period.

The Contractor shall furnish the Engineer with a certificate stating that the slag material stockpiling requirements have been complied with for all such material furnished to the work. This certification shall include the estimated yardage, the detailed location, and the beginning and ending dates of the aging periods, of each stockpile. The certification shall be submitted with sufficient lead time, prior to intended use, to allow for inspection, sampling, and testing.

Air Cooled Blast Furnace Slag. In addition to meeting the same requirements stated above for open-hearth and basic oxygen furnace slags, all air cooled blast furnace slag shall be subject to the acceptance requirements set forth in ODOT Supplemental 1027 (Sulphur Leachate Test).

Size. Aggregate shall conform to the size specified in the material specifications, the construction item or as shown in AASHTO M 43.

APPLICABLE DOCUMENTS

- ASTM C142 Amount finer than No. 200 Sieve - AASHTO T11 or ASTM C117 Clay Lumps and Friable Particles.
- ASTM D75 Sampling Aggregate.
- ASTM C29 Test for unit weight and voids in aggregate.
- ASTM C39 Test for compressive strength of cylindrical concrete specimens.
- ASTM C40 Test for organic impurities in sands for concrete.
- ASTM C78 Test for Flexural strength of concrete (using simple beam with third-point loading).

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- ASTM C87 Test of effect of organic impurities in fine aggregate on strength of mortar.
- ASTM C88 Test for soundness of aggregates by use of Sodium Sulfate or Magnesium Sulfate.
- ASTM C117 Test for materials finer than No. 200 (75-mm) sieve in mineral aggregates by washing.
- ASTM C123 Test for lightweight pieces in aggregate.
- ASTM C125 Definitions of terms relating to concrete and concrete aggregates.
- ASTM C131 Test for resistance to abrasion of small size coarse aggregate by use of Los Angeles machine.
- ASTM C136 Test for sieve or screen analysis of fine and coarse aggregates.
- ASTM C142 Test for clay lumps and friable particles in aggregates.
- ASTM C227 Test for potential alkali reactivity of cement-aggregate combinations (mortar-bar method).
- ASTM C289 Test for potential reactivity of aggregates (chemical method).
- ASTM C295 Recommended practice for petrographic examination of aggregates for concrete.
- ASTM C342 Test for potential volume change of cement- aggregate combinations.
- ASTM C535 Test for resistance to abrasion of large size coarse aggregate by use of the Los Angeles machine.
- ASTM C586 Test for potential alkali reactivity of carbonate rocks for concrete aggregates (rock cylinder method).
- ASTM C666 Test for resistance of concrete to rapid freezing and thawing.
- ASTM D75 Sampling Aggregates.
- ASTM E11 Specifications for wire-cloth sieves for testing purposes.

Method of Test. Aggregate shall be tested by the following methods:

- Amount finer than No. 200 sieve S1004*
- Clay lumps S1017*
- Coal and lignite AASHTO T113

Crushed pieces	S1021*
Deleterious materials.....	S1029*
Effect of organic impurities on strength of mortar	AASHTO T71
Liquid limit	AASHTO T89
Percentage of wear, Los Angeles abrasion test. AASHTO T96 or ASTM C535	
Plasticity index.....	AASHTO T90
Sieve analysis.....	.S1004*, S1005*
Sieve analysis of mineral filler.....	AASHTO T37
Sodium sulfate soundness test, 5 cycles ...	AASHTO T104
Specific gravity and percent absorption for fine and coarse aggregate	S1031*
Unit weight.....	AASHTO T19

* Supplement on file in the Office of the Engineer.

**TABLE 703-1
SIZES OF COARSE AGGREGATE
(AASHTO M 43)**

SIEVE SIZE	1	2	24	3	357	4	467	5	56	57
4"	100									
3-1/2"	90-100									
3"		100	100							
2-1/2"	25-60	90-100	90-100	100	100					
2"		35-70		90-100	95-100	100	100			
1-1/2"	0-15	0-15	25-60	35-70		90-100	95-100	100	100	100
1"				0-15	35-70	20-55		90-100		95-100
3/4"	0-5	0-5	0-10			0-15	35-70	20-55	40-75	
1/2"			0-5	0-5	10-30			0-10	15-35	25-60
3/8"						0-5	10-30	0-5	0-15	
No. 4					0-5		0-5		0-5	0-10
No. 8										0-5
No. 16										
No. 50										
No. 100										

SIEVE SIZE	6	67	68	7	78	8	89	9	10
4"									
3-1/2"									
3"									
2-1/2"									
2"									
1-1/2"									
1"	100	100	100						
3/4"	90-100	90-100	90-100	100	100				
1/2"	20-55			90-100	90-100	100	100		
3/8"	0-15	20-55	30-65	40-70	40-75	85-100	90-100	100	100
No. 4	0-5	0-10	5-25	0-15	5-25	10-30	20-55	85-100	85-100
No. 8		0-5	0-10	0-5	0-10	0-10	0-10	5-30	10-40
No. 16			0-5		0-5	0-5	0-10	0-10	
No. 50							0-5	0-5	
No. 100									10-30

(1) Numbered sieves are those of the United States Standard Sieve Sizes.

(2) Amounts given are the percentages by weight passing each sieve size (square openings).

(3) Screenings. Where sizes of coarse aggregate designated by two or three digit numbers are specified, the specified gradation may be obtained by combining the appropriate single digit standard size aggregates by a suitable proportioning device which has a separate compartment for each coarse aggregate combined. The blending shall be done as directed by the laboratory.

703.02 Aggregate for Portland Cement Concrete.

Fine Aggregate.

1. The fine aggregate shall be natural sand.

2. Sieve Analysis:

Total Percent Passing

<u>Sieve Size</u>	<u>Natural Sand</u>
3/8 Inch	100
No. 4	95-100

703.02

No. 8	70-95
No. 16	45-80
No. 30	5-60
No. 50	10-30
No. 100	1-10
No. 200	0-4

Fine aggregate failing to meet the minimum requirement for amount passing either the No. 50 or No. 100 Sieve, or both, may be used provided an approved fine material is added to correct the deficiency. The amount added shall be determined by the laboratory.

Should the fineness modulus of a job control sample of sand from any source vary by more than 0.20 from that of a representative sample from that source, the sand may be rejected.

3. Soundness, Sulfur, etc.:

Maximum	<u>Percent</u>
Loss, Sodium Sulfate Soundness test	
Section 305.....	12
Sec. 451, 452, 511, 515, 519, 603, 604, 453, 454, 455, 456 457, 458, 704 and 706	10

When the sand has more than 0.3 percent by weight of sulfur compounds, the service record of the sand when exposed to weathering in concrete will be examined before classifying the material as satisfactory or unsatisfactory for use.

When tested for the effect of organic impurities on strength of mortar, the compressive strength at three and seven days of mortar made with untreated sand shall be not less than 95 percent of the compressive strength of mortar made with treated sand.

Aggregations of soil, silt, etc., maximum percent, by weight, 0.5.

Coarse Aggregate.

1. The coarse aggregate shall be washed gravel, crushed carbonate stone, or crushed air-cooled blast furnace slag. Gravel for coarse aggregate in concrete may be used only where specifically noted on the plans or with written permission of the Engineer.

2. Physical Properties:

Percent of wear, Los Angeles test, maximum (stone or gravel)	40
Unit weight, compacted, minimum pounds (slag).....	70

Loss, Sodium Sulfate Soundness Test, percent, maximum:

305	15
451, 452, 511, 519, 551, 562, 563, 613, 622, 704 and 706	12
515	10

Deleterious substances shall not exceed the following:

	Percent by Weight	
	Super-Structure	All Other Concrete
Soft Pieces	2.0	3.0
Coal and Lignite	0.25	1.0
Clay Lumps	0.25	0.25
Pieces having a length greater than 5 times the average thickness	15	15
Shale and Shaly Material	0.5	1.0
Other Deleterious substances, such as limonitic concretions, alkali, metallic particles and chert which disintegrates in 5 cycles of soundness test	0.5	1.0

3. Amount finer than No. 200 sieve. The percentage of material finer than the No. 200 sieve in the aggregate portion of the concrete mix shall not exceed the following:

	Percent by Weight	
	Super-Structure	All Other Concrete
Where the finer than No. 200 sieve material from the coarse aggregate consists of the dust of fracture essentially free from clay and shale	3.4	3.8
Where the finer than No. 200 sieve material from the coarse aggregate may consist of or include material other than dust of fracture	2.0	2.2

703.03 Fine Aggregate for Mortar or Grout.

1. The fine aggregate shall be natural sand.
2. Sieve Analysis:

703.04

Sieve Size	Total Percent Passing
No. 4	100
No. 8	95-100
No. 50	10-40
No. 100	0-10
No. 200	0-5

3. Soundness Sulfur, Etc.:

Loss, Sodium Sulfate Soundness test, percent, max..... 10

When the sand has more than 0.3 percent by weight of sulfur compounds, the service record of the sand when exposed to weathering in mortar or grout will be examined before classifying the material as satisfactory or unsatisfactory for use.

When tested for the effect of organic impurities on strength of mortar, the compressive strength of mortar made with untreated sand shall be not less than 95 percent of the compressive strength of mortar made with treated sand.

Aggregations of soil, silt, etc., max. percent, by weight, 0.5.

703.04 Aggregate for:

Bituminous Aggregate Base, 301
 Aggregate Base, 304
 Slope and Channel Protection, 601

1. The coarse aggregate for bituminous aggregate base used in flexible pavements shall be crushed carbonate stone or crushed gravel. The fine aggregate for bituminous aggregate base shall be natural sand.

2. Physical Properties	<u>301</u>	<u>304</u>	<u>601</u>
Percentage of wear, Los Angeles Test, maximum	50	50	50
Unit weight, compacted, pounds minimum (slag)	65	---	65
Loss, Sodium Sulfate Soundness test, percent maximum	15	15	15
Percentage of fractured pieces, minimum	40	90	90

Deleterious substances shall not exceed the following:

Percent by Weight
Item 301

Soft Pieces.....	3.0
Coal and Lignite.....	1.0
Clay Lumps.....	0.25
Pieces having a length greater than 5 times the average thickness	15.0
Shale, shaly material, and chert which disintegrates in 5 cycles of the soundness test.....	2.5

703.05 Aggregate for:

- (1) Asphalt Concrete, 302, Asphalt Concrete (Intermediate and Surface Courses), 412, and 413
- (2) Prime Coat (408).
- (3) Seal Coat, 409
- (4) Bituminous Road Mix, 406

A. Fine Aggregate.

1. Provide fine aggregate consisting of natural sand or sand manufactured from stone, gravel or air-cooled slag.

2. Sieve analysis.

Sieve Size	Total Percent Passing
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	90 to 100
No. 8 (2.36 mm)	65 to 100
No. 16 (1.18 mm)	40 to 85
No. 30 (600 mm)	20 to 60
No. 50 (300 mm)	7 to 40
No. 100 (150 mm)	0 to 20
No. 200 (75 mm)	0 to 10

3. Soundness, etc.

	Maximum Percent
Loss, sodium sulfate soundness test, %	15
Aggregations of soil, silt, etc., by weight	0.5

B. Coarse Aggregate.

1. Provide coarse aggregate consisting of CCS, crushed air-cooled slag, or washed gravel.

2. Physical properties.

703.06

Percent of wear, Los Angeles test, maximum (stone or gravel)	40
Unit weight, compacted, lb/ft ³ (kg/m ³), minimum (slag): Asphalt Concrete, 406,408,409 and 41270 (1120)
Loss, sodium sulfate soundness test, %, maximum: Asphalt Concrete, and 412	12
Loss, sodium sulfate soundness test, %, maximum: 405 and 409.....	15
Percent by weight of fractured pieces, minimum	40

Deleterious substances shall not exceed the following:

Material Type	Percent by Weight
Soft pieces	3.0
Coal and lignite	1.0
Lightweight pieces	1.0
Clay lumps	0.25
Amount finer than No. 200 (75 m) sieve	3.0
Pieces having a length greater than 5 times the average thickness	15
Shale and shaly material	2.5
Limonitic concretions	2.5
Alkali	2.5
Chert, that disintegrates in 5 cycles of the soundness test	2.5

C. General Requirements for Coarse and Fine Aggregate.

1. Calculate each individual sieve fraction soundness loss and ensure that the fractional size does not exceed the following:
 - a. 13.0 percent for all surface courses and any asphalt concrete course directly below an open graded friction course.
 - b. 13.0 percent for No. 8 aggregate fractions used in intermediate courses that will be exposed to traffic over the winter months.
 - c. 15.0 percent for all other coarse aggregate used in intermediate courses that will be exposed to traffic over the winter months.

Statistical evaluation of data will be per Group List procedures.

703.06 Sand Cover (407 and 408). 1. For 407 and 408 the sand shall be natural sand.

2. Sieve Analysis:

<u>Sieve Size</u>	<u>Total Percent Passing</u>
No. 4	90-100
No. 50	7-40
No. 200	0-10

703.07 Mineral Filler.

1. The mineral filler shall be limestone dust, portland cement, or other inert mineral matter. It shall be thoroughly dry and free from lumps.

2. Sieve Analysis:

<u>Sieve Size</u>	<u>Total Percent Passing</u>
No. 30	100
No. 50	95-100
No. 200	5-100

703.08 Granulated Slag.

1. The granulated slag shall be the glassy, granular materials formed when molten blast-furnace slag or electric-furnace slag is rapidly chilled, as by immersion in water. Material containing mill waste, cinders, large pieces of ungranulated slag, or other matter foreign to the production of slag in the normal operation of the blast-furnace or electric furnace may be rejected.

The material shall be of such nature that it will compact to the satisfaction of the engineer.

2. Sieve Analysis:

<u>Sieve Size</u>	<u>Total Percent Passing</u>
2 Inch	100
1 Inch	5-100
No. 100	0-15

703.09 Slacker Aggregate.

1. The slacker aggregate shall be the by-product of lime slackers and shall consist of unburned and underburned limestone, or silica, or both. Material containing calcium oxide, coke, or other foreign matter may be rejected.

The material shall be of such nature that it will compact to the satisfaction of the Engineer.

2. Sieve Analysis:

703.10

<u>Sieve Size</u>	<u>Total Percent Passing</u>
2 Inch	100
3/4 Inch	75-100
No. 4	35-75
No. 200	0-15

703.10 Screenings.

1. The screenings shall be No. 10 size gravel, stone, or air-cooled slag. Where crushed material is specified, it shall be crushed from material larger than the 1/2 inch sieve.
2. Loss, sodium sulfate soundness, percent, maximum..... 15

704 MASONRY UNITS

704.01 Clay or Shale Brick. ASTM C 32, Grade SM, with the following exception:

- 4.1 Size. The units shall be 8-1/4" x 3-5/8" x 2-3/4".
- 7.1 Sampling and Testing. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

704.02 Concrete Brick. ASTM C 55, Type II, Grades N 11 or S 11 with the following exceptions and additions:

3. Materials. 3.1.1 and 3.1.2, Cement shall conform to 701 Portland Cement. 3.2 Aggregate shall conform to the quality requirements of 703.02.
7. Methods of Sampling and Testing. 7.1. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer. 7.2. Brick shall be sampled and tested in accordance with ASTM C 140 except that each sample shall consist of 12 full sized brick.

Size and Shape. The units shall be of such size and shape as to permit their incorporation in the structure in conformance with the specified dimensions of the structure. They shall be of a rectangular cross section with square corners. The ends, edges and one face shall have plain surfaces.

704.03 Concrete Masonry Blocks. ASTM C 139, with the following exceptions and additions:

4. Dimensions and Permissible Variations. In addition, the units shall be of such size and shape as to permit their incorporation in the structure in conformance with the specified dimensions of the structure.

5. Sampling and Testing. 5.1 Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

705 CONCRETE PAVEMENT INCIDENTALS

705.01 Hot Applied Joint and Crack Sealer. ASTM D 3405.

705.02 Cold Applied Joint Sealer. ASTM D 1850.

705.03 Preformed Fillers. AASHTO M 153 or AASHTO M 213, with the following exceptions and additions:

3.7 Asphalt Content. The producer shall certify to the Engineer that the asphalt cement content is at least 35 percent by weight of the filler.

Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

705.04 Hot Applied Joint Sealer. Furnish hot applied joint sealer conforming to ASTM D 6690, Type II Use this material as the primer for Type 3 membrane.

705.05 Burlap Cloth. AASHTO M 182, Class 2.

705.06 Sheet Materials for Concrete Curing. AASHTO M 171, moisture loss and reflectance only.

705.07 Liquid Membrane-forming Compounds for Curing Concrete. ASTM C 309 Type 1, Type 1-D or Type 2, Class B, with the following additions:

8.1 Packing and Marking. The containers for Type 2 white pigmented liquid membrane forming compounds shall be equipped with mechanical agitators. Drums containing resin base compound shall be marked "Resin Base." Each drum in any batch or lot shall have a number assigned as the drum is being filled.

705.08 Waterproofing Polyethylene Film.

705.10 Air-Entraining Admixtures. AASHTO M 154.

705.11

705.11 Preformed Elastomeric Compression Joint Seal for Concrete.

AASHTO M 220 with the following exceptions and additions:

- 5.1 Size and design shall be as shown on the plans.
- 7.2 Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site, or at other locations designated by the Engineer.
- 7.3 A minimum of 6 linear feet shall constitute one sample.
- 8.3 Specimens for the low temperature recovery tests shall be lightly dusted with talc on the outside surfaces only.
- 11.1 In addition, one-foot length markings shall be not less than 11-15/16 nor more than 12-1/8 inches from center to center.

The lubricants for installation of preformed compression seals shall be as recommended by the seal manufacturer.

Qualification. Each design, shape, width, depth, web and shell thickness shall be approved by the Engineer prior to use. Drawings of the seals showing all dimensions and dimension tolerances and weight per foot shall be submitted with the request for design approval. A copy of Certified Test Data covering the specified properties of preformed elastomeric joint seals shall accompany the request for approval. A 6-foot length of elastomeric joint sealer shall be submitted concurrently with the request for qualification.

705.12 Chemical Admixture for Concrete. ASTM C 494. The minimum relative durability factor shall be 90.

705.13 Fly Ash for Use in Portland Cement Concrete. ASTM C 618, Class C or F, except the maximum loss on ignition shall be 3 percent.

705.15 High Molecular Weight Methacrylate (HMWM) Resin. Provide low viscosity, non-fuming high molecular weight methacrylate (HMWM) resin conforming to the following:

Viscosity	Less than 25 cps (Brookfield viscometer, Model RVT with UL adaptor or Model LVF, # spindle and UL adaptor C @ 77 °F (25 °C) (ASTM D 2849)
Density	Greater than 8.4 lb/gal Ca 77 °F (25 °C) (ASTM D 2849)
Flash Point	Greater than 200 °F (93 °C) (PenskyMartens CC) (ASTM D 93)
Vapor Pressure	Less than 1.0 mm Hg C @ 77 °F (25 °C) (ASTM D 323)
TG (DSC)	Greater than 135 °F (58 °C) (ASTM D3418)
Shelf Life	Must be 1 year minimum at manufacturers recommended environmental considerations
Gel Time	Greater than 40 min, 100 g mass (ASTM D 2471) (thin film)
Percent Solids	Greater than 90% by weight

Bond Strength	Greater than 1500 psi (10.5 MPa) (ASTM C 882)
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Use a No. 6 (20M) deformed reinforcing bar 30 inches (760 mm) long, cleaned and degreased. After thoroughly cleaning the hole, grout the bar into the test block or cylinder as recommended by the resin manufacturer. Hold and center the bar perpendicular to the concrete surface in the grout-filled hole during the curing period.

Cure the resulting specimen at $77 \pm 5^\circ \text{F}$ ($25 \pm 3^\circ \text{C}$) for 24 hours. Apply an axial pull out load to the bar at a rate of 1/2 inch (13 mm) per minute until the bar pulls out of the specimen, or the concrete block or cylinder cracks or spalls. Record the failure mode and applied load.

Supply the polyester, vinylester, and epoxy resins in non-reactive containers and with their MSDS. Label containers with the name of the mixture, the manufacturer, the shelf life expiration date, the batch number, quantity, and instructions.

Maintain storage areas between 40° and 100°F (5° and 38°C).

705.23A Epoxy-Urethane Sealers. Provide an Epoxy-Urethane sealer conforming to the following requirements: Absorption - ASTM C642 (non-air entrained concrete). Proportion and mix concrete according to ASTM C672. Sealed concrete, under total immersion, will not exceed 1.0% after 48 hours or 2.0% after 50 days

Scaling Resistance - ASTM C672 A rating of "No scaling" after 100 cycles on the sealed concrete (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete.

NCHRP 244, Series 11 - Cube Test

3.1 Weight gain - not to exceed 25% of untreated cube

3.2 Absorbed chloride - not to exceed 25% of untreated cube

NCHRP 244, Series IV - Southern Exposure

4.1 Absorbed chloride - not to exceed 10% of untreated concrete

Record and report the application rate (square footage/gallon) of sealer during the tests.

Provide test data from an approved independent testing facility. The sealer manufacturer funds the testing costs.

Furnish the test data, a one quart sample, and the MSDS to the City of Akron Materials Testing Lab for approval.

705.23

705.23B Non-Epoxy Sealer. Provide an Non-Epoxy sealer conforming to the following requirements:

Absorption - ASTM C642 (non-air entrained concrete). Proportion and mix concrete according to ASTM C672. Sealed concrete, under total immersion, will not exceed 1.0% after 48 hours or 2.0% after 50 days

Scaling Resistance - ASTM C672 A rating of "No scaling" after 100 cycles on the sealed concrete (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete.

NCHRP 244, Series 11 - Cube Test

3.1 Weight gain - not to exceed 25% of untreated cube

3.2 Absorbed chloride - not to exceed 25% of untreated cube

NCHRP 244, Series IV - Southern Exposure

4.1 Absorbed chloride - not to exceed 10% of untreated concrete

Record and report the application rate (square footage/gallon) of sealer during the tests.

Provide test data from an approved independent testing facility. The sealer manufacturer funds the testing costs.

Furnish the test data, a one quart sample, and the MSDS to the City of Akron Materials Testing Lab, who will determine material acceptance.

705.24 Soluble Reactive Silicate. Provide a soluble reactive silicate (SRS) that is a blend of Na/K/FlxSiOx (sodium, potassium, fluoro or other silicate), surfactants, polymers, and stabilizers capable of thoroughly saturating and sealing concrete. The treatment system will meet the following performance requirements:

A. Scaling Resistance - Treated concrete will pass ASTM C 672, Scaling Resistance test with a rating of 'No Scaling' after 100 cycles (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete

B. Absorption - The absorption of treated concrete under total immersion will not exceed 1.0 percent after 48 hours or 2.0 percent after 50 days (ASTM C 642, non-air entrained concrete). Concrete should be proportioned and mixed in accordance with ASTM C 672.

C. Skid resistance - The skid resistance of treated concrete pavement will not be reduced by more than 10 percent as compared to the same untreated pavement. ASTM E 274 using ASTM E 501 ribbed tire at 40 mph (64 kph), five test average.

D. AASHTO T 259 as modified. The standard T 259 Resistance of Concrete to Chloride Ion Penetration will be modified as follows:

In addition to section 3.1, intentionally break the specimens so they have a full depth crack through the middle of the slab. Install section 3.2 dams around the perimeter of the re-assembled, cracked, concrete specimens. Caulk around the perimeter of the dam to assure that only the crack and the concrete will allow water to pass through or be absorbed. After assembly, measure the crack width at three locations and report the crack width.

Perform the ponding of 3.4 until the 3% solution comes through the specimen's crack. Record and report the time required for the solution to appear through the specimen's crack. Remove the solution from the specimens and re-dry according to 3.3 (T 259).

After drying apply the SRS to the specimen's top surface at the manufacturer's recommended rate of application. Record and report the rate of application. Air dry the SRS coated dammed sample specimens for 7 days. After 7 days, re perform the ponding with 3% chloride solution until solution comes through the specimen's crack or 14 days. Record the time till the ponded solution comes through the crack.

Acceptable SRS materials will have a value of 2 or more when the ponding time before SRS application is divided into the ponding time after SRS application. Sections 3.5, 3.6, 4.1.4.2 and 5.1 (of T 259) will not apply.

Have tests performed by an approved independent testing facility acceptable to the Engineer.

Submit test data and a one quart (one liter) a technical data sheet and the MSDS to the City of Akron Materials Testing Lab for approval

705.25 Gravity-Fed Resin. Provide non shrink, non metallic resin conforming to ASTM C 881, Type 1, Grade 1, Class B or C and the following:

The maximum viscosity at the lowest allowable temperature will be 250 cps. The manufacturer will provide test data to verify the viscosity at the lowest temperature for the class for which it is to be approved.

A minimum average sand retention of 95.0% for three samples tested according to the Sand Penetration Test Method described below.

Show no signs of cracking, debonding or insufficient curing during the sand penetration test

SAND PENETRATION TEST METHOD. This test will be conducted with the following equipment and materials:

1. 4 oz [118 ml] wax coated paper cup. Maximum top diameter 2 5/16" [59 mm]; bottom diameter 1 11/16" [43 mm]; height 2 3/8" [60 mm].
2. 20 - 30 grade sand (ASTM C 778)
3. Pint non-absorbent container
4. 8 oz [240 ml] plastic cup
5. Stirring stick or spatula
6. Scale accurate to 0.1 g
7. Disposable gloves
8. Stop watch
9. Thermometer
10. Paint brush

Perform the test as follows

1. Assure the material and the room is at 73° F [23°C]
2. Determine and record the tare weight of the paper cup (1).
3. Introduce 100.0 grams of 20 - 30 graded sand (2) into the paper cup.
4. Record the weight of the cup and the sand
5. Consolidate the sand in the cup by lifting the cup approximately ½ " [13 mm] and dropping 25 to 30 times. Then lightly tap the sides of the cup 25 to 30 times with the fingers. The sample may also be placed on a vibrating table for 10 to 15 seconds.
6. Measure enough material into the 8 oz plastic cups (4) to make at least a 200 g sample.
7. Combine the components into the non-absorbent container (3) and mix according to the manufacturer's recommendations using a spatula or stirring stick (5).
8. Pour 40.0g of material over the sand and record the weight of the resin, cup and sand
9. Allow the resin, sand and cup to set undisturbed for 24 hours at 73°F [23°C]. Re-weigh the resin, cup and sand
10. Remove as much of the paper cup from around the hardened resin and sand matrix as possible. Lightly brush any loose sand from the matrix. Weigh the hardened matrix.
11. Calculate the percent of sand retained [F] as follows:

$$F = [E / (D-A)] \times 100$$

[A] Tare weight of paper cup (g)

[B] Weight of cup and sand (g)

[C] Weight of fresh mixture of resin, cup and sand (g)

[D] Weight of cured mixture of resin, cup and sand (g)

[E] Weight of resin sand matrix as measured in step 10 (g)

12. Report the average of three specimens mixed separately

13. Also calculate and report the percent loss due to curing [G] as follows:

$$G = [(D - C) / (C - B)] \times 100$$

14. Examine the sand / resin matrix for signs of insufficient curing and bond, or excessive shrinkage.

MATERIAL APPROVAL. The manufacturer will provide certified test data verifying compliance with the above requirements; technical data sheet; current MSDS for the material; 1 gallon sample; and a letter certifying that the product formulation will not be altered without notification to the Engineer.

The City of Akron Materials Testing Lab will determine acceptance of the material.

705.26 Epoxy injection Resin. Provide epoxy injection resin capable of application,, positive adherence and strength development when applied to moist or wet surfaces at temperatures of 33° F (1° C) and above.

Use products that contain 100% solids material and no non-reactive diluents, solvents or other fillers. Provide materials that meet the following requirements:

A. The injection will meet the requirements of ASTM C 881 Type IV, Grade 1 and Class B or C and viscosity 600cps at the lowest ambient material and substrate temperature to be used.

B. The paste materials will meet the requirements of ASTM C 881 Type I , Grade 3 and Class B or C.

Material Approval.

The manufacturer of the materials is responsible for prequalifying the material and submitting the following to the City of Akron Materials Testing Lab:

A. An Independent certified test data indicating that the materials, when mixed according to the manufacturer's recommendations, meet the requirements listed above.

B. Manufacturer's technical data sheet for the paste and injection materials.

706.01

- C. MSDS for paste and injection materials.
- D. 1 Gallon Sample or 2 kits of the injection materials

706 CONCRETE AND CLAY PIPE

706.01 Non-Reinforced Concrete Pipe. ASTM C 14.

706.02 Reinforced Concrete Circular Pipe. ASTM C 76.

Acceptance. Concrete pipe may also be judged for acceptance on the basis of cores cut from the pipe wall.

Visual Inspection. The core will be examined for reinforcing steel area and spacing, steel position as to cover depth, lack of bond between cement paste and reinforcing steel, and void around the reinforcing steel.

Void Inspection. If voids are found larger than one quarter of the diameter of the reinforcing steel and extending along the steel throughout the core diameter, the pipe will be subject to retest. If the same condition is found in the retest pipe, the pipe will be rejected.

Test Specimens. The pipe to be cored will be the same as tested for three edge bearing test and the retest pipe will be two for one the same as ASTM C 76.

Marking. In addition, after the capital letter "D" designating the D-load, the design wall thickness in inches expressed as a decimal. Pipe with "S" stirrups shall have the symbol S. Pipe requiring axis orientation without lift holes (i.e., stirrup pipe, quadrant reinforced pipe, elliptically reinforced pipe) shall have the center line of the crown of the pipe marked inside and outside with the symbol TB. Pipe with quadrant steel shall be marked with the symbol Q. Pipe with elliptical reinforcement shall be marked with the symbol E. Pipe with deformed wire reinforcement required in the design shall have the symbol DF.

All reinforced concrete pipe shall be manufactured using Type II Cement.

706.03 Reinforced Concrete Pipe, Epoxy Coated. ASTM C 76. In the plant, the interior barrel and joint surface areas of the concrete pipe for sanitary or combined sewers shall be prepared as per manufacturer's recommendations so as to remove all forms of oil, laitance and other deleterious materials. Concrete must be etched with a 15 to 20% muriatic acid solution or brush blasted to achieve a medium grade profile. The surface so prepared shall then be lined with a high build, polyamide-cured, 2-component coal tar epoxy coating "Bitumastic No. 300-M" as manufactured by Koppers Company, Inc., Pittsburgh, Pennsylvania 15219, or an approved equal, each meeting Military Specification DOD-P-23236A (SH), Type 1,

Class 2. The lining compound shall be sprayed two or more coats with a maximum of ten to twelve dry mils (twelve to fourteen wet mils) per coat to obtain a continuous and relatively uniform and smooth lining. The total dry film thickness should not be less than 20 mils (0.02 inches). Additional coatings may be necessary for pipes to be laid on steel grades or within industrial areas, as shown on plans. All coated pipe shall be free of surface irregularities such as air bubbles, delaminations, lumping, sagging, blistering, pinholes or porosity in the coating film.

All reinforced concrete pipe shall be manufactured using Type II cement.

706.04 Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe. ASTM C 507. All reinforced concrete pipe shall be manufactured using Type II cement.

706.06 Perforated Concrete Pipe. ASTM C 444. All reinforced concrete pipe shall be manufactured using Type II cement.

706.07 Concrete Drain Tile. Extra-quality concrete drain tile ASTM C 412.

706.08 Vitrified Clay Pipe. ASTM C 700, extra strength.

706.11 Resilient and Flexible Gasket Joints. For concrete pipe, ASTM C 443.

706.12 Resilient and Flexible Joints. For vitrified clay pipe, ASTM C 425.

706.13 Precast Reinforced Concrete Manhole Riser Sections and Precast Catch Basin and Inlet Tops. ASTM C 478 with the following additions:

Joints. ASTM C 443.

Compression Tests. Compression tests for satisfying the minimum specified concrete strength requirements shall be made from cores not less than 3-1/2 inches in diameter drilled from the wall of the risers, cones or tops. Cores shall be obtained, prepared for testing, and tested by the appropriate methods of AASHTO T 33.

Precast Reinforced Concrete Manhole, Epoxy Coated. In the plant, the interior barrel, joint and slab top surface areas of the precast manhole for sanitary or combined sewers shall be prepared as per manufacturer's recommendations so as to remove all forms of oil, laitance and other deleterious materials. Concrete must be etched with 15 to 20% muriatic acid solution or sandblasted. The surface so prepared shall then be lined with a high-build, polyamide-cured, 2-component coal tar epoxy coating "Bitumastic No. 300-M" as manufactured by Koppers Company, Inc., Pittsburgh, Pennsylvania 15219, or an approved equal, each meeting Military Specifications DOD-P-23236A (SH), Type I, Class 2. The lining compound shall be sprayed two or more coats with a maximum of ten to twelve dry mils (twelve to fourteen wet mils) per coat to obtain a continuous and relatively uniform and smooth lining. The total dry film thickness should not be less than 20 mils (0.02 inches).

706.14

Additional coatings may be necessary within industrial areas, as shown on the plans. All coated surface of manhole shall be free of surface irregularities such as air bubbles, delaminations, lumping, sagging, blistering, pinholes or porosity in the coating film.

706.14 Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes. ASTM C 923.

706.15 Flexible Plastic Gasket. For concrete pipe, AASHTO M 198, Type B, with the following exception:

4.3 Flash point and fire point are waived.

707 STEEL AND PLASTIC PIPE

707.01 Galvanized Corrugated (2-2/3 x 1/2) Steel Pipe. This pipe shall conform to AASHTO M 36 with the following additions:

Type I Pipe and Type II Pipe. Helical corrugated pipe, 12 inch diameter and larger, shall have at least two circumferential corrugations at each end of each pipe length.

Dimensions. The minimum wall thickness (before galvanization) of steel pipe and pipe-arches shall be as follows:

	Pipe		Pipe-Arch	
	Diameter Inches	Wall Thickness Inches	Size Inches	Wall thickness Inches
Item 554 Roadway Culverts	6	0.052		
	8	0.064		
	10	0.064		
	12	0.064		
	15	0.064	17 x 13	0.064
	18	0.064	21 x 15	0.064
	21	0.064	24 x 18	0.064
	24	0.064	28 x 20	0.064
Item 555 Drainage Culverts	27	0.064		
	30	0.064	35 x 24	0.064
	33	0.064		
	36	0.064	42 x 29	0.064
	42	0.064	49 x 33	0.079
	48	0.064	57 x 38	0.109
	54	0.079	64 x 43	0.109
	60	0.109	71 x 47	0.138
	66	0.138	77 x 52	0.168
	72	0.138	83 x 57	0.168
	78	0.168		
	84	0.168		

Minus tolerances shall be in accordance with AASHTO M 218

TABLE 1 - PIPE REQUIREMENTS

Nominal inside Diameter (inches)	Corrugation Depth Nominal (inches)	Minimum Width of Lap (inches)
27	1/2	2
33	1/2	2

Coupling Bands. The bands for pipe diameters 60 inches and greater may be less than 16-1/4 inches, provided they have a circumferential corrugation that indexes into the inboard corrugation of the pipe, have a minimum width of 10-1/2 inches and are equipped with harness fasteners consisting of two bolts through each strap-bar assembly.

Samples. Six inch by six inch manufacturer's coupons which are representative of furnished pipe will be accepted as samples if they are properly identified as to manufacturer, size, type of pipe, thickness and heat number of base material. Samples cut from the pipe will be required if coupons are not available or if there is any question as to the identity of the coupons.

707.02

707.02 Galvanized Corrugated (3 x 1) Steel Pipe. This pipe shall conform to AASHTO M 36 with the following additions:

Type I pipe and type II pipe. Helical corrugated pipe shall have at least two circumferential corrugations at each end of each pipe length.

Dimensions. The minimum wall thickness (before galvanization) of steel pipe and pipe-arches shall be as follows:

Pipe		Pipe-Arch	
Diameter Inches	Wall Thickness Inches	Size Inches	Wall thickness Inches
36	0.064	40 x 31	0.079
42	0.064	46 x 36	0.079
48	0.064	53 x 41	0.079
54	0.064	60 x 46	0.079
60	0.064	66 x 51	0.079
66	0.064	73 x 55	0.079
72	0.064	81 x 59	0.079
78	0.064	87 x 63	0.079
84	0.064	95 x 67	0.079
90	0.064	103 x 71	0.109
96	0.079	112 x 75	0.109
102	0.079	117 x 79	0.109
108	0.109	128 x 83	0.138
114	0.109	137 x 87	0.138
120	0.109	142 x 91	0.168

Minus tolerances shall be in accordance with AASHTO M 218.

Coupling Bands. The bands for pipe diameters 60 inches and greater may be less than 16-1/4 inches provided they have a circumferential corrugation that indexes into the inboard corrugation of the pipe, have a minimum width of 10-1/2 inches and are equipped with harness fasteners consisting of two bolts through each strap-bar assembly.

707.03 Structural Plate Corrugated Steel Structures. Structural plate pipe, pipe-arch and arch structures shall conform to AASHTO M 167, with the following exceptions:

Random Sampling. Six inch by six inch coupons which are representative of furnished plates will be accepted as samples if they are properly identified as to manufacturer, thickness, weight of coating and heat number of base metal. Samples cut from the plates will be required if coupons are not available or if there is any question as to the identity of the coupons.

Accessories. Assembly bolts may be galvanized by mechanical or electrolytic processes in lieu of hot-dipping.

707.04 Bituminous Coated Corrugated (2-2/3 x 1/2) Steel Pipe and Pipe Arches. These pipes and coupling bands shall conform to 707.01 and to AASHTO M 190, Type A, with the following exception:

Methods of Sampling and Testing (Par. 5.3.2). Flow Test. The bituminous cement shall not lose its stability when subjected to the following test:

Parallel lines shall be drawn along the crest of the corrugations of a representative sample of coated pipe and a specimen placed on end in a constant temperature oven, with the parallel lines horizontal. The temperature of the specimen shall be maintained within 2°F of 150°F (65°C) for a period of four hours. At the end of this time, no part of any line shall have dropped more than 1/4 inch.

707.05 Paved Bituminous Coated Corrugated (2-2/3 x 1/2) Steel Pipe and Pipe Arches. These pipes and coupling bands shall conform to 707.01 and to AASHTO M 190, Type B half bituminous coated and paved invert or Type C fully bituminous coated and paved invert, except that the flow test shall be as specified in 707.04.

707.06 Bituminous Coated Corrugated (3 x 1) Steel Pipe and Pipe Arches. These pipes and coupling bands shall conform to 707.02 and to AASHTO M 190, Type A, except that the flow test shall be as specified in 707.04.

707.07 Paved Bituminous Coated Corrugated (3 x 1) Steel Pipe and Pipe Arches. These pipes and coupling bands shall conform to 707.02 and to AASHTO M 190, Type B half bituminous coated and paved invert, or Type C fully bituminous coated and paved invert, except that the flow test shall be as specified in 707.04.

707.08 Welded and Seamless Steel Pipe. ASTM A 53.

707.10 Square and Rectangular Steel Tubing. ASTM A 500 or A 501.

707.11 Welded and Seamless Alloy Steel Pipe. Scope 1. These specifications cover welded and seamless alloy steel pipe. The pipe shall comply with the requirements of ASTM A 53 with the following exceptions:

Chemical Requirements 5. The steel shall conform to the following requirements:

	Minimum Percent	Maximum Percent
Carbon		0.20
Manganese		1.00
Phosphorus		0.08
Sulfur		0.05
Copper	0.75	1.25

707.12

Nickel	1.60	2.20
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Tensile Requirements 7. The steel shall conform to the following minimum requirements:

Tensile strength, pounds per square inch, min.....	50,000
Yield strength, pounds per square inch, min.....	37,500
Elongation in two inches, min., percent.....	30

Rejection 24. Each length of pipe failing to meet the requirements of these specifications or which develops injurious defects in shop working or application will be rejected.

707.12 Corrugated Aluminum Alloy Pipe. This pipe shall conform to AASHTO M 196.

707.13 Bituminous Lined Corrugated (2-2/3 x 1/2) Steel Pipe and Pipe Arches. This pipe shall comply with the requirements of 707.04 and AASHTO M 190, Type D, and shall have an essentially concentric, cylindrical, smooth inner surface formed by a bituminous lining. The bituminous lining shall have a minimum thickness of 1/8 inch above the crests of the corrugations.

707.14 Bituminous Lined Corrugated (3 x 1) Steel Pipe and Pipe Arches. This pipe shall comply with the requirements of 707.06 and AASHTO M 190, Type D, and shall have an essentially concentric, cylindrical, smooth inner surface formed by a bituminous lining. The bituminous lining shall have a minimum thickness of 1/8 inch above the crests of the corrugations.

707.15 Plastic and Polyethylene Corrugated Drainage Pipe or Tubing. AASHTO M 252, with the following exceptions:

Nominal Diameter. Tolerances shall be plus or minus 3 percent.

Heavy Duty Tubing shall be marked "heavy duty."

Table I Heavy Duty Tubing Stretch Resistance shall be 7.5 percent maximum.

707.16 Fiber Bonded Corrugated Steel Pipe. The pipe shall conform to 707.01 and 707.02 with the following exceptions:

The pipe shall be fabricated from corrugated sheets coated on both sides with a layer of heavy inert fibers which are saturated with bitumen after they have been embedded in the pipe coating.

Prior to furnishing the pipe, the contractor or supplier shall submit for the Engineer's approval a complete set of the manufacturer's detailed specifications for the coating materials and coating process.

707.17 Fiber Bonded Corrugated Steel Pipe Arches. The pipe arches shall conform to 707.03 with the following exceptions:

Corrugated steel sections used in the pipe arches shall be coated as specified in 707.16.

707.18 PVC Composite Sewer Pipe. Pipe and fittings shall conform to ASTM D 2680, with the following additions and exceptions:

Solid wall PVC pipe for house connection sewers (6" diameter) shall conform to 707.20.

All pipe shall be certified by the manufacturer to meet the applicable ASTM specification requirements. Certification forms, together with a report of the test results, shall be provided to the inspector with pipe deliveries, and copies shall be forwarded to the Engineer and Testing Lab.

The City may choose to make tests for which the manufacturer shall submit samples at no cost to the City. Certification forms shall include project name, location, contractor, and test lot number. Lot sizes shall be acceptable to the Engineer.

Joints shall be gasketed conforming to ASTM D-3212, using elastomeric gaskets conforming to ASTM F477. Use only lubricant supplied or recommended for use by the pipe manufacturer. Verify that the ends of the pipe are marked to indicate insertion stop (home) position, and ensure that pipe is inserted into pipe or fitting bells to this mark. Protect the end of the pipe during homing and do not use excessive force that may result in over-assembled joints or dislodged gaskets. If full insertion is not achieved, disassemble and clean the joint and reassemble. All pipe ends shall be properly sealed prior to joining the pipe using a material recommended by the pipe manufacturer.

Factory made fittings must be used on all house connections or other connections. Bedding material for house connections (sanitary sewer house laterals) shall be equal to that of the main sewer. Risers in deep or unstable trenches should be embedded in Class I materials only. Brackets or anchors shall be used to hold end caps or plugs in place on sanitary sewers for the purpose of withstanding air test pressures. Caps or plugs shall not be chemically welded in place.

All pipe and fittings shall be suitably marked to provide manufacturer's name, lot or production number, ASTM designation, ABS, nominal diameter and SDR number. Fittings, however, need not contain the lot or production number. Pipe shall have a "home" mark. Composite pipe with an absence of filler material at the ends greater than 1/4" deep shall be subject to rejection or must be repaired, if required, to an acceptable condition.

707.19

707.19 P.V.C. Pressure Pipe. Pipe and fittings shall conform to ASTM D 2241 and ASTM D 2672 with the following additions or exceptions:

All pipe and fittings shall conform to the design stress required by the plans or specifications. Where no design stress is shown all pipe and fittings shall be designed for 100 psi or greater.

All pipe and fittings shall be suitably marked to provide manufacturer's name or trademark, lot or production number, ASTM designation, PVC cell classification, SDR number and nominal diameter. Fittings, however, need not contain a lot number, cell classification or SDR number. Pipe shall have a "Home" mark.

707.20 PVC Gravity Sewer Pipe. Pipe and fittings shall conform to ASTM D 3034 for 4"-15" pipe, with the following additions and exceptions:

All pipe and fittings for sanitary, storm and combined sewers shall conform to SDR 26 for mainline and SDR 23.5 for laterals.

All pipe shall be certified by the manufacturer to meet the applicable ASTM Specifications requirements. Certification forms, together with a report of the test results, shall be provided to the inspector with pipe deliveries, and copies shall be forwarded to the Engineer and Testing Lab. The City may choose to make spot tests for which the manufacturer shall submit samples at no cost to the City. Certification forms shall include project name, location, Contractor and test lot number. Lot sizes shall be acceptable to the Engineer.

All joints shall be of the elastomeric gasket type, and shall be assembled per manufacturer's recommendations and ASTM D3212. Care shall be taken to insure all joints are being pushed to the full "Home" position and held tightly in the "Home" position during any grade or line adjustments.

Factory made fittings must be used on all house connections or other connections. Bedding material for house connections (sanitary sewer house laterals) shall be equal to that of the main sewer. Risers in deep or unstable trenches shall be embedded in Class I materials only. Brackets or anchors shall be used to hold end caps or plugs in place on sanitary sewers and house laterals for the purpose of withstanding air testing pressures. Caps or plugs shall not be chemically welded in place.

All pipe and fittings shall be suitably marked to provide manufacturer's name or trademark, lot or production number, ASTM designation, PVC cell classification, SDR number and nominal diameter. Fittings, however, need not contain a lot number, cell classification or SDR number. Pipe shall have a "Home" mark.

707.21 Polyethylene Corrugated Drainage Pipe and Tubing. Diameters 12" to 24" conforming to AASHTO M 294

707.22 Aluminized Steel. Type II pipe shall conform to AASHTO M 274.

707.23 Corrugated Polyethylene Watertight Smooth Lined Pipe. Smooth lined corrugated polyethylene pipe, closed profile polyethylene pipe, couplings and fittings conforming to AASHTO M 294, Type S, SP or D, with the following modifications:

- 1.1.1 Nominal sizes of 4 to 60 inches are included.
- 4.1.2 Annular corrugated pipe (Type S or SP) or closed profile pipe (Type D) shall be provided.
- 6.1 Carbon black may be blended with the virgin resin by means of a carrier resin. The proportioning of the carrier resin to carbon black shall not be greater than 3:1.
- 7.2.1 Nominal diameters shall be 4, 6, 8, 10, 12, 15, 18, 24, 30, 36, 42, 48, 54, and 60 inches.
- 7.2.2 The inner liner of Type S and SP pipe, and both inner and outer walls of Type D pipe shall have the following minimum thicknesses, when measured in accordance to 7.2.2.

Diameter (Inches)	Inner Wall Thickness (Inches)	Diameter (Inches)	Inner Wall Thickness (Inches)
4	0.020	24	0.060
6	0.020	30	0.060
8	0.025	36	0.060
10	0.025	42	0.065
12	0.035	48	0.070
15	0.040	54	0.070
18	0.050	60	0.070

- 7.4 When tested in accordance with Section 9.1, the pipe shall have a minimum pipe stiffness at 5 percent deflection as follows:

Diameter (Inches)	Pipe Stiffness (lbs./in./in.)	Diameter (Inches)	Pipe Stiffness (lbs./in./in.)
4	50	24	34
6	50	30	28
8	50	36	22
10	50	42	20

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12	50	48	18
15	42	54	16
18	40	60	14

- 7.8.5 For Corrugated Polyethylene Smooth Lined Pipe, joints shall conform to the most current edition of AASHTO M 294. All joints shall be gasketed and watertight according to the requirements of ASTM D3212. Gaskets shall be made of polyisoprene meeting the requirements of ASTM F477. If deemed necessary by the Engineer, water-tightness of joints shall be field-tested per ASTM F1417 or C969. Any testing shall be performed by the Contractor, with the cost to be included in the unit price bid for the pipe.

- 9.1 Test specimens shall have a minimum length of 12 inches or one pipe diameter, whichever is greater.

- 11.1.3 In addition, pipe with diameters 4 through 10 inches inclusive may be marked "AASHTO M 252". Pipe with diameters 54 or 60 inches may be marked "AASHTO M P7".

- 12.1 All pipe shall be certified by the manufacturer to meet all applicable ASTM or AASHTO specification requirements, including all amendments herein. Certification forms, along with test results shall be provided to Resident Project Representative with pipe deliveries, and copies shall be forwarded to the Engineer and Testing Lab.

707.24 PVC Smooth Interior Pipe. Provide PVC profile wall pipe with a smooth interior that consists of an outer wall fused to a smooth inner wall. Nominal size of 4, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, and 36 inch diameter pipe are included for pipe, joints, and fittings. Minimum pipe stiffness shall be 46 pounds/inch/inch. Pipe shall be made of PVC compounds having a cell classification of 12454B as defined in ASTM D 1784. Provide storm sewer and drain pipe conforming to ASTM F 949 or AASHTO M 304, with the following modifications:

ASTM F 949

5.2.4 Perforated pipe may be specified.

- 10.1 The manufacturer shall furnish test data annually to the City or at any time when the method of manufacture has changed. Provide letter of certification to cover each shipment of material verifying that it meets specification requirements.

ASTM M 304

- 10.5 The manufacturer shall furnish test data annually to the City or at any time when the method of manufacture has changed. Provide letter of

certification to cover each shipment of material verifying that it meets specification requirements.

707.25 Glass Fiber Reinforced Pipe. Provide Glass Fiber Reinforced Thermosetting Resin Pipe (RTRP), or Glass Fiber Reinforced Polymer Mortar Pipe (RPMP), conforming to ASTM D 3262. Minimum pipe stiffness shall be 36 pounds/inch/inch.

All pipe shall be certified by the manufacturer to meet all applicable ASTM or AASHTO specification requirements, including all amendments herein. Certification forms, along with test results shall be provided to Resident Project Representative with pipe deliveries, and copies shall be forwarded to the Engineer and Testing Lab.

707.26 High Density Polyethylene Pipe (HDPE). Provide High Density Solid Wall Polyethylene Pipe and fittings conforming to ASTM F 714.

Materials used for the manufacture of polyethylene pipe and fittings shall be PE3408 high density polyethylene meeting cell classification 355464C for black or 345464E for color or stripes per ASTM D 3350; and shall be listed in the name of the pipe and fitting manufacturer in the PPI (Plastic Pipe Institute) TR-4 with a standard grade HDB rating of 1600 psi at 73° F.

Joints between plain end pipes and fittings shall be made by butt fusion. Joints between the main and saddle branch fittings shall be made using saddle fusion. The butt fusion and saddle branch fusion used shall be procedures that are recommended by the pipe and fitting manufacturer. The Contractor shall ensure that persons making heat fusion joints have received training in the manufacturer's recommended procedure. The Contractor shall maintain records of trained personnel, and shall certify that training was received not more than 12 months prior to commencing construction. External and internal beads shall not be removed.

All pipe shall be certified by the manufacturer to meet all applicable ASTM or AASHTO specification requirements, including all amendments herein. Certification forms, along with test results shall be provided to Resident Project Representative with pipe deliveries, and copies shall be forwarded to the Engineer and Testing Lab.

707.27 PVC Drain waste and Vent Pipe. Provide PVC drain, waste, and vent pipe and fittings with nominal size of 1 1/4 through 12 inch diameter conforming to ASTM D 2665, with the following modifications:

8.1 The retest provisions do not apply.

- 10 Furnish certified test data as defined in 101.08 to the Engineer. Perform inspection at the project site.

708 PAINT

708.01 Raw Linseed Oil. ASTM D 234.

708.02 Boiled Linseed Oil. ASTM D 260, Type 1.

708.03 Turpentine. Destructively distilled wood turpentine, ASTM D 13.

708.04 Mineral Spirits. ASTM D 235, Type 1.

708.05 White Structural Paint. AASHTO M 70, Type I, with the following exception:

Vehicle 5. The vehicle shall contain not less than 85 percent raw or boiled linseed oil 708.01 or 708.02, the balance to be combined drier and thinner. The thinner shall be turpentine 708.03, mineral spirits 708.04, or a mixture thereof.

When this paint is used as a prime coat for wood, linseed oil and thinner shall be added as follows and thoroughly mixed.

	Minimum	Maximum
Paint	1 gal.	1 gal.
Linseed Oil, 708.01 or 708.02	1 qt.	2 qts.
Drier where raw linseed oil is used		1/4 pt.
Turpentine, 708.03	1 pt.	1 qt.

708.12 Aluminum Paint. AASHTO M 69 with the following exceptions:

Scope 1. This specification covers two types of aluminum paint for exterior use, both of which are two-component systems. The primer paint containing a non-leafing pigment is suitable for prime coats on wood and intermediate on metal after undercoating with a suitable primer. The finish paint containing a leafing pigment is suitable for finish coat on wood and metal.

Aluminum paste and varnish shall be furnished in separate compartments or containers and in the proportion of two pounds of paste per gallon of varnish. In addition, the packages shall contain the correct amount of paste to combine with the containers of varnish furnished. The aluminum paste and varnish shall be combined immediately prior to the use of the aluminum paint.

Detailed Requirements 3. The pigment shall be aluminum paste meeting the requirements of ASTM D 962. The primer shall meet Type 4, Class B, medium. The finish shall meet Type 2, Class B, medium. The primer pigment shall have no leafing.

General Requirements 4. The varnish used for both primer and finish shall be a high grade long oil, water-resisting type FSS TT-V-81 Type II and shall show the specified leafing when used with finish pigment. It shall be clear and free from suspended matter and shall not thicken in the container. The use of free or limed rosin will not be permitted. The oils, resins, driers and thinners shall be of such type and so proportioned and treated that proper drying and brushing characteristics will be obtained on both cold and hot days. Manufacturers desiring to use solvent naphtha must first have the approval of the Engineer. When flowed on a smooth vertical tin panel the varnish shall dry hard without wrinkling. The varnish shall also meet the following requirements:

	Minimum	Maximum
Non-volatile oils and resins	50%	---
Acid number (based on non-volatile)	---	15
Viscosity, Gardner Holdt	C	E
Set to touch	1/2 hr.	4 hrs.
Dry hard	---	18 hrs.

Air Dry Bend Test. The varnish shall be flowed on a smooth vertical tin panel (thickness 0.011 inches) and allowed to air dry at room temperature for 72 hours. The panel shall then be bent through 180 degrees over a 1/8 inch rod. No cracking, checking or flaking shall be noticeable.

The same panel shall be cooled at 0° C (32° F) for 1 hour and immediately bent through 180 degrees over a 1/8 inch rod. No cracking, checking or flaking shall be noticeable.

The bent portion at either temperature shall show satisfactory adhesion under a knife test.

Cold Bend Test. The varnish shall be flowed on a smooth vertical tin panel (thickness 0.011 inches) and allowed to air dry for one hour at room temperature. The panel shall then be baked for five hours at 105° C to 110° C (221° F to 230° F), cooled at 0° C (32° F) for one hour and immediately bent through 180 degrees over a 1/8 inch rod. No cracking, checking, or flaking shall be noticeable.

Water Resistance. The varnish shall be flowed on a smooth vertical tin panel and allowed to air dry for 48 hours at room temperature. The panel shall then be placed for 18 hours in a beaker containing 2-1/2 inches of distilled water at room temperature (immerse the end of the panel which was uppermost during the drying period). Only slight whitening shall occur and shall entirely disappear within one hour after removal from the water.

Color of Varnish. The color shall not be darker than a freshly prepared solution of three grams of potassium dichromate in 100 cubic centimeters of pure sulfuric acid (sp. gr. 1.84).

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Tinting. 6a. Note 2 does not apply.

708.14 Traffic Zone Paint. White and yellow ready-mixed traffic paint suitable for centerlining and edgelineing the various types of pavement.

Composition. The manufacturer shall formulate the paint in such a manner as to meet the requirements of this specification.

Finished Paint. The paint shall be a suitable binder for glass beads on pavement exposed to traffic. It shall not deteriorate in storage, within one year after date of receipt, to the extent that it cannot be readily broken up with a paddle to a smooth uniform paint capable of easy application by spray. Paint, purchased by Purchase Orders, which deteriorates in storage within one year shall be replaced at no cost to the City.

The paint shall not bleed or discolor when sprayed on bituminous surfaces.

Type 1 paint shall be the fast dry, water-based 100% acrylic type.

Type 2 paint shall be the fast dry, alkyd type.

Type 3 paint shall be the conventional, water-based 100% acrylic type.

Type 4 paint shall be the conventional, alkyd type.

All paint shall comply to the following requirements:

	Minimum	Maximum
Consistency, Krebs Units		
Type 1	75	85
Type 2	90	110
Type 3	65	75
Type 4	65	75
Dry Time (No Track), minutes:		
Type 1	---	2
Type 2	---	2
Type 3	---	30
Type 4	---	30
Prime Pigment Content, percent by weight of paint:		
Type 1 white	11.0	---
yellow	10.0	---
Type 2 white	17.0	---
yellow	17.0	---
Type 3 white	8.0	---
yellow	9.0	---
Type 4 white	17.0	---
yellow	17.0	---
Pigment Content, percent by weight of paint:		
Type 1 white		
yellow	---	50
Type 2 white	---	50
yellow	---	61
Type 3 white	---	61
yellow	---	53
Type 4 white	---	53
yellow	---	61
	---	61
Nonvolatile Vehicle Solids Content, percent by weight of paint:		
Type 1 white		
yellow	24	---
Type 2 white	24	---
yellow	12	---
Type 3 white	12	---
yellow	17	---
Type 4 white	17	---
yellow	13	---
	13	---
Fineness of Grind, micrometers:		
All types	50	---
Bleeding Ratio, D969:		
Type 1 white	0.97	---
yellow	0.97	---
Type 2 white	0.95	---
yellow	0.93	---

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Type 3 white	0.97	---
yellow	0.97	---
Type 4 white	0.94	---
yellow	0.94	---
Color		
a. White, Daylight Directional Reflectance, ASTM E 1347:		
Type 1		
Type 2	90	---
Type 3	91	---
Type 4	88	---
	90	---
b. Yellow		
1. Refer to Highway Yellow Color Tolerance Chart PR Color No. 1, June, 1965 U.S. Dept. Of Transportation FHWA: Yellow, Color Difference 595-33538, ASTM D2244 I. Measure E, L, a, b as Cielab, Source "C"		
Type 1 and 3		
L		
a		
b	+1.5	+5.0
Type 2 and 4		
L	+1.0	+5.0
a	+3.0	+13.5
b	+1.5	+5.5
	+0.5	+9.0
	+0.5	+15.0
Dry Opacity, D 2805 at 0.005 wet:		
Type 1 and 3	097	---
Flexibility, all types and colors:		
a. TT-P-1952 B, Section 4.5.4		
Type 1	---	Passes
Type 3	---	Passes
b. TT-P-85E		
Type 2	---	Passes
Type 4	---	Passes
Freeze-Thaw Stability, TT-P-1952 B, Section 4.5.7:		
Type 1 and 3	---	5 KU
Change 10% difference in Scrub Resist		

708.15 Prime Paint. A semi-quick drying paint suitable for use as a prime coat on clean iron and steel surfaces. This paint shall have a basic lead silicochromate pigment and a linseed oil-alkyd (1 to 1) vehicle. The paint shall comply with FSS TT-P-615, Type II.

708.16 White Guardrail Paint. SSPC-PS 1.04:

- a. Primer: TT-P-641, Type I.
- b. Intermediate Coat: SSPC - Paint 104, Type II, tinted. The color shall closely approach FSS 595A-16492.
- c. Finish Coat: SSPC - Paint 104, type I.

708.17 Inorganic Zinc Silicate Primer Paint. AASHTO M 300, Type I or Type III, with the following additions.

Color. A green colorant approximating No. 34159 of FS 595A.

Prequalification. Prior to use, the Contractor shall submit to the Engineer copies of the manufacturer's certified test data showing that the material complies with the qualitative, quantitative and performance requirements of this specification. The test data shall be developed by an approved testing laboratory, and shall include the brand name of the paint, name of manufacturer, number of the lot tested and date of manufacture. When the paint has been approved by the Engineer, further performance testing by the manufacturer will not be required unless the formulation or manufacturing process has been changed, in which case new certified test results will be required.

708.18 Blue-Green Vinyl Finish Coat. This specification covers a vinyl paint suitable for use over cured inorganic zinc silicate prime paint when applied in accordance with the manufacturer's printed instructions.

Pigment. The pigments shall be finely ground and not be livered, skinned or settled to the degree that they cannot easily be redispersed.

Vehicle. The vehicle shall consist essentially of vinyl chloride-vinyl acetate copolymer resins containing sufficient plasticizers to insure an adequate tensile strength for the binder.

Finished Paint. The finished paint shall meet the following requirement and possess a color closely approaching Federal Standard No. 595-34241:

	Minimum	Maximum
Pigment, percent	27.0	---
Vehicle solids, percent	21.0	---
Total solids, percent	48.0	---
Weight per gallon, pounds	9.0	11.0

Material Quality Assurance. The viscosity of the paint shall be within ± 5.0 Krebs Units of the viscosity of the previously submitted sample. The weight per gallon of the paint shall be within ± 0.3 pounds of the previously submitted sample.

708.19 Structural Steel Prime Paint. FSS TT-P-615, Type V.

709 REINFORCING STEEL

709.01 Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
ASTM A 615, with the following exceptions and additions:

Test Specimens 12.1. Tension test specimens shall be the full section of the bar as rolled.

Number of Tests 13.1. Where positive identification of a heat can be made, one tension test and one bend test shall be made from each bar designation number of each heat in the lot. Where identification of the heat is not practicable, one tension test and one bend test shall be made for each bar designation number in each lot of 10 tons or fraction thereof.

Inspection 15.1. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Laboratory.

709.03 Rail Steel Deformed and Plain Bars for Concrete Reinforcement.
ASTM A 616, with the following exceptions and additions:

Note 2. A lot is defined as all of the bars of one bar number and pattern of deformation or bar size for plain bars contained in an individual shipment, or all bars of one bar number and pattern of deformation or bar size for plain bars in a stock identified as rolled from rails varying not more than ten pounds per yard.

Test Specimens 11.1. Tension test specimens shall be the full section of the bar as rolled.

Inspection 14.1. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Laboratory.

709.05 Axle Steel Deformed and Plain Bars for Concrete Reinforcement.
ASTM A 617, with the following exceptions and additions:

Note 2. A lot is defined as all the bars of one bar number and pattern of deformation or bar size for plain bars contained in an individual shipment, or all bars of one bar number and pattern of deformation or bar size for plain bars in a stock identified as rolled from axles with a single carbon range.

Test Specimens 12.1. Tension test specimens shall be the full section of the bar as rolled.

Inspection 15.1. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

709.08 Cold-Drawn Steel Wire for Concrete Reinforcement. ASTM A 82, with the following exceptions:

Finish 8.2. Galvanized wire shall be completely covered in a workmanlike manner with a coating of pure zinc of uniform thickness, so applied that it will adhere firmly to the surface of the wire. The minimum weight of zinc coating shall be 0.8 ounces of zinc per square foot of surface as determined by ASTM A 90.

Inspection 11. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

709.09 Fabricated Steel Bar or Rod Mats for Concrete Reinforcement. ASTM A 184 with the following exceptions:

4. Materials. Bars shall be deformed.

(a) Welded bar mats. Bar mats shall have a maximum carbon content of 0.35 percent. Longitudinal bars shall conform to 709.01 Grade 60. Transverse bars shall conform to 709.01.

(b) Clipped bar mats. Longitudinal bars shall conform to Grade 60 of 709.01, 709.03 or 709.05.

Inspection 9.1. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

709.10 Welded Steel Wire Fabric For Concrete Reinforcement. ASTM A 185 with the following exceptions:

Inspection 13. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

709.11 Deformed Steel Wire for Concrete Reinforcement. ASTM A 496, with the following exception:

709.12

Inspection 13. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

709.12 Welded Deformed Steel Wire Fabric for Concrete Reinforcement. ASTM A 497, with the following exception:

Inspection 13. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

709.13 Epoxy Coated Reinforcing Steel. ASTM A 775, with the following exceptions and additions:

4.1 Steel reinforcing bars to be coated shall meet the requirements of 709.01, 709.03 or 709.05, and shall be free of oil, grease, or paint.

4.2 The coating material shall meet the requirements listed in Annex A7 and shall be a color that facilitates inspection of the installed bar. The color shall be subject to approval of the Engineer.

4.2.1 and 4.3 In addition, written certification and samples mentioned in these sections shall be required.

7.3.1 The adhesion of the coating shall be evaluated by bending production coated bars around a mandrel of specified size as prescribed in bending tables in ASTM A 615, ASTM A 616 or ASTM A 617 as applicable. The bend test for adhesion of the coating shall be made at a uniform rate and shall take up to 90 seconds to complete. The two longitudinal deformations shall be placed in a plane perpendicular to the mandrel radius, and the test specimens shall be at thermal equilibrium between 68°F and 86°F (20°C and 30°C).

11. Delete last sentence. Replace with: Tests, inspection and sampling shall be made at a site as specified by the Engineer. Sampling for testing shall require three 30-inch samples for each bar size, for each coating lot or for each heat of steel reinforcing bars.

12.1 All damaged coating areas greater than 1/4-inch square or 1/4-inch diameter; approximately 1/8-inch square or 1/8-inch diameter if the opening is within 1/4 inch of an equal or larger opening; or, a length of 6 inches regardless of area, shall be repaired with a patching material.

12.2 Coating damage due to fabrication or handling need not be repaired in cases where the damaged area is less than 12.1.

12.4 The patching material shall be of the same composition and quality as the original coating. The surface preparation shall be as per section 5.1

(SSPC-SP10 near white metal blast) or a surface preparation approved by the Engineer.

14. Certification shall be required.

Where reinforcing bar cages for prestressed concrete beams are fabricated by tack welding, the areas damaged by the tack welding shall be patched as outlined above.

710 FENCE AND GUARDRAIL

710.01 Barbed Wire. ASTM A 121, Class 3 Galvanizing, or ASTM A 585, Type 1, Class 2 coating, with the following exceptions:

(a) Exceptions to ASTM A 121, Class 3:

Ordering Information 3.2. Sentence one relative to billing shall not apply.

Size and Construction 5. Barbed wire strand wires shall be No. 12^{1/2}, 13^{1/2} or 15^{1/2} steel wire gage. Barbs shall be 4 point round steel wire spaced 5 inches center to center.

Weight of Coating 8. The weight of coating for various gages of wire composing the strands and barbs shall be not less than 0.80 ounces per square foot of surface.

Sampling 10.2. Test Specimens. Sufficient completed barbed wire shall be cut from the end of a spool to provide a sample length of 5 feet.

10.3. Does not apply.

Inspection 12. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

(b) Exceptions to ASTM A 585, Type I, Class 2:

Size and Construction 6. Barbed wire strand wires shall be No. 12^{1/2} steel wire gage. Barbs shall be 4 point round steel wire spaced 5 inches center to center.

Weight of Coating 9. The weight of coating of various gages of wire composing the strands and barbs shall be not less than 0.30 ounces per square foot of surface.

Sampling 11. Test specimens. Sufficient completed barbed wire shall be cut from the end of a spool to provide length of 5 feet.

710.02

11.3. Does not apply.

In addition the minimum breaking strength shall be in accordance with ASTM A 121.

Inspection 13. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

710.02 Woven Steel Wire Fence Type 47 ASTM A 116 Class 3 galvanizing, with the following exceptions:

Basis of Purchase 3.2. Sentence one relative to billing does not apply.

Size and Style 7. The fence fabric shall be Simplified Practice Recommendations R 9-47 design number 1047-6.9.

Inspection 11. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

Galvanizing. In addition, all hardware and attachments shall be galvanized in accordance with 711.02.

710.03 Chain-Link Fence. AASHTO M 181 with the following exceptions and additions:

(1) General. Gate frames shall be constructed of tubular members and, for gate leaves more than 8 feet wide, shall have intermediate members and/or diagonal truss rods to provide gates of ample strength free from sag or twist.

Gates shall be swing type, complete with latches, stops, keepers, hinges, locks and fabric. Hinges shall be of adequate strength to support the gate and shall not twist or turn under action of the gate. Latches shall be of the plunger bar type and shall be full gate height located in a manner that will engage the gate stop. Forked latches may be used for single gates less than 10 feet wide. Latches shall provide for locking. Stops shall consist of a flush plate with anchor to be placed in concrete to engage the plunger bar of the latch. Other approved types of stops may be used for single gates less than 10 feet wide. Keepers shall be substantial devices for securing and supporting the free end of the gate in open position.

Gates shall be covered with fabric matching the fence.

Top rails shall be furnished in lengths not less than 18 feet. Top rail couplings shall be self-centering, outside sleeve type at least 6 inches long. A minimum of 20

percent of the couplings shall have an internal heavy spring to take up expansion and contraction.

Post tops shall be provided with a hole suitable for through passage of the top rail. They shall fit snugly to the post, have a means of attaching securely to the post and exclude moisture from tubular posts.

Truss and brace rods shall be steel 3/8 inch outside diameter or equivalent cross section and shall have suitable adjustment.

Brace bands shall be beveled edge bars 1 x 1/8 inch section.

Chain-link fence fabric 60 inches high and under shall be furnished knuckled on both selvages.

Chain-link fence fabric over 60 inches high shall be furnished with knuckling at one selvage and barbing at the other.

Sampling. Certified copies of the chemical and physical properties of each of the aluminum components shall be furnished the Engineer.

Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Engineer.

(2) Steel posts, gate frames, post braces, brace rails and top rails shall conform to the requirements of Table 710.03-1.

Stretcher bars shall have a 3/16 x 3/4 inch cross section or equivalent cross section with length equal to full height of fabric.

Gate frames shall be assembled by welding or by means of heavy fittings making rigid and watertight connections.

Post tops shall be ornamental caps of steel, malleable iron or cast iron.

Fabric ties shall be not less than 0.148 inch diameter aluminum alloy or galvanized steel wire or bands having not less than 0.8 ounces of zinc per square foot.

Type I zinc-coated steel chain link fabric shall be (9 gage) 0.148 inch diameter wire, Class B weight coating, 2 inch mesh. Vinyl coated fabric shall be 0.148 inch wire before coating.

The vinyl covering shall be uniformly colored as specified.

(3) Aluminum posts, gate frames, post braces, brace rails and top rails shall conform to the requirements of Table 710.03-2.

710.03

Stretcher bars shall be flat bars 3/4 to 1/4 inch section.

Gate frames shall be assembled by welding using properly designed, formed sheet or sandcast fittings.

Hinges shall be the offset type. Latches, stops and keepers shall be galvanized malleable iron except plunger bars which may be galvanized tubular or bar steel conforming to 6.2.

Turnbuckles shall be wrought or cast.

Bolts shall have anodic coating at least 0.0002-inch in thickness, chromate sealed.

Tie wire shall be 0.148-inch diameter wire ASTM B 211 Alloy 100 H 18 temper.

**TABLE 710.03-1
STEEL POSTS, GATE FRAMES, POST BRACES, AND TOP RAILS**

Usage--nominal fence height 6 feet or less	Section	Outside Diameter or Dimension Inches	Weight		Min. Yield Strength Psi	
			Nominal lb./ft.	Tolerance %		
Line Posts	Grade 1 Pipe	2.375	3.65	-5	25,800	
	Grade 2 Pipe	2.375	3.12	-5	50,000	
	C-Section	2.25 x 1.70	2.73	-6	45,000	
	H-Section	2.25 x 1.70	3.26	-5	45,000	
End, corner pull posts	Grade 1 Pipe	2.875	5.79	-5	25,800	
	Grade 2 Pipe	2.875	4.64	-5	50,000	
	Square	2.5	5.70	-3	40,000	
	Roll-form	3.5 x 3.5	5.14	-6	35,000	
Gate posts, for nominal width of gate (Single or one leaf of Double): Up to 6 feet incl. Over 6 to 13 feet incl. Over 13 to 18 feet incl. Over 18 feet	Grade 1 Pipe Grade 2 Pipe Square Roll-form	2.875	5.79	-5	25,800	
		2.875	4.64	-5	50,000	
		2.5	5.70	-3	40,000	
		3.5 x 3.5	5.14	-6	35,000	
	Grade 1 Pipe Grade 2 Pipe Square	4.0	9.11	-5	25,800	
		3.5	5.21	-5	48,000	
		3.0	9.35	-3	40,000	
	Grade 1 Pipe	6.625	18.97	-5	25,800	
	Round	8.625	24.70	-5	25,800	
	Gate Frames	Grade 1 Pipe	1.900	2.72	-5	25,800
		Grade 2 Pipe	1.900	2.28	-5	50,000
		Square	2.00	2.66	-3	40,000
Top Rails, *post braces	Grade 1 Pipe	1.660	2.27	-5	25,800	
	Grade 2 Pipe	1.660	1.84	-5	50,000	
	H-Section	1.50 x 1.31	2.25	-5	45,000	
	Roll-form	1.625 x 1.25	1.35	-6	35,000	
	Round tubing	1.660	1.38	-5	50,000	

*When tension wire is specified, it shall be of 0.177 inch diameter.

**TABLE 710.03-2
DIAMETERS OF PLAIN END, SCHEDULE 40 ALUMINUM ALLOY PIPE**

The weights and dimensions shall be as specified in ANSI H 35.2.

<u>Material</u>	<u>Nominal Pipe Size in.</u>
Brace rails and top rails.....	1-1/4
Gate frames and rail couplings.....	1-1/2

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Line posts	2
End and corner posts	2-1/2

Gate posts--single or one leaf of double:

Gate opening--feet	
to 6, inclusive	2-1/2
over 6 to 12, inclusive	3-1/2
over 12 to 18, inclusive	6
over 18 to 32, inclusive	8

710.06 Deep Beam Rail. AASHTO M 180, Type II Class A, with the following exceptions:

The minimum check limits for both triple and single-spot tests apply.

Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the laboratory.

Acceptance by sampling shall apply.

In addition: (a) in lieu of samples, Certified Test Data covering the mechanical properties may be furnished with each identified heat of guardrail in conjunction with a field check of coating thickness indicating satisfactory coating weights. However, when a field check of coating thickness shows insufficient coating weight the guardrail shall be sampled and tested.

(b) One piece of rail element, back up plate and end or buffer section may represent the entire lot.

710.09 Wire Rope Rail. AASHTO M 30 Class A, Type I Rope.

Inspection. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Laboratory.

710.10 Guardrail Hardware. Unless otherwise specified, all fittings, bolts, washers and other accessories shall be galvanized in accordance with 711.12.

710.11 Fence Posts and Braces. Wood posts shall be round and conform to the requirements of 710.12 and 710.14. Dimension timber, posts and lumber for braces and stream crossings shall be sound, straight, free from knots, splits and shakes, and shall be treated in accordance with 712.06.

Steel line posts shall be either U, Y, T or channel sections. They shall have corrugations, knobs, notches or studs so placed and constructed as to engage a

substantial number of fence line wires in the proper position. Punched tabs for fastening wires are not permitted. Posts shall have tapered anchors weighing 0.67 pounds or more, each firmly attached by means of welding, riveting or clamping. Posts shall have a nominal weight of 1.33 pounds per linear foot exclusive of the anchor plus or minus 3-1/2 percent for any lot of posts. Permissible variation in length shall be a maximum of one inch under and two inches over the designated length. Excessive bow, camber, twist or other injurious defects in posts shall be cause for rejection. Each post and anchor shall be hot dip galvanized in accordance with 711.02. Each line post shall be furnished with a sufficient number of galvanized wire fasteners or clamps, of not less than 0.120 inch in diameter, for attaching fence wire to the post. Fasteners or clamps shall be galvanized in accordance with ASTM A 116 Class 3.

710.12 Square Sawed, and Round Guardrail Posts. Butt treated posts shall be made of seasoned white oak, pine or fir. Pressure treated posts shall comply with 710.14 and 712.06. Posts shall be cut from growing timbers and shall be free from unsound or loose knots and rot and from injurious or excessive shake, and season checks that exceed 1/4 inch in width.

Round posts shall have a uniform taper and sweep shall not exceed three inches. Round posts shall be peeled their entire length, removing all outer and inner bark and leather fiber by shaving the surface. Knots shall be trimmed even with the post, and both ends of the post shall be sawed square.

Square sawed posts shall be free from injurious cross grain and sapwood. They may contain a limited number of sound knots that do not exceed two inches in diameter. They shall be free from wane above the ground line. Wane below the ground line shall be limited to two adjacent corners and shall not exceed 1-1/2 inches measured along the wane.

710.13 Butt Treated Guardrail Posts. Posts shall conform to the requirements of 710.12. The lower four feet of all posts to be butt treated shall be continuously immersed or soaked in a bath of hot creosote oil, 712.06, for a period of at least two hours. The oil shall be maintained at a temperature of 175°F to 225°F and for at least three-fourths of that time the temperature shall be 210°F or higher. The time of immersion shall be increased, if necessary, to obtain a minimum penetration of 1/8 inch.

710.14 Pressure Treated Guardrail and Fence Posts, Braces and Blocks. Posts, braces and blocks shall conform to the requirements of AASHTO M 168 and 710.11, 710.12 and 712.06.

All posts, braces and blocks originating within the State of Ohio shall be subject to inspection by an authorized Agent of the City. Material originating outside the State of Ohio shall be inspected before treatment for conformance to the requirements of this specification, other than treatment, by an agency qualified and approved by the Engineer for such inspection. The material shall bear the identification mark of the

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inspection agency and a certificate of inspection shall be forwarded to the Engineer. The cost of this inspection and furnishing reports shall be included in the price bid for material.

710.15 Steel Guardrail Posts. These posts shall be of the section and length as specified. They shall be of copper bearing steel when so specified. Steel shall conform to ASTM A 36. Posts shall be galvanized in accordance with 711.02.

711 STRUCTURAL STEEL AND STRUCTURE INCIDENTALS

711.01 Structural Steel. Steel shall be structural steel ASTM A 36 or, when specifically called for, high-strength low alloy steel ASTM A 572 Grades 42 through 50, or A 588.

Material designated to meet notch toughness requirements shall have a minimum longitudinal Charpy V-notch (CVN) energy absorption value as listed below. Sampling and testing procedures shall be in accordance with ASTM A 673. The (H) frequency of heat testing shall be used, and the test data shall be provided as required by 501.07.

ASTM Designation	Thickness and Connection Method	Min CVN Value
A 36	Up to 4" mechanically fastened or welded	15 ft lb @ 40° F
A 572, A 588	Up to 4" mechanically fastened	15 ft lb @ 40° F*
A 572, A 588	Over 2" to 4" welded	20 ft lb @ 40° F*
A 572, A 588	Up to 2" welded	15 ft lb @ 40° F*

*If the yield point of the material exceeds 65 ksi, the temperature of the CVN value for acceptability should be reduced by 15°F for each increment, or part of increment, of 10 ksi above 65 ksi.

711.02 Galvanized Steel. Steel shall be galvanized to conform to ASTM A 123 after cutting, bending and welding. At the discretion of the Engineer, damaged galvanized material shall be replaced, regalvanized or repaired. If a repair is authorized, the method shall be acceptable to the Engineer.

Weight of coating. Bolts and similar threaded fasteners may be mechanically zinc coated in accordance with ASTM B 454, Class 50. Except for ASTM A 325, electrogalvanized items meeting the above coating requirements may also be used.

All galvanized parts that are to be embedded in fresh concrete, except chairs for reinforcing bar support, shall be given a chromate treatment in accordance with the

American Hot Dip Galvanizers Association, Inc. recommendations. The galvanizer shall furnish a certification for each lot of chromate treated steel.

711.03 Steel for Sheet Piling. ASTM A 328.

711.04 Cold Rolled Steel. ASTM A 108, Grade 1016 through 1030 for pins, rollers, trunnions and other similar parts.

711.07 Steel Castings. ASTM A 486, Class 70 or ASTM A 27, Grade 70-36 with the following additions.

Steel castings shall be free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. No sharp, unfilleted angles or corners will be allowed.

711.08 Arc-Welding Electrodes and Fluxes. The following applies except for exposed bare ASTM A 242 and A 588 steels. See Table 711.08-1 for exposed bare ASTM A 242 and A 588 applications.

(A) Manual shielded metal-arc welding.

- (1) AWS A 5.1
- (2) AWS A 5.5

(B) Submerged arc welding.

- (1) AWS A 5.17
- (2) AWS A 5.23

(C) Gas metal-arc welding, AWS A 5.18

(D) Flux cored arc welding, AWS A 5.20

Table 711.08-1

Filler Metal requirements for exposed bare applications of ASTM A 242 and A 588 steel

711.09

Welding Process		
Shielded metal arc	Submerged arc	Gas metal arc or Flux cored arc ^{2, 4}
AWS A5.5	AWS A5.23	AWS A5.18
E8016 or 18-G ^{1, 2}	F7X-EXXX-W ^{2, 3}	AWS A5.20
E8016 or 18-B1 ²	F7X-EXXX-B1 ^{2, 3}	AWS A5.28
E8016 or 18-B2 ²	F7X-EXXX-B2 ^{2, 3}	AWS A5.29
E8015 or 18-B2L ²		62 ksi min YP
E8016 or 18-Cg	F7X-EXXX-Ni1 ³	(403 M Pa)
E8016 or 18-C2	F7X-EXXX-Ni2 ³	72 ksi min TS
E8016 or 18-C3	F7X-EXXX-Ni3 ³	(495 M Pa) Elon. 18% min.

1. Deposited weld metal shall have the following chemical composition: C, max %, 0.12; Mn, %, 0.50/1.30; P, max %, 0.03; S, max %, 0.04; Si, %, 0.35/0.80; Cu, %, 0.30/0.75; Ni, %, 0.40/0.80; Cr, %, 0.45/0.70.

2. Deposited weld metal shall have a minimum impact strength of Charpy V-notch 20 ft/lb (27.1 J) at 0°F (-18°C) (only applied to bridges).

3. The use of the same type of filler metal having next higher mechanical properties as listed in AWS specification is permitted.

4. Deposited weld metal shall have a chemical composition the same as that for any one of the weld metals in this table for the shielded metal arc welding process.

Certified test data showing compliance with the specified requirements shall be submitted for each lot of electrodes proposed for use.

711.09 High-Strength Steel Bolts, Nuts and Washers. ASTM A 325, with the following exception:

Inspection 11. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Laboratory.

Bolts for steel used in bare unpainted applications shall be ASTM A 325 Type 3.

When galvanized bolts, nuts and washers are specified, they may be mechanically galvanized.

Bolts used to fasten steel painted according to 514 System A shall be galvanized and need not be painted

711.10 Machine Bolts. ASTM A 307 with the following exception:

Inspection 11. Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site or at other locations designated by the Laboratory.

Mechanical galvanizing is permitted.

711.12 Gray Iron Castings. ASTM A 48, minimum Class 30, and AASHTO M 306-05 with the following exceptions:

Number of tests and retests. (a) Two or more test bars shall accompany each lot of castings, or one pair of test bars may represent castings shipped to two or more projects provided the lot number or date cast are cast in both the bars and castings, or such identification shall be anchored in the castings and test bars. The identifying data on castings shall not interfere with the use of the casting.

Workmanship and Finish. In addition, the castings shall be free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. They shall be generously filleted at angles and the arrises shall be sharp and perfect.

Inspection. Inspection shall be made at the project site. Test bars representing the lot shall be made available to the Laboratory at the place of manufacture or warehouse from the lot to be shipped, or shall accompany the lot shipped.

711.13 Ductile Iron Castings. ASTM A 536 and AASHTO M 306-05 with the following additions and exceptions:

Workmanship and Finish. In addition, the castings shall be free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength. They shall be generously filleted at angles and arrises shall be sharp and perfect. All castings shall be cleaned of all rust, scale, grease and foreign matter and shall receive two coats of an approved bituminous paint, if required by plans or standard drawings.

Number of tests. A keel block or Y-block specimen made in accordance with A 536 shall accompany the shipment for each heat number, ladle number and date of casting.

Inspection. Inspection shall be made at the project site.

Certification. Test bars shipped with castings shall be accompanied by a certification stating the bars were prepared in accordance with specified requirements.

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711.14 Stainless Steel Fasteners. Stainless steel fasteners shall be passivated and have a smooth lustrous finish. The manufacturer shall certify that the material furnished was passivated.

711.15 Sheet Copper. ASTM B 370.

711.16 Phosphor Bronze Plate. ASTM B 100.

711.17 Cast Bronze. ASTM B 22, Copper Alloy No. 91100 with the following addition:

The cast plate shall be finished to plane surfaces and one plate of a pair shall be finished at right angles to the other plate of the pair.

711.18 Leaded Bronze. ASTM B 584, Copper Alloy No. 93700 with the following addition:

The cast plate shall be finished to plane surfaces and one plate of a pair shall be finished at right angles to the other plate of the pair.

711.19 Sheet Lead. ASTM B 29.

711.20 Aluminum for Railings. Aluminum other than permanent mold castings shall conform to the following requirements:

	American Society for Testing Materials		
	Designation	Alloy	Condition or Temper (B 296)
Sand castings	B 26	356.0	T6
Shims	B 209	1100	0
Washers	B 209	Clad 2024	T4
		6061	T6
Sheet and plate	B 209	6061	T6
Drawn seamless tubes			
Bars, rods, wire	B 210	6061 or 6063	T6
Bolts, set screws	B 211	6061	T6
	B 211	2024*	T4
Nuts		6061	T6
	B 211	6061	T6
Extruded bars, rods, shapes		6262	T9
	B221	6061 or 6063	T6
		6351	T5
Extruded tubes			
	B 221	6061 or 6063	T6
Pipe		6351	T5
Rivets	B241	6061 or 6063	T6
	B316	6061	T6

* Shall have an anodic coating.

Permanent mold cast aluminum for bridge railing posts shall comply with the requirements of AASHTO M 193.

711.21 Preformed Bearing Pads. Composition. Preformed bearing pads shall consist of a fabric and rubber body. The pad shall be made with new, unvulcanized, natural and/or synthetic rubber and unused cotton and/or synthetic fabric fibers in proper proportion to maintain strength and stability.

Physical Properties. The surface hardness expressed in standard rubber hardness figures shall be 80 ± 10 Shore Durometer. The ultimate breakdown limit of pads under compressive loading shall not be less than 10,000 pounds per square inch. The pads shall be furnished to specified dimensions with all bolt holes accurately located and cleanly cut.

711.23 Elastomeric Bearings. Bearing pads and laminated bearings shall be of the compound known as neoprene and shall be cast in molds under pressure and heat. A plain elastomeric bearing pad and steel load distribution plate combination shall be classified as a laminated elastomeric bearing. Test specimens shall be in accordance with ASTM D 3182 or D 3183. Where test specimens are cut from the finished product, a 20 percent variation from the original physical properties is allowed. Compound of nominal hardness between the values shown in the following table may be used and the test requirements interpolated.

PHYSICAL PROPERTIES	GRADE		
	50	60	70
Original Physical Properties: Hardness, Durometer A, ASTM D 2240 Tensile Strength, min psi, ASTM D 412 Elongation at break, min %	50 ± 5 2,500 400	60 ± 5 2,500 350	70 ± 5 2,500 300
Accelerated Tests to Determine Long-Term Aging Characteristics, Oven-Aged 70 hrs/212° F, ASTM D 573: Hardness, points change, max Tensile strength, % change, max. Elongation at break, % change, max Ozone-1 ppm in air by volume - 20% strain - 104° F - ASTM D 1149, 100 hrs	+15 -15 -40 No Cracks	+15 -15 -40 No Cracks	+15 -15 -40 No Cracks
Samples to be solvent wiped before test to remove any traces of surface impurities) Compression set - 22 hrs/212 °F - ASTM D 395, Method B, % max Adhesion, bond made during vulcanization - ASTM D 428, Method B, lbs/in.	35 40	35 40	35 40

Bearing pads may be molded individually, cut from previously molded strips or slabs, or extruded and cut to length. Laminated bearings shall be molded together into an integral unit with all edges of internal steel laminates covered by a 1/8 inch minimum thickness of elastomer. Indentations or groves on the exterior surface of the bearings caused by external laminate restraining devices shall be filled to a 1/8 inch minimum cover by a re-vulcanized patch; or by a silicone caulk conforming to Federal Specification TTS - 001543A; or by an approved equal. The patching shall be done by the bearing manufacturer.

The external connection or distribution plates of laminated bearings shall be the same material as the attached structural steel and be similarly cleaned and coated; internal plates shall be ASTM A 36 or A 570, Grade 36 or Grade 40. All plates shall be deburred. The internal plates shall not be less than 0.074 inch thick.

The manufacturer shall proof load each laminated elastomeric bearing with a compressive load equal to 1.5 times the maximum design load as per Article 25.7, Bearing Tests and Acceptance Criteria, Division II, Construction, of the AASHTO Standard Specifications for Highway Bridges. The testing shall be included in the price bid for the bearings. Acceptance of the bearing shall be according to Level I acceptance criteria of Article 25.7.

The manufacturer shall furnish certified test data for the elastomer, base plate, steel laminates and proof load.

711.24 Waterproofing Fabric. Furnish waterproofing fabric according to ASTM D 173.

711.25 Type 2 Membrane Waterproofing.

Physical Properties

Thickness ASTM D 1777	60 mils (1500 m) min.
Width	36 inches (914 mm) min.
Pliability [180 bend over 1/4 inch (6 mm) mandrel @ -25 F (-32 C)] ASTM D 146	No Effect
Elongation ASTM D 412 (Die C)	300% min
Puncture Resistance-Membrane ASTM E 154	40 lb (18 kg) min.
Permeance (Grains/ft ² /hr/in Hg) ASTM E 96, Method B	0.1 max.
Water Absorption (% by Weight) ASTM D 570	0.2 max.
Adhesion to concrete ASTM D 903	5.0 min.
Submit certified test data and letter of certification to the Engineer.	

711.26 Structural Timber, Lumber and Piling. AASHTO M 168 with the following additions:

Timber and lumber shall be air dried or kiln dried to a moisture content not to exceed 19 percent by weight. Size and grade shall conform to American Lumber Standards.

All untreated lumber shall bear the Association Grade Mark of a Regional Association of Lumber Manufacturers and shall be graded under the rules of one of the following associations:

- (1) West Coast Lumber Inspection Bureau
- (2) Western Wood Products Association
- (3) Southern Pine Inspection Bureau
- (4) Northern Hardwood and Pine Manufacturers Association

The untreated lumber shall be graded by, and bear the mark of an agency certified for grading under the rules of one of the above associations.

All treated timber and lumber except piling, guardrail posts, fence posts, braces, and spacer blocks originating outside the State of Ohio shall be certified before treatment as to grade, specie, and grading agency by the following means:

- (a) A certificate of inspection from an approved grading agency.
- (b) A mark of identification on one end of each piece indicating grading agency, grade and producer. Such identification is to be applied by the manufacturer producing the material.

711.27

711.27 Prestressing Steel. ASTM A 416 with the following exception:

Inspection. Sampling and inspection as directed by the Laboratory.

711.28 Cellular Polyvinyl Chloride Sponge. Cellular polyvinyl chloride sponge shall meet the requirements of AASHTO M 153, Type I, except the density of the PVC sponge shall be not less than 20 pounds per cubic foot.

711.29 Plastic Pipe and Fittings. ASTM D 2661, D 2665, D 2680, D 2751, D 3033, D 3034 or F679 with the following additions:

Certification and Inspection. Certified test data as defined in Section 101.08 shall be furnished the Engineer. Inspection shall be done at the project site. Random samples shall be obtained at the project site or at other locations designated by the Laboratory.

The retest provisions of the above ASTM specifications do not apply.

711.30 Type 3 Membrane Waterproofing. Furnish Type 3 membrane waterproofing conforming to the following requirements.

Physical Properties

Thickness	0.135 inches (3.43 mm) min.
Width	36 inches (914 mm) min.
Weight	0.8 lb/ft ² (3.875 kg/mm ²) min.
Tensile strength (machine direction) ASTM D 882	275 lb/in (48.1 N/mm)
Modified ^[1]	200 psi (13.8 MPa)
Tensile strength ASTM D 882 (90 machine direction)	150 lb/in (26.2 N/mm)
Modified ^[1]	1000 psi (6.9 MPa)
Elongation at break ASTM D 882	
Modified ^[1]	100%
Brittleness ASTM D 517	Pass
Softening point (mastic) ASTM D 36	200° F (93° C) min.
Peel adhesion ASTM D 413 ^[1]	2.0 lb/in (0.35 N/mm)
Cold flex ASTM D 146	No cracking
2 5 inch (50 125 mm) Specimen-180 bend over 2 inch (50 mm) mandrel	
Heat stability	No dripping or delamination
2 5 inch (50 125 mm) specimen vertically suspended in a mechanical convection oven 2 hr @ 190° F (88° C)	

[1]12 inches (300 mm)/minute test speed and 1 inch (25 mm) initial distance between the grips.

Submit certified test data and letter of certification to the Engineer.

711.31 Reinforced Propylene Plastic Manhole Steps. Steps shall conform substantially with details shown on the plans. Steel rods shall be continuous through the entire length of legs and tread.

Steel shall conform to the requirements of 709.01, Grade 60.

Propylene plastic shall conform to ASTM D 2146, Type II, Class 16906 or Class 43758. The manufacturer shall furnish certified test data for the propylene plastic used in each lot of steps.

712 MISCELLANEOUS

712.01 Expansion Shield Anchors, Self Drilling. Federal Specification FF-S-325, Group III, Type I (a) or (c).

The supplier and/or producer of the anchors shall provide a certification showing test results of the proof load required in Federal Specification FF-S-325.

712.02 Calcium Chloride. ASTM D 98.

712.03 Sodium Chloride. ASTM D 632 Type I, Grade 1, with the following exception:

Chemical Composition 4. Total Chlorides (NaCl, CaCl₂, and MgCl₂ as NaCl based on dry weight) not less than 97 percent.

712.04 Lime.

(a) Lime for masonry purposes shall conform to ASTM C 207 Type S. Soundness Section 5 of ASTM C 110 shall replace Section 3. Section 6 shall not apply.

(b) Lime for soil and soil aggregate stabilization shall conform to ASTM C 207, except that the requirements of Sections 7, 8, 9 and 10 shall not apply. A minimum of 85 percent shall pass a No. 200 sieve when tested by wet sieving as per ASTM C 110.

712.05 Glass Beads Used in Traffic Paint. AASHTO M 247, Type 1 without flotation properties but coated for moisture resistance, with the following exceptions:

Inspection shall be done at the project site. Random samples shall be obtained from material delivered to the project site, or at other locations designated by the Laboratory.

Flotation Test. Not applicable.

712.06 Preservative Treatment for Structural Timber, Lumber, Piling, Posts, Braces and Blocks. All structural timber, lumber and piling shall conform to 711.26, and all posts, braces and blocks shall conform to 710.14, except that moisture may be removed from the untreated lumber at the time of preservative treatment. Material treated within the State of Ohio shall either be inspected by the Engineer, or where such inspection is waived, the company treating the material shall submit for each charge: (1) charts from automatic recording instruments showing conditions within the treating cylinder at all times during treatment; (2) computations showing the volume of wood in the charge, the volume of preservative materials used and the final net retention of each charge; and (3) approximately one dozen representative cores taken from the material with an increment borer. The City shall be notified at least 72 hours (exclusive of Saturdays, Sunday and holidays) in advance of the treating of the material.

Material treated outside the State of Ohio shall be inspected for conformance to the current AWPA standards and the requirements of this section of the specifications. The material shall bear the identification mark of the inspection agency and a certificate of inspection for treatment shall be forwarded to the Engineer. An agency qualified and approved by the Engineer for such inspection shall make the required inspection, and the cost of this inspection and furnishing the reports shall be included in the price bid for the respective item for which the material is required.

When guardrail offset blocks are furnished by an Ohio supplier, a Notarized Certificate of Conformance shall be furnished by the supplier with each shipment of material stating the size, specie, quantity shipped, project number, vendor's order number, type of treatment and retention in pounds per cubic foot.

Materials. The timbers shall be pressure treated using Ammoniacal Copper Quaternary (ACQ), per ASTM D 5654. No CCA (Chromated Copper Arsenate) treated material shall be permitted.

Preparation for Treatment. Sorting. Whenever it is practicable, the material shall be sorted into one kind or designated group of kinds of wood and into pieces of approximately equal size and moisture and sapwood content, and separated so as to insure contact of the treating medium with all surfaces.

Framing. So far as practicable, all adzing, boring, chamfering, framing, graining, mortising, surfacing, etc., shall be done prior to treatment.

Incising. All Douglas fir, except rails and rail posts, the least dimension of which is two inches or over shall be incised by a suitable power-driven machine before treatment. Lumber having a thickness of three inches and over shall be incised on all four sides. Lumber less than three inches thick shall be incised on the wide faces only, except where indicated on the plans. The spacing and shape of the cutting teeth and the method of incising shall be such as to produce a uniform penetration. The depth of the incisions shall be not less than the following:

Size	Minimum depth of incision, in.
2 x 12	3/8
3 x 12	7/16
4 x 12	1/2
8 x 10	9/16
10 x 12	5/8
12 x 12	3/4

Intermediate sizes in proportions.

Amount of Preservative. The net retention in any charge shall be not less than 90 percent of the quantity of preservative specified; but the average retention by the material treated under any contract or order and the average retention of any five consecutive charges shall be at least 100 percent of the quantity specified. The minimum amounts of preservative retained shall be as specified by the American Wood-Preservers' Association Standard. All species of structure timber, lumber, piling, posts and blocks shall be treated according to the current AWPA standard specifications.

712.08 Coating and Antistripping Agents. Coating and antistripping agents shall conform to the following requirements:

General. Coating and antistripping agents shall provide suitable coating of bituminous materials mixed with wet aggregates, and they shall prevent the bituminous coating from stripping in the presence of water. The agents shall not be deleterious to the mixture in any manner.

Materials. The aggregates and bituminous material used to test the agent shall be from sources approved by the Laboratory.

Aggregate. The standard reference aggregate shall be composed of 50 percent silica gravel and 50 percent crushed limestone, and it shall meet the following grading requirements:

Passing a 3/8 inch sieve.....100%
 Passing a 1/4 inch sieve0%

Bituminous Material. The standard bituminous material shall meet the requirements of 702.02, MC 800.

Agent. The antistripping agent shall have the following properties:

Furol viscosity at 50°C (122°F)75 seconds max.
 Pour point.....12°C max. (54°F)

712.09

Flash point (Tag closed cup) 46°C min. (115°F)

The maximum amount of agent that may be used to meet the coating and antistripping requirements shall not exceed two percent, by weight, of the total bituminous material used in the mixture. At least 50 grams of the standard bituminous material and agent shall be prepared for testing according to the directions of the manufacturer.

Wet Coating Test. The standard aggregate shall be washed with distilled water until free from dust and dried. One hundred grams of dry standard reference aggregate shall be placed in an 8 ounce seamless ointment can or equivalent, covered with distilled water and then placed in a 140°F constant temperature oven for 1 hour. Immediately after the heating and soaking period a wire gauze shall be placed on the can and the water drained off. While inverted, the can shall be shaken vigorously 4 times to remove excess water.

Six grams of the mixture of MC 800 and agent shall be heated to 140°F and mixed immediately with the wet aggregate. The materials shall be mixed vigorously with a small spatula for not over 5 minutes without further application of heat. At least 95 percent of the aggregate particles shall be completely coated at the end of the mixing period.

Stripping Test. The coated aggregate from the wet coating test shall be covered for 1 hour with distilled water at room temperature. At least 95 percent of the aggregate particles shall be completely coated at the end of the immersion period.

712.09 Geotextile Fabric. Furnish fabric composed of strong rot-proof polymeric fibers formed into a woven or non-woven fabric conforming to the following requirements:

Type A: Underdrains and Slope Drains

Minimum Tensile Strength ^[1]	80 lb (355 N)
Minimum Puncture Strength ^[2]	25 lb (110 N)
Minimum Tear Strength ^[3]	25 lb (110 N)
Apparent Opening Size ^[4]	
Soil Type-1: Soils with 50% or less passing No. 200 (75 µm) sieve	AOS ≤ 0.6 mm
Soil Type-2: Soils with 50 to 85% passing No. 200 (75 µm) sieve	AOS ≤ 0.3 mm
Minimum Permeability ^[5]	1×10 ⁻² cm/sec

Type B: Filter Blankets for Rock Channel Protection

Minimum Tensile Strength ^[1]	200 lb (890 N)
Minimum Puncture Strength ^[2]	80 lb (355 N)
Minimum Tear Strength ^[3]	50 lb (220 N)
Minimum Elongation ^[1]	15%
Apparent Opening Size ^[4]	AOS ≤ 0.6 mm
Minimum Permeability ^[5]	1×10 ⁻³ cm/sec

Type C: Sediment Fences

Minimum Tensile Strength ^[1]	120 lb (535 N)
Maximum Elongation at 60 lb (265 N) ^[1]	50%
Minimum Puncture Strength ^[2]	50 lb (220 N)
Minimum Tear Strength ^[3]	40 lb (180 N)
Apparent Opening Size ^[4]	AOS ≤ 0.84 mm.
Minimum Permittivity ^[5]	1×10 ⁻² sec ⁻¹
Ultraviolet Exposure Strength Retention ^[6]	70%

Type D: Subgrade-Base Separation or Stabilization

Minimum Tensile Strength ^[1]	180 lb (800 N)
Maximum Elongation at 170 lb (755 N) ^[1]	35%
Minimum Tear Strength ^[3]	70 lb (310 N)
Minimum Puncture Strength ^[2]	70 lb (310 N)
Apparent Opening Size ^[4]	Same as Type A
Permeability ^[5]	1×10 ⁻³ cm/sec

Type E: Pavement Reinforcement Fabric

AASHTO M 288, Section 9, Table 7

[1] ASTM D 4632

[2] ASTM D 4833

[3] ASTM D 4533

[4] ASTM D 4751

[5] ASTM D 4491

[6] ASTM D 4355

All minimum strengths shown are average roll minimum values in the weakest principal direction.

712.20

Ensure that the fabric is free of any treatment that might significantly alter its physical properties. During shipment and storage, wrap the fabric in a heavy-duty protective covering to protect it from direct sunlight, dirt, dust, and other debris.

For all fabric types, the manufacturer shall submit a certification with each shipment of material stating that it meets the specification requirements.

712.20 Drive Posts. Drive posts shall be fabricated from steel into a characteristic cross section which may be used alone or paired to form a heavier post by being bolted together back to back. The posts shall be of the weight per foot and length as specified. Posts shall be cut square to a length tolerance of \pm one inch and shall be free of ragged or sharp edges and cracks or other imperfections affecting strength or durability. The back of channel sections may contain raised longitudinal ribs or may be flat. The channels shall be designed for bolting back to back for use as a single post.

Posts shall be of Grade 60 material having the physical properties of ASTM A 615, A 616 or A 617.

The nominal weight of posts before punching or galvanizing shall be as follows:

POST SIZE NUMBER	WEIGHT POUNDS PER FOOT
1	1.12
2	2.00
3	3.00

The weight tolerance shall be -3.5 and + 10.00 percent.

All posts shall have 3/8 inch diameter holes on the centerline spaced accurately at one inch centers beginning not more than 1-1/8 inch from the top of the post through its entire length. Punching or drilling accuracy shall be sufficient to allow bolting posts together back to back without re-drilling holes, using 3/8 inch diameter bolts. Posts shall be galvanized in accordance with 711.02, after punching.

Posts shall meet the requirements of the following load deflection test. Paired posts shall be assembled with 3/8 inch diameter SAE J 429 Grade 8 bolts on four inch spacings starting two inches from one end. Drilling for bolt assembly shall be as required and the bolts shall be torqued to 150 inch-pounds.

The posts shall be loaded as horizontal beams resting on 1-1/2 inch diameter non-restricting supports six feet ten inches apart. Back to back posts shall be loaded with the axis of the bolts parallel to the direction of the applied bending load. Single U-channel posts shall be loaded with the flanges in tension.

The total bending load shall be divided into two equal loads three feet apart and applied vertically so as to be centered between the supports. The maximum rate of the testing machine cross-head movement shall be 1/2 inch per minute. Deflection shall be measured at the load application points and shall not exceed 0.55 inches under the following total applied loads:

SPECIMEN CONFIGURATION	TOTAL BEARING LOADS pounds
Single No. 1 Post	60
Single No. 2 Post	400
Single No. 3 Post	800
Two No. 2 Posts Paired	1,000
Two No. 3 Posts Paired	3,000

The permanent set after the load has been removed for one minute shall not exceed 0.10 inch.

713 LIGHTING AND ELECTRICAL MATERIALS

713.00 General. Lighting and electrical materials covered by these specifications shall be inspected and certified as follows:

1. Inspection. Lighting and electrical materials are subject to inspection at the project site. Such inspection will include, but is not limited to, the identification of the item, type, size and manufacturer's markings, and documentation of these data. When required by the Engineer, random samples will be selected from the material delivered or at the place of manufacture or warehouse prior to delivery.
2. Certification. When required by the Engineer, certified test data shall be furnished.

In the case of light poles and light towers, certified test data in triplicate covering the specified requirements for all materials incorporated in the poles, towers, and accessories and the results obtained from the deflection tests shall be furnished to the Engineer.

713.01 Light Poles. 1. Scope. These specifications cover materials and manufacturing methods to be used in the fabrication of light poles used to support luminaires. Any aluminum or steel material permitted by the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" may be used in this item. Pole designs shall conform to minimum requirements of the AASHTO specifications cited, except that the design wind load shall, in all cases, be based on a wind speed of 90 miles per hour.

713.01

2. Shafts

(a) There shall be not more than one longitudinal, automatically electrically welded seam and no transverse seams or welds, except as permitted hereinafter. The longitudinal welded seam shall be neat and uniform in appearance, the weld shall not be less than the thickness of the base material, and the bead height shall not exceed 1/16 inch. The wall shall be of uniform thickness throughout, except at the weld bead. The cross section of the shaft shall be circular, or multisided, and the diameters or cross sectional dimensions, measured at any point along the longitudinal axis, shall not vary from each other more than 3/16 inch. Poles may consist of not more than two vertical shafts joined by overlapping the sections at least 1-1/2 diameters of the bottom of top section, and by use of a 5/8 inch minimum stainless steel hex head through bolt.

(b) Shafts for steel poles shall be tapered tubes with a true continuous taper.

(c) Shafts for aluminum poles shall be tapered tubes either spun or rolled. The shaft shall have a true continuous taper except for the top and bottom sections which may be straight. No more than 40 percent of the total shaft length shall be straight.

(d) The average rate of shaft taper including straight portions of the shaft shall be between 0.06 and 0.16 inches per foot.

(e) The deflection of the unloaded shaft from the vertical position when placed under load by attachment of the bracket arm, luminaire weighing 75 pounds and lamp shall not exceed an angle of one degree and ten minutes.

(f) On poles equipped with tubular sleeve supports for bracket arms, the sleeve shall pass through a hole in the shaft and be made an integral part of the shaft by means of circumferential welds where sleeve and shaft join. The sleeve shall extend from the shaft sufficiently to insure stability of the connection.

(g) Fittings shall be as detailed on the plans and the approved shop drawings. Fasteners, washers, shims, nuts, and bolts, unless otherwise specified, shall be either stainless steel conforming to ASTM A 320 (AISI-300 series), galvanized steel conforming to 711.02 or silicon bronze conforming to ASTM B 98. Nonstructural castings for aluminum poles, including the shaft cap and transformer base door, shall be ASTM B 26 or B 108, Alloy S 5 A, Condition F.

3. Anchor type bases.

(a) Anchor bases for steel poles shall be one piece cast steel conforming to 711.07, or steel plate conforming to 711.01. The anchor bases shall be secured to the lower end of the shaft by two continuous electric arc welds. The base shall telescope the shaft with one weld at the lower end of the shaft and the other weld

at the top of the base. The two welds shall be at least 1-1/2 inches apart and the welded connection shall develop the full strength of the adjacent shaft section.

(b) Anchor bases for aluminum poles shall be one-piece cast aluminum conforming to ASTM B 26 or B 108, Alloy SG70A, Temper T6. The anchor bases shall be secured to the lower end of the shaft and the base shall telescope the shaft. When a welded connection is used, two continuous welds shall be required with one weld at the lower end of the shaft and the other weld at the top of the base. The two welds shall be at least 1-1/2 inches apart. The base connection shall develop the full design strength of the adjacent shaft section in bending.

4. Transformer type bases. Transformer type bases shall be fabricated from steel or aluminum in accordance with the following:

(a) Steel transformer bases meeting the dimensional requirements of plans and approved shop drawings shall be made from steel conforming to ASTM A 36. Bases for poles mounted on median barriers shall be one-pass welded unless otherwise noted.

(b) Aluminum transformer bases meeting the dimension requirements of the plans and approved shop drawings shall comply with the frangibility requirements specified in the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," and shall be permanently marked for exterior identification.

(c) The aluminum transformer bases designated on the plans by Styles AT-A, AT-C and AT-X shall; (1) be capable of resisting the following moments in foot pounds applied at a distance of 20 feet above the top of the base without collapsing or rupturing; (2) not produce, while supporting a full sized pole, a change in impacting weight momentum greater than 400 pound-seconds when tested in the laboratory with a ballistic pendulum or equivalent, or greater than 1,100 pound seconds when tested in the field under full scale vehicular impact.

Style	Bolt Circle Diameter	Base Height	Moment Foot Pounds
AT-A	15"	20"	37,000
AT-C	17-1/4"	20"	56,000
AT-X	10-1/2" - 13"	20"	34,000

(d) The transformer base shall be fastened to the shaft anchor base with four heavy hex head bolts and nuts conforming to ASTM A 307 and galvanized in accordance with 711.02. When aluminum transformer bases are used with steel anchor base poles, both the bottom of the steel anchor base and the top of the aluminum transformer base shall be coated or painted with a heavy film of zinc rich paint (Federal Specification TT-P641-Type II).

4. Anchor bolts.

713.01

(a) Anchor bolts conforming to the dimensions shown on the plans and approved shop drawings shall meet the requirements of the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals."

(b) The threaded ends of the anchor bolts and the nuts shall be galvanized in accordance with 711.02, with galvanizing extending at least one inch beyond the threads.

5. Bracket arms.

(a) Bracket plates and other fittings shall be dimensioned and detailed as shown on the plans, the standard drawings, and the approved shop drawings. The arms shall be made of not less than two inch nominal pipe size material and have; (1) the longitudinal axis of the luminaire end canted not less than one degree nor more than four degrees above the horizontal, (2) an internal raceway of 1-3/32 inches minimum I.D. free of projections and obstructions, which when assembled to the shaft, will permit installation of luminaire supply conductors without insulation damage and with a minimum radius bend of conductors of three inches, (3) a two inch nominal pipe size slipfitter end with a minimum length of eight inches to receive a slipfitter-mounted luminaire. The bracket arm members may be formed of straight or tapered stock but shall be of a round or ovaliptic cross section. Except for poles equipped with tubular sleeve supports, the bracket arm assembly for arms eight feet or longer shall consist of an upper and lower member securely joined by means of a vertical strut or struts.

(b) Steel bracket arms supported on a circular tapered stud, integral with the pole shaft, shall be made from a one or two-piece round tapered sleeve. The bracket arm shall be securely held within the sleeve by means of a 5/8 inch machine bolt extending diametrically through both bracket arm and sleeve. A hex head nut and lock type washer shall be used to secure the bolt.

(c) The shaft end of each aluminum bracket arm member shall have a cast, wrought, or extruded aluminum fitting welded to it for attaching to the shaft.

7. Welding. Steel shall be welded as required by 513.17. Aluminum welding shall be done by the gas metal-arc process or the gas tungsten-arc process.

Fabrication and welding of aluminum poles and bracket arms shall conform to the requirements of AWS D 1.2 Structural Welding Code - Aluminum.

8. Finishing. Steel poles, except stainless, shall be hot dipped galvanized after fabrication in accordance with the requirements of 711.02.

Color and finish of aluminum poles shall be as detailed on the plans. Shaft and bracket arm assembly shall be wrapped with a heavy water-resistant paper or be otherwise suitably protected during shipment and installation. The wrapping shall not be removed until after complete installation.

9. Galvanized poles specified to be field painted shall be treated in accordance with one of the following:

(a) Given one coat of wash primer conforming to federal specifications MIL-P-15328c primer (wash) pretreatment, blue (formula No. 117-B for metals) and shall be given one shop coat of paint 708.15 immediately when the wash primer is dry.

(b) Given one shop coat of zinc-rich base paint (zinc dust paint) conforming to federal specifications TT-P-641, Type II.

Non-galvanized steel poles shall have all interior and exterior surfaces shop primed in accordance with 514.04 using materials as specified in 708.15. Two coats of an approved "matte" black paint shall then be applied to all exterior surfaces. The first coat shall be shop applied, the second coat shall be applied after erecting in accordance with 514.05. The Contractor shall submit for approval, color samples and method of painting.

Bracket arms for luminaire support on combination poles shall be 0.1196 inches thick steel ellipsoidal or round cross- section and tapered its full length. The arm shall be straight and attached with one simplex connection. The arm shall be installed at five degrees above horizontal. Bracket arms shall be painted by the same method as approved for the pole.

10. City of Akron Pole. In addition to the above, the standard City of Akron Pole shall comply with the following:

Anchor bolts shall be supplied with double nuts. The first set shall be installed 1/4 inch minimum from the top of the foundation and leveled to align and plumb the pole.

The pole shaft shall be an equilaterally diamond cross section its full length, tapered throughout.

Luminaire arm of the same shape, cross section and taper shall be welded to the pole at 6-1/2 degrees with 1/2 inch back up plate. A smooth wireway shall be provided between the pole and arm. A 2-3/8 inch schedule 40 tenon shall be welded to the end of the luminaire arm. The tenon shall project from the end of the arm.

713.02 Electrical Cables. 1. Scope. This item shall consist of insulated conductor cables. All cable shall meet requirements of the IPCEA standards publication S-66-524. Conductor identification shall conform to the requirements of the latest edition of the National Electric Code.

713.03

2. Cable to be used for 600 volt and under (secondary class) service shall be of the sizes specified, nonjacketed, single conductor, stranded copper and shall meet the following requirements:

(a) Cable sizes No. 8 AWG and larger shall meet the requirements of Underwriters Laboratories Type THWN/THHN or USE.

(b) Cable sizes No. 10 AWG and smaller shall meet the requirements of UL Type XHHW or THWN/THHN.

3. Cable to be used for 5,000 volt (secondary class) service shall be of the sizes specified, single conductor, stranded copper having an unshielded, chemically cross-linked polyethylene insulation, and shall meet the requirements of UL Type MV-90 dry.

4. Cable to be used for 5,000 volt and above (primary class) service shall be of the sizes and types specified.

713.03 Unit Type Duct-Cable Systems.

1. Scope. This item shall consist of a factory preassembled cable in a coilable, high density polyethylene pipe type duct providing the number and size of insulated conductors which are specified. The number of conductors used in the duct and the duct fill shall conform to the requirements of the National Electrical Code.
2. Conductors and neutrals. The cables used as conductors and neutrals shall conform to 713.02,2.
3. Polyethylene duct. Duct shall conform to ASTM D 2104 with the following exceptions and additions:
 - 3.5 Standard Thermoplastic Pipe Materials Designation Code. The two figures indicating hydrostatic design stress may be omitted.
 - 4.4 Compound. Compound shall be grade P33 or P34.
 - 6.2.3 Eccentricity. The eccentricity shall be within 20 percent.
 - 6.6 Sustained Pressure. This requirement is waived.
 - 6.7 Burst Pressure. This requirement is waived.
- 9.1.3 and 9.1.4 These markings are not required.
- 9.1.5 In addition to the manufacturer's name, the year of manufacture shall be included in the marking.

713.04 Rigid Ferrous Metal Electrical Conduit and Fittings. Galvanized steel conduit and fittings furnished under this specification shall comply with the requirements of ANSI C 80.1, C 80.4, and UL 6 for Type I rigid steel conduit. Each length of conduit shall bear the UL label.

713.06 Reinforced Polymer Concrete Pull Boxes. 1. Pull boxes and covers shall be composed of reinforced polymer concrete and be designed and tested to temperatures of -50°F and meet requirements of the following tests: ASTM D 756, ASTM D 543, ASTM D 1501, ASTM D 570, ASTM D 790 and ASTM D 635.

713.07 Polyvinyl Chloride Conduit and Fittings. This specification covers polyvinyl chloride conduit, Schedule 40 for direct burial without concrete encasement, and Type DB for encased burial in concrete. Polyvinyl chloride conduit and fittings, of the size and type specified, shall conform to NEMA Standards Publication No. TC-6.

713.08 Concrete Pull Box. 1. Pull box. Concrete pull boxes shall be constructed and installed as detailed in the plans.

2. Covers. Pull box covers shall be constructed and installed as detailed in the plans, and shall have the word "ELECTRIC," "TFC SIG" or "COMMUNICATIONS" as required, cast in the top surface of the cover forming letters one to two inches in height.

713.09 Circular Corrugated Metal Pull Box. 1. Scope. This specification covers circular helically corrugated metal pull boxes as follows:

2. Pull box. Circular corrugated metal pull boxes shall be fabricated from 0.059 inch minimum galvanized steel with a 20 mil minimum coating of asphalt on each side, 18 or 24 inches in diameter and 30 inches long, helically corrugated pipe sections. The bottom end shall have three 4 inch by 10 inch slots with the 10 inch dimensions parallel to the long axis of the box and the center lines of the slots shall be spaced 90 degrees apart. Field cutting of slots will be permitted, subject to project requirements, and provided restoration or protection of damaged coatings acceptable to the Engineer is made.

3. Covers. Metal pull box covers shall be either of the following:

- (a) 1/4 inch thick steel plate conforming to 711.01 with 1/2 inch minimum flange around the edge and galvanized to conform to 711.02.

Each steel plate cover shall have a brass or stainless steel plate approximately 1/32 inch in thickness and not less than two inches in width by ten inches in length with the word "ELECTRIC," "TFC SIG," or "TELEPHONE" etched, engraved, or die-stamped thereon in letters approximately 5/8 inches wide by 1-1/4 inches high, riveted or otherwise permanently attached to the steel plate cover.

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(b) 3/8 inch minimum thickness, gray iron or ductile iron ASTM A 48 or A 536. Certification will be required. The word "ELECTRIC," "TFC SIG", or "TELEPHONE" as required, shall be cast in the top surface of the cover forming letters one to two inches in height.

4. Grade adjustment extensions. If specified on the plans, grade adjustment extensions, corrugated and coated, and of the same material as specified in 2 above, shall be furnished and installed. Extension section shall have an inside diameter of such size as to allow the corrugation to mesh with those of the outside diameter of the pull box, thereby forming a screw type vertical adjustment between the two pipe sections. Extensions and pull box sections shall overlap each other a minimum of four inches.

713.10 Junction Boxes. 1. Scope. This specification covers junction boxes of the sizes and types shown on the plans.

2. Composition. Junction boxes shall be iron castings and shall be hot-dip galvanized in accordance with 711.02.

3. Detailed requirements.

(a) Junction boxes shall be NEMA Type 4 of the size specified, shall be UL approved, and shall be watertight.

(b) Conduit entrances shall be provided as shown on the plans.

713.11 Luminaires for High Intensity Discharge Lamps. 1. Scope. This specification covers luminaires for high intensity discharge lamps. The luminaire shall be a complete lighting device consisting of a housing, lamp, support clamp, reflector, refractor, socket, integral ballast or separate ballast when specified and terminal block. The luminaire shall be capable of operating the lamp in a completely sealed optical assembly at the line voltage specified. The luminaire shall provide the ANSI-IES Type distribution and cut-off specified.

The use of the small, medium, or large size luminaire shall be determined by the initial lamp lumen rating of the specified lamp type as follows:

(a) The small horizontal Style A luminaire shall not be used for lamps rated over 250 watts.

(b) The medium horizontal Style B luminaire shall not be used for lamps rated over 400 watts.

(c) The large horizontal Style C luminaire shall not be used for lamps rated over 1,000 watts.

The luminaire shall be supplied with a label or decal indicating the type of source and wattage rating. With the luminaire installed in its normal operating position, the

label or decal shall be clearly legible in daylight at a distance of 50 feet. Labeling shall be in accordance with the provisions of NEMA Publication No. OD-150 or EEI Publication No. TDJ-150.

2. Detailed requirements.

(a) Housing. The housing shall be of cast aluminum with natural finish or a painted finish using aluminum or a light gray color paint. The housing shall contain and support the reflector, refractor, socket, ballast, terminal block and support clamp. Provision shall be made for leveling to adjust the luminaire to the specified transverse and longitudinal position with respect to the roadway.

(b) Refractor retaining ring. The refractor retaining ring shall be securely latched and hinged with non-corrodible material and shall be operable and removable without the use of tools. The assembly shall provide a weatherproof enclosure for the optical system.

(c) Support clamp. The support clamp shall be the slip-fitter type adaptable to 1-1/4 or 2 inch mounting bracket. A stop shall be provided to allow an engagement of at least 4-1/2 inches of the bracket arm. Provision shall be made to adjust and hold the luminaire in its specified vertical and horizontal position.

(d) Reflector. The reflector shall be of an approved specular polished aluminum reflective surface. It shall be held firmly in the housing but shall be easily removed without the use of special tools. Silicone rubber, ethylene propylene terpolymer, or dacron felt gaskets or approved equal shall seal the optical assembly at the socket entry and between the refractor and reflector to make a dust tight optical system. The reflector shall be clean and free from scratches.

(e) Refractor-glass. The refractor shall be heat resistant borosilicate glass and shall have prisms on the inside and on the outside to provide the ANSI-IES type distribution and cutoff as specified and shall be free of striations and imperfections. The refractor shall be embossed to clearly indicate the street side and curb side prisms. The refractor shall be securely fastened to the holder but easily removed. The refractor, reflector assembly shall meet the specified ANSI-IES distribution and cutoff. The Contractor shall provide complete photometric data for every combination of each assembly.

(f) Socket. The socket shall be mogul screw shell with large center contact spring providing a firm contact with the lamp base. The socket shell shall have lamp grips to prevent the lamp from loosening. The shell may be of the skeleton type or shrouded in porcelain. The contacts shall be identifiable. Socket extension adapters will be permitted for special applications. Luminaires providing various ANSI-IES types of distribution by socket adjustment shall also include a means of identification to associate each lamp position with each distribution type. The socket adjustment shall provide positive positionings by means of index holes, lugs or notches. Slots with infinite settings will not be acceptable.

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(g) Ballast. Ballasts shall conform to the following requirements.

(1) The mercury ballast shall be a high power factor, constant wattage or regulator type with separate primary and secondary windings and shall be rated to the circuit voltage and size of lamp specified. The ballast shall start the lamp at temperatures as low as -20°F and shall deliver rated lamp current at circuit voltage variation of plus or minus 13 percent. The regulation output of lamp wattage shall not exceed a total range of four percent for lamps rated 400 watts or less or six percent for lamps rated in excess of 400 watts.

(2) The metal halide ballast shall be a high power factor, peak load autoregulator type rated to the circuit voltage and size of lamp specified. The ballast shall start the lamp at temperatures as low as -20°F and shall deliver rated lamp watts within plus or minus 10 percent with plus or minus ten percent variation in applied voltage.

(3) The high pressure sodium ballasts for lamps through 400 watts shall be a high power factor, regulator type with isolated primary and secondary windings and shall be rated to the circuit voltage and size of lamp specified. Ballasts for 1,000 watt high pressure sodium lamps shall be a high power factor, autoregulator type rated to the circuit voltage specified. The ballast shall start the lamp at temperatures as low as -20°F and shall deliver rated lamp current at circuit voltage variations of plus or minus ten percent. All ballasts shall be complete with starter components.

The starter component shall be comprised of solid state devices capable of withstanding ambient temperatures of 100°C. The starter shall provide timed pulsing with sufficient follow through current to completely ionize and start all lamps that meet published ANSI standards. The starter component shall be field replaceable and completely interchangeable with no adjustment necessary for proper operation. It shall have push-on type electrical terminations to provide good electrical and mechanical integrity and ease of replacement. The starter circuit board shall be treated in an approved manner to provide a water and contaminant resistant coating.

The starting circuit-ballast combination shall be designed to consistently provide the following parameters:

a) Lamp wattage must be maintained within the trapezoid recommended by lamp manufacturers within the full rated input voltage range.

b) Amplitude of the pulse shall be 2,500 volts minimum and 4,000 volts maximum. Operation of the pulse at spike voltage levels near minimum is desirable.

c) The minimum pulse width shall be 1 microsecond at 2,250 volts, and shall be applied within 20 electrical degrees of the peak of the open circuit voltage wave, and have a minimum repetition rate of one pulse per cycle of the 60 cycle wave.

d) Pulses must be present when ballast is correctly wired and nominal voltage less 15 percent is applied to the ballast windings.

(4) The low pressure sodium ballast shall be a high power factor corrected (90 percent minimum) reactor type rated to the circuit voltage and size of lamp specified. The ballast shall start the lamp at temperatures as low as -20°F and shall deliver rated lamp current at circuit voltage variations of plus or minus ten percent. Wattage regulation shall not exceed a range of -5 percent to +3 percent for lamps rated at 90 watts or more.

(h) Glare shields. Glare shields of aluminum or opaque plastic material shall be provided when specified. The shield shall be supplied by the manufacturer of the luminaire. The glare shield shall cut off the upward component of light but shall not reduce the total output of the luminaire more than three percent.

713.12 Akron Luminaire. Luminaires designated on the plan as "City of Akron Luminaire" shall be as specified in 713.11 except: the luminaire shall be rectangular in shape with a peaked top to provide runoff. The housing shall be an integral assembly consisting of cast or extruded aluminum. Extruded units shall have a one-piece top.

Luminaires shall be fitted with a two inch cast aluminum slipfitter connector or integral support clamp. An engagement of at least 4-1/2 inches of the arm shall be provided. A minimum of three stainless steel hex head set screws shall be provided on slipfitter connections. Slipfitter connections shall be attached to the luminaire housing with four stainless steel hex head nuts and bolts with lock washers. Luminaires and slipfitters are to be painted to match the paint designated for the poles.

713.13 Luminaires for Underpasses. 1. Scope. This specification covers luminaires for mounting in underpasses. The luminaire shall be a complete lighting device, consisting of a housing, reflector, lamp, shrouded porcelain socket, refractor, door, integral ballast, and fuse holder with fuse.

2. Detail Requirements. (a) The fixture shall consist of a cast aluminum housing and door frame assembly containing a thermal shock resistant glass refractor attached to the frame with stainless steel latch and hinges. The glass refractor shall be protected by an approved guard or shield. (b) An alternate fixture to "(a)" may consist of a cast aluminum rear mounting plate with a one-piece luminaire housing and refractor molded of a polycarbonate material with integral prismatic design for proper beam control. The one-piece housing shall be hinged and secured to the rear mounting plate. (c) The luminaire shall provide for accommodation of lamps as specified in the plans. (d) The integral ballast, when required, shall conform with the requirements of 713.11, and shall be rated to the circuit voltage and size of lamp specified. (e) The assembly shall be prewired and when in operation shall be weatherproof and sealed against dust or bug entry.

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713.14 Lamps. 1. Scope. This specification covers mercury, metal halide, high pressure sodium, low pressure sodium, incandescent and fluorescent lamps for use in luminaires. The lamps shall be the type and wattage specified.

2. Mercury lamps. (a) Mercury lamps for use in the luminaire specified shall be first line, high quality lamps having heat resistant clear glass envelopes with a quartz arc tube interior. The horizontal initial lumens and approximate hours of life shall not be less than the values shown in the following table:

ANSI	Horizontal Initial Lumens	Economic Life Hours
C78.1300 H38HT-100	3900	16000
C78.1308 H39KB-175	6950	16000
C78.1301 H37KB-250	10500	16000
C78.1305 H33CD-400	19200	16000
C78.1311 H35NA-700	34600	16000
C78.1309 H36GV-1000	53000	16000

(b) The lumen output of the mercury lamps after 12,000 hours use shall produce a minimum of 78 percent of its initial lumen rating.

3. High pressure sodium lamps. (a) High pressure sodium lamps for use in the luminaire specified shall be first line, high quality lamps having heat resistant clear glass envelopes with a ceramic arc tube interior. The horizontal initial lumens and approximate hours of life shall not be less than the values shown in the following table:

ANSI	Watts	Horizontal Initial Lumens	Economic Life Hours
S62	70	5,800	14,000
S54	100	9,500	14,000
S56	150	16,000	16,000
S66	200	22,000	16,000
S50	250	25,500	16,000
S67	310	37,000	16,000
S51	400	50,000	16,000
S52	1,000	130,000	16,000

(b) The lumen output at the end of economic life shall be not less than 80 percent of the initial lumen rating.

4. Metal halide lamps. (a) Metal halide lamps for use in the luminaire specified shall be first line, high quality lamps having heat resistant clear glass envelopes with a quartz arc tube interior. The horizontal initial lumens and approximate hours of life shall not be less than the values shown in the following table:

ANSI	Watts	Horizontal Initial Lumens	Economic Life Hours
M57	175	14,000	4,000
M58	250	18,000	4,000
M59	400	32,000	10,000
M47	1,000	95,000	7,500

(b) The lumen output at the end of economic life shall be not less than 65 percent of the initial lumen rating.

5. Low pressure sodium lamps. Low pressure sodium lamps for use in the luminaire specified shall be first line, high quality lamps, with a sodium resistant discharge tube contained in a clear glass envelope. The initial lumens and approximate hours of life shall not be less than the values shown in the following table:

Watts	Horizontal Initial Lumens	Economic Life Hours
35	4,000	16,000
55	8,000	16,000
90	13,500	16,000
135	22,500	16,000
180	33,000	16,000

6. Incandescent lamps. Incandescent lamps of the size, type and wattage specified shall conform to Federal Specification Number W-L-101.

7. Fluorescent lamps. Fluorescent lamps of the size, type and wattage specified shall conform to Federal Specification Number W-L-116.

713.15 Cable Connecting Devices. 1. Scope. This specification covers cable connecting devices, including connectors, connector kits, and in-the-line type fuseholder kits for use in handholes of light poles as well as in junction and pull boxes rated for minimum 600 volt service.

2. Cable connectors. Cable connectors shall be the types which are applied to the conductor by means of a compression tool and they shall be capable of fully enclosing the conductors upon which they are compressed in accordance with the manufacturer's instructions. Connectors shall be fabricated from high strength copper alloy. Plated connectors fabricated from metals other than copper shall not be accepted. Connectors shall be available in two styles as follows:

(a) Style "H" shall be the parallel groove connector consisting of a metal body having two fully-opened grooves or slots parallel to each other, and separated by a portion of the center section of the body. The total circumference of each conductor shall be completely surrounded by metal when the connector is compressed.

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(b) Style "C" shall be the splicing sleeve type which consists of a crimpable plated copper sleeve with a thin metal wall or "stop" in the barrel centered between each sleeve end so the sleeve shall enclose equal lengths of the two conductors being spliced end-to-end. The barrel of the sleeve shall be manufactured to fit specific ranges of conductor sizes. The manufacturer's instructions relating thereto shall be strictly followed.

3. Cable connector kits. Each cable connector kit shall be furnished complete with all component parts described under the various listed types and each kit shall have the following:

(a) Sufficient silicone compound to lubricate metal parts and the housing for each assembly.

(b) Complete installation instructions.

The component parts of each type of kit shall comply with the following:

(c) Housing. All housings shall be made of water-resistant synthetic rubber suitable for burial in the ground or exposure to sunlight. Each housing shall form a waterseal around the cable, between each housing at the point of disconnection and between an insert body and enveloping "Y" housing.

(d) Copper pins, sockets and fuse contacts shall have a minimum conductivity of 90 percent. They shall be of at least half hard material and the crimpable portion shall be fully annealed while the rest of the device is maintained in its original state of hardness.

(e) Contact pressure between a pin and a socket shall be maintained by the use of an approved socket spring.

(f) Where a mounting hole is provided for fastening terminal lugs to a ring-tongue terminal, they shall be fastened with a bolt and self-locking nut.

(g) Plastic sleeves shall be rigid, molded insulating plastic material of sufficient outside diameter to form a watertight fit with its related housing. Wall thickness shall be 0.10 inch maximum and sleeve lengths shall be as required.

(h) All fuses shall be rated 600 volts, 100,000 amperes RMS interrupting capacity.

Each cable connector kit furnished under this specification shall conform to one of the following types:

Type I. In-line connector kit for pull box installation. Each Type I kit shall contain:

- (a) A copper pin crimpable to a conductor. (b) A receptacle having a centrally located, recessed socket so constructed that it is filled and retained by its housing. (c) A plug housing for retention of the copper pin. (d) A receptacle housing.

Type II. Fused, Quick Disconnect "Y" Connector Kit. Each Type II kit shall contain: (a) A pair of spring loaded copper fuse contacts suitable for gripping the specified cartridge fuse. One contact shall be crimpable on a conductor and after insertion into its proper position within the load-side plug housing be capable of being securely retained therein. The other contact shall be preassembled for retention within a "Y" insert body. (b) A line-side "Y" housing with two cable ports. (c) Two terminal lugs, each having a mounting hole. (d) A bolt and self-locking nut. (e) A "Y" insert body with preassembled line side fuse contact and a ring tongue terminal. (f) A load-side plug housing permanently marked "load side." (g) A fuse of specified ampere rating.

Type III. Unfused, Quick Disconnect "Y" Connector Kit. Each Type III kit shall contain: (a) A copper pin crimpable to a conductor and suitable for retention in the load-side receptacle housing. (b) A "Y" insert body with preassembled load-side copper socket and ring-tongue terminal. (c) A line-side "Y" housing with two cable ports. (d) Two terminal lugs, each having a mounting hole. (e) A bolt and self-locking nut. (f) A load-side receptacle housing.

Type IV. Semi-permanent "Y" Cable Connector Kit. Each Type IV kit shall contain: (a) A ring-tongue terminal crimpable to a conductor. (b) Two terminal lugs, each having a mounting hole. (c) A bolt and self-locking nut. (d) A line-side "Y" housing with two cable ports. (e) A load-side insert body with one cable port.

Type V. Unfused In-line Connector Kit for Junction Box Installation. Each Type V kit shall contain: (a) A copper pin crimpable to a conductor and suitable for retention in the receptacle housing. (b) A copper socket crimpable to a conductor and suitable for retention in the plug housing. (c) A receptacle housing. (d) A plug housing.

Type VI. Fused In-Line Connector Kit for Junction Box Installation. Each Type VI kit shall contain: (a) A pair of spring loaded copper fuse contacts, both crimpable to conductors and suitable for gripping the specified cartridge fuse. Both contacts shall be capable of being securely retained in their housings. (b) A plug housing. (c) A receptacle housing.

Type VII. Splice Insulating Kit. Type VII kits shall be classified as follows: (a) Type VII A kit consisting of: two identical housings, each having a single cable port, one plastic sleeve, one Style "S" cable connector. (b) Type VII B kit consisting of: one housing having a single cable port, one housing having a twin cable port, one plastic sleeve, two style "H" cable connectors. (c) Type VII C kit consisting of: two identical housings, each having a twin cable port, one plastic sleeve, three Style "H" cable connectors.

4. In-the-line type fuseholder kits. Each in-the-line type fuseholder kit shall be provided with a breakaway receptacle to physically interrupt the circuit under impact. The breakaway unit shall be mounted on the line side and consist of a wire

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connector for the external circuit and an insulating sleeve housing a deeply recessed female terminal. The assembly shall be completed by a conventional in-the-line fuseholder with its line terminal being a solid copper rod. When assembled, the male terminal of the fuseholder shall telescope into the insulating sleeve of the receptacle and make a sliding contact with the female receptacle terminal. There shall be four similar styles of breakaway receptacles differing only in the type of connector for the line side conductors as follows:

(a) Type VIII--AL Kits shall provide an in-the-line mounting for the fuseholder. It shall contain a setscrew-type connector for aluminum conductor.

(b) Type VIII--CU Kits shall provide an in-the-line mounting for the fuseholder. It shall contain a crimp type terminal that will accept a single copper conductor.

(c) Type IX--AL Kits shall provide a tee tap to the fuseholder. The setscrew connector shall be made of aluminum to accept aluminum conductors.

(d) Type IX--CU Kits shall provide a tee tap to the fuseholder. The setscrew connector shall be made of copper to accept copper conductors.

Insulating boots of water-resistant, synthetic rubber, suitable for burial in the ground or exposure to sunlight, shall be provided for both the line and load side of all fuseholder kits with breakaway receptacles.

5. Cable splicing kits. Each cable splicing kit shall contain all items necessary to complete a permanent, direct buried, water resistant, inline wye or tap splice as required by the plans. Each kit shall include the following:

(a) A sleeve or tee cable connector conforming with the general requirements of Style "C" or "H" or other connecting device approved by the Engineer.

(b) A means of containing the sealing material around the cable connector.

(c) Sufficient self-hardening compound to assure a water-tight splice.

(d) Heat shrinkable tubing, molded boots, or self-fusing hi-dielectric insulating compound.

(e) Complete installation instructions.

713.16 Ground Rods and Ground Grid. 1. Scope. This specification shall cover ground rods and ground grids.

2. Detail requirements. Ground rods shall have either a circular cross section with a diameter of one inch or more or, if other than circular in cross section, they shall have a periphery of 3.2 inches or more. Rods shall be ten feet long, solid, and having a driving point on one end. Rods for ground grid shall be 3/8 inch minimum

diameter solid rods with blunt ends approximately 30 feet in length. Rod material shall be stainless steel jacketed steel bearing UL label or hot-dip galvanized steel in accordance with 711.02.

In lieu of solid metal rods, ground grids composed of 5/16 inch diameter, preformed, three wire, BB Grade, Class C, messenger wire conforming to ASTM A 111 may be used.

713.17 Structure Ground Cable. 1. Scope. This specification shall cover the cable to be used for electrical grounding of structures.

2. Requirements: Cable shall be stranded, soft-drawn, insulated, copper of the size shown, bearing a UL label or conforming to paragraph No. 2 of Section 713.02.

713.18 Circuit and Light Pole Identification Materials. 1. Scope. This specification covers the materials to be used as identifying markings on cables and light poles.

2. Tags to be used as specified shall be circular in shape, 1-3/8 inch minimum diameter, 0.031 inch minimum thickness copper, brass or plastic except that tags within switch and device cabinets shall be of nonmetallic material. Identifying bands shall be approximately 1/32 inch thick, 3/16 inch wide and four inch minimum length nylon, self-clinching type with adequate size tab for labeling. Tags shall be permanently fastened to cables by means of tying straps of the same material and dimensions as identifying bands without tabs. Each tag or band tab shall be marked using 1/4 inch minimum lettering dies, engraving device or other equivalent permanent marking process. Markings shall indicate "GRD" for all ground and grounded neutral conductors. Companion circuit conductors shall be marked "CKT" followed by the designated letter, numeral or symbol as may be shown on the plans.

3. Pole identification shall be accomplished by means of adhesive labels with 1-1/2 inch silver white reflective characters on a black background meeting the requirements of federal specification L-S-300. The reflectivity characteristic shall be equivalent to No. 1 as described in such specification.

713.19 Service Pole and Components. 1. Scope. This specification covers materials and equipment normally comprising a service pole and service equipment:

2. Poles and Pole Keys. Poles and pole keys shall be Western, Red Cedar, Douglas Fir, or Southern Yellow Pine, full length, pressure treated in compliance with specifications of the American Wood Preservers Association with either a five percent solution pentachlorophenol or a high grade of pure coal tar creosote. Retention of preservative shall be not less than ten pounds of creosote type or not less than one-half pound dry chemical pentachlorophenol, per cubic foot of wood. Poles shall be 35 feet minimum length and Class 4 or heavier conforming to the applicable requirements specified by ANSI Pole Dimensions. Poles shall be reasonably straight without pronounced sweep or short crooks.

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3. Wood crossarms. Wood crossarms shall be treated and of the specified dimensions. Treatment shall be as specified in No. 2 above.

4. Pole hardware. Pole hardware, including bolts, nuts, washers, clamps, screws, braces, racks, etc., shall be of specified sizes, galvanized in accordance with 711.02.

5. Ground wire supports. Ground wire fastened to the pole shall be attached with copper clad, rolled point staples of adequate size to accommodate the ground wire to be supported.

6. Ground wire moulding. Ground wire moulding shall be either wood or plastic, in sections not less than eight feet long and of sufficient width and groove depth to completely enclose the ground wire. Moulding shall be attached to pole by means of galvanized steel pipe straps and galvanized nails.

7. Anchors and anchor rods. Anchors shall be malleable iron, six inch minimum diameter, two-way or four-way expanding type. Anchor rods shall be 5/8 inch minimum diameter, eight feet minimum length galvanized steel provided with twin thimbleye.

8. Guy strand. Guy strand shall be 3/8 inch minimum diameter, conforming to ASTM A 475, galvanized steel.

9. Primary service equipment:

(a) Transformer shall be pole mounted, distribution type, oil-filled, single or double primary bushing, with taps of 2-1/2 percent above and below the specified voltage, furnished with hanger bracket or equipped for cross arm mounting and having the specified ratings for KVA capacity, primary and secondary voltages. Transformers may be self-protected with internal primary fuse and secondary breaker or conventional type.

(b) Primary fused disconnects and lightning arresters shall be open type having the specified ratings for voltage, amperage, interrupting capacity and instantaneous amperes RMS.

(c) Primary switches shall be open blade type, single-pole, single-throw; remote controlled oil immersed type or ground operated air break type.

(d) Cable pothead terminations shall have the specified ratings for phase-to-phase operating voltage, impulse voltage at 1-1/2 x 40 wave, corona voltage level to ground, cable range and corona voltage acceptance level.

10. Secondary service equipment. Riser conduit shall be as specified in 713.04 with a rain tight galvanized steel service entrance head (weatherhead) threaded to fit the specified size of conduit and provided with a composition cover for two or three wire service.

The service disconnecting device shall be a fused safety switch or circuit breaker rated 600 volts AC minimum for 480 volt service or 240 volts AC minimum for 240 volts or less service. Current rating of the device shall be as specified but not less than 30 amperes. Circuit breaker shall be service equipment type. Devices shall be single throw with the specified number of poles and solid neutral not interruptible with operation of the device, but other means for disconnecting the grounded neutral shall be provided at the neutral terminal block. Fuse clips for cartridge type fuses shall be provided at the load side terminals of the switch. If the disconnecting device is a circuit breaker type and separate load side protection is required for two circuits, this shall be accomplished by the use of one single pole, single-throw circuit breaker type device, of the specified ampere rating mounted in series with the main breaker.

Line and loadside cable terminal lugs of the device should be sized to accommodate the specified wire sizes. If lugs of adequate size to enclose the total outside diameter of the cables cannot be furnished, insulated buses of specified ampere rating and dimensions and providing acceptable cable terminations shall be furnished and installed as directed by the Engineer.

The enclosure for the device shall be as specified for enclosures in 713.20. If the service pole does not support the control center, the enclosure door shall be stenciled "SERVICE SWITCH" with weather-resistant paint on the outside.

713.20 Control Center Components. 1. Scope. This specification covers electrical devices, materials and equipment composing a control center.

2. Safety switches and circuit breakers used in the control center shall conform to 713.19, 10.

3. Lighting circuit transformers shall be dry type without taps having the specified KVA rating to step up the supply voltage of 120/240 volts to 480 volts, single-phase, 60 Hz.

4. Contactor circuit transformers shall be dry type having the specified wattage rating to step down the lighting circuit voltage of 480 volts to 120 volts, single-phase, 60 Hz. A fuse shall be provided in series with the 480 volt winding.

5. Lighting contactor shall be open type provided with an electromagnetically held, 120 volt, 60 Hz coil. The contactor shall be rated at 30 amperes minimum and have a minimum of three poles. A "HAND-OFF-AUTO" selector switch shall be provided in the photoelectric cell circuit and located within the enclosure.

6. Photoelectric control shall be a solid state, cadmium-sulfide type with hermetically sealed silicon rectifier rated 120 volts, 60 Hz and 1,000 watts maximum load. Built in surge protection shall be provided and a fail-safe operating feature shall be included so that the lighting circuits will remain energized in the event the photo control components become inoperative. Nominal operating levels of this

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control shall be "turn on" at a minimum illumination value of three vertical footcandles and "turn-off" at a maximum illumination value of six vertical footcandles. These limitations shall be set by the manufacturer and maximum tolerances of plus or minus 20 percent for the specified values shall be acceptable.

Photoelectric controller shall be twist-lock type. A suitable mounting bracket with a locking type receptacle and all other necessary mounting hardware shall be furnished.

7. Lightning arrester shall be secondary type having the specified number of poles and rated 0-650 volts RMS. Arrester shall be provided with suitable mounting brackets and all other necessary mounting hardware.

8. Enclosures shall be NEMA ICS 1-110.15 Type 4 and shall be adequate to house the designated equipment for outdoor locations. All seams in sheet metal enclosures shall be fully welded. All fastenings used in assembly or mounting of the enclosures shall conform to ASTM A 320 (AISI-300 series).

Each enclosure shall be provided with a door so constructed that it may not be opened when the principal electrical disconnecting device mounted therein is in the "ON" position. However, provision shall be made by means of a lockable double-defeater opening handle to permit intentional opening of the door with a screwdriver when the disconnecting device is in the "ON" position.

Each enclosure shall be provided with the following:

(a) A door provided with a mechanism interlocking the door latch and the operating handle, including provision for padlocking. The mechanism shall be defeatable in the following sequence when the operating handle of the disconnecting device is in the "ON" position. (1) Release door latch with one hand on door latch handle while simultaneously operating door latch defeater screw with a screwdriver in the other hand. (2) Open door with one hand on door latch handle while simultaneously operating disconnect handle defeater screw with a screwdriver in the other hand.

The door latch defeater screw shall be sufficiently recessed within its housing so as not to be turned with a coin or flat washer.

The door latching mechanism shall provide that the door handle must be turned to fully engage its latch before the disconnect handle can be moved to the "ON" position.

(b) An insulated solid copper common neutral bus of adequate ampere rating and capable of terminating the specified sizes of wire.

(c) A schematic wiring decal of the entire control center installed on the inside of the door.

(d) An equipment warning sign reading "DANGER-HIGH VOLTAGE" stenciled on the outside of the door in red weather-resistant paint or the same wording etched on a brass plate riveted to the outside of the door. See 625.18 for other markings.

(e) A 14 gage or heavier enameled steel panel, securely fastened to the inside of the back of the enclosure and of adequate size to accommodate all devices and integral wiring on all sides and to the rear.

(f) Mounting flanges, hubs, weep holes, etc., as shown on the plans.

713.21 Light Towers. 1. Scope. This specification covers materials and manufacturing methods to be used in the fabrication of light towers, tower components, and anchors used to support luminaires. The design of light towers shall comply with applicable AASHTO requirements as set forth in the "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," with the design wind load based on a wind speed of 90 miles per hour, with a maximum load of six luminaires, each weighing 75 pounds with a projected area of 3.5 square feet, mounted on a head frame assembly with top latched lowering device having a projected area of 5.3 square feet and weighing 340 pounds.

2. General. The integral luminaire lowering mechanism or device shall be compatible with the tower design and consist of a head frame assembly, a luminaire ring assembly, and winch assembly. The system shall permit luminaire maintenance at ground level, provide a permanently attached plug cord for energizing the lighting assembly when it is at ground level, support two to six 75 pound luminaires in a symmetrical arrangement, and include power cables and all miscellaneous electrical and mechanical equipment in the tower necessary to provide a complete and workable device. Disconnection of the electrical service at each tower shall be accomplished by means of a two-pole, 30-ampere, 480-volt breaker with a minimum symmetrical RMS interrupting capacity of 14,000 amperes, complete with NEMA 1 enclosure. The breaker shall be accessible through the tower handhole.

A complete service manual including instructions on installation, operation, and maintenance shall be furnished for each lowering device, winch assembly, and power drive system furnished on the project.

3. Shafts. Tower shafts shall consist of not more than four round or multisided tapered steel sections for shafts up to and including 100 feet in length, five sections between 101 and 120 feet, and six sections over 120 feet. Steel used in fabricating the shaft shall have a minimum yield strength of 55,000 psi after fabrication or meet the requirements of an approved alternate design. Shop drawing submissions of alternate proposed designs shall be accompanied by sufficient calculations to demonstrate to the satisfaction of the Engineer that the design proposed meets the minimum requirements of the AASHTO specifications cited.

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Sections shall either telescope with each other or be shop butt welded by electric arc welding. The lap joint produced by telescoping shall have a length not less than 1-1/2 diameters of the shaft at the joint, measured at the minimum diameter of the inner telescoping section. The sections shall be pre-fitted and match-marked at the factory. The inside surface of the shaft shall be relatively smooth to provide a cable raceway.

There shall be no more than two longitudinal welds in the tapered sections of the shaft which shall be made by automatic electric arc welding. Transverse butt welds may be used, but only under closely-controlled shop conditions. All shaft welds, except on longitudinal seams, shall have complete penetration, shall have uniform density, and shall be no thinner than the shaft material nor more than 20 percent thicker than the shaft material. Shaft welds on longitudinal seams shall have at least 60 percent penetration except in areas where the shaft section telescopes over another section. In the overlapping areas, the penetration shall be at least 95 percent complete.

The shaft shall be joined to the base plate using the American Welding Society prequalified joint TC-U4a-S or TC-U4c-GF. All handholes or openings in the shaft shall be properly reinforced to avoid stress risers, and be welded to the shaft using a joint and techniques designed to insure total penetration plus an outside fillet equal to the thickness of the shaft material. The handhole shall be gasketed to make it weatherproof. The door shall be fabricated from the same type steel as the shaft and attached with stainless steel hinges having nonremovable stainless steel hinge pins. The door shall include provisions for padlocking. A tapped hole shall be provided at the base of the tower for a 1/2x13 galvanized bolt and washer connection for the grounding cable to be carried through the electrical metallic tubing in the foundation to the ground rod. Grounding of the circuit breaker enclosure in the base of the tower shall be accomplished by a jumper bonded to the incoming neutral conductor.

Shafts of material other than weathering or corrosion resistant alloy steels having four or more times the corrosion resistance of carbon structural steel shall be hot dipped galvanized after fabrication in accordance with the requirements of 711.02. Where A 588 steel is used, the exterior of the shaft shall be thoroughly shotblasted or otherwise cleaned to remove all oily or foreign matter to insure a uniform weathering pattern. The interior of the shaft shall be cleared of all mill scale and foreign matter by a pickling process or by being thoroughly shotblasted.

4. Luminaire Ring Assembly. The luminaire ring assembly shall be fabricated from steel which conforms to ASTM A 36 or material which has the same strength and weathering characteristics as the tower. The ring shall be fitted with the appropriate number of two inch nominal steel pipe mounting arms. The luminaire ring shall be prewired with copper conductor of adequate size and insulation to facilitate wiring the required number of luminaires. All power cables shall be attached to a weathertight junction box with weathertight cable connections. The main electrical supply cable and its connector shall support one and one-half times the full cable weight without cutting the conductors or insulation and without stretching the outer

jacket of the cable. If a "Kellams" grip is used, it shall be protected to prevent its rubbing against any object which is in relative motion to it during the lowering and raising of the luminaire ring assembly. The similar connection of the electrical cable to the cable termination within the tower shall meet the same requirements, but shall be capable of supporting the weight of the cable plus a wind load on the cable length due to 30 mile per hour winds. The junction box shall include a secondary line lightning arrester and 600 volt terminal block, completely prewired. A weathertight twist lock power inlet shall be provided on the luminaire ring to allow testing of the luminaire ring while in the lowered position.

The luminaire ring shall be supported by three galvanized steel aircraft cables of seven strands, 19 wires each, with a minimum diameter of 3/16 inch. Each of the three cables shall be secured to the ring and to the cable terminating device within the tower by means of compatible corrosion resistant devices. The connection of the three cables to the terminator shall be by shop applied, swage-type fittings designed to develop a holding strength equal to the breaking strength of the cable.

Positive latching devices shall be incorporated into the ring assembly. These devices shall be designed to prevent any movement of the ring assembly when it is latched to the top of the pole and tension is removed from the ring support cables. All moving parts of the latching devices shall be a part of the luminaire ring assembly. Reflectors or flags shall be provided to indicate when the luminaire ring assembly is completely and securely latched to the head assembly. To prevent unnecessary stresses on luminaires and lamps, the latching sequence shall not exert a horizontal force sufficient to cause an excess of four g's acceleration upon the luminaires.

The ring assembly shall have nonabrasive rollers mounted on the ring interior or have a minimum of three roller-contact spring loaded centering arms to prevent the ring or luminaires from striking the pole shaft during raising and lowering of the ring. If centering arms are not used, the rollers shall be of sufficient quantity and at proper positions to prevent the pole from striking any part of the ring except the rollers. This cushioning mechanism shall be capable of reducing the shock experienced by the luminaire ring assembly when it strikes a rigid pole shaft at a speed of two feet per second, to a maximum deceleration of four g's.

5. Head Frame Assembly. The head frame assembly shall be fabricated from steel which conforms to the requirements of ASTM A 36, or steel which has the same strength and weathering characteristics as the tower. It shall consist of all necessary pulleys and rollers to guide the hoisting cables and electrical cable. The minimum tread diameter for the hoisting cable sheaves shall be 20 times the cable diameter for galvanized cable and 25 times the cable diameter for stainless steel cable. The hoisting cable sheave groove cross section shall be semicircular with a radius of one-half the cable diameter plus 1/64 inch. All hoisting cable sheaves shall be suspended on stainless steel shafts fitted with oil-impregnated bronze bushings.

The electrical cable shall not be bent at a radius less than five times the cable diameter, and the groove cross section shall prevent the cable from rolling out of the

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groove if the cable is twisting. All electrical cable sheaves and rollers shall be suspended on stainless steel shafts fitted with self-lubricating bushings or be fabricated of self-lubricating material.

A guide shall be provided to separate the individual cables so that twisted or tangled cables cannot reach a pulley.

The headframe assembly shall be protected from the weather by a dome having the same weathering characteristics as the tower, by a fiberglass hood, or by a spun aluminum cover.

6. Winch Assembly. The winch drum shall have a diameter not less than four inches, and shall be supported by rigidly mounted bearings of the proper load capacity. The drum flanges shall have a diameter at least three inches greater than the drum. A set of guides or a cable follower shall be provided to prevent cable buildup at the ends of the winch drum. Keepers shall be provided to prevent cable from fouling after the tension has been relieved.

The winch shall be driven by a worm gear reducer equipped with a self-locking device. The gear reducer shall be permanently lubricated and shall be enclosed in a housing of cast aluminum, cast iron, or other approved material. The gear reducer shall have an ultimate output torque capacity five times greater than that required to lift the nominal load.

7. Winch Drive System. The winch assembly shall be externally powered by a heavy duty reversing drill motor, or NEMA frame motor, minimum 3/4 horsepower rating, 120 volt. A torque limiter of size and rating recommended by the manufacturer shall be incorporated into the system to prevent overloading the hoisting system. The system shall include a transformer to step down the existing system voltage to 120 volts. The hoisting rate shall be between 15 and 25 feet per minute. A remote hand control unit with not less than 20 feet of cord shall be provided to allow operation of the unit while positioned away from the pole.

8. Base Plates. The base plate shall be fabricated from steel which conforms to the requirements of ASTM A 36.

9. Anchor Bolts. Anchor bolts shall be steel with a 85,000 psi (minimum) yield strength and shall be galvanized in accordance with 711.02. Galvanizing shall extend at least two inches beyond the threads. In lieu of a bent end, a drilled and tapped steel plate of approved size and thickness may be used. Anchor bolt sizes, projections and length, and bolt circle diameters are optional, and plan data of this type shall not be considered as restrictive or exclusive. However, no additional compensation will be permitted for any increase of the plan foundation cross section required to accommodate the tower design proposed.

10. Fittings. 713.01, 2(g), except that galvanized steel fittings shall not be permitted.

11. Welding. 513.17. All welds in the shaft shall be tested by ultrasonic or approved alternate method, and certification of this requirement shall be furnished to the Laboratory. Acceptance level shall satisfy AWS Structural Welding Code Article 9.25.3 for tensile stress.

12. Luminaires. The luminaires shall consist of an optical assembly, lamp, ballast, and aluminum housing with side entry mounting for a two inch pipe, which shall provide adjustment for leveling. The mounting attachments shall prevent twisting of the luminaire about the bracket. The entire unit shall be of substantial design adequate to operate at 70 to 150 foot mounting heights when subjected to wind velocities of 90 miles per hour.

The lamp socket shall be a heavy duty mogul, multiple prewired, porcelain enclosed type, with integral lamp grip, and large center contact spring providing a firm contact with the lamp base. It shall be provided with a lamp support around the neck of the lamp and independent of the socket. The socket assembly shall be preset to provide the ANSI-IES distribution specified in the plans but shall have provisions for adjustment to provide vertical control of the angle of maximum candlepower. The actual projected area of the ballasted luminaire shall not exceed 3.5 square feet. The ballast shall comply with the applicable sections of 713.11 and be rated to the circuit voltage, type and size of lamp specified in the plans.

The maximum beam intensity for the Type V distribution shall not exceed 325 candlepower per 1,000 lamp lumens at angles between 55 degrees and 65 degrees from nadir (downward). The nadir initial intensity shall not exceed 100 candlepower per 1,000 lamp lumens. The Type V optical design shall be capable of producing a uniformity of illumination with a maximum to minimum ratio not greater than 6.0 to 1, and an average to minimum ratio not greater than 3.0 to 1, with luminaires mounted in a square array spaced at 4.0 times the mounting height.

The maximum beam intensity for the Type II and III asymmetric distributions shall not exceed 425 candlepower per 1,000 lamp lumens at angles between 66 degrees and 73 degrees from nadir. The nadir initial intensity shall not exceed 175 candlepower per 1000 lamp lumens. The system illumination results obtained from the asymmetric optical design shall be capable of producing a uniformity of illumination with a maximum to minimum ratio not greater than 6.0 to 1, and an average to minimum ratio not greater than 3.0 to 1, with luminaires spaced at 5.0 times the mounting height and located along one side of an area whose width is 1.5 times the mounting height.

The maximum beam intensity for the Type I asymmetric distribution shall not exceed 425 candlepower per 1,000 lamp lumens at angles between 66 degrees and 73 degrees from nadir. The nadir initial intensity shall not exceed 175 candlepower per 1,000 lamp lumens. The system illumination results obtained from the asymmetric optical design shall be capable of producing a uniformity of illumination with a maximum to minimum ratio not greater than 6.0 to 1, and an average to

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minimum ratio not greater than 3.0 to 1, with luminaires spaced at 5.0 times the mounting height and located along the center line of an area whose width is 0.75 times the mounting height on either side of the center line.

The output efficiency of all high mast luminaires shall be not less than 65 percent of the bare lamp lumens, with 25 to 35 percent of the bare lamp lumens contained in the 60 to 90-degree vertical zone.

The design of the high mast luminaires shall be such that the entire arc tube of the lamp shall be optically shielded at angles above 70 degrees from nadir.

715 WATER MAIN MATERIALS

715.01 Materials-General. The Contractor shall submit to the Engineer for approval two copies of detailed drawings and/or specifications for all materials proposed to be furnished prior to the ordering or manufacture of the materials. The drawings and/or specifications shall contain all pertinent design information required to determine compliance with the specifications given herein.

For prestressed concrete cylinder pipe, the specifications and drawings must include design data, laying schedule and details for restrained type joints.

The Engineer shall, at all times, have access to all places of manufacture where materials are being fabricated or tested, in accordance with 106.03, and shall be at liberty at all times to inspect all materials and observe all tests on the materials. Any materials which, in the opinion of the Engineer, are not in conformity with the specifications herein stated, or the drawings submitted to the Engineer as herein required, will be rejected.

Unless otherwise specified herein, materials shall be manufactured, tested and inspected by the manufacturer in the manner required by the latest revision of AWWA/ANSI specifications. Such tests shall be at the Contractor's expense. The Contractor shall furnish to the Engineer two certified copies of the results of all materials tests and inspections. Should the Engineer not be present for the tests, the Contractor shall furnish a sworn statement that the inspections and tests have been made in accordance with AWWA/ANSI standards. Materials will not be accepted until test results are approved by the Engineer.

All materials must be delivered in all respects sound and in conformance with these specifications. The inspection shall not relieve the Contractor of any of his obligations specified herein, and any material found to be defective which may have been approved by the Engineer at the foundry or elsewhere shall be at all times liable to rejection until installed, tested and accepted. Care shall be taken not to injure the coating or lining of pipe or other materials during handling and transportation of the materials.

All materials furnished by a Contractor or supplier shall be guaranteed against defects in materials and workmanship for a period of one year after these materials are put in operation. This written guarantee shall be given to the Engineer before installation of these materials.

715.02 Ductile Iron Pipe. All ductile iron pipe shall be centrifugally cast Class 53 with bell and spigot push-on joints, complete with gaskets, lubricants, and shall be cement lined. The pipe shall be manufactured in strict conformity with the latest revision of the American National Standard for Ductile Iron Pipe ANSI A21.51

715.03

(AWWA C 151). The pipe shall be lined in accordance with ANSI A 21.4 (AWWA C 104). When ductile iron pipe is used for sewer force main, the lining shall be ceramic epoxy, or other lining material as specified in the contract.

All pipe shall be thoroughly cleaned and subjected to a careful hammer inspection. No pipe shall be coated or lined unless entirely clean and free from rust immediately before being dipped or lined. Any pipe that is to be recoated shall first be thoroughly scraped and cleaned.

All pipe shall have an asphaltic-based seal coat applied to the exterior and interior surfaces. The seal coat material must be approved for potable water service.

All pipe shall be furnished in 18 or 20 foot laying lengths, plus or minus one inch. No cut off pipe will be accepted.

Each pipe shall be subjected to a hydrostatic test pressure in accordance with ANSI A 21.51 Section 51-10 (AWWA C 151).

Every pipe shall be marked in accordance with ANSI A 21.51 Section 51-11 (AWWA C 151).

Gaskets and lubricant for all joints furnished under these specifications shall be manufactured in accordance with ANSI A 21.11 (AWWA C 111).

No centrifugally cast pipe shall be accepted, the weight of which is less than the tabulated weight by more than five (5) percent for pipe 12 inches or smaller in diameter, and four (4) percent for pipe larger than 12 inches in diameter.

When restrained joint pipe is specified on the construction drawings, the restrained joint shall be completely boltless and shall be rated at a working pressure up to 350 psi. The joint shall be capable of being deflected 3 degrees after assembly, with uniform load distribution between the restraining components when the joint is deflected. The joint shall have a ductile iron lock ring welded to the plain end with a 360 degree continuous weld. All welds on field-cut pipe shall be made inside a shop by a certified welder. The joint shall be capable of being easily disassembled should the need arise. The joint shall meet all push-on joint requirements of the latest revision of ANSI A21.11 (AWWA C111).

715.03 Special Castings. Bell and spigot special castings, mechanical joint bell to shouldered Victaulic coupling adapters, and flange and bell pipe shall be manufactured in strict conformity with ANSI/AWWA C 110 or C 153. Pressure rating shall be 150 psi or 250 psi, as directed by the Engineer.

Special castings shall have mechanical joint ends. Valve adapters shall have mechanical joint and Victaulic ends. Mechanical joint bell to Victaulic adapters shall be one foot long.

Every special casting shall be marked in accordance with ANSI/AWWA C 110 or C 153. Compact fittings per AWWA C153 must be ductile iron.

All special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust immediately before being dipped or sprayed.

Special castings shall be cement lined in accordance with ANSI A 21.4 (AWWA C 104), or epoxy-coated in accordance with ANSI A 21.16 (AWWA C 116) requirements.

Every casting shall have an asphaltic-based seal coat applied to the exterior and interior surfaces. The seal coat material must be approved for potable water service.

No special castings shall be accepted, the weight of which shall be less than the tabulated weight by more than ten percent for fittings 12 inches or less in diameter, or eight percent for larger sizes, and no excess above the standard weight of more than the above percentages for the several sizes will be paid for. These variations apply only to castings made from the standard patterns.

Mechanical joint bell to Victaulic adapters shall have shouldered ends and be fabricated to the dimensions shown on the plans, and have a pressure rating of 150 psi or 250 psi, as directed by the Engineer.

715.04 Prestressed Concrete Cylinder Pipe. Prestressed concrete cylinder pipe shall be manufactured in accordance with AWWA C 301. Special pipe sections (including but not limited to pipe with beveled ends, pipe with outlets for air release valves and access hatches, and pipe with special ends) and fittings (including but not limited to bends and tees), closure pieces, and adapters for connection to other types of pipe shall also be manufactured in accordance with the above specification.

The pipe sections and fittings shall be designed for and rated at a maximum working water pressure of 300 psi. Except for special pipe sections, the pipe shall be furnished in 20 foot lengths.

Outlets shall be provided in the pipe for items such as air release valves, blow offs, pitometer taps, and water service fittings. The locations of the outlets in the finished pipe line shall be as shown on the plans, or modified by the Engineer.

Outlets two inch and smaller in diameter shall be of brass with female threads, and shall have temporary plugs to protect the threads. Two inch and one inch size outlets for automatic air release systems shall have I.P.S. threads. One inch size outlets for manual air release systems shall have threads compatible with the corporation stop furnished with the air release assembly. All other outlets two inches and smaller shall be of the type shown on the plans.

715.05

All outlets larger than two inches shall be of the size and type shown on the plans. Access hatches shall be provided in the finished pipe line at the locations shown on the plans, or modified by the Engineer.

Pipe sections shall be provided with shouldered Victaulic or other types of ends as required for connection to butterfly valves or other types of pipe. Restrained type joints shall be provided for all special pipe sections where unbalanced pressures occur. The joints shall be a harness clamp or snap ring type, and shall be sealed with grout after installation. Bolted type joints will not be permitted. Bolts may be used for securing the harness clamp or snap ring, provided that such bolts are covered with grout. The joints shall be designed to resist the outward thrust caused by the design pressure specified above.

715.05 Steel Water Pipe. Furnish and install steel pipe and accessories as indicated on the drawings and/or specified herein. Design pipe in accordance with AWWA M-11. Design all pipe, fittings, and specials to withstand the effects of a full vacuum of 34 feet of hydrostatic pressure.

Manufacture pipe in accordance with AWWA C-200 from steel plates spirally formed into cylinders with seams butt welded. Fabricate steel pipe, fittings, and specials to the dimensions, diameters, and shapes indicated on the drawings from steel sheets conforming to the latest revisions of ASTM A-53 Grade B, or ASTM A-139 Grade A, B, or C. Fabricate fittings in accordance with the latest revision of AWWA C-200, section 4, from pipe conforming to the standard.

Furnish pipe in 20 to 45 foot lengths in quantities as specifically requested. Stull all pipe with a diameter to thickness ratio of 100 or more during shipping and handling.

Test every pipe pursuant to the latest revision of AWWA C-200, section 3.4. Do not ship to the jobsite any pipe which has been used for testing purposes. Limit the maximum allowable deflection for all buried pipe to two (2) percent of the inside pipe diameter to prevent damage to the cement mortar lining.

The interior surfaces of all steel pipe shall be shop lined with a centrifugally-applied cement mortar coating a minimum of 5/16 inch thick for diameters up to and including 20 inches, 3/8 inch thick for 24 through 36 inch diameters, and 1/2 inch for diameters greater than 36 inch.

Apply exterior corrosion protection coating consisting of prefabricated cold-applied tapes placed by mechanical methods to all steel pipe, fittings, specials, and field joints. The primary reference standards for the exterior tape coating work of this contract shall be the latest revisions of AWWA C-214 for pipe and AWWA C-209 for fittings. Apply the tape coating system as a three-layer system consisting of a primer, an innerwrap tape for corrosion protection and a double layer or outerwrap tapes for mechanical protection.

Weld all joints in accordance with the latest revision of the AWWA Standard C-206, field welding of steel water pipe. All welds shall be butt or lap welds. Any repaired weld shall be inspected by the same means, and to the same standards, as the original weld.

In addition to the field hydrostatic testing of the entire pipeline, test each field butt-welded joint 100 percent by radiographic examination. Radiographic examination procedure and acceptability shall be in accordance of Sections 8 and G of A.P.I. Standard 1004.

Clean and mortar line all unlined ends adjacent to field welded joints, including the weld, after installation of pipe, fittings, and specials.

Handle the lined and tape-wrapped pipe at all times with wide belt slings and wide padded skids and other equipment designed to prevent damage to the wrapping and the lining. Install pipe, fittings, and specials in such a manner so as to prevent any damage to the coating. Prior to backfilling any section of the pipeline, final inspect all surfaces using an approved holiday detector. Note any defects and repair and retest the surfaces until satisfactory results are obtained.

Place granular backfill material in the trench bottom and compact to 90 percent relative density. Lay pipe on this compacted material to the required grade. Provide bell holes to permit coating the exterior pipe joints following joint welding. Support the pipe barrel uniformly for its full length.

Carefully place granular backfill material uniformly on both sides of the pipe to an elevation of four-tenths (0.4) of the outside diameter of the pipe, taking precautions not to disturb the pipe alignment. Give special attention to assure that the material flows under the pipe haunches and that vibrators are compacting this area of the backfill.

Furnish and install a cathodic protection system after the proper completion of the geotechnical survey, galvanic anode system, and follow-up baseline survey.

Bond all steep pipe and fitting joints, except dielectric insulated joints and welded joints, to make the entire pipeline electrically continuous.

Furnish and install dielectric unions at all locations where the steel transmission main connects to the existing water distribution system, whether the existing system is of prestressed concrete, cast iron, or ductile iron. Install electric isolation test stations at all dielectric insulator locations.

Install electrolysis test stations where shown on the contract drawings. Make all cathodic protection cable and wire connections by the thermite weld method. Use a bituminous coating compound for thermite welds.

715.06

715.06 Gate valves. Gate valves for diameters 4 inch through 16 inch shall be resilient seat wedge complying with the latest revision of ANSI/AWWA Standard C509, or C515.

Gate valves shall be cast or ductile iron body meeting AWWA C509 or ductile iron meeting AWWA C515, with inside-screw design and non-rising stem with thrust bearing washers. The stem shall be protected by a weathershield and an upper o-ring above the stem collar. Another o-ring shall be provided underneath the stem collar to seal the bearing surfaces from line content.

Gate valves shall be furnished with mechanical joint ends unless otherwise specified on the plans. If flanged-end valves are furnished, stainless steel type 304 bolts and nuts shall be used.

All bolts and nuts shall be zinc-plated steel or stainless steel with a minimum bolt size of 5/8 inch. If 5/8 inch bolts are not used, 1/2 inch diameter stainless steel type 304 bolts and nuts shall be used.

All gate valves will be installed in a vertical position without actuators and designed to operate equally well with pressure on either side of the gate. The valves shall be designed for 400 pounds per square inch test and 200 pounds per square inch working pressure with no leakage. Valves are to open by turning the red two inch square operating nut to the right (clockwise).

After inspection and testing, the valves shall be painted with two coats of paint meeting the requirements of ANSI/AWWA C509.

715.07 Butterfly Valves. Butterfly valves and operators shall be manufactured in conformity with AWWA C504 except as amended herein.

Butterfly valves shall have a pressure rating of 150 psi or 250 psi, as directed by the Engineer, with a cast or ductile iron short body, corrosion resistant ductile iron disc, rubber seal, stainless steel body seat ring, nylon bearings, and a replaceable rubber seat. Valve bodies shall be furnished with mechanical joint or shouldered ends compatible with the Victaulic coupling specified in 715.09. Flanged end or wafer style valves will not be permitted. Butterfly valves shall have an adjustable rubber seal mounted on the valve body.

Actuators shall be sized to minimize the number of turns required to operate the valve. Actuators shall withstand a minimum input torque of 400 foot-pounds.

Valves are to be used as control valves in the water distribution system. Valves shall be designed to work with the shaft in a horizontal position and shall have enclosed gears, and shall be manually operated through a valve box by turning a two inch square operating nut with the stainless steel or brass retaining nut to the right or clockwise to open. The valves shall be designed for complete burial.

Valves shall receive the standard asphalt varnish finish in accordance with AWWA C504.

715.08 Check Valves. Check valves shall be iron body, bronze mounted, horizontal swing, with the standard flange ends. The valves shall be suitable for buried service. Bolts and nuts attaching the access flange and all other flanges shall be of construction-grade stainless steel 316.

Check valves shall be factory hydrostatically tested at 300 psi. The valves shall be designed for a minimum working pressure of 125 psi.

715.09 Couplings. Mechanical-compression sleeve type couplings shall be used for joining steel or ductile iron water mains. The couplings shall be constructed of epoxy-coated steel with a strength at least as great as that of the pipe being joined, and shall have high strength low alloy shopcoated steel bolts. The couplings shall be designed to compress rubber gasket rings against the abutting sections of pipe when the coupling bolts are tightened. The couplings shall provide sufficient flexibility so that the pipe may be installed on slight curves and grades without the use of special pipe sections, while remaining watertight.

Reducing couplings for connecting pipes of different outside diameters shall be of the same design specified above. Expansion couplings for absorbing thermal pipe movements shall be constructed of the same materials as the previously mentioned couplings, with alternate rubber sealing rings and alternate jute lubricating rings for packing material. Single-end expansion couplings shall provide up to ten inches of concentrated pipe movement. Double-end expansion joints shall permit up to eight inches movement if the body is anchored.

Style 44N Victaulic couplings shall be used for connecting butterfly valves with shouldered ends to cast or ductile iron bell to Victaulic adapters and Victaulic ends on concrete and steel pipe. Victaulic couplings shall be painted with at least one prime and one shop coat of paint, and shall be furnished with Type 304 stainless steel bolts. The style 44N Victaulic coupling is a single source item.

715.10 Valve Boxes. Valve boxes shall be constructed of cast iron, and shall be of the design and dimensions shown on the plans.

715.11 Fire Hydrants. Fire hydrants shall conform to the requirements of AWWA C502, except as hereinafter modified.

Fire hydrants shall be of the post type with compression type valves that close with the line pressure and shall be designed for a working pressure of 150 pounds per square inch in ordinary water works service. Wet barrel hydrants are not acceptable.

Fire hydrants shall meet the following specifications:

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Bury length. The Bury length, the distance from the bottom of the inlet connection to the ground line, shall be five feet, six inches.

Type of shut off. Compression type closing with the line pressure and shall be of the center stem construction.

Inlet connection. The inlet shall be a six-inch or eight-inch bell end connection, as specified on the plans, suitable for a mechanical joint of Class 53 ductile iron spigot end pipe.

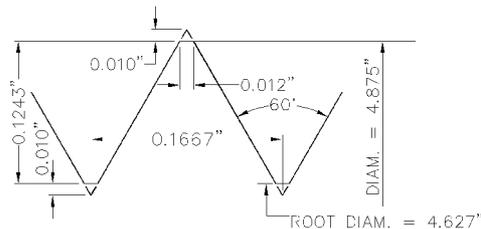
Hose nozzles and caps. Each hydrant shall have two 2-1/2 inch and one 4 inch bronze nozzle nipples threaded to conform with Akron, Ohio Fire Department Standard Hose Coupling as follows:

Data for nozzle threads:

<u>Diameter of nozzle</u>	<u>4"</u>	<u>2-1/2"</u>
Outside diam. of thread	4.875"	3.230"
Root diam.	4.627"	2.962"
Total length threaded	1-1/8"	15/16"
Flat top & valley of thread	.010"	.010"
Threads per inch	6	6

Outer end of thread left blank for 1/8 inch and terminated by "Higbee Cut" to avoid crossing and mutilation of otherwise finely drawn out thread.

4 inch nozzle form of thread:



Nipples shall be threaded directly into the hydrant barrel with left-hand thread or bayonet-style and secured. Bushings will not be permitted. Nozzle chains are not required.

Direction of opening. Hydrants shall open by turning to the left counter-clockwise). There shall be cast on the hydrant in characters raised 1/8 inch the type of hydrant,

an arrow at least 2-1/2 inches long, and the word "OPEN" in letters 1/2 inch high in relief, indicating direction to turn to open the hydrant.

Operating nut. The size and shape of the operating nut shall be a 1-1/2 inch pentagon measured from point to flat. The operating nut thrust collar shall bear against an anti-friction washer to ball bearing when the operating nut is turned in the opening direction.

Hydrant barrel. Hydrant barrels shall be in two sections. The union between the upper and lower barrels shall be made by means of a traffic safety device which will break cleanly upon traffic impact. The design shall be strong enough to withstand normal handling such as would be encountered in loading, unloading and installation. The design shall be such that the upper barrel can be rotated from 1 to 360 degrees without total disassembly of the device. Breaking devices relying on bolted flanges and weakened bolts for a safety device are not acceptable. Devices that are acceptable are a one- or two-part safety flange.

All lower barrel parts shall be made of cast iron Class "B" ASTM 126. If ductile iron is used, the wall thickness shall be a minimum of 0.40 inches and the shoe must be made of the same material. All flanges are to be integrally cast regardless of the type of material used. Threaded on flanges are not permitted. Bolts securing the lower barrel to the shoe shall be made of stainless steel.

The hydrant barrel shall be designed to permit the valve and operating mechanism to be removed without disturbing the barrel.

The hydrant shall be so constructed that if the barrel be broken, the valve will remain closed. Flange bolts shall have exposed nuts to facilitate their removal.

The ground line coupling or safety flange joint shall be two inches above grade line. The barrel shall be so designed as to permit the use of one or more standard flanged extensions, which shall be available from the hydrant manufacturer, in lengths of six inches to 60 inches in six inch increments.

Valve and drain stem. Valve and drain shall be operated by a single stem. An auxiliary stem or rod for operating the drain will not be permitted. The stem shall be designed to permit the use of standard stem extensions, which shall be available from the hydrant manufacturer in lengths of six inches to 60 inches in six inch increments. The hydrant stem shall be a two part stem jointed by a breakable stem coupling, with stainless steel pins or stainless steel bolts and nuts. The stem coupling shall be located at the same approximate elevation as the ground coupling. The valve assembly shall include no less than two positive acting drain valves.

Main valve and seat ring. All hydrants shall have a main valve opening of 5-1/4 or 6 inches in diameter, as specified on the plans. The valve gasket shall be of synthetic rubber at least one (1) inch thick.

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The seat ring and main valve assembly shall be designed so that it can be removed from above ground through the upper barrel by means of a light weight seat removal wrench. The seat ring must thread directly into a bronze seat bushing. The seat ring, in conjunction with the bronze bushing, shall form an all bronze drain way. All bronze parts must contain less than 16 percent zinc. All pressure seals used between the seat ring and bronze bushing shall be rubber "O" rings.

If bolts and nuts are used to retain the drain ring and seat ring between the lower barrel and hydrant shoe, they must be made of stainless steel type 304.

Packing and stuffing box. O-ring seals shall be used.

Gaskets. Flanged joints shall have approved rubber impregnated cloth gaskets or 'o' ring gaskets.

Materials. All hydrants shall be fully bronze mounted. All bolts and nuts shall be zinc plated, or stainless steel where specified.

Painting. All iron work shall be thoroughly cleaned and the valve rods, the inside of all iron parts, and the outside of the hydrant below the ground line shall be thoroughly painted with two coats of an approved paint complying with AWWA C550. The outside of the hydrants, including the bonnet and caps, above the ground line shall be painted with two coats of chrome yellow paint approved by the Engineer.

Testing. All hydrants shall be tested at a pressure of 300 pounds per square inch before leaving the factory as specified in AWWA C502. If required by the Engineer, the hydrants shall be subjected to a hammer test while under pressure.

Hydrants shall be fully opened and closed before shipping in order to test the freedom and strength of the parts. In order to test the strength of the operating mechanism, the operating stem nut shall be subjected to a minimum torque of 200 foot pounds in the manner specified in AWWA C 502.

Pressure loss and quantity of flow tests. Pressure loss and quantity of flow tests shall be conducted on the exact production line model of the hydrant to be furnished. The testing shall be done by a qualified reputable testing laboratory, or shall be done by the manufacturer and witnessed by an independent Professional Engineer knowledgeable in hydraulic testing. The Engineer may waive the requirement of the tests if such tests have been conducted within the last five years in the manner hereinafter specified, and the test results are available.

The testing procedure shall be in accordance with AWWA C 502 as modified to obtain the following results.

Pressure loss through a 5.25 inch main valve hydrant shall not exceed the following:

One 2 ½" Nozzle (Both Nozzles) @ 250 GPM Flow	0.50 psi
Two 2 ½" Nozzles @ 500 GPM Flow	1.00 psi
One 4" Pumper Nozzle @ 1,000 GPM Flow	2.90 psi
One 4" Pumper Nozzle @ 1,500 GPM Flow	5.50 psi
One 4" Pumper Nozzle @ 2,500 GPM Flow	20.00 psi

Pressure loss through a 6 inch main valve hydrant shall not exceed the following:

One 4" Pumper Nozzle @ 1,000 GPM Flow	2.00 psi
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The results and the procedures of the testing shall be certified by the testing laboratory or independent Professional Engineer. The report of the results shall include, but shall not be limited to, the following:

1. Flow and pressure loss charts for the hydrant.
2. Name, model or catalog number and year of production of the hydrant being tested.
3. Schematic of testing arrangement with all pertinent dimensions such as the following:
 - a. Interior diameter of inlet piping.
 - b. Distance from meter flange to manometer inlet tube.
 - c. Distance from the meter flange to the hydrant inlet.
 - d. Distance from the nozzles to the manometer.
 - e. Depth of hydrant bury.
 - f. Interior diameter and length of discharge tube.
4. If used on these tests, recent accuracy tests or curves of meter used in measuring the flows.
5. Accuracy of all other measuring devices.

Additional testing. Teardown and traffic accident tests shall be conducted on the exact production model of the hydrant to be furnished, upon request by the City.

715.12 Air Release Assemblies. Automatic air release assemblies shall consist of an automatic air release valve, a riser consisting of two brass nipples, and a brass gate valve. The brass nipples shall be used to connect the air release valve to the gate valve and the gate valve to the tap in the water main.

Automatic air release valves shall be composed of an air release valve and an air and vacuum valve in combination that will allow large volumes of air to escape out of the large air vacuum orifice when filling a pipeline and close watertight when the liquid enters the valve. During large orifice closure, the small air release orifice shall open to allow small pockets of air to escape automatically and independently of the large orifice. The large air vacuum orifice shall permit large volumes of air to

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enter during pipeline drainage to relieve the vacuum. The combination air and vacuum valve shall be designed for a working pressure of 150 psi, and test pressure of 300 psi.

Gate valves shall be designed for a test pressure of 300 psi and a working pressure of 150 psi.

Air release valves, gate valves and brass nipples shall be I.P.S., threaded, and shall be of the sizes shown on the plans. Air release valve height shall not exceed 15 inches.

Manual Air Release Assemblies. Manual air release assemblies shall be constructed of the materials and in the configuration shown on the plans.

Corporation stops, curb stops, and elbows shall be brass with connections for copper pipe, and shall meet the requirements of 715.13. The elbow below the riser pipe shall be provided with a 1/8 inch hole for drainage. Brass fittings shall be painted with a coating of red lead as specified above.

Copper pipe shall be Type K and shall conform to AWWA C 800.

The copper riser pipe shall be provided with a galvanized iron cap with appropriate copper to iron connections.

The rod for operating the curb stop shall be constructed of the material and to the dimensions shown on the plans. The valve box shall be as specified in 715.10.

715.13 Brass Service Fittings. Brass fittings shall meet or exceed AWWA C800 and all other design requirements herein specified.

Corporation stops, one inch and under. All corporation stops shall be of the round way type for insertion into water mains under pressure. The inlet thread shall be AWWA and conform to Table 6 of AWWA C800. All threads shall be protected in shipment by a plastic coating or other equally satisfactory means. All corporation stops one inch and under shall be designed to rotate about the axis of the flow passageway inside a minimum of 2-7/8 inches circle of rotation. All corporation stops must be of the straight or tapered plug type using rubber "O" rings as pressure seals.

The plugs of corporation stops one inch and under shall be provided with integral cast tee heads 3/8 inch by 3/8 inch wide for shut off key. All corporation stops must operate (open and close) with a fifty foot pound maximum torque at 40°F under a head of sixty psi. The key and the body shall be tapered and shall be accurately fitted together by turning the key and reaming the body, and the seating surfaces shall be lapped together using abrasive suspension to insure accurate fit. The key shall be securely fastened in place with the 5/8 inch threaded brass nut and washer at

the bottom of the plug. The nut must be prestaked to distort the last thread and prevent accidental backing off of the nut.

The outlet connection shall be either a copper flare or compression type joint, as specified on the plans. The fitting thread for use with flared copper pipe shall be as specified in Table 3 of AWWA C 800. The coupling nut threads for the flared connections shall be as specified in Table 4. The length of the nut must be sufficient to support the pipe loading. Compression joints shall be as hereinafter specified.

Curb valves, 1, 1-1/2 and 2 inches. All curb valves are to be of the sealed ball type with a tee head to permit attachment of a slotted operating rod for on-off operation with a 90° turn of the rod. All valves when in the closed position must have zero leakage through the top, bottom, and ports at the maximum rated working pressure of 175 psi.

The body of the ball valves shall be of cast red brass containing 85% copper and 5% each of tin, lead, and zinc. The ball shall be of Teflon-coated brass, and shall be held in position by, and seal off against, seats of rubber that are held securely in place with epoxy adhesive. Valves shall be watertight against flow in either direction. The waterway shall be no smaller than the nominal size of the valve and shall be smooth with no abrupt changes in size to create resistance to flow. The stem that turns the ball shall exert no other force on it except to open or close the ball and shall be held securely in place by means of a bronze ring. The minimum diameter of the stem at the point of attachment to the valve body shall be as follows:

<u>Valve Size</u>	<u>Minimum Dia.</u>
1 inch	9/16 inch
1-1/2 inch	7/8 inch
2 inch	1 inch

The seal around the stem shall consist of two "O" rings. The stops or lugs for controlling the motion of the T-head shall be enclosed and properly positioned to line up the waterway through the ball with the water passage through the valve body.

Optional end connections shall be iron pipe threads, copper flare connections, or compression type connections for copper pipe.

All curb valves must be able to withstand minimum torque requirements of 125 ft. pounds input turning torque:

- a) Against the check in the opening direction
- b) Against the check in the closing direction

The inlet and outlet connections for curb valves shall be either copper flare or compression type joints as specified on the plans. The fitting thread for use with flared copper pipe shall be as specified in Table 3 of AWWA C 800. The coupling nut threads for the flared connection shall be as specified in Table 4. The length of

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the nut must be sufficient to support the pipe loading. Compression joints shall be as hereinafter specified.

Service Fittings, 3/4, 1, 1-1/4 and 2 inch. All other service fittings shall fully comply with the latest AWWA Standards, and the following design requirements. The end connections shall be male iron pipe, female iron pipe, copper flare, or compression joints.

Compression joints. All compression joints must be of the conductive type. The compression nut must have a baked on coating to reduce friction and to prevent galling. All compression joints must be of the design so that the gasket cannot be over-compressed. The joint design must permit a stab connection not requiring total disassembly of the joint. All 1-1/2 inch and 2 inch compression joints must be able to withstand a pull out of 3,000 pounds tensile load. All compression joints shall be adaptable to other standard service fittings with a minimum number of adapting fittings.

715.14 Steel Casing Pipe. Casing pipe shall be welded steel meeting the requirements of ASTM A 139 having a nominal diameter and minimum wall thickness in accordance with the table below, unless otherwise specified by the plans. Minimum yield strength of the pipe wall material shall be 35,000 psi.

The inside diameter of the casing pipe shall be no less than six inches greater than the largest outside diameter of the carrier pipe bell. When carrier pipe is for water main, minimum casing pipe wall thickness shall be 3/8 inch.

Steel Casing Pipe Diameter Vs. Minimum Thickness

Nominal Diameter (inches)	Nominal Thickness (inches)
12-3/4" and under	0.188" (3/16")
14"	0.250" (1/4")
16"	0.281" (9/32")
18"	0.312" (5/16")
20" and 22"	0.344" (11/32")
24"	0.375" (3/8")
26"	0.406" (13/32")
28"	0.438" (7/16")
30"	0.469" (15/32")
32"	0.500" (1/2")
34" and 36"	0.531" (17/32")
38"	0.562" (9/16")
40"	0.594" (19/32")
42"	0.625" (5/8")
44" and 46"	0.656" (21/32")
48"	0.688" (11/16")
50"	0.719" (23/32")
52"	0.750" (3/4")
54"	0.781" (25/32")
56" and 58"	0.812" (13/16")
60"	0.844" (27/32")
62"	0.875" (7/8")
64"	0.906" (29/32")
66" and 68"	0.938" (15/16")
70"	0.969" (31/32")
72"	1.000" (1")

If shown on the plans, casing pipe installed with cathodic protection may allow a minimum pipe wall thickness 0.063" (1/16") less than the thickness specified on the table, except for casing pipe diameters 12-3/4" and under.

The interior and exterior of the steel casing pipe shall be coated according to the specifications and application schedule of AWWA C210.

715.15 Polyethylene Encasement. Polyethylene encasement shall be clear, high quality, virgin polyethylene, labeled and meeting the latest requirements of AWWA C105.

715.16 Restrained Joints. All valves, bends, offsets, hydrant inlets, caps, plugs, and branches of tees and wyes must be restrained using a restraining ductile iron follower gland. Follower glands employing wedgeless set screws for restraint will not be permitted. Where required, straight pipe shall be restrained using a rubber gasket employing stainless steel locking segments, molded into the gasket.

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Where restrained joints are required for ductile iron pipe installed in a casing pipe, a boltless pipe locking system is required. The use of restraining gaskets with impregnated stainless steel locking segments shall not be permitted.

All restrained mechanical joints shall be made with construction-grade alloyed ductile iron, cor-ten, or passivated stainless steel 316 bolts, and 6-ounce zinc anode caps on every other T-head bolt.

715.17 Wood Blocking. Wood blocking for thrust blocks shall be white oak or other equivalent hardwood as defined by the National Hardwood Lumber Association, subject to the approval of the Engineer.

715.18 Gasket Lubricant. Gasket lubricant for concrete or ductile iron pipe joints shall be a material which is non-toxic, odorless, tasteless, and will not support bacteria.

715.19 Sterilizing Powder. Sterilizing powder shall be a sodium hypochlorite powder containing 15% available chlorine by weight. An alternate type of sterilizing material meeting the requirements of AWWA C 651 may be used if so approved by the Engineer.

715.20 Insulation. Insulation for above ground water pipe shall be a rigid hydrous calcium silicate insulation, two inches thick and molded in half sections to fit the contour of the pipe. The insulation shall be held in place with a water tight aluminum jacket, with a moisture barrier between the jacket and the insulation to prevent galvanic or chemical corrosion of the jacketing surface.

The conductivity rating of the insulating material shall be a maximum of 42 at 200°F. The insulation material shall conform to Federal Government Specifications HH-I-523 (A Class 2), MIL-I-2781-D (or E), MIL-I-24244, and ASTM C 533.

The aluminum jacket and all aluminum straps and bands shall be T-3003 or T-5005 H14 alloy, 0.016 inch thick. The aluminum jackets shall be in sections a minimum length of 36 inches, and shall be held in place with a locking weatherproof continuous friction type longitudinal joint. Each circumferential joint shall be sealed with a preformed aluminum strap containing a permanently plastic weatherproof sealant. The strap shall be centered over the joint and sealed with aluminum banding. The jacket and banding system shall be constructed to allow for thermal movement of the jacket without the joints pulling apart.

The moisture barrier shall consist of one layer of one mil polyethylene film with a protective coat of #40 virgin kraft paper, or other material with similar moisture resistant properties. The moisture barrier material shall be continuously laminated to the aluminum jacket.

Factory cut mitered sections of insulation and jacketing shall be provided for all elbows or special pipe sections, and prefabricated sections shall also be provided for all valves and couplings.

Where specified on the plans or by the Engineer, insulation for buried water mains shall be free-flowing, load bearing calcium carbonate particles chemically treated to be moisture repellant and coated with adhesive. Water mains shall be insulated with a minimum of four inches of compacted carbonate particles and covered with polyethylene moisture barrier.

715.21 Tapping Sleeves and Valves. Tapping sleeves shall be made of cast ductile iron and shall be dual compression seal type. Tapping valves shall cast iron body, flanged by mechanical joint ends, right to open and shall otherwise comply with 715.06.

715.22 Casing Spacers. Casing spacers shall be two-piece bolt-on style with ribbed bolt flanges for centering the carrier pipe on all sides within the casing pipe. The casing spacer must be fabricated of minimum 14 gage 304 stainless steel and 5/16 inch 304 stainless steel bolts. The shell shall be lined with a ribbed PVC extrusion to prevent slippage. Runners shall be made from a low friction polymer attached to the stainless steel risers by threaded fasteners. The risers shall be mig welded to the shell and the welds passivated. All risers over two inches in height shall be reinforced. Casing spacers shall be installed on the carrier pipe at the manufacturer's spacing recommendations.

715.23 Copper Tubing. Extra soft type K copper service tubing for underground services shall conform to the latest revision of AWWA C800, Section A.2 and ASTM B-88 specifications. Tubing shall be clean, free of dirt, defects, and cuprous oxide when inspected by a microscope magnification of 75 diameters.

715.24 Curb Boxes. All curb boxes, lids, pentagon nuts, and rods shall conform to the dimensions and requirements shown on the drawings. Riser pipe shall be yolo corrosion-resistant material. Each rod shall include a brass cotter pin for attachment to the curb box stop. All curb box tops shall have a brass ring insert to prevent galling of the plug to the box. Curb box rods shall be 3/4 inch square cold rolled steel.

715.25 Tapping Saddles. Service tapping saddles shall conform to the latest revision of AWWA C800, Section 4.3.

715.26 Valve Stem Extensions. Valve stem extension shall be heavy duty steel with a two-inch square operating nut. The extension shall attach to the valve operating nut and center the stem in the valve box.

715.27 Anchoring Pipe. Anchoring pipe shall be ductile iron, furnished in six-inch increments with a fixed mechanical joint flange and rotating ring gland.

730 TRAFFIC SIGN AND SUPPORT MATERIALS

730.01 Steel Tube and Pipe. ASTM A 53 Grade B or A 501 except that tubing for truss and end frame diagonals shall conform with 711.01.

730.02 Steel Anchor Bolts. Anchor bolts shall be steel with an 85,000 psi (minimum) yield strength and shall be galvanized in accordance with 711.02. Galvanizing shall extend at least two inches beyond the threads. Ends shall be either bent or have a drilled and tapped steel plate as specified in the plans.

730.03 Steel Poles and Arms. Poles and arms shall be steel with a 52,000 psi minimum yield strength and shall be galvanized in accordance with 711.02.

730.04 Steel Anchor Bases. Pole anchor bases shall be steel plate conforming to ASTM A 36 or ASTM A 572 Grade 42. The base plate shall be welded to the pole both inside and outside with fillet welds equal to the pole wall thickness, or by AWS prequalified welding joints TC U4a-S or TC U4a-GF. A cast steel base of equivalent strength may be used.

730.05 Handhole Covers. Handhole covers for poles and overhead sign supports shall be 0.109 inch (minimum) galvanized steel or 0.125 inch (nominal) aluminum alloy.

730.06 Pole Caps. Pole caps shall be aluminum or galvanized ferrous metal.

730.07 Arm Caps. Arm caps shall be steel and cover at least 50 percent of the end area.

730.08 Steel Hardware. Bolts 5/8 inch diameter or larger shall comply with ASTM A 325 and shall be protected against corrosion by mechanical galvanizing in accordance with ASTM B 454 Class 50. Bolts and screws less than 5/8 inch diameter shall comply with SAE J429 Grade 5, nuts of all sizes shall comply with SAE J995 Grade 2, flat washers shall comply with SAE J488, lockwashers shall comply with SAE J489, and the foregoing hardware shall be protected against corrosion by mechanical galvanizing in accordance with ASTM B 454 Class 25. U-bolts shall comply with ASTM A 307 and shall be galvanized in accordance with 711.02.

730.09 Stainless Steel. Any AISI 300 or 400 series stainless steel may be used.

730.10 Stainless Steel Hardware. Bolts, screws, nuts, washers, handhole cover chains and U-bolts shall be passivated commercial grade. ASTM A 320 (AISI 300 series).

730.11 Aluminum Sheet and Plate. Sheet for extrusheet panels shall be ASTM B 209, 3003-H18. Sheet for embossed copy shall be ASTM B 209, 3003-H14. Sheet

for flat sheet signs, overlay signs and flat copy, as well as plate for sign support structures, shall be ASTM B 209, 6061-T6.

730.12 Aluminum Extrusions. Extrusions for extrusheet panels shall be ASTM B 221, 6063-T6. Extrusions for sign support structure in the form of tubes, channels, angles, zees, bars, rods, wire and other shapes shall be ASTM B 211, 6061-T6.

730.13 Aluminum Tube and Pipe. Tubing shall be seamless drawn and shall be ASTM B 210, 6061-T6. Pipe shall be ASTM B 241, 6061-T6 or ASTM B 429, 6061-T6.

730.14 Aluminum Castings. Sand castings shall be ASTM B 26, 356-T6 or T7. Permanent mold castings shall be ASTM B 108, 356-T6 or T7.

730.15 Aluminum Forgings. ASTM B 247, 6061-T6.

730.16 Aluminum Welding Rods. AWS ER4043.

730.17 Aluminum Hardware. Hardware shall conform to the following:

	ASTM		
	Designation	Alloy	Condition or Temper
Bolts, and screws	B 211	2024	T4
Studs-welded	B 211	1100	H16
Nuts-hex	B 211	6061	T6
		6262	T9
Nuts-lock	B 211	2017	T4
Washers-flat	B 209	Clad 2024	T4
Lockwashers	B 211	7075	T6
Rivets-solid	B 316	6053	T6
		6061	T6
Rivets-blind	B 316	2017	F
		2117	F
		5056	F

730.18 Reflective Sheeting Type F. Type F reflective sheeting shall comply with Section 633.06 Type II sheet reflective material of U.S. Department of Transportation "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," FP-79.

730.19 Reflective Sheeting Type G. Type G reflective sheeting shall comply with Section 718 Type III sheet reflective material of U.S. Department of Transportation standard specifications FP-85.

730.20 Nonreflective Sheeting. Nonreflective sheeting shall comply with Section 633.06 of U.S. Department of Transportation standard specification FP-79, with the exception that the sheeting shall not incorporate any optical elements.

730.21 Reflector Units. Reflector units shall consist of transparent units with a smooth front surface and a rear surface sculptured in such a way as to return light from a vehicle's head-lights to the driver's eye in conformance with optical performance specifications given herein. The front surface shall contain no projection or identification other than may be required for product identification. The rear surface shall be permanently sealed against dust, water or water vapor by a seal backing of similar material fused around the perimeter. Reflector units assembled with gaskets will not be acceptable.

Reflector units shall have retaining lugs which will deform within elastic limits for insertion into accurately sized holes in embossed sign copy. Retaining lugs shall be undercut, and the reflector unit size shall be such as to permit free movement in the mounting hole to allow for differences in expansion and contraction between the reflector unit and sign copy.

Reflector units shall be fabricated of colorless methyl methacrylate plastic conforming to Federal Specification L-P-380, Type I, Class 3. Reflector units may be of several sizes to fit differing sign copy.

Reflective intensity values for reflector units shall not be less than those shown in the following table. Reflective intensity values are expressed in candlepower returned at the chosen angle by a reflector per square inch of reflective surface for each footcandle of illumination at the reflector. For light incidence angles of zero and 20 degrees, the minimum intensity value is given for divergence angles of one-tenth, one-sixth and one-third of a degree.

Reflective Intensity Values				
Divergence angle		0.10°	0.17°	0.33°
Incidence angle	0°	14°	10°	7°
	20°	5.6°	4°	2.8°

When required by the Laboratory, not less than 50 reflector units, including at least ten of each size, shall be submitted by the manufacturer for qualification testing purposes. The manufacturer shall certify that units shipped to the project are of the same type and quality as the sample units tested and prequalified.

Reflective intensity test. Reflector units will be tested for intensity values shown on the foregoing table. Intensity value measurements at other than zero degree incidence angle will be made with reflector units in a spinning fixture so that intensity variations due to the pattern of the sculptured back surface are averaged. Failure of two or more of the 50 samples to meet minimum intensity values shall

require a resampling of 100 reflector units. Failure of three or more of the 100 shall be cause for rejection of the reflector units.

Seal test. A sample of 50 reflector units will be submerged in water of room temperature and subjected for five minutes to a vacuum of five inches of mercury (gage). After restoring atmospheric pressure, the reflector units will be left submerged for an additional five minutes. When examined for water intake, failure of more than one unit shall be cause for rejection of the reflector units.

Heat resistance test. A sample of embossed aluminum sign copy containing reflector units will be placed in a horizontal position on a grid or perforated shelf of a circulating air oven so as to receive free circulation of air. The sample will be subjected to a temperature of 175°F plus or minus 5° for a period of four hours. At the conclusion of the test period the sample will be allowed to cool to room temperature and examined for any change in reflector unit shape or appearance when compared to unexposed reflector units. The reflector units will be removed from the copy and subjected to the seal test of the previous paragraph. Failure of more than one unit shall be cause for rejection of the reflector units.

730.22 Silk Screen Paste. Silk screen paste shall be of high quality and shall consist of opaque viscous paint or transparent colored overlay fluid deposited by the screened area to form a film of the desired legend on the sign surface. When dry, the film shall be smooth, hard, tough, and free from defects such as wrinkling, sagging, checking or peeling. The ingredients of the paste shall be compatible with reflective sheeting so that when deposited on the sheeting there shall be proper adhesion with no deterioration. The paste shall not dry in the screen in less than two hours.

Opaque screen paste shall be formulated so that it will flow out of the screened area without running, sagging, or streaking to form a uniform opaque film on the sign surface which shall be entirely satisfactory as to thickness, shade and hiding power.

Colored transparent paste shall be formulated so that it may be applied by the reverse silk screen process to the surface of reflective sheeting. The transparent film shall present a true color, whether by viewing the sign in daylight or by headlight beams. The paste shall be compatible with any sheeting or clear coating used. Colored transparent silk screen paste shall conform to standard interstate color charts of the FHWA as specified for reflective sheeting in accordance with 730.18.

730.24 Clear Coating. Clear coating shall consist of a colorless transparent plastic fluid coating material for application to the surface of reflective sheeting by the use of roller, spray or by dipping. Clear coating material shall be compatible with and shall extend the useful life of reflective sheeting.

730.25 Plywood. Panels shall be exterior type, Group 1, 60/60 high density plywood with both sides overlaid with resin treated fiber surfacing material with a matte finish, in accordance with United States Product Standard PS-1. Panel surfaces shall be covered with easily removable protective materials.

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730.26 Messenger Wire. Messenger wire shall be Utilities Grade, twisted strand galvanized steel wire conforming to ASTM A 475 Class B and the following table, with the exception that tags according to section 16b shall not be required on lengths less than 1,000 feet. Strain insulators shall be the wet porcelain process type. All accessories shall have a rated loading strength equal to or greater than the messenger wire minimum breaking strength.

Nominal diameter, inches	Number of wires in strand	Minimum breaking strength, pounds
½	7	25,000
7/16	7	18,000
3/8	7	11,500
5/16	7	6,000
1/4	3	4,500
		4,750*

*High strength instead of utilities grade

731 SIGN LIGHTING MATERIAL

731.01 Mercury Vapor Luminaire. Mercury vapor luminaires shall be complete lighting units consisting of a housing, door frame, refractor lens, reflector, socket and lamp. The luminaire shall have a weatherproof optical system.

The projected height of the luminaire including mounting device shall be not more than eleven inches high when positioned to provide optimum illumination of a sign face, 12-1/2 feet high.

The luminaire housing shall be cast aluminum of a natural finish or of gray baked acrylic enamel. The housing shall be adequately reinforced, and shall contain and support the reflector and lamp socket. A flexible permanent-set and heat-resistant waterproofed gasket shall be provided between the housing and door frame. The gasket shall be compressed to form a weatherproof seal when the door frame is closed. The gasket shall be suitably attached and shall be readily removable. Weepholes shall be provided in the luminaire housing or cover as required for drainage.

The door frame shall be either cast aluminum of the same finish as the housing, or an aluminum extrusion with an anodized finish. The door frame shall be hinged on one edge and fastened in place with spring loaded latches requiring no tools to open. Hinges, latches and other external hardware shall be stainless steel. When the door frame is opened, the hinge shall retain the door frame in a secure condition and shall not permit unintentional separation.

The refractor or lens of the optical system shall be borosilicate glass or its equivalent, capable of withstanding thermal shock and the impact of freezing rain or hail. The waterproof seal between refractor or lens and the door frame shall consist of a heat-resistant gasket or elastic cement.

The reflector shall be fabricated from aluminum and shaped to distribute light uniformly over the sign face, in conjunction with the lens or refractor supplied with the luminaire. The surface of the reflector shall be finished to preserve the original reflective characteristics.

Mercury lamp sockets shall be a mogul screw shell with a large center contact spring providing firm contact with the lamp base. The socket shall be porcelain-shrouded and shall include lamp grips.

The manufacturer shall provide, in addition to catalog cuts submitted for determination of compliance, complete photometric data for each type luminaire as used with a 175 watt, H39KB-175 lamp. Photometric performance data shall be certified by the manufacturer or a qualified independent testing laboratory. Minimum data required shall include a tabulation of illumination values at the centers of one foot square areas over a vertically-oriented ten by ten foot square grid with the luminaire positioned four feet in front of the vertical centerline of the grid and one foot below the bottom edge of the grid. The data shall include:

- (a) the maximum value obtained,
- (b) the minimum value obtained;
- (c) the average of the 100 measured values;
- (d) the ratio of the maximum and minimum values obtained;
- (e) the maximum ratio of illumination values obtained in any two contiguous areas.

Illumination shall be measured using a cosine-corrected receptor in the plane of the grid with the receptor optical axis perpendicular to the plane of the grid. Spectral response of the measuring device shall conform to the CIE (Commission Internationale de l'Eclairage) standard "photopic" response. The luminaire shall meet the following illumination requirements when tested under the above conditions:

- (1) the maximum illumination on any one foot square area shall be 50 foot-candles.
- (2) the average of the individual measurements shall be at least 20 foot-candles.
- (3) the ratio of the maximum and minimum values obtained shall be no greater than 6.0.

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- (4) the maximum ratio of values obtained in any two contiguous areas shall be no greater than 2.0.

The Engineer may require a special test to confirm that a mercury-vapor luminaire meets the weatherproof requirements. A luminaire complete with mounting connections and electrical conduit connections will be mounted in a manner simulating actual service. A water spray, adjusted to be equivalent to a driving rain, will be applied to the top, sides and bottom for a period of one hour. Any entrance of water resulting in wetting of a normally live electrical component, or internal part of the optical assembly, shall be cause for rejection.

731.02 Fluorescent Fixture. Fluorescent fixtures shall be complete lighting units consisting of a housing, plastic cover with frame, reflector, lamp sockets, and including a lamp. The fixture shall accommodate the specified lamp and shall have a completely weatherproof optical system.

Fixture design shall provide an integral wiring raceway permitting wiring from either end. When adjacent fixtures are wired together through the raceway, the wiring between fixtures shall be completely enclosed. The raceway shall be shaped to fit behind the reflector and shall be equivalent in area to at least a one inch conduit.

The fixture shall include end-mounting hubs designed to securely lock the fixture at any aiming position. Indicator graduations at increments not greater than ten degrees shall be integrally cast or stamped onto the hubs to facilitate the aiming adjustment.

The fixture housing shall be of materials which are corrosion resistant or with a high quality corrosion resistant finish. The housing shall be of sturdy construction and shall contain and support the reflector and lamp sockets. An attached flexible permanent-set resistant waterproof gasket shall be provided between the housing and cover frame. The gasket shall be compressed to form a weatherproof seal when the cover frame is closed and shall not be subject to any pulling away when the cover is opened.

The housing shall be painted in accordance with 514 with two prime coats and one finish coat which shall be baked-on enamel, matching the green sign sheeting.

The fixture cover shall be clear acrylic plastic and the cover frame shall be stainless steel or aluminum. The waterproof seal between the cover and the frame shall consist of a gasket or elastic cement. The cover frame shall be hinged on one edge and fastened in place with spring loaded latches requiring no tools to open. Hinges, latches and other external hardware shall be stainless steel. The cover frame shall not separate from the housing when opened.

The reflector shall be fabricated from aluminum with a highly specular surface shaped to distribute light uniformly over the sign face. The surface of the reflector shall be finished to preserve the original reflective characteristics.

Lamp sockets shall be spring loaded, plunger type and the socket and lamp junction shall be protected against moisture by the use of flexible permanent-set resistant boots.

The fluorescent lamp shall be 48, 72, or 96 inches long; T-12 bulb size; cool white; high, super high, or very high output type (F48, 72 or 96 T-12 CW/HO, SHO or VHO).

The Engineer may require the waterproof test described in 731.01.

731.03 Changeable-Message Sign, Lamp Type. (a) General. Changeable-message lamp type signs shall consist of units or groups of units containing arrangements of incandescent lamps so that by electrical circuitry, different messages may be displayed.

Alternate designs may be approved by the Engineer, providing the design is documented to the extent that plan requirements are shown to be met and equivalent legibility is achieved.

Housings, covers and hardware shall be of cast or sheet corrosion resistant materials fabricated by forming, welding, and riveting or bolting to provide adequate reinforcement. Synthetic elastomeric gaskets shall be used to provide a weatherproof unit. Louvers, vents or other cooling devices shall be used to maintain interior temperature within the capabilities of the components. Removable panels shall be used to physically separate wiring and lamps. Sign units shall be designed, and provided with hardware, for mounting within panel signs or to sign support structure.

Lamps shall be included and shall be the clear glass integral reflector type, of the base configuration, envelope diameter and wattage required. Lamps shall be readily accessible for replacement and shall be protected from extremes of weather conditions, shocks and vibrations of traffic, and from vandalism. Lamp sockets shall be UL approved and shall be of plated or unplated brass.

A dimmer shall be included to automatically reduce lamp output during low ambient light conditions. The dimming action shall be dual, multistage, or unlimited stage as specified.

(b) Limited message type. Changeable-message signs of this type shall contain lamps in an arrangement so that by the energizing of selected lamps two or more messages may be displayed.

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Type A signs shall contain lamps on panels behind an opaque screen with holes coinciding with lamp positions. When specified, a sunscreen shall be provided to insure that no face detail is visible when lamps are not energized.

Type B signs shall contain lamps on a panel coinciding with clear or colored glass lenses mounted in an opaque cover. Lamp tunnels or shields shall insure that each lamp when energized shall illuminate only its coincident lens.

Type C signs shall contain lamps on panels with each lamp enclosed in a metal cylinder with a removable cover containing a protective glass lens.

(c) Unlimited message type. Changeable-message signs of this type shall consist of lamps arranged in full matrix or alphanumeric type modules positioned side-by-side to provide line units of the length required. Line units shall be capable of displaying messages containing letters and numerals, limited only by the number of characters which can be accommodated. Line units shall be capable of displaying alternate messages by flashing.

Lamp modules shall be attached by suitable fasteners to line units. Control logic units, load switches, monitor feedback circuits, power supply, etc., shall be integrated within the line limits, or mounted within separate weatherproof corrosion-resistant enclosures as required.

731.04 Changeable-Message Sign, Drum Type. Changeable- message signs of this type shall consist of a drum of the required number of faces and mechanically rotated.

Drums shall be supported by bearings or bushings in a housing structure designed for easy drum dismantling. Individual sign messages on drum faces shall be removable flat sheet overlays. The drum and its housing shall be fabricated of corrosion-resistant material.

The gap between drum edges and the housing opening at normal viewing positions shall not exceed 1/2 inch and shall be closed with a flexible reinforced elastic flap for prevention of the ingress of foreign material. Heating elements shall be provided to insure drum rotation during icing conditions.

Controls for drum face selection shall be mounted in a weatherproof compartment of the housing and shall include an electric motor, speed reducer gear box and driving mechanism. The design shall insure that the drum face selected is retained in the proper position. Drum rotational speed shall provide message changes in three to five seconds. Controls shall be provided for: (1) remote powered operation, (2) on-site powered operation from a roadside control, and (3) manual drum rotation.

731.05 Internally Illuminated Sign. Internally illuminated signs shall be of the required legend and shall consist of an opaque housing with a face of translucent

plastic. When specified, signs shall be double faced. Signs shall be illuminated by interior lamps located so the sign face is uniformly lighted.

Signs shall be one of two types, either with legend on the exterior surface to maintain legibility when unlighted due to power failure, or with legend on the interior surface so as to be invisible when the sign is unlighted. Legend shall be black silk screening or by direct applied characters, and sign faces shall be white unless otherwise specified. Sign faces shall be designed for quick removal for maintenance and provided with a safety chain or like device. When specified, sign faces may be shielded by sunscreens, louvering or visors.

The housing shall be of corrosion-resistant material which shall be of cast, extruded or formed construction. Mounting hubs shall be provided and shall be similar to traffic signal design. The sign shall be weatherproof and shall include drainage weepholes.

The sign shall be furnished with appropriate hardware for mounting by span wire, mast arm, pedestal top, or pole type bracket arms. Lamps shall be included and shall be fluorescent type with ballast.

731.06 Sign Flasher Assembly. Sign flasher assemblies shall consist of a pair of flashing beacons for placement above and below a warning sign and shall include a fixture for lighting the sign, a flasher control unit with enclosure, and mounting hardware. Mounting hardware shall be compatible with the support design.

The beacons shall be of single traffic signal sections with eight or twelve inch yellow or red lenses. The sign lighting fixture shall be weatherproof and shielded to project its output downward on the sign. The flasher control unit shall flash the beacons alternately at a rate for each beacon of between 50 to 60 times per minute with the light period from one-half to two-thirds of the total cycle. EL71- Single Channel and EL72- Two Channel Electronic Time flasher control units shall include an interference filter. Control units shall be housed within a weatherproof corrosion-resistant enclosure with a lockable door. Incandescent lamps shall be included. The sign, support and foundation will be paid for separately.

731.07 School Speed Limit Sign Assembly. School speed limit sign assemblies shall consist of a reflectorized sign with an internally illuminated speed limit display unit. The unit shall be designed so that no number is visible when the sign is unlighted. The sign shall be fitted with a pair of flashing beacons arranged above and below, backing structure members with hardware for attachment of the sign to support structure, and shall include a flasher control unit and a timer in an enclosure. The beacons may be external to the sign or visible through holes in the sign face.

The beacons shall be yellow and eight inches or greater in size. The speed limit display unit shall be weatherproof and shall have black numerals on a white background or translucent white numerals on a black background.

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The flasher control unit shall flash the beacons alternately at a rate for each beacon of 50 to 60 times per minute with the light period from one-half to two-thirds of the total cycle. The timer shall permit automatic sign operation for selected times of the day and selected days in the week. The school speed limit sign assembly shall be provided with manual control of sign operation on site and from the school office. Flasher control unit, timer and switches shall be housed within a weatherproof corrosion-resistant enclosure with lockable door. Backing members with hardware shall be compatible with the method of support. Incandescent lamps shall be included.

731.08 Flexible Conduit. Flexible conduit for wiring of lighted signs shall be galvanized steel flextube with a waterproof polyvinyl chloride (PVC) jacket.

732 TRAFFIC SIGNAL MATERIAL

732.01 Vehicular Signal Heads, Conventional. Ensure that vehicular traffic signal heads conform to the ITE "Vehicle Traffic Control Signal Heads" standard. In conformance with the above standard, provide signal heads that are of cast nonferrous corrosion resistant metal or polycarbonate, with LED plastic or glass lenses. When provided, plastic lenses are ultraviolet stabilized, weather and impact resistant, and heat resistant so that operation does not cause crazing, cracking, deformation, color change, or other changes in physical properties.

Traffic signals consist of specified assemblies of optical sections 12-inch (300 mm) diameter colored lenses, a housing, a door frame with stainless steel hinge pins and latching device, gasketing, visor, wiring, and LED Lenses. Twelve-inch (300 mm) lenses are the standard wide angle type.

Fit each optical section with tunnel type visors unless other type visors or louvering is specified. Ensure that the visors for 12-inch (300 mm) lenses are at least 9 1/2 inches (240 mm) long.

Ensure that optical sections are designed for assembly with all 8-inch (200 mm), all 12-inch (300 mm), or intermixed arrangements. Assemble using suitable hardware that forms weatherproof joints with no light leakage from one section to another. Ensure that the assembly arrangements contain the specified number of optical sections, lens size, lens color, and circular or arrow configuration. Assemble from one to a maximum of five sections as specified to form a signal face.

Furnish multi-way heads with appropriate top and bottom brackets with an opening in the center of the top bracket provided for mounting purposes. Correct signal face height inequalities for multi-way heads for proper accommodation between top and bottom brackets by the use of pipe spacers.

Furnish signal heads with required mounting hardware. Furnish signal face orientation to traffic by serrated rings or other devices on housing sections and mounting hardware. Permit adjustment in increments not greater than 5 degrees of rotation and not affected by wind gusts when locked. Furnish galvanized steel or

aluminum spacers and drop pipes 1 1/2 inches (38 mm) in diameter. Ensure that disconnect hangers have at least twelve terminals unless a greater number is required.

Paint signal external surfaces with yellow enamel paint, Color 13655, Federal Standard 595. Only paint interior surfaces of visors flat black.

732.02 Vehicular Signal Heads, Optically Programmed, 12-inch (300 mm) Lens. Shall not be used in the City of Akron, Ohio.

732.03 Vehicular Signal Heads, Optically Programmed, 8-inch (200 mm) Lens. Shall not be used in the City of Akron, Ohio.

732.04 Signal Lamps.

A. Pedestrian Signal Lamps. Ensure that pedestrian signal LED's conform to the *ITE A Standard for Traffic Signal Lamps* and Table 732.04-1.

Lens Configuration	Lumens min. initial	Watts max. input	Rated Life, hours
Pedestrian, type D-2	550	8.1/6.6	60000

B. Vehicular Signal Lamps. Prequalify all traffic vehicular signal lamps with the City of Akron Traffic Engineering Division. Ensure that vehicular signal LED's conform to the *ITE A Standard for Traffic Signal Lamps* and Table 732.04-2.

Lens Configuration	Lumens, min. initial	Watts, max. input	Rated Life, hours
12-inch (300 mm) vehicular	1650	10/20/15	80000

Ensure that the LED is indelibly marked to show: original manufacturer's identification, rated voltage, rated lumens, rated average life, rated wattage, date of manufacture, and batch code.

732.05 Pedestrian Signal Heads. Furnish pedestrian signal heads that conform to the *ITE Pedestrian Traffic Control Signal Indications*. Furnish signal heads that are complete units. Ensure that the signal heads alternately display the symbol of an upraised hand in portland orange and the symbol of a walking person in white light. Furnish material for housings that consist of cast or sheet, corrosion resistant, non-ferrous metal. Adequately reinforce the housings. Ensure that the lens frames are non-ferrous metal or polycarbonate material.

Ensure that the lenses are glass or ultraviolet and impact-resistant plastic and display the legend with translucent symbols within an opaque black background.

Seal the lens to the door frame by the use of a weatherproof seal. Furnish an elastomeric gasket between the door frame and housing to ensure a dust and weatherproof seal.

Use a signal head design that provides adequate dissipation of heat to ensure rated lamp life.

Fit each compartment of pedestrian signal heads with a visor that is at least 7 inches (175 mm) in length or, in lieu of visors, protect the entire face with a

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sunshade fastened close to the lens. Furnish a black grid sunshade fabricated of high impact resistant plastic with a nominal depth of 1 1/2 inches (38 mm) and consisting of horizontal members spaced at not more than 1/2-inch (13 mm) and vertical members spaced appropriately.

Furnish pedestrian signal heads with required mounting brackets. Furnish either pipe type brackets or, when compatible with the mounting position required by the plans, two-piece hinged type brackets that support the signal head close to the pole.

Furnish 1 1/2-inch (38 mm) galvanized steel pipe brackets with necessary fittings and adapters, and that are one-way or two-way as required. Orient the signal face to crosswalks by selective meshing of serration rings or other devices provided on housings and mounting brackets. Make adjustment in increments not greater than 5 degrees of rotation and that is not affected by wind gusts when locked.

Furnish two-piece hinged brackets of cast aluminum with stainless steel hinge pins, and when closed shall be secured by a tamperproof bolt. Ensure that the mounting incorporates a terminal block for quick disconnect of field wiring. Ensure that the mounting design permits attachment to the pole by banding, bolting or by lag screws in the case of wood poles.

Paint signal exterior surfaces black with enamel paint. Only paint interior surfaces of visors flat black.

Furnish pedestrian signal head types according to Table 732.05-1.

Signal Head Type	Symbol Height, Inches, (mm)	Light Source
D2	9 (229)	LED

If specified, furnish the types listed below:

Type D2. Furnish a single housing signal head with an LED lens in one piece. Color and mask the lens to display in portland orange the symbol of an upraised hand and the overlaid symbol of a walking person in white.

732.06 Pedestrian Pushbuttons. Furnish pushbuttons of sturdy construction that consist of a base housing and a removable cover. Furnish components that provide a pushbutton with normally open contacts and that include all electrical and mechanical parts required for operation. Ensure that the electrical circuitry is suitable for testing at 120 volts although a lower voltage is used when operating.

Ensure that the design of the pushbutton and its associated contacts and housing are sturdy and resistant to mechanical shocks and abuse. Ensure that a concentrated force of 50 pounds (225 N) applied to the button or any exposed portion does not damage the unit or misadjusts the contacts. Furnish a housing with a curved back surface for mounting on poles of various diameters. Integrate the curved surface with the housing or supply an adapter with a flat back type housing. Attach the cover assembly to the housing by stainless steel machine screws, resulting in a weatherproof and shockproof assembly. Furnish a hole threaded for a 1/2-inch (13 mm) pipe in the housing for conduit attachment purposes. Paint external surfaces yellow with enamel paint of Color 13655, Federal Standard 595.

Ensure that the maximum force required to operate the pushbutton is 5 pounds per foot (22.5 N). Furnish a raised or flush pushbutton with a minimum of 2 inches (50 mm) at its smallest dimension.

Furnish pedestrian pushbutton signs that are a minimum of 0.07-inch (1.8 mm) steel or 0.10-inch (2.5 mm) aluminum. Ensure that the legends and backgrounds are baked enamel paint for steel signs and enamel paint or non-reflective sheeting for aluminum signs.

732.07 Loop Detector Units.

A. NEMA TS-1. Ensure that the loop detector units comply with the requirements of NEMA TS-1, section 15, with the following modifications. Furnish shelf mounted loop detector units that are powered from 120 volts. Use solid state isolated output units for all controller applications where directly connected to a solid state digital controller unit. Ensure that the conductors in the cable harness for loop input pins are twisted three to five times per 1 foot (300 mm).

Ensure that the electrical connections for four-channel shelf-mounted units either are the 19-pin MS connector, as required by the foregoing specification, or consist of four connectors of the type required for single-channel shelf-mounted detector units.

If specified, design detector unit electrical connection plugs or wiring harness such that any multi-channel shelf-mounted detector unit may be readily replaced with single-channel detector units. Accomplish this by furnishing only units with the connector type required for single-channel shelf-mounted detector units, or by wiring the controller back panel to single-channel harnesses which are, in turn, plug-connected to an adapter harness which is mated to the multi-channel connector of the detector unit.

B. NEMA TS-2. Furnish loop detector units according to NEMA Standards TS-2.

732.08 Loop Detector Units, Delay and Extension Type. Ensure that the loop detector units of this type comply with the requirements of NEMA TS-1, section 15. Furnish shelf-mounted loop detector units that are powered from 120 volts. Use solid state isolated output units for all controller application where directly connected to a solid state digital controller unit. When specified, apply the provisions of 732.07 for possible replacement of multi-channel units with single channel units.

732.09 Magnetometer Detector Units. Ensure that the detection system is capable of satisfactory operation when the probes are installed in locations in close proximity to steel structure such as on or within bridges. Ensure that each detector unit is suitable for connection with up to six sensor probes and with lead-in cable lengths up to 750 feet (230 m). Furnish magnetometer detector units that comply with applicable requirements of 732.07.

732.10 Magnetometer Sensor Probes. Furnish magnetometer sensor probes that are fully compatible with the detector unit supplied. Furnish sensor probes that include attached leads of sufficient length for proper installation and ensure that the operation is satisfactory with up to six probes connected to a single lead. Furnish

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probes that are moisture proof, corrosion resistant, and suitable for embedment within pavement holes with flexible sealant.

732.11 Signal Supports. Furnish signal poles and mast arms that are continuously tapered circular tubes. Ensure that any measurements of circular tube diameter at a specific point along the longitudinal axis do not vary by more than 3/16-inch (5 mm). Ensure that the taper is between 0.54 and 1.3 percent (0.14"/ft).

Fabricate mast arms of the true continuous taper type in two portions joined by overlapping of sections with the overlap being at least 1 1/2 diameters as determined by the largest diameter of the outer portion. Assemble the sections with a 5/8-inch (16 mm) minimum stainless steel or galvanized steel hex head through-bolt.

Ensure that there is not more than one longitudinal, automatically electrically welded seam on circular poles. Ensure that the welded seams are neat and uniform in appearance and have a thickness not less than the base material and a bead height not exceeding 1/16-inch (2 mm). Ensure that the wall thickness at each pole or arm cross-section is of uniform thickness, except at weld beads. Do not place transverse seams or welds on true continuous taper type poles or arms, except on types consisting of straight sections. Weld according to 513.17.

If using straight sections, relate the number of sections to pole or arm length according to Table 732.11-1. Do not use section lengths less than 20 percent or more than 50 percent of the respective pole or arm length.

Table 732.11-1

Pole Length (feet)	Arm Length (feet)	Number of Sections
Less than 15	Less than 10	1
15 to less than 30	10 to less than 20	2
30 to less than 40	20 to less than 30	3
40 or more	30 or more	4

Table 732.11-1M

Pole Length (meter)	Arm Length (meter)	Number of Sections
Less than 4.6	Less than 3	1
4.6 to less than 9	3 to less than 6.1	2
9 to less than 12	6.1 to less than 9.1	3
12 or more	9.1 or more	4

After fabrication, hot-dip galvanize poles and arms according to 711.02.

Do not use guy rods or truss-type arms. Furnish poles and mast arms with attachment plates and gussets. Assemble using high-strength bolts with the connection developing the full moment-resisting capability of the arm. Do not allow the butt diameter of mast arms to exceed the nominal diameter of the pole at the point of attachment.

Fit poles with a welded-on cast or plate steel base designed to mount on an anchor bolt foundation and ensure that each pole includes the furnishing of anchor bolts and

conduit ells for installation in the foundation. Furnish at least one 3-inch (75mm) and one 2-inch (50 mm) diameter conduit ell for installation in each foundation. Furnish conduit ells made from steel complying with 725.04; however, if they connect to non-metallic conduit, ensure that they are of the same non-metallic material. Use steel anchor bolts with a minimum yield strength of 85,000 pounds per square inch (586 MPa) and galvanized according to 711.02. Ensure that the galvanizing extends at least 2 inches (50 mm) beyond the threads. Ensure that ends either are bent or have a drilled and tapped steel plate as shown on the plans.

Ensure that the poles include a handhole near the base oriented as required. Reinforce the handhole with a welded-on steel frame with a grounding lug and fit it with a cover plate fastened by stainless steel screws. Ensure that the poles also include a cable and wire support J-hook welded near the top and a removable pole cap. Design poles and arms so their interiors conceal wiring and their mast arms include grommets wire outlets for the signal heads. Furnish hanger clamps with clevises on the mast arms for the signal heads as required. Ensure that arm caps are made of steel and cover at least 50 percent of the end area.

Ensure that signal poles combining provisions for roadway lighting include an additional handhole located opposite the mast arm flange with the poles' J-hook located above.

Furnish pedestrian pushbutton access holes and blind half couplings for controllers and pedestrian signal heads as required. Plug any unused holes.

732.12 Strain Poles. Furnish signal strain poles for the attachment of span wire that are steel tapered tubes according to the requirements of 732.11. For embedded poles, do not use the portion below groundline in determining the taper. Ensure that all poles include a removable pole cap, and messenger wire clamps with clevis and shackle unless otherwise specified.

Furnish anchor bolt foundation type strain poles that include a welded-on cast or plate steel base, bolt covers, a handhole, and a J-hook, as required by 732.11, and that also include at least one 2-inch (50 mm) cable entrance with a weatherhead and a welded blind half-coupling. Ensure that the poles include the furnishing of anchor bolts and conduit ells for installation in the foundation. Furnish at least one 3-inch (75mm) and one 2-inch (50 mm) diameter conduit ell for installation in each foundation. Furnish steel conduit ells that comply with 725.04; however, if they connect to non-metallic conduit, ensure that they are of the same non-metallic material.

732.13 Wood Poles. Furnish wood poles that conform to ANSI 05.1 "Specifications and Dimensions for Wood Poles", that are made of Southern Pine or Western Red Cedar, and that are full-length pressure treated according to 713.19.

732.14 Down Guy Assemblies. Furnish down guy assemblies according to 713.19. Furnish insulators and hardware that conform to 732.18. Furnish expanding or screw type anchors capable of withstanding a guy tension of 8000 pounds (35 kN) when installed in firm moist soil.

732.15 Pedestals. Fabricate pedestals for the support of traffic control equipment of 4-inch (100 mm) schedule 40 steel or aluminum pipe. Fit the steel

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pipe with a welded-on base of plate or cast steel, or when specified thread the steel pipe into a gray cast iron transformer type base. Furnish galvanized steel pedestals according to 711.02. Thread aluminum pipe into an aluminum cast transformer type base. Design pedestals to mount on an anchor bolt foundation and include the furnishing of anchor bolts and conduit ells for installation in the foundation.

732.16 Conduit Risers. Ensure that risers have conduit and fittings according to 713.04 and the weatherhead is made of aluminum or galvanized ferrous metal and threaded.

732.17 Cable Support Assemblies. Ensure that the cable grip used with cable support assemblies is of the proper size and strength for the cables and is of the flexible “closed” or “split with rod” type, of stainless steel or tin coated bronze, and equipped with a single “U” eye bale. Ensure that the smallest cable grip permitted has a minimum rated breaking strength of 250 pounds (1.1 kN).

Ensure that the slings for cable supports are made from copper clad or galvanized multi-strand steel wire with an overall diameter of not less than 1/8-inch (3 mm) and a breaking strength of at least 400 pounds (1.7 N). Use thimbles to form eyes at each end of the sling with grooves to match the wire. Adjust the sling to the proper length with the wire at each thimble lapped and secured with split bolt clamps.

732.18 Messenger Wire. Furnish Utilities Grade messenger wire, twisted strand galvanized steel wire conforming to ASTM A 475, Class B, with the exception that tags according to Section 19.2 are not required on lengths less than 1000 feet (300 m), and that 1/4-inch (6 mm) seven-strand be high-strength. Ensure that all accessories have a rated loading strength equal to or greater than the messenger wire minimum breaking strength. Furnish galvanized steel helical lashing rods in 5-foot (1.5 m) lengths.

732.19 Cable and Wire. Furnish cable and wire meeting the requirements of Table 732.19-1 and rated at 600 volts with conductors of copper unless otherwise specified. Ensure that the cable or wire jacket is indelibly marked at intervals of not more than 6 feet (2 m) with nomenclature stating the size, the type, the organization specifying the type, and the manufacturer’s name or trademark.

732.20 Power Service. Furnish risers for power service that are 2-inch (50 mm) diameter conduit and fittings according to 713.04. Furnish weatherheads that are threaded and made of aluminum or galvanized ferrous metal or polyvinyl chloride.

TABLE 732.19-1 CABLE AND WIRE

Cable or Wire	Number of Conductors	Wire Gage	Specification or type	Conductor Type	Notes
Signal cable	As specified	As specified	IMSA 19-1	Copper, color coded, stranded	
			IMSA 20-1		
			IPCEA S-61-402		
Interconnect cable	As specified	As specified	IMSA 19-1	Copper, color coded, stranded	
			IMSA 20-1		
			IPCEA S-61-402		
	Twisted pairs as specified	As specified	REA PE-39	Copper, color coded, solid	
			IMSA 19-2		
			IMSA 20-2		
Interconnect cable, integral, messenger type	As specified	As specified	IMSA 19-3	Copper, color coded, stranded	
			IMSA 20-3		

Cable or Wire	Number of Conductors	Wire Gauge	Specification or type	Conductor Type	Notes
	Twisted pairs, as specified	As specified	REA PE-38 IMSA 19-4 IMSA 20-4	Copper, color coded, solid	
Loop detector wire	Single conductor	No. 14 AWG	IMSA 51-5	Copper, stranded	
Loop detector lead-in cable	Two conductor	No. 14 AWG		Copper, twisted pair, stranded, shielded	Jacket: Black polyethylene Thickness 0.04 in (1.00 mm) (min.) Insulation: polyethylene
Magnetometer lead-in cable	Four conductor	No. 18 AWG	Heavy duty, direct burial type	Copper, color coded, stranded	Jacket: High density polyethylene. Thickness 0.026 in (0.66 mm)(min.) Low conductor to conductor capacitance ^[2]

Cable or Wire	Number of Conductors	Wire Gage	Specification or type	Conductor Type	Notes
Power cable	Two conductor	As specified	UL: RHH/RHW/ USE XHHW or cross linked polyethylene w. an insulation thickness of 0.045 in (1.14 mm) (min.)	Aluminum, ^[1] color coded, stranded	Three-conductor cable may be specified. Permitted substitution: 2 (or 3) single conductor cable.
Service cable	Two conductor (duplex)	As specified		Aluminum, ^[1] twisted, stranded	Three-conductor cable (triplex) may be specified. Aerial self-supporting aluminum conductor steel reinforced support wire as elec. Neutral
Ground wire	Single conductor		UL: RHH/RHW/ USE, XHHW cross linked Polyethylene	Copper, stranded	Minimum size is equal to the power or service cable, whichever is larger.
Loop detector lead-in cable, direct burial	As specified	No. 12 or 14 AWG, or as specified	IMSA 19-6	Copper, stranded	
			IMSA 20-6		

Cable or Wire	Number of Conductors	Wire Gage	Specification or type	Conductor Type	Notes
Loop detector lead-in cable, Integral messenger type	As specified	No. 12 or 14 AWG, or as specified	IMSA 19-4	Copper, stranded	
			IMSA 20-4		

[1] Copper conductors may be substituted. If used, wire gage may be one size smaller.

[2] 18 picofarads per foot (59 pF/m), 15 picofarads per foot (49 pF/m).

733 TRAFFIC SIGNAL CONTROLLER MATERIAL

733.01 References and Definitions.

“**NEMA TS-2,**” “**Type TS-2/A2,**” and “**Type TS-2/A1**” refers to equipment manufactured in conformance with the National Electrical Manufacturers Association (NEMA) Standards Publication No. TS-2.

“**NEMA TS-1**” and “**Type TS-1**” refers to equipment manufactured in conformance with the National Electrical Manufacturers Association (NEMA) Standards Publication No. TS-1.

“**Type 332**” and “**Type 336**” refers to equipment manufactured in conformance with the California Department of Transportation (CalTrans) specifications titled “Traffic Signal Control Equipment Specifications” and “Transportation Electrical Equipment Specifications”, including all addenda.

“**Type 170E**” and “**Type 2070**” refers to equipment manufactured in conformance with the California Department of Transportation (CalTrans) specifications titled “Transportation Electrical Equipment Specifications”, including all addenda.

“**CalTrans QPL**” refers to the California Department of Transportation (CalTrans) “Qualified Product List” for traffic signal equipment.

733.02 Controller Units.

A. General Requirements. Ensure that each controller unit contains internal time based coordination and, if used in a hardwired coordination system, provide an internal communication device or transceiver for connection to interconnect cables including multi-conductor 120 volt cables, twisted pair low voltage cables or fiber optic cables as shown on the plans.

If used in a closed loop system, ensure that the local intersection controller contains all of the software features necessary to operate with the system requirements given in 733.06 and 733.07. Furnish the necessary dial-up communications capability for isolated local intersections when part of the monitoring and control system described in 733.08.

When the signal timing and phasing configuration shown on the plans requires a pre-timed operation, ensure that the controller unit meets all requirements of this section and can also be configured in a pre-timed, sequential phase, fixed interval mode.

Furnish controller memories that are nonvolatile and do not require batteries or other sources of energy to retain data while power is removed from the controller.

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B. Software. Furnish a communication port for connection to a laptop computer for database upload/download. Furnish software for the personal computer to completely program all features of the controller unit. Unless otherwise shown on the plans, provide the controller unit with software that provides the following features even if not used by the signal phasing operation shown on the plans:

1. NEMA 8 phase, dual ring capability with four pedestrian movements, 4 overlaps, and the ability to program an exclusive pedestrian movement. Ensure that the controller is capable of being programmed for sequential phasing operation.
2. Volume density functions
3. Secondary coordination plans
4. Time of day/day of week scheduler
5. Time based coordination, minimum 3 dials, 3 offsets, 3 splits
6. Internal preemption for railroad and emergency vehicles
7. Operator selectable single or dual entry in dual ring use
8. Security access codes
9. Detector features including delay timing, carryover (extension) timing and detector switching
10. Simultaneous gap out feature
11. If operated in a system, communication capabilities to interface with hardwired masters or dial up modems
12. Data upload and download capability to a personal computer
13. Storage of detector counts utilizing phase detectors for a minimum 24 hour period in 15 minute increments
14. Detector failure monitoring and logging features for constant calls and absence of calls

Furnish controllers with 24-month warranties or for the manufacturers standard warranty, whichever is greater. Ensure that the warranty period begins on the date of shipment to the project. Ensure that each unit has a permanent label or stamp indicating the date of shipment.

A. Type TS 2/A1. Furnish a controller unit that meets NEMA TS-2 specifications and is shelf or rack mounted. Ensure that controller settings are programmable

through a keyboard on the front panel. Ensure that the front panel contains an 8-line by 40-character display.

B.Type TS-2/A2. Furnish a controller unit that meets NEMA TS-2 specifications and is suitable for shelf mounting. Furnish a controller unit that includes all ports and input/output connectors for complete interchangeability between NEMA TS-1 and TS-2 cabinets. Ensure that controller settings are programmable through a keyboard on the front panel. Ensure that the front panel contains an eight-line by 40-character display.

C.Type 170E. Furnish a controller units that meets the specifications for “Transportation Electrical Equipment Specifications”, California Department of Transportation, including all addenda. Furnish a controller unit that is listed on the CalTrans QPL.

In addition to the above requirements, apply the following requirements:

1. Vertically mount all circuit boards. If ribbon cables are used, ensure that they terminate with properly rated and easily repairable connectors on each end. Ensure that ribbon cables do not terminate onto plug-in modules.
2. Furnish a power supply that is modular and easily removable from the chassis.
3. Furnish a unit that contains separate input and output modules.
4. Do not supply the controller unit with the M170E auxiliary board.
5. Furnish a controller unit that includes a Model 412C Program Module with the memory configuration for the software either shown on the plans or as provided by the maintaining agency.
6. As per CalTrans specifications, socket mount all memory, microprocessor and ACIA devices. Furnish sockets that have machined beryllium copper contacts with gold plating.

D.Types 2070L, 2070LC, 2070LCN. Furnish controller units that meet the specifications for “Transportation Electrical Equipment Specifications”, California Department of Transportation, including all addenda. Furnish a controller unit that is listed on the CalTrans QPL.

Chapter 9, Section 1 of the CalTrans specification lists the following modules for the 2070 controller unit:

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Unit Chassis	Item Description
Model 2070-1A	CPU module, two board
Model 2070-1B	CPU module, single board
Model 2070-2A	Field I/O for 170 cabinet
Model 2070-2B	Field I/O for ITS and TS-2 cabinet
Model 2070-3A	Front panel, Display A (4 lines of 40 char.)
Model 2070-3B	Front panel, Display B (8 lines of 40 char.)
Model 2070-3C	Front panel, Blank
Model 2070-4A	Power supply, 10 amp.
Model 2070-4B	Power supply, 3.5 amp.
Model 2070-5A	VME cage assembly
Model 2070-5B	MCB 1A mounting assembly
Model 2070-8	NEMA interface module
Model 2070-9	2070N backcover

The Type 2070L version controller unit consists of the following assembled modules:

Unit Chassis

Model 2070-1A or Model 2070-1B
 Model 2070-2A
 Model 2070-3B
 Model 2070-4A or Model 2070-4B

The Type 2070LC version controller unit consists of the following assembled modules:

Unit Chassis

Model 2070-1A or Model 2070-1B
 Model 2070-2B
 Model 2070-3B
 Model 2070-4A or Model 2070-4B

The Type 2070LCN version controller unit consists of the following assembled modules:

Unit Chassis

Model 2070-1A or Model 2070-1B
 Model 2070-2B
 Model 2070-3B
 Model 2070-4A or Model 2070-4B
 Model 2070-8
 Model 2070-9

Also, equip all versions of the Type 2070 controller unit with the following:

1. The appropriate communication port, cables, and connectors for communicating with a laptop computer.
2. Modems, ports, and cables for system communication, if the controller is to operate as part of an interconnected signal system or has a telephone drop shown on the plans.

733.03 Cabinet. Ensure that all cabinets comply with the requirements of this Section unless otherwise stated in the specifications for the specific type of cabinet.

Unless otherwise required by the signal phasing shown on the plans, equip all NEMA specified cabinets as follows:

A. Supply two through four phase controller operation with a minimum eight position backpanel, configured for two pedestrian movements and two overlaps, with a NEMA TS-1 six channel conflict monitor or a NEMA TS-2 malfunction management unit.

B. Supply five through eight phase controller operation with a minimum 12 position backpanel, configured for four pedestrian movements and no overlaps, with a NEMA TS-1 12 channel conflict monitor or a NEMA TS-2 malfunction management unit.

C. If the signal phasing configuration shown on the plans requires a larger capacity backpanel or conflict monitor, supply the cabinet with the hardware required to perform the operational configuration.

D. When future phasing configurations are shown on the plans, provide the cabinet and hardware to accommodate the future operation through only the future addition of load switches and detector units.

E. Furnish each cabinet main door with a sturdy, permanently lubricated lock that is covered with a weatherproof tab. Key the project locks to the master key used by the agency that will maintain the equipment. Supply two keys with each lock. Also, equip the small door-in-door with a lock that is keyed to the maintaining agency's master key.

A. Type TS-1.

1. Cabinets. Furnish a cabinet 58" high x 30" wide x 17" deep that provides ample space for housing the controller unit and all associated electrical devices furnished with it, together with any other auxiliary devices that are specified. Furnish a cabinet with sufficient shelf space to accommodate all existing, proposed, and designated future equipment. Ensure that the shelves do not restrict any ventilation necessary for the mounted equipment. Ensure that the space provided accommodates the appropriate controller unit frame as designated in NEMA TS-1, Section 14.

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Construct the cabinets of cast aluminum or sheet aluminum, drawn or formed, with aluminum support and stiffening of members provided as necessary. Ensure that the exterior is smooth with no sharp edges. Weld all joints. Ensure that the cabinet is rigid and is designed to support all components. Ensure that the application of the following loads do not result in breakage, deformation, or loss of weatherproof qualities: a 100-pound (445 N) load applied to any 1-inch (25 mm) square surface of the cabinet or door (open or closed), in any direction; or a 300-pound (1.3 kN) load applied vertically downward to any 4-inch (100 mm) square of the top surface or to the top edge of the closed and latched door.

Unless otherwise shown on the plans, provide cabinet exterior surfaces of bare aluminum. When the plans specify a cabinet color, prime and finish all cabinet exteriors with two coats of high-grade enamel paint of the specified color. Ensure that the cabinet interior surfaces are the same as the exterior, or may be painted flat white.

Ensure that the cabinet contains at least one rain-tight louvered vent equipped with a replaceable filter. Install vents to allow for the release of excessive heat and any explosive gases that might enter the cabinet.

Ensure that the cabinets are functional in design and have a door in the front providing access to substantially the full interior area. Attach a gasket of elastomeric material to the cabinet or door to form a weatherproof seal. Furnish door hinge pins of stainless steel or equivalent corrosion resistant material. Furnish a door stop to retain the door in at least a 90 degree open position.

Include a small, hinged, and gasketed door-in-door (police door) on the outside of the main controller door. Ensure that the door-in-door does not allow entrance to the controller mechanism nor to exposed electrical terminals, but provides access to a small switch panel and compartment (police panel).

Fit the cabinet with the necessary provisions for mounting, with a bottom conduit connection provided for pole-mounted cabinets. Furnish suitable hardware and equipment for each cabinet mounting method, including bolts for drilled and tapped holes on metal supports, pole attachment clamps, pedestal slipfitter, and anchor bolts and conduit ells for installation in concrete foundations. Furnish steel anchor bolts that are galvanized at least 1 inch (25 mm) beyond the threads. Certified cabinet anchor bolts are not required.

2.Accessory Equipment. Directly place all equipment designed for shelf mounting on a shelf except for loop detector units (amplifiers) and similar devices designed for stacking on each other. Arrange components on shelves and devices on the door so that a 1-inch (25 mm) minimum space separates them when the door is shut. Ensure that plugs, wires, controls, or similar items do not compromise this space.

Reserve a minimum 4-inch (100 mm) clear area on the bottom of the cabinet for the routing of cables. Do not locate panel mounted equipment in the bottom 6 inches (150 mm) of the cabinet. Do not locate shelves or components within 6 inches (150 mm) of the bottom of foundation mounted cabinets.

Arrange all equipment for easy withdrawal and replacement, without the necessity of disturbing adjacent equipment. Permanently locate devices within the cabinet to allow free circulation of air and that do not restrict air flow from fan ducts or vents. Ensure that the auxiliary equipment operates within a weatherproof cabinet at ambient temperatures between -30 and 165 °F (-34 and 74 °C).

When terminals and panel mounted devices with exposed electrical contact points are located next to shelf mounted equipment, provide spacers, shelf lips, or other means to assure that component units cannot be accidentally moved into contact with any exposed electrical terminal points.

Ensure that load switches, relays, flashers, fuses, switches, terminal blocks, and other equipment mounted or plugged into the back or side panels are readily accessible. Ensure that switches, controls, and indicator lights are visible and easily operable without moving the components from their normal shelf positions.

a. Ventilating Fan. Equip all cabinets with a forced air ventilating fan. Furnish a fan that provides a capacity of at least 100 cubic feet (2.8 m³) per minute. Furnish a fan that is thermostatically controlled and adjusted to start at cabinet temperatures above 120 °F (49 °C) and to stop when the temperature has dropped below 100 °F (38 °C).

b. Load Switches. Furnish all cabinets with solid state, triple-signal load switches complying with NEMA TS-1, Section 5. Additionally, ensure that all load switches have both input and output indicators.

c. Conflict Monitor. Furnish all cabinets with a separate solid-state conflict monitor device. Ensure that the cabinet wiring, in the event of monitor disconnection, transfers the signals to a flashing condition. Furnish conflict monitors that comply with NEMA TS-1, Section 6. Additionally, ensure that all conflict monitors are capable of causing the signals to flash as a result of the following events:

- (1) All red lamps associated with a load switch are burned out;
- (2) Within one second when red and green, or yellow and green color pairings are displayed on the same phase;
- (3) The absence of a minimum yellow interval.

Ensure that the monitor indicates the exact load switch output channel upon which the failure event occurred. Furnish conflict monitors that are capable of storing a

minimum of nine fault events (event logging feature). Furnish a monitor that utilizes a LCD display and has a RS-232 port for connection to a laptop computer. Furnish software and connector cables to diagnose the conflict monitor.

d. Flashers. Furnish solid-state flashers that comply with NEMA TS-1, Section 8. When signals have a normal stop-and-go sequence that includes flashing, either ensure that the controller unit generates that flashing display or provide flashers. For this purpose, provide separate flashers from those provided for emergency back-up. Furnish flashers that are designed with two circuits of at least 10 amperes each.

Equip each controller cabinet with terminals that are wired so that, by an interchange of jumpers, the flashing operation is arranged to display either flashing yellow or flashing red on the vehicular signals.

e. Relays. Ensure that the relays required for proper operation of the specified equipment are furnished and completely wired. Furnish relays that are enclosed, readily replaceable, and designed for one-million operations without failure or need for adjustment.

f. Lightning Protection Devices. Furnish lightning protection on incoming power lines, interconnect lines, and detector leads.

Connect the AC power line to a surge protection device (SPD). The electrical position of the SPD shall be after the cabinet circuit breaker and the AC signal bus for the load switches and flashers, but before the traffic signal controller, monitor, coordinator and detector units. Furnish a SPD that has 5-terminals for the following connections: LINE-IN, LINE-OUT, NEUTRAL-IN, NEUTRAL-OUT, and GROUND. It may have a 6th terminal for MAIN LINE. Furnish a two stage metal oxide varistor (MOV) based SPD. Ensure that it does not contain gas tubes. Ensure that the first stage contains two MOVs, one connected between LINE-IN and GROUND and the second between the NEUTRAL-IN and GROUND. Ensure that the second stage is a filtering network with a MOV connected across LINE-OUT and NEUTRAL-OUT. The specified MOVs may be single devices or MOVs in parallel as needed to obtain the specified performance.

Mount the SPD inside the controller cabinet in a space of no more than 8 inches (200 mm) wide, 4 inches (100 mm) high, and 3 inches (75 mm) deep. Connect the IN and OUT terminals to the appropriate AC power lines and connect the GROUND terminal to the ground rod for the controller cabinet.

Furnish a SPD that meets the following performance requirements:

(1)Furnish a SPD that is capable of withstanding 20 repeated surges each of 20,000 amps with an 8 microsecond rise time to the peak current and a fall to one-half of the peak current after 20 micro-seconds. Ensure that the surges are applied across the LINE-IN and GROUND terminals with the NEUTRAL-IN terminal externally connected to the GROUND terminal. During the application of the

20,000 amp surges, ensure that the voltage across the LINE-OUT and NEUTRAL-OUT terminals is no more than 260 volts after one nano-second.

(2)Ensure that the filtering capacity is such that there is no loss in a 60 hertz signal applied across the IN terminals and measured across the OUT terminals. Ensure that the measured losses for signals from 50 kilohertz to 5 Megahertz is at least 40 dbs.

(3)Ensure that the line switching mitigation capacity is such that during the application of an input spike voltage of ± 700 volts by a Berkley Model 3020 spike generator connected to the LINE-IN and GROUND terminals with the NEUTRAL-IN externally connected to GROUND, the maximum excursion from the sine wave monitored across the OUT terminals is more than ± 50 volts.

(4)Ensure that the current capacity is such that it can carry 10 amps at 120 VAC RMS continuously for one week without damage.

Furnish loop detector lead-in cable protection that consists of devices installed in each detector circuit where the lead-in connects to the terminal block. House each device in a case that consists of two stages; a 3-electrode gas tube arrestor and a semiconductor circuit. Ensure that the arrestor shunts to ground a common mode transient with a 1,000 ampere peak and an 8/20 microsecond wave-shape, ionizing at 400 volts within 100 nanoseconds when subjected to a 1,000 volt per microsecond transient. Furnish a semiconductor circuit that clamps a differential transient to 30 volts within 40 nanoseconds of the appearance of the transient, and a common mode transient to 30 volts within 500 nanoseconds of the ionization of the gas tube arrestor. Ensure that the second stage is able to withstand a peak current of 13 amperes. Furnish a device that has impedance characteristics compatible with the detector unit so as not to cause false calls or increase the loop impedance above the sensitivity of the detector unit.

Furnish pedestrian pushbutton inputs with the same protection as specified for the loop detector lead-in cables.

Protect interconnect cable against transients by devices across each conductor of the cable and ground. The devices may be either 2 or 3-terminal devices. If 3-terminal devices are used, connect two conductors and ground to the same device. Furnish a protection device that consists of a gas tube arrestor with a maximum ionization voltage of 1000 volts on a 10,000 volt per microsecond transient or a maximum ionization voltage of 950 volts on a 3000 volt per microsecond transient. Ensure that the maximum time from beginning of the transient to ionization is 1.1 microseconds on a 10,000 volt per microsecond transient. Ensure that the device is not ionized by normal voltage variations on a 120-volt AC line. Furnish a device that is able to withstand a 10,000 ampere peak with an 8/20 microsecond waveshape.

g. Main Power Breaker. Furnish an incoming AC+ power line that is controlled by a main circuit breaker rated at 240 volts and an auxiliary breaker, with capacity and wiring as specified in NEMA TS-1, Section 10.3.2.2 and Figure 10-4.

h. Radio Interference Filter. Furnish an incoming AC+ power line that contains a radio frequency interference (RFI) filter installed between the main circuit breaker and the solid state equipment. Also, provide RFI filtering for the load switches and flasher, unless the equipment furnished provides signal and flasher circuits switching at the zero voltage point of the power line sinusoid wave form.

i. Convenience Outlet and Light. Wire a convenience outlet into the cabinet for use by electrical maintenance equipment. Ensure that the outlet contains at least one standard duplex three-wire plug receptacle of the ground-fault circuit-interrupting type. Furnish and mount a standard incandescent lamp and socket in the upper portion of the cabinet. Furnish a door switch to control the convenience light.

j. Manual Control and Pushbutton. When required by the plans, provide intersection controller units with means for substituting manual operation of interval timing for automatic interval timing. Ensure that manual operation provides the same interval sequence as when the controller unit is operating automatically.

Obtain manual interval timing by a momentary pushbutton contact switch mounted on a 5-foot (1.5 m) minimum flexible weatherproof extension cord. Store that switch and cord behind the small door-in-door.

k. Switches. Furnish completely wired switches that are required for proper operation of specified equipment. Clearly and permanently label switches as to function and setting position, and ensure that they are accessible without the necessity of moving components.

(1) Signal Shutdown Switch. Furnish a cabinet with a signal shutdown switch for turning off the power to the signals at the intersection. Ensure that this switch only affects the power to the signals, and allows the controller to continue in operation. Locate the switch in the panel behind the small door-in-door (police door).

(2) Auto/Flash Switch. Furnish a cabinet with a flash control switch for activating the flashing of vehicular signals in a preselected emergency flash display. Ensure that the operation of the flash control switch causes a flashing display even under conditions of controller unit malfunction or of its removal from the cabinet. Ensure that the operation of the switch overrides any operation commands from a local or remote time switch. Locate the switch in the panel behind the small door-in-door (police door).

Program transfer to and from flashing operation, when called remotely or by a local time switch, to occur only at points in the cycle allowed by the OMUTCD.

(3)Automatic/Manual Transfer Switch. Furnish a cabinet with an automatic/manual transfer switch. In the automatic position, ensure that the controller unit automatically sequences the signal head displays. In the manual position, ensure that the signal phase or interval sequencing occurs only upon manual activation of the manual control pushbutton. Locate the switch in the door-in-door (police door). Ensure that it is unnecessary, when switching from manual to automatic operation, or vice versa, to do so at any certain time or to make any time adjustments.

(4)Run/Stop-Time Switch. Furnish a cabinet with a run/stop-time switch that activates the controller stop-time feature when in the “stop-time” position. Locate the run/stop-time switch on a switch panel in the cabinet.

(5)Controller Shutdown Switch. Furnish a cabinet with a controller shutdown switch that cuts off power to the controller unit, conflict monitor, and detector units. Ensure that power is not cut off to those components required to maintain flashing operation. Locate the controller shutdown switch on a switch panel in the cabinet.

(6)Coordinated/Free Switch. Furnish controllers operated in a coordinated system with a coordinated/free switch. Ensure that this switch allows the choice of operating the controller under the supervision of a coordination device or operating the controller independently of coordination control. Locate the coordinated/free switch on a switch panel in the cabinet.

(7)Detector Test Switches. Furnish momentary contact switches that will enter a vehicular or pedestrian call for any actuated phase. Furnish a switch for each actuated phase vehicular and pedestrian detection input. Conveniently group and label the switches.

1. Terminal Blocks. Furnish cabinets that include terminal blocks mounted on panels on the walls of the cabinet. Ensure that the blocks are not obstructed by shelf-mounted devices. Furnish sufficient terminal sets for each individual harness wire as well as for contacts of signal load switches, flasher transfer relays, flasher, and other components. Also, provide separate terminal sets for field wiring connections, including power, signal, interconnection, and detector lead-in cables. Group terminal sets to separate higher voltage (120 VAC) from lower voltage, and arrange them into logical groups. Protect terminal blocks from accidental contact during the installation and removal of shelf-mounted equipment. Locate the blocks no closer than 4 inches (100 mm) from the bottom of pole and pedestal mounted cabinets, and no closer than 6 inches (150 mm) from the bottom of foundation mounted cabinets.

Ensure that the terminal points are UL listed as suitable to carry the rated loading. Ensure that the capacity and size of the terminals are as specified in NEMA TS-1, Section 10.2.5. Ensure that the terminal points for signal field wiring for each circuit accommodates at least four No. 12 AWG conductors with spade type terminals.

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Furnish terminal points for incoming power wiring that accepts either spade terminals or bare stranded wire and are suitable for either aluminum or copper conductors.

Widely space terminal sets for ease of wiring. Furnish at least six reserve terminal sets for controllers. Harnesses may terminate on the back of terminal blocks using through-panel terminals. Clearly mark terminal sets for ready identification including through-panel terminals that are identified on both sides. Ensure that the contact between adjacent terminal points are made by bus bar, or by wire jumpers having spade type terminals securely attached to each end.

m. Terminal Buses. Furnish a cabinet with supply terminal buses fed from the line side of the incoming 120 VAC power line, after the phase wire has passed through the main power switch. Ensure that the requirements for use of radio interference filters are according to Item 8 of this Section, with the buses supplying load switches and with flashers being filtered when required. Ensure that a signal bus relay controls power to the bus supplying power for the signal load switches.

Furnish a common terminal bus for the connection of the neutral wire of the incoming 120 VAC power line. Ensure that the common bus has sufficient terminal points to accommodate all potential cabinet wiring as well as field wiring. Use a separate common terminal, insulated from the panel, for the interconnect common.

Furnish bus terminal points that comply with Item 12 of this Section for conductor accommodation, attachment and identification.

n. Grounding System/Bus Bars. Furnish a cabinet that includes a grounding system as specified in NEMA TS-1, Section 10.3.2.1 with an adequate number (minimum of three) of ground terminal points. Bond the ground bus bar and the common terminal bus together with a No. 8 AWG or larger stranded copper wire.

o. Wiring. Neatly organize and route the harnesses and wiring bundles to individual terminals. Ensure that the harness provides a wire for each pin or contact of the device. Connect each wire to a marked terminal position. Use labeled spade type terminals or plug connections on all harness wiring. Group and lash or restrain wire bundles in such a manner that they will not interfere with the access to components, terminal blocks or buses, or the legibility of terminal identification. Ensure that the harnesses are of sufficient length to reach any point within the cabinet. Ensure that the cables and harness bundles are easily traced through the cabinet to their terminations.

Wire the cabinet so that controller pin connections associated with a given phase number matches the phase number assigned to the specified traffic movement as shown on the plans.

Furnish all wiring with stranded conductors. Ensure that the wiring is adequate for the voltage and load that represents the ultimate load of the devices connected.

Ensure that the ampacity rating of the wires are as specified in NEMA TS-1, Section 10.3.3.1. Ensure that the wiring is color coded as follows:

- (1) Solid white, AC common.
- (2) Solid green or white with green stripes, safety (chassis) ground.
- (3) Solid black, AC line side power (AC+).

p. Loop Detector Units. Furnish loop detector units that comply with the requirements of NEMA TS-1, Section 15, with the following modifications:

- (1) Furnish loop detector units that are shelf mounted and powered from 120 volts.
- (2) Ensure that the unit uses solid-state isolated output devices.
- (3) Furnish conductors in the cable harness for loop input pins that are twisted three to five times per foot (300 mm).
- (4) Furnish detector unit electrical connection plugs or wiring harness that are designed such that any multi-channel shelf mounted detector unit is readily replaced with single channel detector units. Furnish only units with the connector type required for single channel shelf mounted detector units, or by wiring the controller back panel to single channel wiring harnesses which are, in turn, plug connected to an adapter harness that is mated to the multi-channel connector of the detector unit.
- (5) When shown on the plans, supply delay and extension timing capability on the detector unit; otherwise, the controller unit software requirements of 733.02 will provide these features.
- (6) Ensure that the harness provides a wire for each pin or contact of the device.

If vehicle detector types other than “loop” detectors are required by the plans, provide these detectors by separate bid item.

B. Type TS-2.

1. Furnish TS-2 cabinets that comply with the general requirements of 733.03. Furnish a prewired cabinet with malfunction management unit, loop detector units, and all accessory equipment as specified in NEMA TS-2, except as follows:

- a. Section 5-3-4, use detector racks for both Type 1 (A1) and Type 2 (A2) controller units.
- b. Section 5-4-2-7, provide an incandescent type light.

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- c. Section 5-4-2-7-2, provide the incandescent lamp.
- d. Section 5-4-2-7-3, provide the door actuated light switch.
- e. Section 6-5-2-2-1, provide 2-channel detector units, without delay/extension features (Type A).
- f. Section 7-2, construct cabinets of cast or sheet aluminum.
- g. Section 7-3, provide a Size 5 cabinet for four phase or less pole mounted cabinets, Size 5 for four phase or less ground mounted cabinets, and Size 6 for 5 phase or more ground mounted cabinets. Supply larger cabinets if required to house the equipment to meet the plan requirements; such as master controllers, preemption devices, 16 position backpanels or special detection units.
- h. Section 7-5-7, ensure that the police panel contains switches for AUTO/FLASH, SIGNALS ON/OFF and AUTO/MANUAL in the police panel. Furnish a pushbutton with a 5-foot (1.5 m) cord.
- i. Section 7-7-3, supply unpainted cabinets.

2. Furnish loop detector and pedestrian inputs that have lightning/surge protection as specified in 733.03.A.2.f.

3. Include loop detector racks with the necessary number of two-channel loop detector units with the cabinet. When shown on the plans, supply delay and extension timing capability on the detector unit; otherwise, provide the controller unit software with these features. If vehicle detector types other than “loop” detectors are required by the plans, provide these detector units by separate bid item. If the special bid detector units use standard TS-2 detector racks, furnish the racks as part of the pre-wired cabinet.

4. Furnish switches to control the controller unit and cabinet functions as specified in 733.03.A.2.k.

5. Furnish load switches that have both input and output indicators.

C. Type 332.

1. General. Furnish Model 332 cabinets that meet the specifications “Traffic Signal Control Equipment Specifications” and “Transportation Electrical Equipment Specifications”, California Department of Transportation. Ensure that the manufacturer of the cabinets is listed on the CalTrans QPL at the time of the project award.

2. Cabinets.

- a. Ensure that the cabinets are constructed of aluminum and are supplied unpainted. An anodic coating is not required. Supply galvanized anchor bolts with nuts and washers with each cabinet. Furnish 3/4-inch (19 mm) diameter by 16 inches (0.4 m) minimum length anchor bolts with an “L” bend on the unthreaded end.
- b. Fit the cabinets with a PDA-2 power distribution assembly.
- c. When shown on the plans, provide the cabinet with door hinges that are “right” or “left” mounted when facing the front of the cabinet.

3. Terminals and Wiring.

- a. “Hardwire” output files. Do not use printed circuit wiring in the output file except for the red monitor board.
- b. Ensure that the vehicle and pedestrian detector field wiring inputs connect to side mounted terminal blocks. Install terminal blocks and associated wiring to the input file. Label the field wiring terminals of the side mounted terminal block by a permanent screening process to identify the input panel (I or J), the input file slot number (1 through 14) and the channel terminal (D, E, J, or K). An example is “I4-E”. Ensure that all terminals on these detector blocks are accessible without removing equipment from the EIA mounting rack.
- c. Install red monitor cabling in the cabinets. Install a program board to enable/disable red monitoring. Ship the cabinets with the red monitor jumpers set in the “enable” position.
- d. Do not connect the pedestrian yellow load switch outputs to the conflict monitor card-edge connector.
- e. Supply each cabinet with a cable approximately 5 feet (1.5 m) long to connect a laptop computer with the controller. Ensure that the cable has a DB-9 connector on one end, and a connector on the other end to mate with the C2 on the back of the controller. The cable will allow a laptop computer to upload/download data to the controller.
- f. On the output file, wire pin No. 11 of each switchpack connector to AC- so that the output indicators on dual indicator switchpacks will display properly.

4. Accessories.

- a. Fully equip the cabinets with two channel loop detector sensors (model 222), flashers, flash transfer relays, power supply, AC and DC isolators, conflict monitor, switchpacks (with both input and output indicators), and a DC isolator in slot 14 for flash sense/stop time. Do not switch the input

file channels from the standard layout in order to minimize the number of two-channel detector units utilized. If vehicle detector types other than “loop” detectors are required by the plans, provide these detectors under a separate bid item.

- b. Furnish a rack mounted detector test panel with test switches for all vehicle and pedestrian phases. Furnish switches with three position “on/off/momentary on” switches.
- c. Furnish a police panel in each cabinet that includes a pushbutton with 5 feet (1.5 m) cord and three switches labeled AUTO/FLASH, SIGNALS ON/OFF and AUTO/MANUAL. Wire the pushbutton cord to the controller harness wiring by a moxex plug connection and not through an AC isolator. When placed in the manual position, apply “manual control enable” to the controller and apply “recall” to all phases. Ensure that activation of the push button “advances” the controller, except prohibit the manual advancement during the minimum green, yellow, and red timing intervals.
- d. Furnish an aluminum shelf with integral storage compartment in the rack below the controller. Ensure that the storage compartment has telescoping drawer guides for full extension. Ensure that the compartment top has a non-slip plastic laminate attached.
- e. Ensure that each cabinet has two fluorescent lights installed at the top of the cabinet, one near each door. Wire the lights to the door switches such that opening either door will turn on both lights.

5.Lightning/Surge Protection.

- a. Furnish lightning protection on pedestrian and detector inputs. Furnish three terminal surge protectors equivalent to EDCO models SRA-6LCA, SRA-6LCB, or SRA-6LC.
- b. Protect the cabinet’s incoming power lines with an EDCO SHA1250 or approved equal surge protector in lieu of the CalTrans specified surge protection. Install the SHA1250 unit in an enclosure within the cabinet.

6.Conflict Monitor. Ensure that the conflict monitor unit was tested and accepted according to Supplement 1060.

a. Materials and Warranties. Ensure that the equipment and materials furnished are new, of first quality, of current design, and free of defects. Furnish electrical parts, switches, and other elements of the installation that are of ample capacity to carry the required current without excessive heating or drop of potential.

Use standard industrial quality components (integrated circuit chips, transistors, diodes, resistors, capacitors, etc.) wherever possible. Clearly identify these components with the original identification. Designate the other vital information such as voltage polarity, emitter or collector terminals, pin locations, etc., by an approved industrial procedure. Ensure that all components are available and in production by a reputable manufacturer.

Ensure that the major items or assemblies of equipment bear a nameplate, indelible marking, or brand that identifies it as to type, model, catalog number, and manufacturer.

Transfer that manufacturers' guarantees or warranties to the City of Akron upon delivery and acceptance of the equipment. Ensure that all conflict monitors are warranted for a period of 24 months or for the manufacturer's standard warranty period, whichever is greater, for parts and labor from date of shipment to the project or the City of Akron Traffic Engineering Division. Ensure that each unit has a permanent label or stamp indicating the date of shipment.

b. General Requirements.

(1)Minimum Standards. This specification establishes minimum standards for Conflict Monitoring Devices designed for use in Model 332 and 336 Traffic Signal Controller Cabinets supplied to the Department. Ensure that the specifications for connectors, components, mechanical workmanship, engineering, and environmental testing comply with CalTrans Specifications.

(2)Indicator Lights. Furnish indicator lights that are water-clear (not colored or diffused lenses), ultra- bright light emitting diodes (LED), whose states are clearly readable in direct sunlight. Ensure that each conflict monitor channel provides separate red, yellow, and green LEDs.

(a)Furnish a GREEN AC POWER indicator light.

(b)Arrange indicator lights in a vertical pattern with FAULT status lights as the upper indications and the output channel lights as the lower indications [See 733.03.C.6.c.(1) and 733.03.C.6.c.(9)]. An acceptable alternative is to provide a single fault indication and a supplemental display that clearly indicates the fault type.

(c)Ensure that a failure causes its respective indicator light to display.

(3)Monitor Power. Ensure that the Monitor does not use the 24VDC power supply being sensed to run any of its internal circuitry. Ensure that the watchdog, stop time, external reset, and 24VDC monitor input circuits are optically isolated from the Monitor internal power supply and are conditioned to provide proper sense circuit operation throughout the operating range.

(4)Power Fail. Consider a line voltage less than $85 \text{ V ac} \pm 2 \text{ V ac}$ as a power failure. Ensure that a power failure does not result in resetting the Monitor. Ensure that once the Monitor is triggered by detection of a fault that it remains in that state until a Reset Command is issued. Reset is issued only by the Front Panel Control Switch or by the External Test Reset input.

(5)Power Up. Furnish a Monitor that is compatible with the Model 170E controller as well as the Model 2070 controller unit that requires several seconds to power-up. When power is established, $> 103 \pm 2 \text{ Vac}$, the 2010 will power up in the FAULT RELAY RECOVERY mode:

When power is established, initiate FAULT RELAY RECOVERY. For an interval of 6.0 ± 0.5 seconds, the following will take place:

(a)The Output Relay contacts remain closed, and the Stop Time output remains active.

(b)All fault monitoring functions remain suspended.

(c)The AC POWER indicator light flashes at a 2 hertz rate.

At the end of this time interval, the Monitor begins counting Watchdog transitions from the controller and prepares to resume normal fault monitoring.

Ensure that the resumption of normal Fault monitoring occurs when either:

(a)The Monitor has counted 5 transitions between the True and False state from the controller Watchdog; or

(b) 10 ± 0.5 seconds has elapsed from the time of LINE RECOVERY.

If the controller Watchdog output does not become active, ensure that the Monitor goes into a Latched Fault condition.

(6)Cabinet Signals Monitored. Furnish a Monitor designed to monitor Green, Yellow, and Red AC circuits at the field output terminals of traffic signal cabinets. In addition, monitor the cabinet 24VDC supply, and the Model 170E/2070 controller Watchdog Timer output. These signals are processed by the Monitor circuitry, and if a failure is determined to have occurred, ensure that a relay output contact closure (FAILED state) places the cabinet and intersection into flashing operation.

(7)Failed State Output Circuits.

(a)Use an electro-mechanical relay to provide the FAILED STATE output circuit. Ensure that the relay contacts are normally closed (FAILED STATE). In a NON-FAILED state (relay coil energized), ensure that the contacts are open. The

function of this output circuit is to initiate flash operation within the cabinet and transfer field circuits from the switch pack outputs to the flash bus during a FAILED STATE.

(b)Furnish relay contacts that are rated for a minimum of 3 amperes at 120 V ac and 100,000 operations. Ensure that the contact opening/closing time is 30 ms or less. Furnish contacts that present a minimum impedance of 50,000 ohms in the open state.

(c)Ensure that the Stop Time output is active whenever the output relay contacts are in the FAILED STATE (closed). Ensure that it is inactive whenever the output relay contacts are in the NON-FAILED (open) STATE.

(8)Monitor Unit Reset. Furnish a front panel momentary SPST pushbutton switch labeled “RESET” to reset the Monitor to a Non-FAILED state and restores normal monitoring operation. Position the switch on the front panel so that the switch can be operated while gripping the front panel handle.

Ensure that the External Test Reset input line resets the Monitor circuitry to a Non-FAILED state and restores normal monitoring operation. Optically isolate it from the internal circuitry. Ensure that a reset issuance by either source (Unit Reset) is triggered by only the leading edge of the input signal (this will prevent a constant reset due to either a switch failure or a constant external input). Ensure that a constant reset input is ignored within 5 seconds of issuance.

(9)Input Impedance. Ensure that the input impedance for all monitored AC inputs are 200 kilohms \pm 100 kilohms.

(10)Connectors. Furnish PCB 28/56P Type Monitor and Conflict Program Card Connectors. Ensure that all edge connectors use the “bifurcated bellow” type contact or equivalent.

(11)Door Ajar Circuit. Connect pin 24 to pin 25 on the Monitor PCB at the edge connector and ensure that it is capable of carrying one ampere per CalTrans specifications.

(12)Handle. Ensure that the handle placement and design is such that no interference between the handle and a closed cabinet door exists.

(13)Fuse Holder. Furnish low profile fuse holders on the front panel.

c.Functional Requirements.

(1)General. The Monitor monitors the cabinet for conflicts and unsafe operation. If an unsafe condition exists, the Monitor will enter into a FAILED state. This places the cabinet into flash operation and applies STOP TIME to the controller unit. Ensure that the Monitor is designed to monitor red circuits, yellow timing,

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multiple outputs, and lack of outputs on a switch selectable, per channel basis. Specific conditions for failure follow:

(a)**24VDC FAIL.** The cabinet +24 volts DC does not meet the specified thresholds.

(b)**CONFLICT.** When the green or yellow input to one or more channels is ON and they are not programmed as permissive on the Conflict Program Card.

(c)**WATCHDOG TIMER (WDT) ERROR.** When the 170E/2070 controller unit watchdog output has ceased.

(d)**CONFLICT PROGRAM CARD AJAR.** Illuminates, if the Conflict Program Card is removed or if it is not properly seated in the connector. When it is not inserted into the monitor, ensure that the warning indicator light is displayed.

(e)**MONITOR FAILURE.** A fault is detected within the operation of the 2010 Monitor itself.

(f)**MULTIPLE OUTPUTS.** Simultaneous indications of Green, Yellow, or Red field outputs on a single channel.

(g)**RED FAIL.** No active field outputs on a single channel (green/yellow/red).

(h)**YELLOW ERROR.** The absence of a minimum yellow field output during a green to red sequence. Minimum yellow shall be 2.7 seconds \pm 100 ms.

(2)**Operating Range.** Furnish a Monitor Unit that is fully operational using an 85 to 135 V ac power source. Ensure that the Monitor suspends Fault monitoring below 85 V ac \pm 2 V ac, closes the output relay, and de-energizes the AC POWER indicator light.

(3)**Watchdog Timing.** Furnish WATCHDOG Timing Circuitry to monitor the controller unit WATCHDOG output. Ensure that the WDT Circuitry senses state changes and the time between the last change. Ensure that an absence of change for 1.5 \pm 0.1 seconds places the Monitor in a FAILED state.

(4)**Channels Monitored.** Furnish a Monitor that senses and responds to conflicts and 24 VDC failures whenever the AC line voltage is within the 85 to 135 V ac operating range of the Monitor, except during FAULT RELAY OPERATION.

(5)**Yellow Inhibit.** Furnish means to selectively inhibit the monitoring of a Yellow channel input.

(6)Power Fail after Fault. In the event that the Monitor senses a fault, followed by a loss of operating voltage, ensure that the initial Failure Status is retained in memory and is redisplayed after restoration of power.

(a)Once the Monitor is LATCHED in a fault condition for any reason, including the removal of the Conflict Program Card, ensure that it REMAINS LATCHED, even through a power fail/recovery, until a RESET is issued by the front panel reset switch, or by the external test reset line.

(b)Display the status of the Green, Yellow, and Red inputs of all channels, at the time the fault was latched. Ensure that a power loss does not affect the retention of this data. An acceptable alternative is to save status of all channels in memory and only display the latched fault.

(7)Insertion/Removal of Unit. Ensure that it is possible to insert and remove the Monitor while the cabinet is energized without placing the cabinet into Flash operation provided that: The cabinet door remains open and the reset switch is held depressed while the unit is being inserted or removed. Any momentary disruption of field signal indications is less than 500 ms.

(8)Microprocessor Use. If a microprocessor is used in the Monitor design, ensure that its program is written so that:

(a)Integrity tests are performed periodically on each memory cell of each memory device, relevant to each device type.

(b)Hardware external to the microprocessor circuits is employed to constantly sense proper microprocessor operation.

(c)The Monitor reverts to a FAILED state if a fault is detected with the microprocessor or during integrity tests.

(9)Front Panel Indicators. Ensure that the Monitor has red/yellow/green indicators for channel inputs and indicators to provide status and failure detection information. Furnish a GREEN AC POWER indicator. Ensure that all indicators are clearly readable in direct sunlight. Arrange and label the indicators as shown below:

(a)AC POWER. Illuminates when the incoming AC Line Voltage exceeds $103 \pm 2V$ ac, and FLASHES during FAULT RELAY OPERATION.

(b)VDC FAIL. Illuminates when the Monitor has detected a 24VDC failure.

(c)CONFLICT. Illuminates when a conflicting signal condition is detected.

(d)WDT ERROR. Illuminates when a Watchdog error is detected. Do not provide a switch or similar device to disable WDT monitoring.

(e)**PC AJAR.** Illuminates when the Conflict Program Card is removed or is not properly seated in its connector.

(f)**MON FAIL.** Illuminates to indicate an internal Monitor failure.

(g)**RED FAIL.** Illuminates when the Monitor detects that there is no active output on any of the field outputs that comprise a monitored channel. Ensure that the failed channels are displayed on the corresponding channel indicators. If for any reason red fail is not enabled, ensure that the red fail indicator light flashes at approximately 2hertz.

(h)**MULT IND.** Illuminates when the Monitor detects simultaneous outputs on more than one of the field outputs that comprise a monitored channel (green/yellow/red). Ensure that the failed channels are displayed on the corresponding channel indicators.

(i)**YELLOW.** Illuminates when the Monitor detects the absence of a minimum period of active yellow field output during a green to red sequence. Ensure that the failed channel is displayed on the corresponding channel indicator.

(j)**1, 2, 3, 48.** Furnish channel indicators that illuminate a FAILED state in conformance with 733.03.C.6.c.(6).

(10)Monitor Board Edge Connector. Furnish monitor board edge connectors that conform to CalTrans specifications.

(11)Monitoring of Conflicting Voltages. Ensure that inputs to any channel that exceed the specified conflict threshold (see Section 6) are sensed as “ON” and illuminate their respective channel indicators. Ensure that the number of active channels in no way affects the conflict threshold.

Ensure that the following voltage levels and times apply: A conflict has occurred and will cause a FAILED state only when voltages appear at the field output terminals.

$> 20 \pm 5.0$ V rms for a duration $> 350 \pm 150$ ms.

(12)Conflict Program Card. Furnish conflict program cards that comply with CalTrans specifications.

d.Fault Relay Operation.

(1)Line Drop Out. Furnish a Monitor that determines that a LINE DROP OUT has occurred when:

The AC Line Voltage is: $< 98 \pm 2$ VAC for $> 400 \pm 100$ ms.

Within this time frame, ensure that the Monitor suspends all fault monitoring functions, closes the output relay contacts, enables Stop Time output, and the AC POWER indicator on the front panel flashes at a rate of 2 hertz ± 20 percent to indicate LINE DROP OUT status. Ensure that the Monitor remains in the FAULT RELAY mode until a LINE RECOVERY has occurred.

(2)Line Recovery. Ensure that the Monitor that determines that a LINE RECOVERY has occurred when:

The AC Line Voltage is: 103 ± 2 VAC for $> 400 \pm 100$ ms.

(3)Fault Relay Recovery. When LINE RECOVERY is established, initiate the FAULT RELAY RECOVERY. For an interval of 6.0 ± 0.5 seconds, the following will take place:

(a)The Output Relay contacts remain closed, and the Stop Time output remains active.

(b)All fault monitoring functions remain suspended.

(c) The AC POWER indicator light flashes at a rate of 2 hertz ± 20 percent.

At the end of this time interval the Monitor begins counting Watchdog transitions from the controller and prepares to resume normal fault monitoring.

(4)Resumption of Normal Monitoring. Ensure that the resumption of normal Fault Monitoring occurs when either:

(a)The Monitor has counted five transitions between the True and False state from the controller Watchdog; or

(b) 10 ± 0.5 seconds has elapsed from the time of LINE RECOVERY.

If the controller Watchdog output does not become active, the Monitor shall go into a Latched Fault condition.

e.Red Monitoring Connector.

(1)Connector. Mount a connector, 3M-3428-5302, with two 3518 polarizing keys, or equivalent, on the Monitor front panel. The pin assignments of the P20 connector and terminal assembly are defined in this specification.

Ensure that it is possible to plug and unplug the Red Monitoring Connector P20 without placing the cabinet into Flash operation.

P20 Connector Pin Assignments

Pin	Function	Pin	Function
1	CHANNEL 15 RED	2	CHANNEL 16 RED
3	CHANNEL 14 RED	4	UNDEFINED
5	CHANNEL 13 RED	6	SPECIAL FUNCTION 2
7	CHANNEL 12 RED	8	SPECIAL FUNCTION 1
9	CHANNEL 10 RED	10	CHANNEL 11 RED
11	CHANNEL 9 RED	12	CHANNEL 8 RED
13	CHANNEL 7 RED	14	CHANNEL 6 RED
15	CHANNEL 5 RED	16	CHANNEL 4 RED
17	CHANNEL 3 RED	18	CHANNEL 2 RED
19	CHANNEL 1 RED	20	RED ENABLE

Ensure that keying is between pins 3/5, and 17/19. The odd numbered pins are on one side, and the even pins are on the other. Key the P20 connector and the CMU connector physically alike (to prevent the Red Monitoring cable from being inserted into the P20 180 degrees out of alignment).

(2)Red Enable Input. Ensure that pin 20 of the Red Monitoring Connector provides the Red Enable input to the Monitor. When the Red Monitoring Connector is disconnected, or Red Enable is not present, ensure that the Monitor checks for conflicting combinations of Greens and Yellows, Watchdog Timer, 24VDC, Conflict Program Card Ajar, and Monitor Fail. When enabled, ensure that the extended Monitor functions become active including: Red Fail, Multiple Output, and Yellow Fail.

(3)Special Function 1 and 2 Inputs.

(a)PIN 8, Special Function 1: Furnish an AC input to the Monitor, which will DISABLE only the RED FAIL monitoring functions while it is active (e.g. during Railroad Preempt).

(b)PIN 6, Special Function 2: Reserved for future use.

Furnish a means to select either a PRESENCE of, or LACK of AC+ to enable these inputs.

f.Electrical Requirements.

(1)Operation Range. Furnish a Monitor that is fully operational from an 85 to 135 V ac power source.

(2)Isolation. Isolate the Chassis Ground and AC ~ from one another.

(3)Monitored AC Inputs. The following voltage and time thresholds apply to all monitored AC inputs.

(a) Green and Yellow Inputs.

Any inputs < 15.0 V rms are considered OFF.
Any inputs > 25.0 V rms are considered ON.

Both sinusoidal and half-wave inputs of the specified RMS values are to meet these thresholds.

(b) Red, Red Enable, and Special Function Inputs.

Any inputs < 50.0 V rms are considered OFF.
Any inputs > 70.0 V rms are considered ON.

Red inputs, both sinusoidal, and half-wave, of the specified RMS values, are to meet these thresholds.

Red enable and special function inputs are to meet these thresholds for sinusoidal waveforms only.

(c) Timing of Conflicting Inputs or Multiple Inputs.

Inputs ON < 200 ms are NOT considered a FAULT.
Inputs ON > 500 ms are considered a FAULT.

(d) Timing of Red Fail.

Lack of output < 1200 ms is NOT considered a FAULT.
Lack of output > 1500 ms is considered a FAULT.

(4) Monitored DC Inputs.**(a) 24VDC Input.**

Input < 18.0 VDC is considered Low VDC input.
Input > 22.0 VDC is NOT considered Low VDC input.

(b) 24VDC Timing.

Low VDC input < 200 ms is NOT considered a FAULT.
Low VDC input > 500 ms is considered a FAULT.

(c) Watchdog Monitor Input.

Input < 4.0 VDC is considered a LOW STATE.
Input > 12.0 VDC (or OPEN) is considered a HIGH STATE.

(d) Watchdog Error Timing.

Lack of valid input state changes for < 1400 ms is NOT a FAULT.

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Lack of valid input state changes for > 1600 ms is a FAULT.

g.Communications and Software.

(1)Install an RS232 port for laptop communications on the front panel of the Monitor.

(2)Furnish a Monitor with compatible communications software for installation on a laptop computer, capable of interfacing with the Monitor via the RS232 port on the front panel. Furnish the software on a 3 1/2-inch (85 mm) floppy disk with each Monitor. Label each disk with revision number and date.

(3)Furnish a Monitor that is capable of being programmed and set-up for intersection operation without the use of a laptop computer and communication software; consider programming the Monitor via the laptop computer a secondary method of set-up.

(4)Furnish a Monitor communications software that is capable of showing and/or programming the status of all programmable set-up parameters of the unit. Furnish a communications software that is capable of displaying the following data:

- (a)Fault type
- (b)Field status (must update status continuously)
- (c)AC line voltage (must update status continuously)
- (d)Status of Red Enable
- (e)Previous fault data
- (f)Program card matrix
- (g)Yellow disable jumpers (if applicable)
- (h)Switch settings per channel (as applicable)
- (i)Option switches
- (j)Current time
- (k)Temperature (must update status continuously)
- (l)Event logs

(5)Furnish a Monitor that is capable of storing events into memory. Typical events are fault events, AC line events, reset events, etc. When a fault event is stored into memory, the Monitor will store the fault condition (type), channel status, date, time, temperature, and line voltage. Ensure that the log history stores a minimum of 100 total events.

h.Diode Matrix and Software. Furnish a Monitor that loads the diode matrix programming into a non-volatile memory device. When the diode matrix is loaded into memory, the memory will regularly compare with diode card and fault condition will occur if memory does not match the diode card matrix.

D. Type 336.

1.General. Furnish Model 336 cabinets that meet the basic cabinet specifications “Traffic Signal Control Equipment Specifications”, California Department of Transportation, latest edition. Ensure that the manufacturer of these Model 336 cabinets is listed on the CalTrans QPL for the Model 332 cabinets at the time of the project award.

2.Cabinets.

a.Furnish cabinets that are constructed of aluminum and is supplied unpainted. An anodic coating is not required.

b.The CalTrans Model 336 cabinet specification is only modified so that the cabinet supplied is the “stretch” type that provides approximately 10 inches of (250 mm) additional cabinet height.

c.Supply galvanized anchor bolts with nuts and washers with each base mounted cabinet. Furnish 3/4-inch (19 mm) diameter by 16 inches (0.4 m) minimum length anchor bolts with an “L” bend on the unthreaded end.

d.Furnish pole mounted cabinets with two pole mounting brackets attached and bottom plates installed. Ensure that both of the cabinet sidewalls are reinforced for pole brackets; however, also ensure that the cabinet is shipped with the brackets installed on the door hinge side of the cabinet. When a pole mounted cabinet is ordered, ensure that the door hinges are specified as “right” or “left” mounted as looking into the front of the cabinet. Ensure that the brackets are designed for banding to a pole.

e.Fit cabinets with a PDA-2 power distribution assembly.

3.Terminals and Wiring. Comply with the requirements of 733.03.C.3.

4.Accessories. Comply with the requirements of 733.03.C.4.

5.Lightning/Surge Protection. Comply with the requirements of 733.03.C.5.

6.Conflict Monitor. Comply with the requirements of 733.03.C.6.

733.04 Cabinet Risers. Furnish the type (size and shape) of cabinet riser that is compatible with the type of controller cabinets specified for the project.

A.Cabinet Riser for NEMA Cabinet. Furnish an aluminum riser with will raise the NEMA cabinet approximately 12 inches (0.3 m) above the concrete foundation. Ensure that the bottom of the riser bolts to the standard cabinet foundation anchor bolts (not included with the riser) and the top of the riser bolts to the bottom of the cabinet. Furnish attachment hardware for connecting the riser to the cabinet.

Construct the riser in a minimum of two pieces such that an existing cabinet can be raised off the foundation without disconnecting the field wiring and the riser can

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be inserted below the cabinet. Furnish hardware for rigidly connecting the riser sections together.

Fabricate the riser from 0.125-inch (3 mm) sheet aluminum with flanges on the top and bottom to provide rigidity. Furnish mounting flanges as necessary to connect with the controller cabinet and foundation anchor bolts. Ensure that the outside surface of the riser has a smooth, uniform, natural finish unless controller cabinet painting is shown on the plans. If painting is required, prepare and paint the riser to match the cabinet.

B. Cabinet Riser for Type 332 or Type 336 Cabinet. Furnish an aluminum riser that will raise the Model 332 or 336 cabinet approximately 8 inches (0.2 m) above the concrete foundation. Ensure that the bottom of the riser bolts to the standard cabinet foundation anchor bolts (not included with the riser) and the top of the riser bolts to the bottom of the cabinet. Furnish attachment hardware for connecting the riser to the cabinet. Manufacture the unit to CalTrans specifications. Ensure that the outside surface of the riser has a smooth, uniform, natural finish unless controller cabinet painting is shown on the plans. If painting is required, prepare and paint the riser to match the cabinet.

733.05 Flasher Controller. Furnish solid-state flasher that complies with NEMA TS-1, Section 8, and have two circuits, each rated at 10 amperes. Furnish a cabinet that conforms to applicable requirements of 733.03.A, except that the following items are not required: a small door-in-door (police door), shelves, and a fan. Ensure that the cabinet size is not less than 12 inches (300 mm) high by 10 inches (250 mm) wide by 6 inches (150 mm) deep. Furnish cabinets that are designed for pole mounting with a 1-1/2 inch (38 mm) or larger conduit opening in the bottom. Ensure that the auxiliary equipment includes: on-off power switch with integral 20-ampere circuit breaker, lightning protection devices on incoming power lines, interference filters, terminal blocks, and a ground bus bar.

733.06 Controller, Master, Traffic Responsive.

A. Description. The traffic responsive master controller is one component of a distributive processing, traffic responsive, control, and monitoring “closed loop” system. The master controller’s principal operational task is to select and implement traffic signal timing plans in response to both actual traffic conditions or time based events. The master controller monitors, in real time, local intersection activity, and overall system performance, reporting failures and status conditions to the Remote Monitoring Station.

The master controller is typically located in a local intersection cabinet; however, in special circumstances it may be located at a Remote Monitoring Station site. The master controller is capable of uploading/downloading information to local intersection controllers and the Remote Monitoring Station.

B. Functional Requirements.

1.Design. Furnish a solid state, digital microprocessor master controller design. Furnish a controller that uses menu driven prompts, unless of Type 170 design. If the master controller is used with Type 170E or Type 2070 controllers, provide software unless otherwise shown on the plans.

Furnish a master controller that has a RS-232 port for connection to a laptop computer or printer. Furnish software and connector cables for communication with a laptop.

2.Local Controllers. Ensure that each master controller is able to supervise and communicate with at least 24 local intersection controllers.

3.System Detectors. Ensure that each master controller is able to analyze traffic sensor data from at least 32 system detectors. Distribute system detectors up to eight per intersection, but do not exceed the total system sensor capacity.

Ensure that the detectors are assignable to each of the computational channels in each group, with the channels representing cycle selection, directionality (offset), non-arterial flow (split), and special congestion indicators of queue or occupancy.

Furnish a master controller that is capable of monitoring and detecting system detector failure and removing failed detectors from volume and occupancy calculations. Upon resumption of satisfactory sensor operation, sensors shall automatically resume input to volume and occupancy calculations.

4.Timing Patterns. Ensure that each master controller provides a minimum of 16 selectable patterns. Ensure that each pattern shall consist of a combination of cycle, offset, and split numbers for each intersection in the system.

Furnish a master controller that is capable of implementing a “free” mode whereby all intersection controllers will operate without system coordination and a “flash” mode whereby all intersection controllers will operate in a flashing operation.

5.Operational Modes. Ensure that each master controller is able to operate in the following modes of operational control:

a. Traffic responsive mode whereby pattern selection is based on dynamic traffic conditions as measured by system sensors located in the control area. As a minimum, base the pattern selection on the quantitative traffic flow parameters of volume, occupancy, and directionality of the arterial traffic.

Base transfer of patterns on programmable threshold values. Furnish system sensors that are capable of selective weighting.

b. Time of day/day of week (time base) mode whereby pattern selection is based on a preprogrammed event scheduler with automatic adjustments for seasonal daylight savings time changes. Ensure that this mode of operation is able to call or override traffic responsive mode.

c. Manual override mode whereby pattern selection is made by operator control at the Remote Monitoring Station or master controller site.

Ensure that the system coordination control for each master controller is selected on a priority basis. The priority from highest to lowest is as follows:

a. Manual control entry or remote command

b. Time base control

c. Traffic responsive control

6. Reports. Ensure that each master controller monitors and formats intersection and system information for immediate output to the Remote Monitoring Station or for storage for a minimum period of 48 hours. As a minimum, ensure that the following types of reports are generated:

a. A local intersection activity log showing the time, date and activity of all monitored local intersection failure conditions.

b. A system sensor failure log that includes time, sensor location, and type of failure.

c. A system log with pattern changes.

d. A system sensor data log that includes volume and occupancy for all system sensors.

7. Alarms. Ensure that each master controller continuously monitors intersection and system information for various systems and user defined critical conditions. Upon detection of an alarm condition, ensure that the master controller attempts to transmit alarm information to the Remote Monitoring Station or a preprogrammed telephone number. In case of failure to connect to the central software, the master will continue to periodically retry reporting to the Remote Monitoring Station.

8. Communications. Furnish a master controller that supports two-way dial-up communications to a Remote Monitoring Station computer for control, monitoring, data collection, and for timing pattern updating purposes. Through continuous, 7 days/week, 24 hours/day system monitoring, ensure that the master controller is able to automatically dial-up the Remote Monitoring Station computer upon detection of user defined critical alarm conditions.

Furnish a master controller that includes any communication devices or modems necessary to interface with the local intersection controllers within its control area.

9.Security. Furnish a master controller that provides for a user specified security code before any data is altered. In order to view any parameter, ensure that a security code entry is not required. Furnish a master controller that has the ability to disable security code requirements, allowing for perpetual access without requiring hardware changes.

733.07 Remote Monitoring Station.

A.Description. The Remote Monitoring Station describes a distributive processing, traffic responsive, control and monitoring “closed loop” system. The system monitors, in real time, local intersection activities, and overall system performance, reporting failures and status conditions both automatically and by operator request. In order to meet current and future traffic control needs, the system also provides extensive control monitoring, data collection, reporting, and analysis functions.

For complete user flexibility, the system provides full access of each local system intersection controller from the Remote Monitoring Station site. Full access includes the capability to upload all time settings, operation parameters, and status information, as well as the capability to download all time settings and operation parameters.

B.System Architecture. The system consists of four principal elements:

- 1.Local intersection controller (see 733.02)
- 2.Communication links
- 3.Traffic responsive master controller (see 733.06)
- 4.A Remote Monitoring Station consisting of computer equipment and software

C.Local Intersection Controllers. Furnish controller units conforming to 733.02 for the type of controller shown on the plans. Furnish a controller that has internal communication capability compatible with the type of interconnect cable shown on the plans. Furnish a local system controller that is capable of processing controller and detector data and provide all necessary intersection control functions.

D.Communications. Ensure that communication between the Remote Monitoring Station and the master controller is through an auto-answer/auto-dial external modem on standard dial-up telephone service. Furnish telephone service at the Remote Monitoring Station site by the maintaining agency, unless otherwise shown on the plans. Furnish telephone service at the master controller or the isolated local intersection location by separate bid item as specified for “Telephone Service”.

Include error checking in the software to assure transmission and reception of valid data between the local controller, master controller, and the Remote Monitoring Station.

E.Equipment. Ensure that the Equipment provided at each Remote Monitoring Station location is as shown on the plans and, as a minimum, consists of the following items:

1. Microcomputer with monitor
2. Software
3. Modem
4. Printer
5. Accessory Items

F. System Functional Requirements. The system software provides a simplified user friendly, color menu format at the Remote Monitoring Station. Ensure that no special computer programming skills are required for the user to fully access and operate this control and monitoring system.

1. Graphical Representation. Furnish system software that enables the operator to display in color, the vehicular signals, pedestrian signals, and detector actuations in a real time mode. Ensure that the user is able to construct an intersection layout graphically by using predetermined intersection shapes.

2. System Capacity. Furnish a Remote Monitoring Station software that has the capacity to monitor and control at least 24 traffic responsive masters. Ensure that the central software is also capable of monitoring and controlling isolated system controllers.

Furnish a system software that has the capability to manually select any timing plan, free mode or flash mode.

Ensure that the system software has the capability of accepting, formatting, and processing data from at least 32 system detectors from each master controller.

3. Data Transfer. Ensure that it is possible to upload/download the signal timing database, including coordination, and preemption settings, between the Remote Monitoring Station and the master controller or local intersection.

Furnish a Remote Monitoring Station that provides a means to compare a currently uploaded timing database with a previously developed database stored in the Remote Monitoring Station memory. Ensure that it reports differences in the databases.

During either uploading or downloading operations, ensure that the normal traffic control operations are not suspended.

4. Security. Furnish a Remote Monitoring Station that provides for a user specified security code before any data is altered. Maintain controller access

procedures from the Remote Monitoring Station allowing the user full security control of all system components from a remote location.

5. Isolated Intersection Management. Furnish a Remote Monitoring Station software that includes the capability of accessing system controllers at remote intersection locations. Ensure that this capability includes total access to controller timing parameters, alarm conditions, detector data, and intersection status conditions in real time without the use of a master controller. Ensure that this feature utilizes the local intersection controller with a dial-up modem and telephone service.

733.08 Telephone Service. Ensure that the telephone service is a standard dial-up service capable of supporting 2400 baud data transmission. Ensure that the external modem provided is a Hayes compatible, auto-answer/auto-dial unit with all connections, cables, and lightning protection on the incoming wires provided.

733.08