DIVISION 700
MATERIALS DETAILS

SECTION 701
HYDRAULIC CEMENT

701.01 Hydraulic Cement. Hydraulic cement shall conform to the requirements of the following specifications for the type specified or permitted:

Portland Cement	ASTM C150
Blended Hydraulic Cement	ASTM C595

All concrete, including precast, prestressed and pipe shall be constructed with one of the following hydraulic cements unless permitted otherwise.

ASTM C150 Type I
ASTM C150 Type II
ASTM C150 Type V
ASTM C595 Type IL(MS)
ASTM C595 Type IL(HS)
ASTM C595 Type IP
ASTM C595 Type IP(MS)
ASTM C595 Type IP(HS)
ASTM C595 Type IT(MS)
ASTM C595 Type IT(HS)

Cement shall be from a preapproved source listed on the Department's Approved Products List.

The cement shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of the cement until the corrections necessary have been taken to ensure that the material meets the specifications.

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement that has become partially set or that contains lumps of caked cement shall not be used.

Cement salvaged from discarded or used bags shall not be used.

701.02 Fly Ash.

Fly ash for concrete shall conform to the requirements of ASTM C618, Class C or Class F with the following exceptions:

(1) The loss on ignition shall not exceed 3.0 percent.

(2) The CaO in Class F fly ash shall not exceed 18 percent.

Blending of pozzolans according to ASTM D5370 is permitted to meet the requirements of ASTM C618.

Fly ash shall be from a preapproved source listed on the Department's Approved Products List.

Preapproval shall include submission of a report from the supplier documenting the results of testing the fly ash from that source per the Toxicity Characteristic Leaching Procedure (TCLP) described in 40 CFR 261, Appendix II. The report shall include the results of TCLP testing for heavy metals and other contaminants found in the fly ash. The report shall list the contaminants tested, and the allowable levels for each contaminant tested. A new report shall be submitted for each preapproved source annually. Additional TCLP testing may be required when the Department suspects that the fly ash source may have been contaminated.

The fly ash shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of fly ash until the corrections necessary have been taken to ensure that the material meets the specifications.

701.03 Silica Fume. Silica fume for concrete shall conform to the requirements of ASTM C1240.

Silica Fume shall be from a preapproved source listed on the Department's Approved Products List.

The silica fume shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of the silica fume until the corrections necessary have been taken to ensure that the material meets the specifications.

701.04 High-Reactivity Pozzolans. High-Reactivity Pozzolans (HRP) shall conform to the requirements of AASHTO M 321. HRPs include but are not limited to metakaolin, rice hull ash, zirconium fume, ultra-fine fly ash, and fume from the production of 50 percent ferrosilicon (with SiO_2 less than 85 percent).

HRPs shall meet the following optional requirement of AASHTO M 321: The sulfate expansion at 14 days shall not exceed 0.045 percent.

HRP shall be from a preapproved source listed on the Department's Approved Products List.

The HRP shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of HRP until the necessary corrections have been taken to ensure that the material conforms to the specifications.

701.05 Slag Cement. Slag cement shall conform to the requirements of ASTM C989. Slag cement shall be Grade 100 or Grade 120. Slag cement shall have a maximum Aluminum Oxide content of 11.0 percent.

Slag cement shall be from a pre-approved source listed on the Department's Approved Products List.

Slag Cement shall be subject to sampling and testing by the Department. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of Slag Cement until the necessary corrections have been taken to ensure that the material conforms to the specifications.

SECTION 702
BITUMINOUS MATERIALS

702.01 Asphalt Cements.

(a) Superpave Performance Graded Binders. Superpave Performance Graded Binders shall conform to the requirements listed in Table 702-1. (Taken from AASHTO M 320)

Asphalt cement shall not be acid modified or alkaline modified.

Asphalt cement shall not contain any used oils that have not been rerefined. Modifiers that do not comply with environmental rules and regulations including 40 CFR Part 261.6(a) (3) (IV), and part 266/Subpart C shall not be added. Modifiers shall not be carcinogenic.

The supplier of the PG binder shall be certified per CP 11.

Table 702-1
SUPERPAVE PERFORMANCE GRADED BINDERS

Property	Requirement for PG Binder						AASHTO Test No.
	58-28	58-34	64-22	64-28	70-28	76-28	
Original Binder Properties							
Flash Point Temp., °C, minimum	230	230	230	230	230	230	T 48
Viscosity at 135 °C, Pa●s, maximum	3	3	3	3	3	3	T 316
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 1.00 kPa	58	58	64	64	70	76	T 315
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	50		-	T 51
Toughness, joules (inch-lbs)	-	-	-	12.4 (110)		-	CP-L 2210
Tenacity, joules (inch-lbs)	-	-	-	8.5 (75)		-	CP-L 2210
Acid or Alkali Modification (pass-fail)	Pass	Pass	Pass	Pass	Pass	Pass	CP-L 2214

Property	Requirement for PG Binder						AASHTO Test No.
	58-28	58-34	64-22	64-28	70-28	76-28	
RTFO Residue Properties							CP-L 2215
Mass Loss, percent maximum	1.00	1.00	1.00	1.00	1.00	1.00	CP-L 2215
Dynamic Shear, Temp. °C, where G*/Sin δ @ 10 rad/s ≥ 2.20 kPa	58	58	64	64	70	76	T 315
Elastic Recovery, 25 °C, percent min.	-	-	-	-	50	50	T 301
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	20	-	-	T 51
PAV Residue Properties, Aging Temperature 100 °C							R 28
Dynamic Shear, Temp. °C, where G*●Sin δ @ 10 rad/s ≤ 6000 kPa	19	16	25	22	25	28	T 315
Creep Stiffness, @ 60 s, Test Temperature in °C	-18	-24	-12	-18	-18	-18	T 315
S, maximum, MPa	300	300	300	300	300	300	T 313
m-value, minimum	0.300	0.300	0.300	0.300	0.300	0.300	T 313

Acceptance Samples of the PG binder will be taken on the project per the Schedule in the *Field Materials Manual*.

The Department will test for acid modification and alkaline modification during the binder certification process. Thereafter, the Department will randomly test for acid modification and alkaline modification.

(b) Dampproofing. Asphalt for dampproofing shall conform to the requirements of ASTM D449, and the asphaltic primer shall conform to the requirements of ASTM D41.

702.02 Emulsified Asphalts. Emulsified asphalts shall conform to AASHTO M 140 or M 208 for the designated types and grades. Emulsified asphalt and aggregate used for surface seals shall be sampled and will be tested for information only per CP-L 2213.

Emulsified asphalt (HFMS-2S) with a residual penetration greater than 300 dmm (0.1 mm) shall conform to all properties listed in AASHTO M 140, Table 1 except that ductility shall be reported for information only.

(a) Emulsion for Tack and Fog Coats. Emulsions for tack and fog coats shall conform to the requirements listed in Table 702-2 or 702-3, before dilution.

Table 702-2
TACK AND FOG COAT EMULSIONS

Property		CSS-1h	SS-1h	AASHTO Test No.
Tests on Emulsion:				
Viscosity, at 25 ºC, Saybolt-Furol, s	min.	20	20	T 59
	max.	100	100	
Storage stability, 24 hr, % max.[1]		1.0	1.0	T 59
Particle charge test		Positive		T 59
Sieve test, % max.		0.10	0.10	T 59
Oil Distillate by volume, % max.		3.0	3.0	T-59
Residue by distillation/ evaporation, % min.[3]		57[3]	57[3]	T 59/ CP-L 2212[2]
Tests on residue:				
Penetration, 25 ºC, 100g, 5s, min., dmm		40	40	T 49
Penetration, 25 ºC, 100g, 5s, max., dmm		120	120	T 49
Ductility, 25 ºC, 5 cm/min, cm, min.		40	40	T 51
Solubility, in trichloroethylene% min.		97.5	97.5	T 44

[1]If successful application is achieved in the field, the Engineer may waive this requirement.

[2] CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test per AASHTO T-59 to determine acceptability.

[3] For polymerized emulsions the distillation and evaporation tests will be performed per AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

(b) Emulsion for Chip Seals. Polymerized emulsions for chip seals shall conform to the requirements listed in Table 702-3. Emulsion for chip seals shall be an emulsified blend of polymerized asphalt, water, and emulsifiers. The asphalt cement shall be polymerized before emulsification and shall contain at least 3 percent polymer by weight of asphalt cement. The emulsion standing undisturbed for a minimum of 24 hours shall show no white, milky separation but shall be smooth and homogeneous throughout. The emulsion shall be pumpable and suitable for application through a distributor.

Table 702-3
POLYMERIZED EMULSIONS FOR CHIP SEALS

Property		CRS-2	CRS-2P	CRS-2R	HFMS-2P	AASHTO Test No.
Tests on Emulsion:						
Viscosity, at 50 ºC, Saybolt-Furol, s	min.	50	50	50	50	T 59
	max.	450	450	450	450	
Storage stability, 24 hr, % max.		1.0	1.0	1.0	1.0	T 59
Particle charge test		Positive	Positive	Positive		T 59
Sieve test, % max.		0.10	0.10	0.10	0.10	T 59
Demulsibility[1], % min.		40	40	40		T 59
Oil Distillate by volume, % max. or range		3.0	3.0	3.0	3.0	T-59
Residue by distillation/ evaporation, % min[3]		65[3]	65[3]	65[3]	65[3]	T 59/ CP-L 2212[2]
Tests on residue:						
Penetration, 25 ºC, 100g, 5s, min., dmm		70	70	70	70	T 49
Penetration, 25 ºC, 100g, 5s, max., dmm		150	150	150	150	T 49
Ductility, 25 ºC, 5 cm/min, cm, min.		40			75	T 51
Ductility, 4 ºC, 5 cm/min, cm, min.				40		
Solubility, in trichloroethylene, % min.[4]		97.5[4]	97.5[4]	97.5[4]	97.5[4]	T 44
Elastic Recovery, 25 ºC min.					58	T 301
Float Test, 60 ºC, s min.					1200	T 50
Toughness, in-lb, min.			70	90		CP-L 2210
Tenacity, in-lb, min.			45	45		CP-L 2210

[1]If successful application is achieved in the field, the Engineer may waive this requirement.

[2] CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test in acccordance with AASHTO T-59 to determine acceptability.

[3] For polymerized emulsions the distillation and evaporation tests will be performed per AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

[4] Solubility may be determined on the base asphalt cement before polymer modification.

(c) Emulsion for Slurry Seals and Micro-Surfacing. Emulsions for slurry seals and micro-surfacing shall conform to the requirements listed in Table 702-4. The modified emulsion shall contain a minimum of 3 percent polymer, SBR latex, or natural latex by weight.

Table 702-4
SLURRY SEAL AND MICRO-SURFACING EMULSIONS

Property		CQS-1hL	CQS-1hP	AASHTO Test No.
Tests on Emulsion:				
Viscosity, at 25 ºC, Saybolt-Furol, s	min.	15	15	T 59
	max.	100	100	
Storage stability, 24 hr, % max.[1]		1.0	1.0	T 59
Particle charge test		Positive	Positive	T 59
Sieve test, % max.		0.10	0.10	T 59
Oil Distillate by volume, % max.		0.5	0.5	T-59
Residue by distillation/ evaporation, % min.[3]		62[3]	62[3]	T 59/ CP-L 2212[2]
Tests on residue:				
Penetration, 25 ºC, 100g, 5s, min., dmm		40	40	T 49
Penetration, 25 ºC, 100g, 5s, max., dmm		150	150	T 49
Ductility, 25 ºC, 5 cm/min, cm, min.		50	50	T 51
Solubility, in trichloroethylene% min.		97.5	97.5	T 44

[1]If successful application is achieved in the field, the Engineer may wave this requirement.

[2] CP-L 2212 is a rapid evaporation test for determining percent residue of an emulsion and providing material for tests on residue. CP-L 2212 is for acceptance only. If the percent residue or any test on the residue fails to meet specifications, the tests will be repeated using the distillation test per AASHTO T-59 to determine acceptability.

[3] For polymerized emulsions the distillation and evaporation tests will be performed per AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5 ºC (400 ± 10 ºF) maximum temperature to be held for 15 minutes.

(d) Emulsion for Prime Coat. Emulsion for prime coat shall conform to the requirements of Table 702-5. Circulate before use if not used within 24 hours.

Table 702-5
ASPHALT EMULSION FOR PRIME COAT (AEP)

Property	Requirement	AASHTO Test No.
Viscosity, Saybolt-Furol, at 50 °C (122 °F), s	20-150	T 59
% Residue	65% min.	T 59 to 260 °C (500 °F)
Oil Distillate by Volume, %	7% max.	T59
Tests on Residue from Distillation:		
Solubility in Trichloroethylene, %	97.5 min.	T 44

(e) Recycling Agent. Recycling Agent for Item 406, Cold Bituminous Pavement (Recycle), shall be either a high float emulsified asphalt (polymerized) or an emulsified recycling agent as follows:

1. High Float Emulsified Asphalt (Polymerized). High Float Emulsified Asphalt (Polymerized) for Cold Bituminous Pavement (Recycle) shall be an emulsified blend of polymer-modified asphalt, water, and emulsifiers conforming to Table 702-6 for HFMS-2sP. The asphalt cement shall be polymerized before emulsification and shall contain at least 3 percent polymer.

   The emulsion standing undisturbed for a minimum of 24 hours shall show no white, milky separation, and shall be smooth and homogeneous throughout.

   The emulsion shall be pumpable and suitable for application through a pressure distributor.

Table 702-6
HIGH FLOAT EMULSIFIED ASPHALT
(POLYMERIZED) (HFMS-2sP)

Property	Requirement		AASHTO Test
	Minimum	Maximum	
Tests on Emulsion:			
Viscosity, Saybolt-Furol at 50 °C (122 °F), sec	50	450	T 59
Storage Stability test, 24 hours, %		1	T 59
Sieve test, %		0.10	T 59
Residue, %[1]	65		T 59
Oil distillate by volume, %	1	7	T 59
Tests on Residue:			
Penetration, 25 °C (77 °F), 100g, 5 sec	150	300[2]	T 49
Float Test, 60 °C (140 °F), sec	1200		T 50
Solubility in TCE, %	97.5		T 44
Elastic Recovery, 4 °C (39.2 °F), %	50		T 301

[1] 400 ± 10 °F maximum temperature to be held for 15 minutes.

[2] When approved by the Engineer, Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 dmm may be used with Cold Bituminous Pavement (Recycle) to address problems with cool weather or extremely aged existing pavement. Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 dmm shall meet all properties listed in Table 702-6 except that Elastic Recovery shall be reported for information only.

2. Emulsified Recycling Agent. Emulsified Recycling Agent for use in Cold Bituminous Pavement (Recycle) shall conform to the requirements in Table 702-7.

Table 702-7
EMULSIFIED RECYCLING AGENT

Property	Requirement		Test
	Minimum	Maximum	
Tests on Emulsion:			
Viscosity @ 25 °C, SFS	20	200	ASTM D244
Pumping Stability	Pass		GB Method[1]
Sieve Test, %w		0.1	ASTM D244[2]
Cement Mixing, %w		2.0	ASTM D244
Particle Charge	Positive		ASTM D244
Conc. Of Oil Phase	64		ASTM D244[3]
Tests on Residue:			
Viscosity @ 60 °C, CST	2000	4000	ASTM D2170
Flash Point, COC, °C (° F)	232		ASTM D92
Maltenes Dist. Ratio[4] $\frac{PC+A_1}{S+A_2}$	0.3	0.6	ASTM D2006
PC/S Ratio	0.4		ASTM D2006
Asphaltenes, % max.		11.0	ASTM D2006

[1] Pumping stability is determined by charging 450 ml of emulsion into a one-liter beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having a 6.3 mm (1/4 inch) inlet and outlet. The emulsion passes if there is no significant separation after circulating10 minutes.

[2] Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2 percent sodium oleate solution.

[3] ASTM D244 Evaporation Test for percent of residue is modified by heating 50-gram sample to 149°C (300 °F) until foaming ceases, then cooling immediately and calculating results.

[4] In the Maltenes Distribution Ratio Test by ASTM Method D2006.
PC = Polar Compounds S = Saturates
A_1 = First Acidaffin A_2 = Second Acidaffins

(f) Asphalt Rejuvenating Agents. Asphalt rejuvenating agents (ARA) shall be composed of a petroleum resin-oil base uniformly emulsified with water and shall conform to the physical and chemical requirements of Table 702-8 or ASTM D4552.

Table 702-8
ASPHALT REJUVENATING AGENT

Property	Test Method	Requirement
Viscosity, S.F., @ 25 °C (77 °F), s	ASTM D244	20-40
[1]Residue, % min.	ASTM D244	60-65
[2]Miscibility Test	ASTM D244	No coagulation
[3]Sieve Test, % max.	ASTM D244	0.10
Particle Charge Test	ASTM D244	Positive
ASTM D244 (Mod):		
Viscosity, 60 °C (140 °F), mm^2/s	ASTM D445	100 - 200
Flash Point, COC, °C, min.	ASTM D92	196
Asphaltenes, % max.	ASTM D2006	1.0
[4]Maltenes Dist. Ratio $\frac{PC+A_1}{S+A_2}$	ASTM D2006	0.3-0.6
Saturated Hydrocarbons, %	ASTM D2006	21-28

[1] ASTM D244 Modified Evaporation Test for percent of residue is made by heating 50-gram sample to 149 °C (300 °F) until foaming ceases, then cooling immediately and calculating results.

[2] Test procedure identical with ASTM D244 except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.

[3] Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2% sodium oleate solution.

[4] In the Maltenes Distribution Ratio Test by ASTM Method D4124:
PC = Polar Compounds S = Saturates
A_1 = First Acidaffin A_2 = Second Acidaffins

For hot-in-place recycling ARA-1P is an acceptable alternative to ARA. ARA-1P shall meet the requirements below:

Emulsified Polymer Modified Asphalt Rejuvenating Agent (ARA-1P) for use in hot-in-place recycling of bituminous pavements shall be modified with a minimum of 1.5 percent styrene-butadiene solution polymer. The finished product shall conform to the physical requirements listed in Table 702-9 below.

Table 702-9
ARA 1P

Property	Test Method	Min	Max
Test on Emulsion			
Viscosity, Saybolt-Furol @ 77 ºF, s	ASTM D244		100
Residue @ 350 ºF, %	ASTM D244 Mod	60	
Sieve Test, %	ASTM D244		0.10
Oil distillate, %	ASTM D244		2.0
Test on Residue			
Penetration @ 39.2 ºF, 100g, 5s, dmm	ASTM D5 Modified	150	250
Asphaltenes, %	ASTM D4124		15

702.03 (unused)

702.04 Hot Poured Joint and Crack Sealant. Hot poured material for filling joints and cracks shall conform to the requirements of ASTM D6690, Type II or Type IV. The concrete blocks used in the Bond Test shall be prepared per CP-L 4101.

Sealant material shall be supplied pre-blended, pre-reacted, and prepackaged. If supplied in solid form the sealant material shall be cast in a plastic or other dissolvable liner having the capability of becoming part of the crack sealing liquid. The sealant shall be delivered in the manufacturer's original sealed container.

Each container shall be legibly marked with the manufacturer's name, the trade name of the sealer, the manufacturer's batch or lot number, the application temperature range, the recommended application temperature, and the safe heating temperature.

The sealant shall be listed in CDOT’s Approved Products List before use.

SECTION 703
AGGREGATES

703.00 General All sieve sizes and designations described in this section refer to laboratory sieves having square openings and conforming to ASTM E11.

The grading and composition requirements for coarse and fine aggregates for concrete are set forth in Table 703-1.

Table 703-1
CONCRETE AGGREGATE GRADATION TABLE
Percentage Passing Designated Sieves and Nominal Size Designation

Sieve Size	Coarse Aggregates (from AASHTO M43)									Fine Aggregate
	No. 3	No. 357	No. 4	No. 467	No. 57	No. 6	No. 67	No. 7	No. 8	
	50 mm to 25.0 mm (2" to 1")	50 mm to 4.75 mm (2" to No. 4)	37.5 mm to 19.0 mm (1 1/2" to 3/4")	37.5 mm to 4.75 mm (1 1/2" to #4)	25.0 mm to 4.75 mm (1" to #4)	19.0 mm to 9.5 mm (3/4" to 3/8")	19.0 mm to 4.75 mm (3/4" to #4)	12.5 mm to 4.75 mm (1/2" to #4)	9.5 mm to 2.36 mm (3/8" to #8)	4.75 mm to 150 µm (#4 to #100)
63 mm (2 1/2")	100	100								
50 mm (2")	90–100	95–100	100	100						
37.5 mm (1 1/2")	35–70		90–100	95–100	100					
25.0 mm (1")	0–15	35–70	20–55		95–100	100	100			
19.0 mm (3/4")			0–15	35 – 70		90–100	90–100	100		
12.5 mm (1/2")	0–5	10–30			25–60	20–55		90–100	100	
9.5 mm (3/8")			0–5	10–30		0–15	20–55	40–70	85–100	100
4.75 mm (#4)		0–5		0–5	0–10	0–5	0–10	0–15	10–30	95–100
2.36 mm (#8)					0–5		0–5	0–5	0–10	80–100
1.18 mm (#16)									0–5	50–85
600 µm (#30)										25–60
300 µm (#50)										10–30
150 µm (#100)										2–10

703.01 Fine Aggregate for Concrete. Fine aggregate for concrete shall conform to the requirements of AASHTO M 6, Class A. The minimum sand equivalent, as tested per Colorado Procedure 37 shall be 80 unless otherwise specified. The fineness modulus, as determined by AASHTO T 27, shall not be less than 2.50 or greater than 3.50 unless otherwise approved.

703.02 Coarse Aggregate for Concrete. Coarse aggregate for concrete shall conform to the requirements of AASHTO M 80, Class A, except that the percentage of wear shall not exceed 45 when tested per AASHTO T 96.

703.03 Aggregate for Bases. Aggregates for bases except Aggregate Base Course (RAP) shall be crushed stone, crushed slag, crushed gravel, natural gravel, or crushed reclaimed concrete. Aggregate Base Course (RAP) shall be 100 percent crushed recycled asphalt pavement material. All materials except Aggregate Base Course (RAP) shall conform to the quality requirements of AASHTO M 147 except that the requirements for the ratio of minus 75 µm (No. 200) sieve fraction to the minus 425 µm (No. 40) sieve fraction, stated in 3.2.2 of AASHTO M 147, shall not apply

The requirements for the Los Angeles wear test (AASHTO T 96 and ASTM C535) shall not apply to Class 1, 2, and 3. Aggregates for bases shall meet the grading requirements of Table 703-2 for the class specified for the project, unless otherwise specified.

The liquid limit shall be as shown in Table 703-2 and the plasticity index shall not exceed six when the aggregate is tested per AASHTO T 89 and T 90 respectively.

Table 703-2
CLASSIFICATION FOR AGGREGATE BASE COURSE

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
150 mm (6")			100				
100 mm (4")		100					
75 mm (3")		95-100					
60 mm (2 1/2")	100						
50 mm (2")	95-100			100			
37.5 mm (1 1/2")				90-100	100		
25 mm (1")					95-100	100	100
19 mm (3/4")				50-90		95-100	
4.75 mm (#4)	30-65			30-50	30-70	30-65	
2.36 mm (#8)						25-55	20-85
75 µm (#200)	3-15	3-15	20 max.	3-12	3-15	3-12	5-15
NOTE: Class 3 material shall consist of bank or pit run material.							

Aggregate Base Coarse (RAP) shall be 100 percent reclaimed asphalt pavement material conforming to the requirements of Table 703-3.

Table 703-3
CLASSIFICATION FOR RECLAIMED ASPHALT PAVEMENT AGGREGATE BASE COURSE

Sieve Size	Mass Percent Passing Square Mesh Sieves
	ABC (RAP)
50 mm (2")	100
25 mm (1")	85-100
19 mm (3/4")	75-100
12.5 mm (1/2")	55-90
9.5 mm (3/8")	45-80
4.75 mm (#4)	25-55
1.18 mm (#16)	5-25
75 µm (#200)	0-5

703.04 Aggregates for Hot Mix Asphalt. Aggregates for hot mix asphalt (HMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, natural gravel, or crushed slag. Excess of fine material shall be wasted before crushing. A percentage of the aggregate retained on the 4.75 mm (No. 4) sieve for Gradings S, SX and SG— and on the 2.36 mm (No. 8) sieve for Gradings SF and ST—shall have at least two mechanically induced fractured faces when tested per Colorado Procedure 45. This percentage will be specified in Table 403-1, as revised for the project in Section 403. The angularity of the fine aggregate shall be a minimum of 45.0 percent when determined according to AASHTO T 304. Grading SF mixes, when determined by the Region Materials Engineer, may not require fine aggregate angularity of 45.0 percent. Aggregate samples representing each aggregate stockpile shall be non-plastic if the percent of aggregate passing the 2.36 mm (No. 8) sieve is greater than or equal to 10 percent by weight of the individual aggregate sample. Plasticity will be determined per AASHTO T 90. The material shall not contain clay balls, vegetable matter, or other deleterious substances.

The aggregate for Gradings ST, S, SX, and SG shall have a percentage of wear of 45 or less when tested per AASHTO T 96.

Table 703-4
MASTER RANGE TABLE FOR HOT MIX ASPHALT

Sieve Size	Percent by Weight Passing Square Mesh Sieves				
	Grading SF	**Grading ST**	**Grading SX**	**Grading S**	**Grading SG**
37.5 mm (11/2″)					100
25.0 mm (1″)				100	90 – 100
19.0 mm (3/4″)			100	90 – 100	
12.5 mm (1/2″)		100	90 – 100	*	*
9.5 mm (3/8″)	100	90 – 100	*	*	*
4.75 mm (#4)	90 – 100	*	*	*	*
2.36 mm (#8)	*	28 – 58	28 – 58	23 – 49	19 – 45
1.18 mm (#16)	30 – 54				
600 µm (#30)	*	*	*	*	*
300 µm (#50)					
150 µm (#100)					
75 µm (#200)	2 – 12	2 – 10	2 – 10	2 – 8	1 – 7

* These additional Form 43 Specification Screens will initially be established using values from the As Used Gradation shown on the Design Mix.

Aggregates for stone matrix asphalt (SMA) shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. A minimum of 90 percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested per Colorado Procedure 45. The particles passing the 4.75 mm (No. 4) sieve shall be the product of crushing rock larger than 12.5 mm (1/2 inch) and shall be non-plastic when tested per AASHTO T 90.

Additionally, each source of aggregate for SMA shall meet the following requirements:

(1) No more than 30 percent when tested per AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

(2) No more than 12 percent when tested per AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate.

Table 703-5
MASTER RANGE TABLE FOR STONE MATRIX ASPHALT

Sieve Size	Percent by Weight Passing Square Mesh Sieves			
	4.75 mm (#4) nominal	**9.5 mm (3/8″) nominal**	**12.5 mm (1/2″) nominal**	**19.0 mm (3/4″) nominal**
25 mm (1")				100
19.0 mm (3/4")			100	90-100
12.5 mm (1/2")	100	100	90-100	50-88
9.5 mm (3⁄8")	100	90-100	50-80	25-60
4.75 mm (#4)	90-100	26-60	20-35	20-28
2.36 mm (#8)	28-65	20-28	16-24	16-24
1.18mm (#16)	22-36			
600 µm (#30)	18-28	12-18	12-18	12-18
300 µm (#50)	15-22	10-15		
150 µm (#100)				
75 µm (#200)	12-15	8-12	8-11	8-11

The aggregates for hot mix asphalt (HMA) and stone matrix asphalt (SMA) shall meet the requirements of Table 703-6 when tested per CP-L 4211 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus. The Contractor shall be assessed a price reduction of $1,000 for each production sample of the combined aggregate with a value greater than 20 according to CP-L 4211.

Table 703-6
AGGREGATE DEGRADATION BY ABRASION
IN THE MICRO-DEVAL CP-L 4211

	Not to exceed
Combined Aggregate (Mix Design)	18
Combined Aggregate (1/10,000 tons, or fraction thereof during production)	20

703.05 Aggregate for Cover Coat Material. Aggregates for cover coat material shall be crushed stone, crushed slag, crushed gravel, or natural gravel. Aggregates shall be composed of clean, tough, durable fragments free from an excess of flat, elongated, soft, or disintegrated pieces and free from fragments coated with dirt or other objectionable matter. Slag shall be air-cooled blast-furnace slag reasonably uniform in density.

The aggregate shall conform to the following requirements:

(1) The percentage of wear, Los Angeles Abrasion Test (AASHTO T 96), shall not be more than 35.

(2) The maximum amount of flat and elongated aggregate with a ratio of 3:1 shall not exceed 12 percent as determined by ASTM D4791.

(3) When blast-furnace slag is used, the weight per cubic foot shall be at least 70 pounds.

(4) For Type I, II, or IV cover coat material, 90 percent by weight of the particles retained on the 4.75 mm (No. 4) sieve shall have at least two fractured faces when tested per Colorado Procedure 45.

(5) Lightweight aggregate used for cover coat material shall be an aggregate prepared by expanding shale, clay, or slate in a rotary fired kiln. Lightweight aggregate shall have a dry loose unit weight of 35 to 55 pounds per cubic foot determined per AASHTO T 19, Shoveling Procedure. The total mass of the test sample of lightweight aggregate used in AASHTO T 96 (Los Angles Abrasion) shall be 2,000 g.

Table 703-7
GRADATION SPECIFICATIONS FOR COVER COAT AGGREGATE

Sieve Size	Percent by Weight Passing Square Mesh Sieve		
	9.5 mm (3⁄8") Type 1	12.5 mm (1/2") Type II	19.0 mm (3/4")* Type IV
19.0 mm (3/4")			100
12.5 mm (1/2")		100	95-100
9.5 mm (3⁄8")	100	65-85	60-80
4.75 mm (#4)	0-15	0-10	0-10
75 µm (#200)	0-1.5	0-1.5	0-1.5
*Type IV shall be used only with lightweight aggregates.			

703.06 Mineral Filler. Mineral filler shall conform to the requirements of AASHTO M 17 and shall consist of rock dust, slag dust, hydrated lime, hydraulic cement, fly ash, or other suitable mineral matter. It shall be free of organic impurities and agglomerations. When used, it shall be dry enough to flow freely.

Mineral filler shall be graded within the following limits:

Table 703-8
MINERAL FILLER GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
600 µm (No. 30)	100
300 µm (No. 50)	95-100
75 µm (No. 200)	70-100

Mineral filler shall have a plasticity index not greater than four excluding hydrated lime and hydraulic cement.
If mineral filler other than limestone dust is used in stone matrix asphalt (SMA) it shall consist of mineral matter that meets the requirements of Tables 703-8, 703-9 and the following:

Alternative mineral filler shall consist of finely divided mineral matter such as rock dust, slag dust, fly ash, loess, or other suitable mineral matter. Calcium oxide content of any mineral filler shall not exceed 22 percent.

Alternative mineral filler test data shall be provided as part of the SMA mix design submittal and as required in Table 703-8 during production.

The Contractor shall sample and test alternative mineral filler at the frequencies listed in Table 703-8. Production will be suspended if alternative mineral filler test results fail to meet requirements. The Contractor shall submit written plans to correct the mineral filler operation to the Engineer for approval before commencing paving.

Table 703-9
REQUIRED TESTING FOR ALTERNATIVE
SMA MINERAL FILLERS

Type of Test	Contractor Testing Frequency	Specification Limit	Remarks
Plasticity Index AASHTO T90	One per 10,000 tons of SMA placed♦	4% Maximum	▲
Hydrometer Analysis AASHTO T88	One at Mix Design submittal	Report	
Gradation AASHTO T37	One per 10,000 tons of SMA placed♦	Table 703-9	▲
Calcium Oxide Content ASTM C25	One at Mix Design submittal	22% Maximum	
Modified Rigden Voids – NAPA Publication IS-101	One per 10,000 tons of SMA placed♦	Shall not exceed 50	▲

♦ The minimum frequency shall be twice per project

▲ Sampling of alternative mineral fillers shall be at the point of introduction to the SMA and a split sample shall be submitted to the Engineer

Table 703-10
ALTERNATIVE SMA MINERAL GRADATION

(AASHTO M17/ASTM D242-95)	
Sieve	**Percent Passing**
600 µm (#30)	100
300 µm (#50)	95 - 100
75 µm (#200)	70 - 100

703.07 Bed Course Material.

(a) Bed course material for sidewalks, curbing, and bikeways shall consist of cinders, sand, slag, gravel, crushed stone, or other approved material of such gradation that all particles shall pass through a sieve having 19.0 mm (3/4 inch) square openings.

(b) Bed course material for slope protection, or riprap filter blanket shall be a porous, free draining material consisting of sand, gravel, cinders, slag, crushed stone, or other approved free draining material. This material shall meet the following gradation requirements:

Table 703-11
BED COURSE MATERIAL GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
75 mm (3 inch)	100
4.75 mm (No. 4)	20-65
75 µm (No. 200)	0-10

703.08 Structure Backfill Material.

(a) Class 1 structure backfill shall meet the following gradation requirements:

Table 703-12
STRUCTURE BACKFILL MATERIAL CLASS 1 GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
50 mm (2 inch)	100
4.75 mm (No. 4)	30-100
300 µm (No. 50)	10-60
75 µm (No. 200)	5-20

In addition, this material shall have a liquid limit not exceeding 35 and a plasticity index of not over six when determined in conformity with AASHTO T 89 and T 90 respectively.

(b) Class 2 structure backfill shall be composed of suitable materials developed on the project. To be suitable for use under this classification, backfill shall be free of frozen lumps, wood, or other organic material. If the material contains rock fragments that, in the opinion of the Engineer, will be injurious to the structure, the native material shall not be used for backfilling and the Contractor shall furnish Class 1 structure backfill material at the contract unit price. If contract unit price does not exist for Class 1 structure backfill, it will be paid for per subsection 104.03.

(c) Class 3 structure backfill shall be a sandy gravel and meet the following gradation:

Table 703-13
STRUCTURE BACKFILL MATERIAL CLASS 3 GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
9.5 mm (3/8 inch)	90-100
4.75 mm (No. 4)	45-80
75 µm (No. 200)	5-12

703.09 Filter Material. Filter material shall consist of free draining sand, gravel, slag, or crushed stone. The grading requirements are set forth in Table 703.14.

Table 703-14
GRADATION SPECIFICATIONS FOR FILTER MATERIAL

Sieve Size	Mass Percent Passing Square Mesh Sieves		
	Class A	Class B	Class C
75 mm (3")	100		
37.5 mm (1 1/2")		100	
19.0 mm (3/4")	20-90		100
4.75 mm (No. 4)	0-20	20-60	60-100
1.18 µm (No. 16)		10-30	
300 µm (No. 50)		0-10	10-30
150 µm (No. 100)			0-10
75 µm (No. 200)	0-3	0-3	0-3

703.10 Aggregate for Median Cover. Aggregate for median cover shall consist of clean crushed stone, crushed gravel, or natural gravel. The percentage of wear, when tested per AASHTO T 96, shall not be more than 70. The grading requirements shall be as follows:

Table 703-15
GRADATION SPECIFICATIONS
FOR MEDIAN COVER AGGREGATE

Sieve Size	Mass Percent Passing Square Mesh Sieves
63 mm (2 1/2 inch)	100
50 mm (2 inch)	95-100
19.0 mm (3/4 inch)	0-15

SECTION 704
MASONRY UNITS

704.01 Clay or Shale Brick. Brick shall conform to the requirements of one of the following specifications:

Sewer and Manhole Brick-AASHTO M 91. Building Brick-AASHTO M 114.

704.02 Concrete Brick. Concrete brick shall conform to the requirements of ASTM C55.

704.03 Concrete Masonry Blocks. Concrete masonry blocks may be rectangular or segmented and, when specified, shall have ends shaped to provide interlock at vertical joints. The blocks shall conform to the requirements of ASTM C139, or, for hollow blocks, to ASTM C90. Dimensions and tolerances shall conform to the above applicable requirements or those specified on the plans.

704.04 Masonry Mortar. Masonry mortar shall be Type S conforming to ASTM C270.

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SECTION 705
JOINT, WATERPROOFING, AND BEARING MATERIAL

705.01 Joint Fillers.

(a) Joint Sealant with Backer Rod. The joint sealant material shall be an approved ASTM D5893 silicone sealant or ASTM D6690 Type II hot applied sealant on the Department's Approved Products List. The materials shall be stored and applied per manufacturer's recommendations, but they shall not be exposed to ambient temperatures in excess of 125 °F or stored in direct sunlight. The backer rod placed before joint sealant shall be an approved ASTM D5249 backer rod compatible with the joint sealant material chosen by the Contractor.

(b) Preformed Joint Fillers. Preformed fillers for joints shall conform to the requirements of AASHTO M 213 and shall be punched to admit the dowels as shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth and thickness required for the joint unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape, by stapling or other positive fastening satisfactory to the Engineer.

705.02 Watertight Joint Systems. Watertight joint systems for plastic pipe shall conform to the requirements of ASTM D3212.

705.03 Gaskets. Rubber gasketed joints shall conform to the requirements of ASTM C443 and shall be flexible and able to withstand expansion, contraction, and settlement.

All rubber gaskets shall be stored in as cool a place as practicable, preferably at 70 °F or less. Rubber gaskets shall not be exposed to the direct rays of the sun for more than 72 hours.

Rubber gaskets, of the type requiring lubrication, shall be lubricated with the lubricant recommended and supplied by the manufacturer of the pipe.

705.04 Pipe Joint Sealing Compounds. Joint sealing compounds for concrete pipe shall conform to the requirements of AASHTO M 198.

Joint sealants for metal pipe shall conform to the pipe manufacturer's recommendations.

705.05 Compression Ring. Compression ring jointing connections for clay pipe, made of resilient material, shall conform to the requirements of ASTM C425.

705.06 Bearing Materials

Table 705-1
POLYISOPRENE (NATURAL RUBBER) ELASTOMER

Specimen Properties	ASTM Test Procedure	Requirements		
		50 Duro	60 Duro	70 Duro
Physical Properties				
Hardness	D2240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa Minimum (psi)	D412	15.5 (2250)	15.5 (2250)	15.5 (2250)
Ultimate Elongation, % Minimum	D412	450	400	300
Heat Resistance, 70 Hr./70 °C (158 °F)				
Change in Durometer Hardness, Maximum Points		+10	+10	+10
Change in Tensile Strength, % Maximum	D573	-25	-25	-25
Change in Ultimate Elongation, % Maximum	D573	-25	-25	-25
Compression Set % Maximum, 22 Hr/70 °C (158 °F)	D395 Method B	25	25	25
Ozone Resistance, 20% Strain 25 ppm Ozone in Air by Volume 38 ± 1 °C (100 ± 2 °F)/48 Hr. Mounting Procedure ASTM D518, Procedure A	D1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made during Vulcanization, N per mm (Lb. per Inch)	D429, B	7 (40)	7 (40)	7 (40)
Low Temperature Brittleness: Grade 3 at -40 °C (-40 °F) Grade 4 at -48 °C (-55 °F) Grade 5 at -57 °C (-70 °F)	D746 Procedure B	No Failure	No Failure	No Failure
Instantaneous Thermal Stiffening: Grade 3 at -40 °C (-40 °F) Grade 4 at -46 °C (-50 °F) Grade 5 at -54 °C (-65 °F)	D1043	[1] [3]	[1] [3]	[1] [3]
Low Temperature Crystallization: Grade 3, 14 Days at -26 °C (-15 °F) Grade 4, 21 Days at -37 °C (-35 °F) Grade 5, 28 Days at -37 °C (-35 °F)	D4014 Quad Shear Test as described in Annex A	[2] [3]	[2] [3]	[2] [3]

[1] Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F).

[2] Stiffness at test time and temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F) with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ± 25° strain cycle shall be used and a complete cycle of strain shall be applied with a period of 100 seconds. The first 3/4 cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next 1/2 cycle of loading.

[3] ASTM D1043 refers to the "Modulus of Rigidity" while ASTM D4014 refers to the "Shear Modulus Stiffness". The word "stiffness" is used to describe both terms.

Table 705-2
CHLOROPRENE (NEOPRENE) ELASTOMER

Specimen Properties	ASTM Test Procedure	Requirements		
		50 Duro	60 Duro	70 Duro
Physical Properties				
Hardness	D240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa Minimum (psi).	D412	17.2 (2500)	17.2 (2500)	17.2 (2500)
Ultimate Elongation, % Minimum	D412	400	350	300
Heat Resistance, 70 Hr/ 70 °C (158 °F)				
Change in Durometer Hardness, Maximum Points		+15	+15	+15
Change in Tensile Strength, % Maximum	D573	-15	-15	-15
Change in Ultimate Elongation, % Maximum	D573	-40	-40	-40
Compression Set % Maximum, 22 Hr/100 °C (212 °F)	D395 Method B	35	35	35
Ozone Resistance, 20% Strain 100 ppm Ozone in Air by Volume 38 ± 1 °C (100 ± 2 °F)/ 100 Hr Mounting Procedure ASTM D518, Procedure A	D1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made during Vulcanization, N per mm (Lb per Inch)	D429, B	7 (40)	7 (40)	7 (40)
Low Temperature Brittleness: Grade 3 at -40 °C (-40 °F) Grade 4 at -48 °C (-55 °F) Grade 5 at -57 °C (-70 °F)	D746 Procedure B	No Failure	No Failure	No Failure
Instantaneous Thermal Stiffening: Grade 3 at -40 °C (-40 °F) Grade 4 at -46 °C (-50 °F) Grade 5 at -54 °C (-65 °F)	D1043	[1] [3]	[1] [3]	[1] [3]
Low Temperature Crystallization: Grade 3, 14 Days at -26 °C (-15 °F) Grade 4, 21 Days at -37 °C (-35 °F) Grade 5, 28 Days at -37 °C (-35 °F)	D4014 Quad Shear Test as described in Annex A	[2] [3]	[2] [3]	[2] [3]

[1] Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F).

[2] Stiffness at test time and temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F) with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ± 25° strain cycle shall be used and a complete cycle of strain shall be applied with a period of 100 seconds. The first 3/4 cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next 1/2 cycle of loading.

[3] ASTM D1043 refers to the "Modulus of Rigidity" while ASTM D4014 refers to the "Shear Modulus Stiffness". The word "stiffness" is used to describe both terms.

(a) Elastomeric Bearing Pads. Laminates shall be rolled mild steel sheets conforming to AASHTO M 270 Grade 36 unless otherwise specified.

A Durometer hardness of 60 shall be used unless otherwise shown on the plans.

The elastomer portion of the elastomeric compound shall be 100 percent virgin natural polyisoprene (natural rubber) or 100 percent virgin chloroprene (neoprene) and shall be at least 60 percent by volume of the total compound.

(b) Sheet Lead. Sheet lead shall conform to the requirements of ASTM B29 for common desilverized lead.

(c) Polytetrafluoroethylene (PTFE) Sheets. PTFE resin shall be virgin material conforming to the requirements of ASTM D 4894 or D4895. The specific gravity shall be 2.13 to 2.19 and the melting point shall be 623 °F plus or minus 2°F.

Filler material shall be milled glass fibers, carbon, or other approved inert filler materials.

Finished unfilled PTFE sheet shall be made from PTFE resin and shall conform to the following requirements:

Tensile strength (minimum)ASTM D4894 or D4895 2,800 psi

Elongation (minimum)ASTM D4894 or D4895 200 percent

Filled PTFE sheet shall be made from PTFE resin uniformly blended with inert filler material. Finished filled PTFE sheet containing glass fiber or carbon shall conform to the following requirements:

Table 705-3

FINISHED FILLED PTFE REQUIREMENTS

Mechanical	**ASTM Method**	**15% Glass Fiber**	**25% Carbon**
Tensile Strength (min.)	D4894 or D4895	2000 psi	1300 psi
Elongation (min.)	D4894 or D4895	150%	75%
Physical	**ASTM Method**	**15% Glass Fiber**	**25% Carbon**
Specific Gravity (min.)	D4894 or D4895	2.20	2.10
Melting Point	D4894 or D4895	621 °F ± 18 °F	621 °F ± 18 °F

The maximum coefficient of friction for the PTFE shall be as follows:

Table 705-4

PTFE MAXIMUM COEFFICIENT OF FRICTION

Bearing Pressure	500 psi	2000 psi	3000 psi
Unfilled PTFE	0.08	0.06	0.04
Filled PTFE	0.12	0.1	0.08

The average bearing pressure on the PTFE sliding surface due to all loads shall not exceed:

Table 705-5

PTFE MAXIMUM AVERAGE BEARING PRESSURE ON SLIDING SURFACE

Type II Bearing Device Unfilled and Filled PTFE	2000 psi
Type III Bearing Device Filled PTFE	3500 psi
Unfilled PTFE (Recessed)	3500 psi
Unfilled PTFE (Not Recessed)	2000 psi

The edge load pressure due to all loads and rotations shall not exceed:

Unfilled and filled PTFE (Type II and III Bearing Device) 5000 psi

(d) Stainless-steel Sheets. The stainless-steel sheet shall be 16-gauge minimum thickness and shall conform to ASTM A240, Type 304.

(e) Adhesive Material. Adhesive material shall be an epoxy resin meeting the requirements of Federal Specification MMM-A-134, FEP film or approved equal.

(f) Certification and Testing. The Contractor shall furnish a manufacturer's certification that the material proposed for use on the project meets the requirements set forth in the tables above. The Department also reserves the right to test random samples of full-size bearings proposed for use on the project. The following values shall be met under laboratory testing of full-size bearings.

1. Compressive strain of any layer of an elastomeric bearing shall not exceed 7 percent at 800-psi average unit pressure, or at the design dead load plus live load pressure when so shown on the plans.

2. The shear resistance of the bearing shall not exceed 30 psi for 50 durometer, 40 psi for 60 durometer, or 50 psi for 70 durometer, polyisoprene compounds, nor 50 psi for 50 durometer, 75 psi for 60 durometer, or 110 psi for 70 durometer, chloroprene compounds. Shear resistance shall be measured at 25 percent strain of the total effective rubber thickness after an extended four-day ambient temperature of minus 20 °F.

   Components of nominal hardness between values shown may be used and test requirements interpolated. When test specimens are cut from the finished product a 10 percent variation in "physical properties" will be permitted.

(g) Tolerances. Flash tolerance, finish and appearance shall meet the requirements of the latest edition of the Rubber Handbook as published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings.

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

Table 705-6

DIMENSIONAL TOLERANCES FOR BEARINGS

Overall Vertical Dimensions:	
Average Total Thickness 1 1/4 inches or less	-0, +1/8 inch
Average Total Thickness over 1 1/4 inches	-0, +1/4 inch
Overall Horizontal Dimension:	
36 inches and less	-0, +1/4 inch
Over 36 inches	-0, +1/2 inch
Thickness of Individual Layers of:	
Elastomer (Laminated Bearings Only)	±1/8 inch
Variation from a Plane parallel to the Theoretical Surface (as determined by measurements at the edges of the bearings):	
Top	±1/8 inch
Sides	±1/4 inch
Individual Non-Elastic Laminates	±1/8 inch
Position of Exposed Connection Members:	±1/8 inch
Edge Cover of Embedded Laminates or Connection Members:	-0, +1/8 inch
Size of Holes, Slots or Inserts:	±1/8 inch
Position of Holes, Slots or Inserts:	±1/8 inch

705.07 Protective Covering for Bridge Deck Waterproofing Membrane. The protective covering shall be composed of one or more layers of felt thoroughly bonded together and saturated with asphalt. Both exposed sides shall be asphalt-coated. The density shall be 55 pounds per 100 square feet. The surfaces shall be coated with suitable mineral matter to prevent the material from sticking to itself.

The covering may be furnished in either rolls or sheets.

The covering shall be free of visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances, and indentations.

The covering furnished in rolls shall not crack nor be so sticky as to cause material damage upon being unrolled at atmospheric temperatures as low as 50 °F.

The covering shall conform to the following requirements when tested per Colorado Procedure L-2202:

Table 705-7

PROTECTIVE COVERING REQUIREMENTS

FOR BRIDGE DECK WATERPROOFING MEMBRANE

Property Determined	Specification
Width	Min. 35 1/2", Max. 60 1/2"
Pliability at 25 °C (77 °F)	At least 4 of 5 strips shall not crack when bent 90° over a rounded corner of 13 mm (1/2") radius.
Behavior on heating to 80 °C (176 °F)	Max. 1.5 percent volatile loss. No flowing, sagging or blistering.
Weight per square foot	0.5 lb

Protective covering may be conditionally accepted in the field based on visual inspection for appearance, workmanship, and weight per square foot of a representative specimen.

705.08 Prefabricated, Reinforced Membrane and Primer. The membrane shall be a factory-laminated sheet composed of either rubberized asphalt, bituminous mastic, or similar compounds reinforced with synthetic or fiberglass fabric. It shall be uniformly manufactured free from blemishes, discontinuities, and other defects. The membrane shall be supplied in rolls, having a minimum width of 30 inches and shall conform to the following requirements:

Table 705-8

PREFABRICATED, REINFORCED MEMBRANE REQUIREMENTS

Property Determined	Test Procedure	Specification
Thickness		70 mils minimum
Pliability	CP L-2203	No cracks

The primer used to bond membrane to the deck and to seal seams and patches shall be a water-resistant adhesive compatible with the membrane. The primer shall be of suitable consistency for application by brush, roller, or spray without further dilution.

705.09 Single Component, Hot Applied, Elastomeric Membrane. The membrane shall be capable of being sprayed or spread to a uniform thickness at the application temperature recommended by the manufacturer. After cooling, it shall form a tough resilient membrane, well bonded to the concrete surface and shall conform to the requirement of ASTM D6690 Type 2, except blocks for the bond test shall be prepared per CP-L 4101.

The sealant shall be listed in CDOT's Approved Products List before use.

705.10 Waterstop. Neoprene waterstop shall be made of suitable synthetic rubber. Neoprene waterstop shall conform to the applicable requirements designated in the latest edition of the Corp of Engineers Specifications for Rubber Waterstops CRD-C513.

Plastic waterstop shall be made of polyvinyl chloride (PVC) plastic. Plastic waterstop shall conform to the requirements designated in the latest edition of the Corp of Engineers Specifications for Polyvinyl chloride Waterstops CRD-C572.

SECTION 706
CONCRETE AND CLAY PIPE

706.01 Nonreinforced Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 86 for the specified diameters and strength classes.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.02 Reinforced Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 170 for the specified diameters and strength classes. Unless otherwise specified, pipe wall design and use of elliptical reinforcement in circular pipe are optional. Reinforced concrete pipe being jacked shall be Class V and shall be furnished with grouting nipples spaced not more than eight feet apart. Joints for this pipe shall come equipped with steel rings and rubber gaskets conforming to ASTM C361.

Elliptical pipe conforming to AASHTO M 207 shall be furnished when required on the plans. Arch pipe conforming to AASHTO M 206 shall be furnished when required on the plans.

Precast reinforced concrete end sections shall have one of the following:

(1) At least one line of reinforcement conforming to the requirements of AASHTO M 170 equivalent to the square inches per linear foot for elliptical reinforcement in circular pipe, Class II, Wall B, or

(2) Macro fiber at 5.0 lb/cy.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.03 Perforated Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 175 for the specified diameters and strength classes. Unless otherwise specified, perforations shall be Type 1.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.04 Drain Tile. This pipe shall conform to the requirements of AASHTO M 178 or M 179 for the specified material, diameters and quality classes.

706.05 Porous Concrete Pipe. This pipe shall conform to the requirements of AASHTO M 176 for the specified diameters.

Pipe shall be obtained from a manufacturer that is a current plant quality certified member of the American Concrete Pipe Association (ACPA), meeting all current ACPA requirements for this certification.

A copy of the ACPA certification shall be submitted to the Engineer before delivery of the pipe.

706.06 Vitrified Clay Pipe. This pipe shall conform to the requirements of AASHTO M 65 for the specified diameter and strength class.

706.07 Coated Concrete Pipe. This pipe may be reinforced or nonreinforced per the requirements shown on the plans for the designated diameters and strength classes, and in addition, shall be coated with asphalt mastic conforming to the requirements of AASHTO M 243.

Asphalt mastic shall be uniformly applied in two coats by spray or brush to the entire designated surface to be coated, to a total thickness of 50 mils. Asphalt mastic may also be applied by trowel in one coat provided the required thickness is obtained. The first coat shall be dry to touch before the second coat is applied. The second coat shall be dry to touch before any handling or backfilling operations.

The finished coat shall cover the surface to be protected evenly, without running, and without any visible holidays, bubbles, or bare spots.

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SECTION 707
METAL PIPE

707.01 Ductile Iron Pipe. This pipe shall conform to the requirements of ASTM A716 for the specified diameters and strength classes. Unless otherwise specified either smooth, corrugated or ribbed pipe may be furnished.

707.02 Corrugated Steel Pipe and Pipe Arches. These conduits and coupling bands shall conform to the requirements of AASHTO M 36, except for the following:

Sawed ends and butt-welded joints will be permitted for pipe with helical corrugations formed with continuous lock or welded seams provided all burrs are removed from sawed ends and provided the welds are acceptable.

Pipe fabricated with resistance spot welds shall also conform to the following additional requirement: Where double welding is necessary, adjacent welds shall not be closer than two spot-weld nugget diameters from center to center.

Shop formed elliptical pipe shall be furnished where specified. Field elongation will be accepted as an alternate to shop elongation when done in a neat workmanlike manner.

Special fittings and elbows for these conduits shall be the same metal thickness as the conduit where they are joined and shall conform to the applicable requirements of AASHTO M 36.

Semicircular corrugated steel pipe for encasement, along with required fastening devices, shall conform to the requirements of this subsection and the requirements of Military Specification MIL-P-236, Type I or II, Class 1.

Coupling bands shall conform to the requirements of AASHTO M 36 with the following exceptions:

(1) The use of channel bands as described in 9.1 of AASHTO M 36 will not be allowed.

(2) Connecting bands shall be at least 10 1/2 inches wide.

707.03 Bituminous Coated Corrugated Steel Pipe and Pipe Arches. Conduit, fittings, elbows, end sections and coupling bands shall be fully coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating or materials conforming to the requirements of AASHTO M 243, except that the use of tar base material will not be permitted. Coatings shall be shop applied. The finished coat shall uniformly cover the surface to be protected. The coating shall not contain any visible holidays, bubbles or bare spots. Minimum thickness shall be 1.3 mm (50 mils) measured on the crest of the corrugations.

In complying with AASHTO M 190, each section shall be given a double dip application. In the first immersion, the section shall remain submerged until the metal has reached a temperature that will allow the hot bituminous material to penetrate and seal each joint.

Other coatings meeting the requirements of AASHTO M 190 or M 243 will be acceptable upon written approval by the Engineer.

Materials meeting the requirements of AASHTO M 243 shall be uniformly applied by spray, trowel, or brush to the entire designated surface to be coated, to a minimum thickness of 1.3 mm (50 mils). The coating shall be dry to the touch before any handling or backfilling operations.

Special fittings and elbows for conduits shall be of the same gauge as the conduit where they are joined.

When aramid fiber bonded corrugated steel pipe is specified the pipe shall conform to ASTM A885 and the bituminous coating shall conform to the requirements of AASHTO M 190, Type A.

707.04 Corrugated Steel Pipe for Underdrains. This pipe shall conform to the requirements of AASHTO M 36, Type I, except that all reference to "sleeve type coupler" or "coupling" as described in 9.1 and 9.2 shall be disregarded. Sleeve type couplers or couplings will not be permitted.

Perforated pipe shall have Class 1 perforations.

707.05 Bituminous Coated Corrugated Steel Pipe for Underdrains. This pipe shall conform to the requirements of AASHTO M 36, Type I.

Perforated pipe shall have Class 1 perforations.

Underdrain, fittings, elbows, end sections, and coupling bands shall be fully coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating or materials conforming to the requirements of AASHTO M 243, except that the use of tar base material will not be permitted. Coatings shall be shop applied. The finished coat shall uniformly cover the surface to be protected. The coating shall not contain any visible holidays, bubbles or bare spots. Minimum thickness shall be 1.3 mm (50 mils) measured on the crest of the corrugations.

In complying with AASHTO M 190, each section shall be given a double dip application. In the first immersion, the section shall remain submerged until the metal has reached a temperature that will allow the hot bituminous material to penetrate and seal each joint.

Other coatings meeting the requirements of AASHTO M 190 or M 243 will be acceptable upon written approval by the Engineer.

Materials meeting the requirements of AASHTO M 243 shall be uniformly applied by spray, trowel, or brush to the entire designated surface to be coated, to a minimum thickness of 1.3 mm (50 mils). The coating shall be dry to the touch before any handling or backfilling operations.

Special fittings and elbows for underdrains shall be of the same gauge as the conduit where they are joined.

The specified minimum size of perforations shall apply after coating.

707.06 Corrugated Aluminum Pipe. This pipe and coupling bands shall conform to the requirements of AASHTO M196, Type 1 pipe.

707.07 Corrugated Aluminum Pipe for Underdrains. This pipe shall conform to the requirements of AASHTO M196. Non-perforated pipe shall be Type 1. Perforated pipe shall be Type III, with Class I perforations.

707.08 Extensions. Connecting bands and extensions to existing culverts shall be of the same type of metal or alloy, unless otherwise shown on the plans.

707.09 Repair of Damaged Coating. Units where the spelter coating has been damaged shall be either regalvanized as provided under AASHTO M 36 or painted with one full brush coat of a zinc rich paint meeting Military Specification DOD-P-21035A, or by other approved process on properly cleaned surface, as determined by the Engineer.

Bituminous coated material that has been damaged shall be repaired with field-applied asphalt mastic conforming to AASHTO M 243. Other coating material may be used when approved by the Engineer.

707.10 Polymer Precoated Corrugated Steel Pipe. Polymer precoated corrugated steel pipe shall conform to the requirements of AASHTO M 245.

707.11 Aluminized Corrugated Steel Pipe Type 2. Aluminized Corrugated Steel Pipe Type 2 shall conform to the requirements of AASHTO M 274.

SECTION 708
PAINTS

708.01 General. This specification covers ready-mixed paints and coatings. Paints and coatings shall be manufactured eight weeks or less before delivery to the project. Each paint container shall be labeled with the name and address of the manufacturer, trade name or trademark, type of paint, number of gallons, batch number, and date of manufacture.

Paints shall be free of foreign material that is capable of clogging screens, valves, pumps, and other parts of the application equipment. Paint shall not contain the following:

(1) Benzene.

(2) Chlorinated solvents.

(3) Ethylene glycol ethers.

(4) Ethylene glycol acetates.

(5) Lead.

(6) Mercury.

(7) Chromium.

(8) Cadmium.

(9) Petroleum products.

The Contractor shall obtain certification in writing from the manufacturer showing that the product is free of the materials described above and that it meets or exceeds the requirements of 29 CFR 1910.1200.

Paints shall not form a surface skin within 48 hours in three-quarter filled, tightly closed containers. Paint and coating pigments shall be lead free, and shall not thicken, become granular, or curdle in their containers.

Volatile Organic Compound (VOC) levels for paints and coatings shall comply with the most current EPA regulations. All product compositional proportions are specified by weight. Material Safety Data Sheets and manufacturer's recommended application instruction sheets representing each paint and coating shall be submitted to the Engineer for the project records before use.

708.02 List of Paints.

PAINTS	SPECIFICATION
Structural Steel Bridge Paint	Subsection 708.03
White Wood Primer	TT-P-25
Outside White Paint	TT-P-102, Class A
Exterior Black Paint	TT-P-61
Black or White Baking Enamel	TT-E-489, Class B
Federal Yellow Enamel	TT-E-489, Class A
Aluminum Paint	Subsection 708.04
Pavement Marking Paint	Subsection 708.05

708.03 Structural Steel Bridge Paint. All structural steel shall be painted using an Inorganic Zinc-Rich Polyurethane System.

The primer shall be an approved inorganic zinc-rich primer conforming to the requirements of Table 1 of the STEEL STRUCTURES PAINTING COUNCIL SPECIFICATION NO. 20 (SSPC-PAINT 20). The vehicle of this primer shall be SSPC-Paint 20, Type 1-C.

The primer shall be applied according to the manufacturer's recommendations with a minimum dry film thickness of three mils.

The manufacturer shall certify in writing to the Engineer that the SSPC-SP 6 steel cleaning is compatible with the primer used.

The topcoat shall be an approved high-build polyurethane enamel with a minimum dry film thickness of three mils. To prevent bubbling, a mist coat shall be applied before application of the topcoat.

708.04 Aluminum Paint. The paint shall be supplied ready-mixed in the proportion of (ASTM D962, Type II, Class B) 2 pounds of aluminum paste per 1 gallon of mixing varnish (see subsection 708.06 (c)). Aluminum paint shall dry to touch in 1/2 to 4 hours and dry hard in 18 hours, maximum. Material will be inspected for leafing on a vertical primed steel surface at a spreading rate of 400 square feet per gallon.

708.05 Pavement Marking Materials. All pavement-marking materials shall be selected from the Department's Approved Products List (APL). Before start of work, a Certificate of Compliance (COC) for all pavement marking materials shall be submitted per subsection 106.12.

(a) Color. The pavement marking paint, without drop-on beads, shall meet the following requirements:

White – Federal Standard No. 595B-17925. The Yellowness Index (YI) of white shall not exceed 8.0 per ASTM E313 initially. The color after drying shall be a flat white, free from tint, and shall provide the maximum amount of opacity and visibility under both daylight and artificial light.

Yellow – Materials for pavement markings shall meet the initial daytime chromaticity that falls within the box created by the following corner points:

Table 708-1
INITIAL DAYTIME CHROMATICITY
COORDINATES (CORNER POINTS)

	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

(b) Low Temperature Acrylic Waterborne Paint. Low temperature acrylic waterborne paint binder (nonvolatile portion of vehicle) shall be 100 percent FASTRACK XSR acrylic polymer, by weight, as determined by infrared analysis or other chemical analysis available to the Department.

The paint shall meet the requirements of Table 708-2.

(c) High Build Acrylic Waterborne Paint. High build acrylic waterborne paint binder (nonvolatile portion of vehicle) shall be 100 percent FASTRACK HD 21A acrylic cross-linking polymer, by weight, as determined by infrared analysis or other chemical analysis available to the Department.

The paint shall meet the requirements of Table 708-3.

(d) Performance Requirements. The Low Temperature Acrylic Waterborne Paint and High Build Acrylic Waterborne paint shall be water resistant and shall show no softening or blistering.

Table 708-2
LOW TEMPERATURE ACRYLIC WATERBORNE PAINT

Property	White	Yellow	Test Method
Nonvolatile portion of vehicle (white and yellow), %	41.0 (min.)	41.0 (min.)	ASTM D2205
Pigment Composition			
Percent by weight♦	58-62	58-62	ASTM D4451 ASTM D3723
Paint			
Titanium Dioxide Content, lb/gal	1.0 (min.)		ASTM D5381
Properties of the Finished Paint			
Total Non-volatiles, (solids) % by weight	75.0 (min.)	75.0 (min.)	FTMS 141C - Method 4053.1, ASTM D2369, or ASTM D4758
Density, lb/gal	13.3-13.9	13.1-14.0	ASTM D2205
Consistency (Viscosity) White and Yellow, Krebs-Stormer Units	75-85	75-85	ASTM D562
Freeze Thaw Stability	Shall complete 5 or more test cycles successfully		ASTM D2243
Fineness of Grind, Cleanliness Rating B, minimum	3	3	ASTM D1210
Scrub Resistance	800	800	ASTM D2486
Directional Reflectance: [15 mil Wet Film]	88 (min.)	50 (min.)	ASTM E1347
Dry Opacity (Contrast Ratio): [15 mil Wet Film]	0.98 (min.)	0.98 (min.)	ASTM D2805
♦Percent by weight shall include percent of organic yellow pigment.			

Table 708-3
HIGH BUILD ACRYLIC WATERBORNE PAINT

Property	White	Yellow	Test Method
Nonvolatile portion of vehicle (white and yellow), %	43.0 (min.)	43.0 (min.)	ASTM D2205
Pigment Composition			
Percent by weight♦	60-62	60-62	ASTM D4451 ASTM D3723
Paint			
Titanium Dioxide Content, lb/gal	1.0 (min.)		ASTM D5381
Properties of the Finished Paint			
Total Non-volatiles, (solids) % by weight	77.0 (min.)	77.0 (min.)	FTMS 141C - Method 4053.1, ASTM D2369, or ASTM D4758
Density, lb/gal	14.0-14.6	13.7-14.3	ASTM D2205
Consistency (Viscosity) White and Yellow, Krebs-Stormer Units	85-95	85-95	ASTM D562
Freeze Thaw Stability	Shall complete 5 or more test cycles successfully		ASTM D2243
Fineness of Grind, Cleanliness Rating B, minimum	3	3	ASTM D1210
Scrub Resistance	800	800	ASTM D2486
Directional Reflectance: [15 mil Wet Film]	88 (min.)	50 (min.)	ASTM E1347
Dry Opacity (Contrast Ratio): [15 mil Wet Film]	0.98 (min.)	0.98 (min.)	ASTM D2805
♦Percent by weight shall include percent of organic yellow pigment.			

708.06 Materials - Specifications

(a) Paint Pigment.

Chrominum Oxide, (Green)	ASTM D263
Magnesium Silicate	ASTM D605
Titanium Dioxide	ASTM D476, Class IV
Red Iron Oxide	ASTM D3721
Black Iron Oxide	ASTM D769
Yellow Iron Oxide	ASTM D768

(b) Organo-montmorillonite. Organo-montmorillonite shall be an organic ammonium compound of montmorillonite with a high gelling efficiency in a wide range of organic liquids. It shall be a fine, creamy, white powder with maximum water content of 3.0 percent and a maximum of 5.0 percent retained on the 75 μm (No. 200) sieve. Organo-montmorillonite shall be prewetted with methanol or ethanol as recommended by the manufacturer.

(c) Varnish for Aluminum Paint.

MATERIAL	**SPECIFICATION**
Resin- 100% Phenol Formaldehyde	MIL-R-15189A
Oil-Tung	ASTM D12
Mineral Spirits	ASTM D235
Driers - Cobalt and/or manganese	ASTM D600

PROPERTIES OF VARNISH	
Viscosity (G-H)	A-C
Oil Length	275 liters per 100 kilograms of resin (33 gal)
Nonvolatile	55% min.
Proportion of Thinners	90% Mineral Spirits, 10% Xylene
Color (Hellige)	12 max.
Zinc Reactivity	None
Kauri Reduction	140% min.
Rosin and Rosin Derivatives	None
Appearance	Clear and Transparent
Drying Time: Set to Touch	1 to 3 hr
Dry Hard	18 hr max.

Alkali Resistance. No visible attack to film dried 72 hours after 8 hours in 5% sodium hydroxide solution at 21 °C (70 °F).

708.07 Pavement Primers. The type and application rate of epoxy resin primer shall be as recommended by the thermoplastic or preformed plastic pavement-marking manufacturer.

A primer application rate of zero will not be accepted, except for thermoplastic marking and inlaid preformed plastic pavement marking placed on new asphalt surfaces as recommended by the manufacturer and approved in writing by the Engineer. However, if the Engineer determines that a new asphalt surface has become soiled, before placement of the pavement markings, pavement primer will be required and shall be applied as approved.

The epoxy resin primer material may be accepted at the job site based on a manufacturer's certification, or a sample may be sent to the Laboratory for testing, in which case three weeks shall be allowed between sampling and intended use.

708.08 Structural Concrete Coating. The Coating shall be a one-component, high-build, non-vapor barrier, 100 percent acrylic emulsion in water, and a texturing agent.

Table 708-4

MINIMUM PHYSICAL PROPERTIES

Solids by Weight	48 percent (Without texturing agent)
Solids by Volume	36 percent (Without texturing agent)
Weight per gallon	8.3 lb/gal (Without texturing agent)
Texturing Agent	3.2 to 3.8 lb/gal), No. 40 to 60 Ottawa sand or equivalent

All coating material shall be delivered to the project site in sealed containers bearing the manufacturer’s original labels.

A material safety data sheet (MSDS) prepared per Federal Standard 313 and a complete set of manufacturer's mixing and application instructions shall be submitted to the Engineer before the Contractor begins applying the coating.

708.09 Inspection and Testing. The manufacturer shall notify the Engineer well in advance of actual paint manufacture in order to arrange for sampling and testing of raw materials and inspection of paint production.

Test methods shall be according to ASTM or, if not covered, Federal Test Method Standard No. 141.

All paint shall have been approved before delivery.

SECTION 709
REINFORCING STEEL AND WIRE ROPE

709.01 Reinforcing Steel. Reinforcing steel shall conform to the requirements of the following specifications:

Deformed and Plain Billet-Steel Bars for Concrete Reinforcement	ASTM A615
Axle-steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A996
Low-Alloy Steel Deformed Bars for Concrete Reinforcement [to be Welded]	ASTM A706
Fabricated Deformed Steel Bar Mats for Concrete Reinforcement	ASTM A184
Steel Welded Wire Fabric, Plain for Concrete Reinforcement	AASHTO M55
Steel Welded Wire Fabric, Deformed for Concrete Reinforcement	AASHTO M221
Epoxy Coated Reinforcing Bars	ASTM A775
Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement	ASTM A767
Deformed and Plain Stainless-steel Bars for Concrete Reinforcement	ASTM A955
Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement	ASTM A1035
Continuous Hot-Dip Galvanized Steel Bars for Concrete Reinforcement	ASTM A1094

Unless otherwise designated, bars conforming to ASTM A615 and ASTM A996 shall be furnished in Grade 60.

In ASTM A184, bar material conforming to ASTM A616 will not be permitted.

In ASTM A955, bar material shall be furnished in Grade 75 unless otherwise designated.

In ASTM A1035, bar material of Type CL will not be permitted unless designated in the plans or otherwise approved by the Engineer.

709.02 Wire Rope. The wire rope shall conform to the requirements of AASHTO M 30 for the specified diameter and strength class.

709.03 Dowel Bars and Tie Bars. Tie bars for longitudinal and transverse joints shall conform to AASHTO A775 and shall be grade 40, epoxy-coated, and deformed. Bar size shall be as designated on Standard Plan M-412-1.

Dowel bars for transverse joints shall conform to AASHTO M 254 for the coating and to ASTM A615, grade 60 for the core material and shall be epoxy-coated, smooth, and lightly greased, precoated with wax or asphalt emulsion, or sprayed with an approved material for their full length. Bar size shall be as designated on the Standard Plan M-412-1.

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SECTION 710
FENCE AND GUARDRAIL

710.01 Barbed Wire. Steel barbed wire shall conform to the requirements of ASTM A121, Class I. Aluminum barbed wire shall be manufactured per ASTM B211 with alloy 5052-O for the line wire and alloy 5052-H38 for the barbs.

710.02 Woven Wire. Woven wire shall conform to the details and requirements shown on the plans and to the following:

Zinc coated steel woven wire shall conform to the requirements of ASTM A116, coating Class I.

Aluminum coated steel woven wire shall conform to the requirements of ASTM A116, Type A.

Fittings and attachments shall be zinc coated to conform to the requirements of AASHTO M 232.

710.03 Chain Link Fabric. Chain link fabric and required fittings and hardware shall conform to the requirements of AASHTO M 181 for the kind of metal, sizes of wire and mesh specified.

Zinc coating for steel fabric shall conform to ASTM A392, Class I; and aluminum coating for steel fabric to ASTM A491, Class I.

710.04 Snow Fence. Wire-bound picket fence shall conform to the requirements of ASTM F537. Posts shall conform to the requirements of AASHTO M281.

710.05 "W" Beam Rail. The rail elements shall be corrugated sheet steel beams conforming to the requirements of AASHTO M 180 of the designated class and type. The beams shall be galvanized, shop painted or corrosion resistant as may be specified. The same requirements shall apply to metal offset devices.

Corrosion resistant steel for rail elements and terminals shall not be painted or galvanized.

Corrosion resistant beam rails shall consist of corrugated sheet steel conforming to the requirements of AASHTO M 180, Type IV and shall have a corrosion resistance of at least 4 times that of carbon steel without copper (0.02 Max), or twice that of carbon steel with copper. The sheet steel may either be in coils or cut lengths when processed for corrugation.

All corrosion resistant material shall be sandblasted to provide a uniform weathered appearance.

All corrosion resistant steel parts shall be handled with care to avoid gouges, scratches, or dents. Care shall be exercised to keep foreign material such as paint, grease, oil, or crayon, from contact with the surface. Steel parts either damaged physically or by contact with foreign substances, will not be accepted.

During shipment or site storage, corrosion resistant steel parts must be positioned to allow free drainage and air circulation on the surfaces. Natural oxide formation on the steel may occur and will not be considered objectionable.

The Contractor shall furnish three copies of a certified mill test report to the Engineer. This report shall show the results of physical and chemical tests of the metal and its coating.

710.06 Timber for Wood Noise Barrier. Timber shall be any of the timber species given in subsection 508.02 including all species defined as "Native." Throughout the project, posts shall be of one species; boards may be of another species; and rails may be a mix of any permissible species, except where single sided fence is built, the rails shall be of one species. The exposed board surfaces shall be of one finish throughout the entire fence and may be rough sawn, SIS, S1S2E, or S48; posts and rails may have any of the finishes. Species selected for posts, rails, and boards shall conform to the grading rules of the Western Wood Products Association (WWPA), the Southern Pine Inspection Bureau (SPIB), or the West Coast Lumber Inspection Bureau (WCLIB) for grading and strength.

(1) Posts. WWPA or WCLIB posts and timbers, No. 1 or better; or SPIB timbers No. 2SR or better.

(2) Rails. WWPA, WCLIB, or SPIB: Light framing, standard or better; or structural joists and planks, No. 2 or better.

(3) Boards. WWPA No. 2 common or better; or SPIB No. 1 or better.

(4) Treatment. The selected species shall be pressure treated lumber conforming in all respects to the AWPA Standard U1, Commodity Specification A: Sawn Products and AWPA Commodity Standard B: Posts (Ground contact for posts, above ground for balance of fence). A treatment report is required from the treatment plant.

(5) Preservative. AASHTO M-133.

All lumber shall be manufactured per Product Standard 20-70 as published by the Department of Commerce and shall be grade marked by a grading agency or have an accompanying certificate from the grading agency. The grading agency shall be certified by the Board of Review of the American Lumber Standards Committee.

All posts, rails, and fence board materials shall be dried after treatment to a maximum of 19 percent moisture content.

710.07 Fence Posts. Wood posts shall conform to the details and dimensions indicated on the plans. Wood posts shall be straight, sound, and seasoned with ends sawed off square or as indicated. All knots shall be trimmed flush with the surface. Wood posts shall be peeled and shall be treated with preservative per AASHTO M 133 or AWPA Standards. When native cedar posts are called for on the plans, the requirements for peeling and for treating may be omitted.

All dimension timber and lumber required for fences or gates shall be sound, straight, and free from knots, splits, and shakes. It shall be of the species and grades indicated on the plans.

Concrete posts shall be made of concrete of the class specified and shall contain steel reinforcement as shown on the plans.

Steel posts shall be galvanized per AASHTO M 111. Fittings, hardware and other appurtenances not specifically covered by the Contract shall be standard commercial grade, and in accord with current standard practice. Pipe or roll-formed steel material for fence posts shall conform to the requirements shown on the plans and to the requirements of Class 1 Pipe, Grade A and Grade B or Class 3 Formed Steel Sections, of Federal Specification RR-F-191/3E. Pipe material for fence posts shall conform to the requirements shown on the plans and to the requirements of Class 1 Pipe, Grade A or Grade B, of Federal Specification RR-F-191/3C.

710.08 Guardrail Posts. Posts shall be of either wood or steel. When the choice of post is at the option of the Contractor, there shall be only one kind furnished on the project unless otherwise specified in the Contract.

(a) Wood posts shall be fabricated from an approved or specified timber species and shall be of the quality, diameter or section, and length as specified or as shown in the Contract. Treated posts shall be fabricated or framed before treatment, and shall conform to the requirements of AASHTO M 133 or AWPA Standards.

(b) Steel posts shall be of the section and length as specified or as shown in the Contract. Steel shall conform to the requirements of AASHTO M 183 for the grade specified.

The posts shall be galvanized or corrosion resistant as may be specified.

All corrosion resistant material shall conform to the requirements of AASHTO M 222.

(c) Concrete deadmen for end anchorages shall be as specified or as shown in the Contract.

710.09 Guardrail Hardware. Splices, end connections, end anchor rods, and accessories shall be as specified or as shown in the Contract.

Bolts, nuts, and washers shall be galvanized per AASHTO M 232, Class C, or AASHTO M 298, Class 50, Type 1. All other fittings shall be galvanized per AASHTO M 111. Bolts, nuts, and washers for corrosion resistant guardrail shall be of corrosion resistant material and conform to or exceed the requirements of ASTM A307.

Where high strength bolts are required, they shall conform to the requirements of ASTM F3125 Grade A325.

SECTION 711
CONCRETE CURING MATERIALS AND ADMIXTURES

711.01 Curing Materials. Curing materials shall conform to the following requirements:

Burlap Cloth made from Jute or Kenaf	AASHTO M 182
Liquid Membrane-Forming Compounds for Curing Concrete	ASTM C309
Sheet Materials for Curing Concrete	AASHTO M 171*
*Only the performance requirements of AASHTO M171 shall apply.	

Straw used for curing shall consist of threshed straw of oats, barley, wheat, or rye. Clean field or marsh hay may be substituted for straw when approved by the Engineer. Old dry straw or hay that breaks readily in the spreading process will not be accepted.

711.02 Air-Entraining Admixtures. Air-entraining admixtures shall conform to the requirements of AASHTO M 154.

Admixtures that have been frozen will be rejected per subsections 106.08 and 106.09.

711.03 Chemical Admixtures. Chemical admixtures for concrete shall conform to the requirements of AASHTO M 194.

Admixtures that have been frozen will be rejected.

Corrosion inhibiting admixtures shall conform to the requirements of ASTM C1582.

Pigments for integrally coloring concrete shall conform to the requirements of ASTM C979.

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SECTION 712
MISCELLANEOUS

712.01 Water. Water used in mixing or curing concrete shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetation, or other substance injurious to the finished product. Concrete mixing water shall meet the requirements of ASTM C1602. The Contractor shall perform and submit tests to the Engineer at the frequencies listed in ASTM C1602. Potable water may be used without testing. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, and other foreign materials.

712.02 Calcium Chloride. Calcium chloride shall conform to the requirements of AASHTO M 144.

712.03 Hydrated Lime. The hydrated lime for hot mix asphalt (HMA) shall conform to the requirements of AASHTO M 303, Type I. In addition, the particle size requirements shall conform to AASHTO M 303 when tested per CP-L 4209 Physical Testing of Quicklime, Hydrated Lime, and Limestone.

712.04 (unused)

712.05 Precast Concrete Units. Precast concrete manhole base sections, riser sections, and grade rings shall conform to AASHTO M 199. All other precast units shall be cast in substantial forms. Structural concrete used shall attain a minimum 28-day compressive strength of 3000 psi as determined per AASHTO T 22. When air-entrained concrete is specified, it shall have an air content of 5 to 8 percent by volume. The precast units shall be cured per AASHTO M 170. Additional reinforcement shall be provided as necessary to provide for handling of the precast units.

A sufficient number of cylinders shall be cast and field cured from each batch, or truck-mixer load, of concrete to permit compression tests at 7, 14, and 28 days, and to allow for at least two cylinders for each test. When the strength requirement is met, the units will be certified for use.

Cracks in units, honeycombed or patched areas in excess of 30 square inches, excessive water absorption, or failure to meet strength requirements will be cause for rejection.

712.06 Frames, Grates, Covers, and Steps. Metal units shall conform to the plan dimensions and to the following specification requirements for the designated materials.

Gray iron castings shall conform to the requirements of AASHTO M 306 and AASHTO M 105, Class 35B.

Carbon-steel castings shall conform to the requirements of AASHTO M 103, grade 415-205, Class 2.

Ductile iron castings shall conform to the requirements of ASTM A536. Grade shall be optional unless otherwise designated.

Structural steel shall conform to the requirements of AASHTO M 270.

Malleable iron castings shall conform to the requirements of ASTM A47. Grade shall be optional unless otherwise designated.

Steps shall conform to the requirements of AASHTO M 199.

Galvanizing, where specified for these units shall conform to the requirements of AASHTO M 111.

712.07 Geosynthetics. Geosynthetic rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure before placement. Each roll shall be labeled to provide product identification sufficient for inventory and process control purposes. Rolls shall be stored in a manner that protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall submit a certified test report from the manufacturer per subsection 106.13 including all data necessary to verify compliance with this specification.

Securing pins shall be made from galvanized steel wire or other approved wire material, 0.091 inch or larger in diameter. They shall be U-shaped, with legs 6 inches long and a 1-inch crown.

Physical requirements of geosynthetics shall meet or exceed what is shown in Table 712-1. Unless otherwise stated, all property values represent minimum average roll values (MARV) in the weakest principal direction. Stated values are for non-critical, non-severe conditions. Lots shall be sampled per ASTM D4354.

(a) Geomembrane. Geomembrane shall be manufactured for stopping seepage loss. The lining shall consist of virgin polyvinyl chloride (PVC) resins, plasticizers, stabilizers, and other necessary materials that, when compounded, shall meet or exceed the physical requirements for the thickness specified in Table 712-1.

Individual widths of PVC materials shall be fabricated into large sections by dielectric sealing into a single piece, or into a minimum number of panels, up to 100 feet wide, as required to fit the facility. Lap joints with a minimum joint width of 1/2 inch shall be used. After fabrication, the lining shall be accordion folded in both directions and packaged for minimum handling in the field. Shipping boxes shall be substantial enough to prevent damage to contents.

Table 712-1
PHYSICAL REQUIREMENTS FOR GEOMEMBRANE

Property	Thickness			Test Method
	0.25 mm (10 mil)	0.51 mm (20 mil)	0.76 mm (30 mil)	
Thickness, % Tolerance	±7	±5	±5	ASTM D1593
Tensile Strength, kN/m (lb/in) width	3.50 (20)	8.75 (50)	12.25 (70)	ASTM D882, Method B
Modulus @ 100% Elongation, kN/m (lb/in)	1.58 (9)	3.50 (20)	5.25 (30)	ASTM D882, Method B
Ultimate Elongation, %	350	350	350	ASTM D882, Method A
Tear Resistance: N (lb)	18 (3.2)	29 (6.5)	38 (8.5)	ASTM D1004
Low Temperature Impact, °C (°F)	-23 (-13)	-26 (-15)	-29 (-20)	ASTM D1790
Volatile loss, % max.	1.5	0.9	0.7	ASTM D1203, Method A
Pinholes, No. /8 m^2 (No. Per 10 sq yd) max.	1	1	1	
Bonded Seam Strength, % of tensile strength	80	80	80	

(b) Reserved.

712.08 Geotextiles. Geotextile rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure before placement. Each roll shall be labeled to provide product identification sufficient for inventory and process control purposes. Rolls shall be stored in a manner that protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall submit a certified test report from the manufacturer per subsection 106.13 including all data necessary to verify compliance with this specification.

Securing pins shall be made from galvanized steel wire or other approved wire material, 0.091 inch or larger in diameter. They shall be U-shaped, with legs 6 inches long and a 1-inch crown.

Physical requirements for all geotextiles shall conform to the requirements of AASHTO M-288. Materials shall be selected from the New York Department of Transportation's Approved Products List of Geosynthetic materials that meet the National Transportation Product Evaluation Program (NTPEP) and AASHTO M-288 testing requirements. The current list of products that meet these requirements is located at:

https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/alme/geo.html

Table 712-2
TYPICAL VALUES OF PERMEABILITY COEFFICIENTS[1]

Turbulent Flow	Particle Size Range Millimeters (inches)		Effective Size	Permeability Coefficient k cm/s
	D max	D min	D 20 mm (inches)	
Derrick STONE	3000 (120)	900 (36)	1200 (48)	100
One-man STONE	300 (12)	100 (4)	150 (6)	30
Clean, fine to coarse GRAVEL	80 (3)	10 (1/4)	13 (1/2)	10
Fine, uniform GRAVEL	8 (3/8)	1.5 (1/16)	3 (1/8)	5
Very coarse, clean, uniform SAND	3 (1/8)	0.8 (1/32)	1.5 (1/16)	3
Laminar Flow				
Uniform, coarse SAND	2 (1/8)	0.5 (1/64)	0.6	0.4
Uniform, medium SAND	0.5	0.25	0.3	0.1
Clean, well-graded SAND and GRAVEL	10	0.05	0.1	0.01
Uniform, fine SAND	0.25	0.05	0.06	40×10^{-4}
Well-graded, silty SAND and GRAVEL	5	0.01	0.02	4×10^{-4}
Silty SAND	2	0.005	0.01	1.0×10^{-4}
Uniform SILT	0.05	0.005	0.006	0.5×10^{-4}
Sandy CLAY	1.0	0.001	0.002	0.05×10^{-4}
Silty CLAY	0.05	0.001	0.0015	0.01×10^{-4}
CLAY (30% to 50% clay sizes)	0.05	0.0005	0.0008	0.001×10^{-4}
Colloidal CLAY (-2 μm 50%)	0.01	10	40	10^{-9}

[1] Basic Soils Engineering, R.K. Hough, 2nd Edition, Ronald Pess Co.; 1969, Page 76.
Note: Since the permeability coefficient of the soil will be unknown in most non-critical, non-severe applications for erosion control and drainage, the soil-permeability coefficients listed in Table 712-2 may be used as a guide for comparing the permeability coefficient of the fabric with that of the in-place soil.

712.09 Gabions and Slope Mattresses. All wire used in the manufacture and assembly of the mesh shall conform to Federal Specification QQ-W-461H, finish 5, class 3.

Wire mesh for gabions (cage thickness 12 inches and greater) shall be 11 gauge (U.S.), soft temper.

Wire mesh for slope mattress (cage thickness up to 10 inches) shall be 14 gauge (U.S.), soft temper.

Samples for testing shall include at least one sample of each component of the mesh.

Tie and connecting wire shall be supplied for securely fastening all edges of the gabions and diaphragms. Gabions shall be provided with four cross connecting wires in each cell 1/2 unit high and eight in each cell one unit high. Gabions shall also have inner tie wires connecting the front face to the rear face at approximate spacing of 12 inches in both vertical and horizontal dimensions. Tie wire shall meet the same specifications for wire used in the mesh except that tie wire for gabion cages shall not be more than two gauges lighter.

All wire used, including tie and connecting wire, shall be certified by mill test reports showing compliance with specification requirements.

(a) *Mesh Opening*. The longer dimension of the mesh openings for gabions and slope *mattresses* shall be as shown on the plans.

(b) *Wire Mesh.* Wire mesh shall be woven in such a manner as to be non-raveling and have elasticity. Tests for compliance with these and the following properties shall be performed by the Contractor. A certified test report, showing these required results and information shall be supplied with each project. Tests are to be run on cages of the same specification, made within a year before the date of letting.

(c) *Non-raveling*. The mesh for both gabions and slope mattresses shall show no raveling beyond the mesh opening where the break occurred when the loading is continued after the first break in the test conducted with the pull parallel to the axis of the wire twist.

(d) *Elasticity*. For gabions, when pulled parallel to the axis of the wire twist and deformation is controlled by spreader bars, no wire shall break until the mesh has been stretched at least 4.5 percent. The pull test shall be performed both parallel and perpendicular to the axis of the wire twist and in either case, the first wire break shall not occur until the loading on the table below has been reached.

(e) *Edge Wire Connection*. The edge wire connection for both gabions and slope mattresses shall be strong enough so that when tested the first wire break shall occur in the wire mesh.

(f) *Selvedge*. The selvedge on each sheet of mesh for both gabions and slope mattresses shall be galvanized steel wire (as described above) two gauges heavier than that used in the body of the mesh. For gabions, it shall be attached to the wire mesh strong enough so that when tested, no wire shall break until the loading on the table below has been reached. For slope mattresses, the first wire break shall be in the wire mesh.

(g) *Field Connections*. The field connections between adjacent wire baskets shall be made as recommended by the manufacturer and shall develop a connection strong enough that the failure under test shall occur in the mesh rather than in the lacing.

Table 712-3
MINIMUM STRENGTH
TESTS FOR GABION BASKETS ONLY

Part	**Minimum Strength (pounds per foot)**
Wire Mesh	
Pulled parallel to wire twist	3400
Pulled perpendicular to wire twist	1000
Connection of Selvedge wire to mesh	2200

(h) *Dimensions*. Gabions and slope mattresses shall be supplied in the various sizes shown on the plans. Cages and mattresses furnished by a manufacturer shall be of uniform size.

(i) *Tolerances*. All gabion and slope mattress dimensions are subject to a tolerance limit of 3 percent of manufacturer's stated sizes.

(j) *Riprap*. Riprap shall consist of hard, dense, sound, rough fractured stone or local sandstone, as nearly cubical as practicable. Thin slab type stones and flaking rock shall not be used.

Stone shall have a specific gravity of at least 2.25 and shall be resistant to the action of air and water. Flaking or fragmental rock will not be permitted.

The sizes of riprap stone for gabions and slope mattresses shall conform to the following:

	Stone Size
Gabions (cage thickness 12 inch or greater)	4 to 8 inch
Slope Mattress	3 to 6 inch

(k) Soil Anchor Stakes for Wire Mesh Slope Mattresses. Soil anchor stakes shall be steel and may be:

(1) Crane rails of a convenient size, minimum 40 pounds per yard.

(2) Size 2-inch steel pipe conforming to ASTM A53 either black or galvanized.

(3) Size 3-inch x 3-inch x 3/8-inch structural steel angles conforming to ASTM A709 Grade 36 or better.

(4) Used rails, pipe or angles may be used provided the material is not rusted or damaged to such an extent that the strength of the stakes is affected.

Soil anchor stakes shall be of the lengths called for on the plans.

712.10 Epoxy. Epoxy used for bonding new, or wet concrete, to old concrete shall be an approved product and shall be of the type specifically intended for bonding wet concrete to existing concrete. Each container of epoxy shall conform to ASTM C881.

712.11 Plastic Pipe for Underdrains. Polyethylene perforated or nonperforated corrugated pipe shall conform to AASHTO M 252.

Perforated or nonperforated Polyvinyl Chloride Pipe-Smooth Interior, Smooth or Ribbed Exterior, shall conform to AASHTO M 304.

712.12 Geocomposite Drains. Geocomposite drains, underdrains, and edge drains for subsurface drainage shall be constructed of a drainage geotextile and a semi-rigid drainage core. A drainage pipe collector may also be included in the drain system.

Drainage geotextile shall be a minimum Class 3, conforming to AASHTO M 288. The drainage pipe collector, when used, shall conform to the requirements designated in subsection 605.02 for the type of pipe used.

The semi-rigid drainage core shall be constructed of material that will not deteriorate in subsurface conditions and shall conform to the physical requirements of Table 712-4.

Table 712-4
PHYSICAL REQUIREMENTS FOR DRAINAGE CORE

Property	Value	Test Method
Compressive Strength, kPa (lb/sq in)	140 (20)	ASTM D1621
In-Plane Flow Capacity L/s/m (gal/min/ft), minimum	2.12 (10)	ASTM D4716
Minimum Core Thickness, mm (inch)	6 (0.25)	

712.13 Plastic Pipe. Plastic pipe shall conform to the following requirements for the type of pipe used:

(a) Polyethylene (PE) Pipe. Polyethylene (PE) pipe shall conform to the following requirements for the type of culvert pipe used:

1. AASHTO M 252 (Corrugated Pipe) for nominal pipe sizes of 3 to 10 inches (75 to 250 mm) with the following additions or exceptions:
   A. Type S, and Type SP are acceptable. (Type C, Type CP and Type D will not be accepted.)
   B. Rotational Molded Pipe will not be accepted.
2. AASHTO M 294 (Corrugated Pipe) for nominal pipe sizes of 12 to 60 inches (300 to 1,500 mm) with the following additions or exceptions:
   A. Type S, and Type SP are acceptable. (Type C, Type CP and Type D will not be accepted.)
   B. Rotational Molded Pipe will not be accepted.
3. ASTM F894 (Ribbed, Profile) with the following additions or exceptions:
   A. AASHTO LRFD Bridge Design Specifications, SECTION 12, 50-year life requirements.
   B. Minimum Cell Class per ASTM D3350 of 334433C or 335434C.
   C. Minimum section properties as noted in SECTION 12.
4. ASTM F 714 (Smooth Wall) with the following additions or exceptions:
   A. A DR of 21 or less will be required.
   B. AASHTO LRFD Bridge Design Specification, SECTION 12, 50-year life requirements.
   C. Minimum Cell Class per ASTM D3350 of 335434C.

The Contractor shall provide a polyethylene (PE) pipe product that is prequalified under the AASHTO National Transportation Product Evaluation Program (NTPEP). Only products from suppliers whose manufacturing plant and PE pipe products comply with this specification shall be placed by the Contractor. The current list of plants and PE pipe products that meet these requirements is located at: www.ntpep.org . The Contractor shall use plants listed as compliant and a size listed in the NTPEP reports on PE Thermoplastic Pipe. Every Certificate of Compliance (COC) on each diameter PE pipe product delivered to the project shall include a statement that the product has been manufactured at a NTPEP inspected plant, has been tested by NTPEP, has a NTPEP product number, and is currently on the NTPEP website. The COC shall confirm that the supplied pipe meets the applicable specification limits in subsection 712.13. Manufacturers shall remain acceptable to CDOT as long as the results of verification samples and performance in the field are satisfactory. Any changes in the PE pipe formulation will require re-submittal for prequalification testing by NTPEP.

(b) Polyvinyl Chloride (PVC) Pipe

(1) AASHTO M 304 (Profile) for nominal pipe sizes of 4 to 36 inches.

(2) ASTM F794 (Profile) for nominal pipe sizes 4 to 36 inches with 46 psi minimum pipe stiffness.

(3) ASTM F949 (Profile) for nominal pipe sizes 4 to 36 inches with 46 psi minimum pipe stiffness.

(c) Polypropylene (PP) Pipe. AASHTO M 330 for nominal pipe sizes of 12 to 60 inches with the following exceptions: Type S and Type SP are acceptable; Type C, Type CP and Type D will not be accepted.

The Contractor shall provide a polypropylene (PP) pipe product that is prequalified under the AASHTO National Transportation Product Evaluation Program (NTPEP). Only products from suppliers whose manufacturing plant and PP pipe products comply with this specification shall be placed by the Contractor. The current list of plants and PP pipe products that meet these requirements is located at: www.ntpep.org. The Contractor shall use plants listed as compliant and a size listed in the NTPEP reports on PP Thermoplastic Pipe. Every Certificate of Compliance (COC) on each diameter PP pipe product delivered to the project shall include a statement that the product has been manufactured at a NTPEP inspected plant, has been tested by NTPEP, has a NTPEP product number, and is currently on the NTPEP website. The COC shall confirm that the supplied pipe meets the applicable specification limits in subsection 712.13. Manufacturers shall remain acceptable to CDOT as long as the results of verification samples and performance in the field are satisfactory. Any changes in the PP pipe formulation will require re-submittal for prequalification testing by NTPEP.

(d) Steel Reinforced Polyethylene (SRPE). SRPE pipe shall be AASHTO MP 20 ribbed pipe for nominal pipe sizes 12 to 60 inches with the following exceptions:

Nominal pipe sizes 30 to 60 inches are acceptable; nominal pipe sizes 12 to 27 inches will not be accepted.

SECTION 713
TRAFFIC CONTROL MATERIALS

713.01 Signs – General. Aluminum or steel used for traffic control shall conform to Table 713-1.

Table 713-1
REQUIREMENTS FOR ALUMINUM OR STEEL
USED IN TRAFFIC CONTROL

Application	Aluminum		Steel
	ASTM Designation	Alloy No. Temper	ASTM Designation
Sign panels	B209 B449[1] B921[1]	6061-T6 5052-H36 5052-H38	A653[2]
Traffic controller cabinets	B209	6061-T6	A709 Grade 36
Clip bolts	B211	2024-T4	
Locknuts or steel nuts and bolts	B211	2014-T4	A307
Clips and backing angles	B221	6061-T6	

[1] In lieu of ASTM treatment, aluminum sign blanks shall receive a Class 2 anodized coating before the placement of retroreflective sheeting.
2 Steel sheets shall have a Z600 zinc coating per ASTM A653 and a light phosphate coating. Phosphate coating of 3.5 oz./sq. ft. will be required for application with reflective sheeting. Nuts and bolts shall be galvanized or cadmium plated.

713.02 Aluminum Sign Panel Tolerances. Aluminum sign panel sheet dimensional tolerances shall conform to the applicable requirements of the American National Standards Institute Dimensional Tolerances for Aluminum Products, ANSI-H35.2(M), with the following exceptions:

The flatness tolerances shall be one-half the values listed in Table 3.12 and shall apply to all aluminum alloy grades permitted for sign panels.

Sign blanks are to be tensile leveled for sheet thickness less than 0.09 inch, and stretcher leveled for thickness equal to or greater than 0.09 inch.

The individual sign blank bow tolerance (deviation of a side edge from a straight line) shall not exceed 1/3 inch, and the dimensions of the opposing sides shall be within 1/16 inch.

Aluminum sign panel shall be subject to the requirements of the first paragraph of subsection 713.09.

713.03 (unused)

713.04 Sign Message Materials. The legend, border, and overlay shall be used per the sheeting manufacturer's recommendation. Retroreflective sheeting background material shall be on the Department's Approved Product List; and the retroreflective sheeting background material shall be the type specified on the plans. At a minimum, ASTM D4956 Type IV shall be used for ground mount signs. ASTM D4956 Type XI shall be used for Class III overhead signs.

For Class III overhead signs, the legend and borders shall be ASTM D4956 Type XI sheeting.

All reflective sheeting shall be sealed at the seams and edges as recommended by the manufacturer.

713.05 Hardware. All hardware shall be compatible with sign material and shall not cause discoloration due to weather.

713.06 (Unused).

713.07 Reflectors. Reflectors shall consist of a clear and transparent acrylic plastic prismatic reflex lens with a smooth front face, except for the legibly molded manufacturer's trademark, and a back hermetically sealed surface with prismatic configuration effecting total internal reflection of light. Firmly fused to the back surface shall be a backing material. The backing material shall be white opaque plastic of the same type as the lens and delineator reflectors may be backed with a plastic-coated metallic foil. Delineator reflectors shall be housed in embossed aluminum and provided with a single grommeted mounting hole. The delineator unit shall withstand the combined corrosion test described in ASTM B117.

713.08 Glass Beads for Traffic Markings. Glass beads for pavement marking shall conform to AASHTO M 247, except for the following:

1.Gradation:

Table 713-2

GRADATION OF GLASS BEADS

U.S. Mesh	Microns	% Passing	
		Modified Epoxy and Methyl Methacrylate	Acrylic Waterborne: Low Temperature and High Build
16	1180	90-100	100
18	1000	65-80	97-100
20	850		85-100
30	600	30-50	50-70
40	425		10-35
50	300	0-5	0-10
80	180		0-5

2. Roundness: All beads shall meet a minimum of 80 percent true spheres per the Office of Federal Lands Highways FLH T520 or a computerized optical testing method.
3. Color / Clarity: Beads shall be colorless, clear, and free of carbon residues.
4. Refractive Index: Minimum 1.51 by oil immersion method.
5. Air Inclusions: Less than 5 percent by visual count.
6. Coatings: According to the manufacturer’s recommendation for optimum adhesion and embedment.
7. Chemical Resistance: Beads shall be resistant to hydrochloric acid, water, calcium chloride, and sodium sulfide as tested using the methods outlined in sections 4.3.6 to 4.3.9 of the TT-B Federal Spec.1325D.
8. For modified epoxy pavement marking, a minimum of 50 percent of the total weight shall be manufactured using a molten kiln direct melt method. For acrylic waterborne paint, a minimum of 15 percent of the total weight shall be manufactured using a molten kiln direct melt method. All molten kiln direct melt glass beads shall be above the 600 µm (#30) sieve.
9. Glass beads used for any type of pavement marking shall not contain more than 75 parts per million (ppm) arsenic, 75 ppm antimony and 100 ppm lead, as tested per EPA methods 3052 and 6010C, or other approved testing method

   Glass beads shall be furnished in fully identified containers and shall be free of extraneous material or clumps.

   Glass beads for thermoplastic pavement marking shall conform to AASHTO M 247, Type 1.

713.09 Sampling and Inspection. The Engineer shall be notified well in advance of beginning of shop work so that adequate arrangements may be made for sampling and inspection. Shop inspection may be waived and complete inspection made when the fabricated sign panels are delivered to the site of the work.

The following samples shall be submitted to the Engineer for approval:

(1) A 12-inch x12-inch sample of finished material for figure frames.

(2) A 12-inch x12-inch sample of reflective sheeting representing each lot used on the project.

(3) Two reflectors for each 100, or part thereof, of each size and color, with a limit of 53 samples for any one size or color. When reflective buttons are so affixed to the cutout frames that their removal for testing will cause breakage, it shall be the responsibility of the sign fabricator to furnish a representative sample of reflective buttons.

(4) 2 pounds of glass beads, representing each lot used on the project.

(5) 1 pint of paint of each color, representing each lot used on the project.

(6) 1 pound of thermoplastic marking material and one liter of each primer component.

(7) 36-inch strip of preformed plastic pavement marking.

(8) 36-inch strip of pavement marking tape.

(9) 1 square foot of preformed thermoplastic pavement marking material.

713.10 Quality Requirements of Reflective Materials. Reflective devices and reflective sheeting shall be materials that are on the Department's Approved Products List.

(a) Reflective Devices.

1. Reflective Quality Requirements.

A. Delineator and Median Barrier Reflectors. The specific intensity of each delineator and median barrier reflector shall be at least equal to the following minimum values when tested per AASHTO T257, with an observation angle of 0.1 degrees.

TABLE 713-3
QUALITY REQUIREMENTS OF
DELINEATOR AND MEDIAN BARRIER REFLECTORS

Entrance Angle Degrees	Specific Intensity Candlepower per Foot-Candle				
	Crystal	Yellow	Blue	Red	Green
0	115	70	48	25	62
20	45	25	26	10	34

B. Cut-out Figure Reflectors. The specific brightness of crystal reflectors used in cut-out figures shall be at least equal to the following minimum values.

Table 713-4
QUALITY REQUIREMENTS OF
CUT-OUT FIGURE REFLECTORS

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness: Candlepower per Sq In per Foot-Candle
0.1	0	14.0
0.1	20	5.6

2. Material and Component Requirements. Plastic for delineator and cutout figure reflectors shall be poly methyl methacrylate conforming to requirements of ASTM D788, Grade 8. The reflectors shall meet test requirements of CP L-2115, Section 3.2 and 3.3.

(b) Retroreflective Sheeting. Reflective sheeting for traffic control devices shall be listed on the CDOT Approved Products List and conform to the requirements of ASTM D4956.

1. Retroreflective Quality Requirements.

Drums and Tubular Markers. Retroreflective sheeting shall conform to ASTM D4956 Type IV, with the following modifications:

The Minimum Coefficient of Retroreflection (RA) shall conform to the following minimum values.

Table 713-5
MINIMUM COEFFICIENT OF RETROREFLECTION (RA)

Observation Angle	Entrance Angle	Minimum Coefficient of Retroreflection (R_A) [cd/fc/ft^2 (cd/lx.m^2)]	
		White	Fluorescent Orange
0.2°	-4°	500	200
0.2°	30°	200	80
0.5°	-4°	225	90
0.5°	30°	85	34

2. Daytime Color.

   Drums and Tubular Markers. All fluorescent orange sheeting shall meet the color requirements of ASTM D4956, with the following modifications:

   The chromaticity coordinates and total luminance factor shall conform to the requirements as described in 23 CFR Part 655 Appendix to Subpart F.

   The Fluorescence Luminance Factor (YF) shall conform to the following minimum values.

Table 713-6
MINIMUM FLUORESCENCE LUMINANCE FACTOR (YF)

Color	Y_F Initial Requirement	Y_F Minimum Requirement
Fluorescent Orange	20	15

713.11 Traffic Signals. Electrical conduit, pull boxes and junction boxes shall conform to the requirements of Section 613 and subsection 715.06, and to the details shown on the plans.

Conductors shall be nineteen strand or seven stranded, tinned copper wire, rated at 600 volts and individually insulated with heat-stabilized polyethylene. Conductors and cables shall be copper and conform to Specification 19-1 of the International Municipal Signal Association (IMSA).

Direct-burial cable shall be copper and conform to Specification 19-5 of the IMSA except that conductorsc x shall be seven, wire, stranded.

Pull rope shall be 1/8-inch nylon.

Messenger cable (span wire) shall be 3/8-inch diameter (minimum), seven wire stranded, common galvanized, utilities grade, rated at 11,500 pounds, per ASTM A475.

Grounding and bonding wires, straps and electrodes shall be copper and conform to NEC Article 250.

Adjustable face vehicle traffic control signal heads and associated equipment shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 1, prepared by the ITE, and as shown on the plans.

Adjustable face pedestrian signal heads and associated equipment shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 5, prepared by the Institute of Traffic Engineers, and as shown on the plans.

Traffic signal lamps shall conform to the general specifications and definitions contained in the latest issue of Technical Report No. 6, prepared by the Institute of Traffic Engineers. Lamps shall be rated for operation at 120 volts AC. Lamp wattages shall be 60-69 Watts for all 8-inch traffic signals, 150 Watts for all 12-inch traffic signals, 116 Watts for all 16-inch pedestrian signals, or as otherwise specified by the manufacturer.

LED Traffic Signal Section optical units shall meet or exceed ITE Adjustable Face Vehicular Traffic Control and Pedestrian Signal Head Standards. In addition to this, LED optical units shall conform to the following requirements:

(1) Wattage

Table 713-7

WATTAGE FOR TRAFFIC CONTROL SIGNAL HEADS

Max. 35 watts, ±5 watts for 12-inch ball
Max. 30 watts, ±5 watts for 8-inch ball
Max. 15 watts, ±5 watts for 12-inch arrow
Max. 15 watts, ±5 watts for PED hand symbol

Maximum total harmonic current distortion (THD) shall be < 20 percent.

Power factor shall be > 90 percent.

Load balance requirement: load in one phase shall not exceed the load in any other phase by 15 percent.

Note: THD and power factor requirements shall be waived for products designed to operate at less than 14 watts.

(2) Voltage

Operating shall be between 85 and 130 VAC. Electronic circuitry shall ensure proper operation of the load switch and monitor in the control cabinet.

(3) Circuit Configuration

The LEDs shall be connected to form multiple series circuits. All series circuits shall be interconnected at intervals, forming subcircuits not exceeding 15 LEDs for the ball and arrow signals, and 10 LEDS for the pedestrian hand symbol. In the event of an LED failure, these subcircuits shall limit the number of extinguished LEDs to no more than 4 percent of the total on the ball and pedestrian hand signal lamps, and 6 percent of the total on the arrow lamp.

(4) Enclosure

Shall be dust and water resistant

(5) Operating Temperature

Between minus 40 °F and plus 165 °F

(6) Lens

Shall be replaceable, polycarbonate (UV stabilized "Lexan") convex lens; meet ITE color standards; minimum of 1/8 inch thickness; and minimum light transmittance of 92 percent, free from bubbles, flaws and other imperfections. Non-polycarbonate tinted lenses will be accepted if they meet ITE color standards. Chromacity shall be measured uniform across the face of the lens. Non-polycarbonate lenses shall also meet 3 1/2-foot drop tests. The outside face of the lens shall be smooth. Grooves, ridges, or both that may be used to enhance optical characteristics of the LED optical unit shall be located on the inside face of the lens.

(7) Candlepower Distribution

Shall meet minimum ITE specifications. Intensity shall be measured uniform across the face of the lens. Brightness shall be maintained in the event of voltage fluctuations or voltage drops.

(8) Beam Spread

30 degrees both horizontally and vertically.

(9) Manufacturer’s Warranty

Repair or replacement guarantee of five years covering all but accidental damage.

Foundations for poles, pedestals, posts, and cabinets shall conform to the requirements of Section 601.

Bonding and grounding jumpers shall be copper wire or copper strap of the same cross-sectional area; the wire size shall be No. 6 AWG for all systems except the ground terminal of controllers, which shall be No. 8 AWG.

All exterior parts of the signal heads requiring paint shall be painted Federal Yellow 595B No. 13538 unless otherwise specified.

Traffic signal faces, which are rigidly supported on the top and bottom, may be of an approved polycarbonate type unless otherwise shown on the plans.

713.12 Thermoplastic Marking Material. Thermoplastic marking material shall conform to AASHTO M 249 except for the following:

(1) In paragraph 3.1.2 of the AASHTO specifications, delete the first two sentences and replace with the following:

The material manufacturer shall have the option of formulating the material according to its own specifications. However, the binder shall be composed of alkyd resins wherein a minimum of 70 percent (by weight) of the binder shall be maleic modified glycerol ester of rosin. The physical and chemical properties contained in this specification shall apply regardless of the type of formulation used.

(2) In paragraph 4.3 of the AASHTO specifications, add the following physical characteristics: The infra-red spectra of the extracted binder will be compared to the characteristic absorption bands of maleic modified glycerol ester of rosin.

(3) In paragraph 6.1 of the AASHTO specifications, delete the second sentence and replace with the following: The containers of thermoplastic material shall weigh approximately 50 pounds.

713.13 Preformed Plastic Material. Preformed plastic pavement marking material shall conform to ASTM D4505 for one of the following requirements:

(1) Class 1 tape will not be permitted.

(2) Class 2: for lane lines, crosswalks, stop lines and edge lines.

(3) Class 3: for legends and symbols.

Preformed plastic pavement marking color shall conform to the requirements of ASTM D6628.

Preformed plastic pavement markings shall meet the dimensional requirements of ASTM D4505.

Skid resistance will not be considered a factor for acceptance.

The edges of the preformed plastic pavement marking shall be straight and uniform, and consistently adhere to the pavement.

Unless otherwise stated in the Contract, preformed plastic pavement marking shall conform to the following material requirements for the Type shown on the plans:

Table 713-8
PREFORMED PLASTIC PAVEMENT MARKING

Property	Type I	Type II[1]	Type III
Minimum thickness (mils)	75	75	60
Minimum Width (in)	4	7	4
Initial Retroreflectivity	Retroreflectivity level I per ASTM D4505	Retroreflectivity level I per ASTM D4505	Retroreflectivity level II per ASTM D4505
Adhesion (ºF)[2]	Roadway surface temperature range of 50 ºF - 115 ºF[3] per ASTM Test Method 1000	Roadway surface temperature range of 50 ºF - 115 ºF[3] per ASTM Test Method 1000	Roadway surface temperature range of 50 ºF - 115 ºF per ASTM Test Method 1000
Beads	Ceramic or combination of glass and ceramic	Ceramic or combination of glass and ceramic	Glass
Minimum refractive index	1.7	1.7	1.5
Surface pattern	Minimum of 31 mils and per ASTM D4505	Minimum of 31 mils and per ASTM D4505	N/A

[1] Contrast pavement marking to be used for skip lines, lane lines and gore markings.
[2] The adhesion temperature is identical to both the application and test temperatures.
[3] Application at a lower temperature may be permitted as approved by the Engineer.

713.14 Preformed Thermoplastic Material.

(a) General. Preformed thermoplastic markings shall be composed of aggregates, pigments, binders and glass beads, and shall conform to AASHTO designation M 249 with the exception of the relevant differences due to the fact that the material is supplied in a preformed state. The material shall be either alkyd or hydrocarbon based. Only preformed thermoplastic pavement marking material listed on the Department's approved products list may be used.

(b) Physical Requirements.

1. Graded Glass Beads. The material shall contain a minimum of 30 percent graded glass beads by weight. The beads shall be clear and transparent. Twenty percent or less shall consist of irregular, fused spheroids, or silica. The refractive index shall be at least 1.50.

2. Pigments. White - Sufficient titanium dioxide pigment shall be used to ensure a color similar to Federal Highway White, Color No. 17886, conforming to Federal Standard 595. Yellow - Sufficient yellow pigment shall be used to ensure a color similar to Federal Highway Yellow, Color No. 13655, conforming to Federal Standard 595. The yellow pigment shall be organic and contain no lead chromate.

3. Skid Resistance. The surface of the preformed thermoplastic markings shall provide a minimum resistance value of 45 BPN when tested according to ASTM E303.

4. Thickness. The material shall be supplied at a minimum thickness of 125 mils.

5. Environmental Resistance. The preformed thermoplastic material shall be resistant to deterioration due to exposure to sunlight, water, oil, gasoline, salt and adverse weather conditions.

713.15 Pavement Marking Tape.

(a) Description. The marking tape shall consist of weather and traffic resistant yellow or white colored reflective material. The material shall consist of conformable (metal foil) backing with a pressure sensitive adhesive designed for adhesion to asphalt or concrete surfaces.

(b) Requirements.

1. Color. The color of the visible or outer surface shall closely match the white or yellow traffic marking paint specified for highway delineation. Glass beads shall be strongly adhered to the tape.

2. Reflectance. The white and yellow tapes shall have the following initial minimum reflectance values at 0.20° and 0.50° observation angles and 86.00° entrance angle as measured per the testing procedures of Federal Test Method Standard 370. The photometric quantity measured is specific luminance (SL) and is expressed as millicandelas per square meter per lux.

TABLE 713-9

SPECIFIC LUMINANCE (SL)

Color	White		Yellow	
Observation Angle	0.2°	0.5°	0.2°	0.5°
Specific Luminance	1360	760	820	510

3. Adhesive. The striping tape shall be supplied in rolls ready for application and have a precoated pressure sensitive adhesive, which shall not have a protective liner or require a solvent activator.

4. Adhesion. The material shall adhere to asphalt and concrete surfaces when applied at surface temperatures of 35 °F and above. Once applied, the tape shall adhere to the pavement at subfreezing temperatures.

5. Conformability. The material shall be thin, flexible, conformable, and show no cracking, flaking, or bead loss. Following application, the tape shall remain conformed to the texture of the pavement surface. The thickness of the material shall not be less than 17 mils.

6. Removability. The tape shall be removable by following manufacturers' recommendations so long as the material is substantially intact. Removal shall not require sandblast, solvents, or grinding methods.

7. Durability. The striping material applied per manufacturers' recommended procedures shall be weather resistant and show no appreciable fading, lifting, or shrinkage during the useful life of the line.

8. Packaging and Delivery. The striping material as supplied shall be of good appearance and free from cracks. The edges shall be true, straight, and unbroken. The material shall be supplied in rolls with no more than one splice per 50 yards of length.

   The striping material shall be packaged per accepted commercial standards to prevent damage during shipment and storage. The tape as supplied shall be suitable for use for a period of at least one year following delivery when stored at temperatures of 100 °F or below.

713.16 Pavement Marking Tape (Removable). Pavement marking tape designated in the pay item as removable shall conform to ASTM D4592, Type I, and shall be four plus or minus 0.1 inches wide.

713.17 Modified Epoxy Pavement Marking Material. Only modified epoxy pavement marking material that is on the Department's Approved Products List may be used. Batches or lots of approved products will be accepted on the project by Certificate of Compliance (COC) per subsection 106.12. The

COC shall confirm that the material meets all CDOT requirements and is the same material that was preapproved in the product evaluation process.

(a) Formulation. Modified epoxy pavement marking material shall be a two component, 100 percent solids, material formulated to provide simple volumetric mixing ratio of two volumes of component A and one volume of component B unless otherwise recommended by the material manufacturer.

(b) Composition. The component A of both white and yellow shall be within the following limits:

Table 713-10

RESIN / PIGMENT COMPONENTS (% BY WEIGHT)

Pigment	WHITE:	YELLOW:
TiO_2, ASTM D476, Type II	18-25	10-17
Organic Yellow		6-10
Epoxy Resin	75-82	73-84

The pigment for yellow modified epoxy shall contain no lead or other material such that the cured epoxy could be considered a hazardous waste under EPA or CDPHE regulations. The Contractor shall submit to the Engineer a manufacturer's certification of compliance with this requirement.

(c) Epoxide Number. The epoxide number of the modified epoxy's resin shall be the manufacturer's target value plus or minus 50 as determined by ASTM D1652 for white and yellow component A on pigment free basis.

(d) Amine Number. The amine number on the curing agent (component B) shall be the manufacturers target value plus or minus 50 per ASTM D2071.

(e) Toxicity. Upon heating to application temperature, the material shall not produce fumes that are toxic or injurious to persons or property.

(f) Color. The modified epoxy material, without drop-on beads, shall correspond following requirements:

White – Federal Standard No. 595B-17925. The Yellowness Index (YI) of white shall not exceed 8.0 per ASTM E313-10 initially.

After 72 QUV exposure per ASTM G154 with a UVA-340 Lamp at an irradiance of 0.89 W/m2/nm with alternating cycles of 4 hours U.V @ 140 ºF, and 4 hours' humidity @ 122 ºF the YI shall not exceed 15 when measured per ASTM E313.

The YI, after 500-hour QUV testing as above, shall not exceed 27.

Yellow – Materials for pavement markings shall meet the initial daytime chromaticity that fall within the box created by the following corner points:

Table 713-11

INITIAL DAYTIME CHROMATICITY

COORDINATES (CORNER POINTS)

	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

After 72-hour QUV exposure per ASTM G154 with a UVA-340 Lamp at an irradiance of 0.89 W/m2/nm with alternating cycles of 4 hours U.V @ 140 ºF, and 4 hours' humidity @ 122 ºF the Yellow shall fall within the initial chromaticity coordinates stated above.

(g) Drying Time. The modified epoxy pavement marking material shall have a setting time to a no-tracking condition of not more than 25 minutes at a temperature of 73 °F and above.

(h) Curing. The modified epoxy material shall be capable of fully curing under the constant surface temperature condition of 35 °F and above.

(i) Adhesion to Concrete. The catalyzed modified epoxy pavement marking material, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified (4,000 psi minimum) concrete surface that there shall be a 100 percent concrete failure in the performance of this test

(j) Hardness. The modified epoxy pavement marking materials, when tested according to ASTM D2240, shall have a minimum Shore D Hardness value of 80. Samples shall be allowed to cure at room temperature, 75 plus or minus 2 °F, for a minimum of 72 hours and a maximum of 168 hours before performing the indicated test.

(k) Abrasion Resistance. The abrasion resistance shall be evaluated on a Taber Abrader with a 1,000-gram load and CS-17 wheels. The duration of the test shall be 1,000 cycles. The wear index shall be calculated based on ASTM test method C-501 and the wear index for the catalyzed material shall not be more than 60. The tests shall be run on cured samples of material that have been applied at film thickness of 15 plus or minus 1/2 mils to code S-16 stainless-steel plates. The samples shall be allowed to cure at 75 plus or minus 2 °F for a minimum of 72 hours before performing the indicated tests.

(l) Tensile Strength. When tested according to ASTM D638, the modified epoxy pavement marking materials shall have a tensile strength of at least 6,000 psi. The Type IV Specimens shall be cast in a suitable mold and pulled at the rate of 1/4 inch per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature, 75 plus or minus 2 °F, for a minimum of 72 hours and a maximum of 168 hours before performing the indicated tests.

(m) Compressive Strength. When tested according to ASTM D695, the catalyzed modified epoxy pavement marking materials shall have a compressive strength of at least 12,000 psi. The cast sample shall be conditioned at room temperature, 75 plus or minus 2 °F, for a minimum of 72 hours and a maximum of 168 hours before performing the tests. The rate of compression of these samples shall be no more than 1/4 inch per minute.

713.18 Raised Pavement Marker. Raised pavement marker shall not be less than 3.5 inches or more than 4.5 inches in the major dimension and not more than 0.75 inch in height. The marker shall contain a retroreflective element at least 0.38 square inch in area. The color of the marker and the retroreflective element shall match the color of the pavement marking line. The reflective quality requirements shall be at least equal to the following minimum values:

Table 713-12
RAISED PAVEMENT MARKER
REFLECTIVE QUALITY REQUIREMENTS

Observation Angle Degrees	Entrance Angle Degrees	Specific Intensity Candela per Lux	
		White	Yellow
0.1	0	0.09	0.06
0.1	20	0.04	0.02

The marker shall be ceramic or plastic and shall be secured to old or new pavement using an adhesive approved by the marker manufacturer.

713.19 Methyl Methacrylate Pavement Marking. The Methyl Methacrylate material shall be preapproved by the Department.

SECTION 714
PRESTRESSED UNIT MATERIALS

714.01 Prestressing Steel. Prestressing reinforcement shall be manufactured from high tensile strength steel or alloyed steel. Reinforcement size and grade shall be designated in the Contract. Prestressing steel materials shall meet the appropriate following requirements:

(1) Seven wire steel strand shall meet the requirements of AASHTO M 203. All furnished strand shall be "weldless" per AASHTO M 203, subsection 8.1.4. The Contractor shall furnish one test specimen per coil. Each test specimen shall be 5 to 6 feet long.

(2) High tensile alloy bars shall meet the requirements of AASHTO M 275. Unless otherwise approved by the Engineer, the Contractor shall furnish two test bars per diameter size, per heat number. Each test bar shall be 5 feet in length.

All testing specimens shall be furnished free of cost. If test specimens are not delivered in time for tests to be performed before time of use, the Contractor may elect to incorporate materials into the work at the Contractor's own risk. All test specimens shall be representative of the furnished material lot. If ordered by the Engineer, selection of test samples shall be witnessed by the Engineer's representative, at any location chosen by the Engineer.

All prestressing unit materials shall be subject to interim inspection and testing, before, during and after incorporation into the work, as ordered by the Engineer.

714.02 Anchorage Assemblies. If the anchorage assemblies are not attached to the reinforcement samples, the Contractor shall furnish two anchorage assemblies, complete with distribution plates, for each size or type to be used when requested by the Engineer.

714.03 Post-tensioning Products. The following lengths of materials shall be furnished by the Contractor:

(1) For strand to be furnished with fittings; 5 feet between near ends of fittings.

(2) For bars to be furnished with threaded ends and nuts; 5 feet threads at ends.

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SECTION 715
LIGHTING AND ELECTRICAL MATERIALS

715.01 General. Materials shall be of a standard line from a manufacturer that has at least three installations of the same type that have been installed and active for a minimum of one year. Electrical material shall be listed by the Underwriters' Laboratories, Inc. (UL), and shall conform to the current edition of the National Electrical Code (NEC).

Material shall be the same as, or compatible with, that used and accepted by the agency responsible for maintenance. The Contractor shall coordinate and conduct a final inspection with the Engineer and each Owner upon completion of construction. This inspection shall assure that all lighting and electrical materials comply with these requirements. The Engineer will obtain the Owner's written approval before accepting the work.

The Engineer may inspect all lighting and electrical materials and accept or reject them at the project site. Samples may be taken, or manufacturer's certifications may be accepted in lieu of samples.

715.02 Light Standard Foundations and Concrete Foundation Pads. Concrete shall be Class BZ for cast-in-place concrete foundations. All concrete shall conform to Section 601.

Anchor bolts shall be designed by the Contractor's Engineer and shown on the working drawings, or as provided by the pole manufacturer. The threaded ends of the anchor bolts, the nuts, and the washers shall be galvanized per ASTM A153. Galvanizing on anchor bolts shall extend 2 to 4 inches beyond the threads.

Reinforcing steel shall conform to Section 602.

715.03 Light Standards.

(a) General. Structural components of light standards, bases, couplers, anchor bolts, luminaires, and other attachments to be used for lighting shall be designed for a minimum of 120 MPH wind speed, per AASHTO's LRFD Specifications for Structural Supports for Highway signs, Luminaires, and Traffic Signals, Figure 3.8.2. For special wind regions, the wind speed shall be per AASHTO's Section 3.8.3. The CDOT Bridge Design Manual, Section 32.3 shall be used for Owner approved wind speeds.

Breakaway bases and couplers shall meet the breakaway requirements specified in AASHTO's LRFD Bridge Design Specifications Section 12. Conformance shall be verified by crash tests reviewed and accepted by FHWA. A certificate of compliance shall be provided.

(b) Metal Light Standards. Metal light standards shall be fabricated of either steel or aluminum, unless otherwise specified. Whenever the light standard metal is not specified, the Contractor may furnish either steel or aluminum. Material type and shape of light standards shall be the same throughout the project, unless otherwise shown in the Contract.

Metal poles shall be tapered and shall be supplied with pole caps.

Standards shall have cable-entrance holes located in conformity with the type of arm mounting used. Metal surfaces shall be free of imperfections marring the appearance and of burrs or sharp edges that might damage the cable.

Aluminum alloys shall have a minimum yield strength of 25,000 psi. Aluminum poles, arms, and fittings shall be made of aluminum alloy conforming to the following for the material form required:

ASTM Standard	Alloy Number
B 209	6061-T6
B 211	6061-T6
B 221	6061-T6 6063-T6 6005-T5
B 241	6061-T6 6063-T6

Aluminum poles may also be made of aluminum alloy 5086-H34 conforming to ASTM B313 (excluding pressure and burst tests).

Aluminum mast arms shall be tapered unless otherwise shown on the plans.

Steel mast arms shall be made of Schedule 40 standard steel pipe conforming to ASTM A53.

Steel poles, mast arms and base flanges shall be hot-dip galvanized per ASTM A123. Units where the spelter coating has been damaged shall be repaired as provided in AASHTO M 36, or other approved method.

Base flanges for both aluminum and steel poles shall have continuous welds both inside and outside, unless otherwise permitted. Base flanges inserted into the pole and bonded shall meet the requirements for materials and strength stated.

Base flanges for aluminum poles and transformer bases shall be aluminum castings of alloy ANSI 356.0-T6 or UNS A03560 T6 conforming to ASTM B26 or an acceptable equivalent.

Each metal light standard shall be wired with a breakaway, submersible fused connector of proper capacity rating. The fused connector shall be located in the transformer base. If the light standard has no transformer base, the fused connector shall be located in the pole at the hand hole.

Transformer bases shall have vandal resistant, removable access doors.
The transformer base shall be a frangible breakaway type as shown in CDOT standard S-613-1 and shall accommodate the anchorage and base flange of the light pole supplied. Each transformer base shall have a 1/2 inch bolt or lug fastened inside the base for grounding; the lug or bolt shall be visible from the door opening.

(c) Hardware. Hardware used with steel standards shall be either cadmium plated steel, hot dip galvanized steel, or stainless-steel. All hardware used with aluminum standards shall be anodized aluminum or stainless-steel. Bolts to be inserted in aluminum threads shall be stainless-steel with an anti-seize compound.

715.04 Luminaires and Lamps. Luminaires shall be UL or Intertek Testing Services (ETL) listed for use in wet locations with a minimum IP66 rating. Luminaires shall be adaptable to the type of power distribution system to be used.

(a) General. Luminaires shall conform to the following requirements:

1. Housing. The luminaire enclosure shall be an injection-molded or die-cast opaque housing. The housing shall have a powder-coated, corrosion-resistant finish. The color shall be gray or as specified per the project.

   The housing shall have a door that provides access to all internal components. The door shall be equipped with a safety catch and a latch. The housing shall have an inner rolled flange to support the door frame. The door frame shall be an aluminum casting, hinged to the housing. The door frame shall be sealed to the housing with a molded silicone gasket and shall be secured with a minimum of four captive screws.

2. Optical Chamber. The luminaire distribution shall be equal to or less than an Illuminating Engineering Society (IES) TM-15-11 Backlight, Uplight, and Glare (BUG) ratings listed below in Table 715-1 based on initial luminaire lumens or Light Loss Factor (LLF) = 1.0. Roadway luminaires with a U value greater than U0 shall not be accepted. The optical chamber shall be completely sealed from the housing, or the housing shall be completely sealed. A seamless one-piece memory-retentive gasket shall seal the optical chamber or housing against the luminaire lens door. All wires entering the optical chamber shall be gasketed at their point of entry. Socket mountings, rivets used in the construction or support of the reflector system, and all other penetrations into the optical chamber shall be completely sealed. The optical chamber shall be watertight when the luminaire door is closed.

Table 715-1
BACKLIGHT, UPLIGHT AND GLARE (BUG) VALUES

Luminaire Mounting Location	Minimum Initial Luminaire Lumen Range	Backlight (B) Rating Maximum	Uplight (U) Rating Maximum	Glare (G) Rating Maximum
Non median-mounted	Less than 6,000	B1	U0	G1
	6,000 – 14,000	B2	U0	G2
	14,000 – 24,000	B3	U0	G3
	Above 24,000*	B3	U0	G4
Median-mounted	Less than 6,000	B2	U0	G1
	6,000 – 14,000	B3	U0	G2
	14,000 – 24, 000	B4	U0	G3
	Above 24,000*	B4	U0	G4
*By special application only.				

3. Lens and Lens Door. The lens shall be either micro-lens fully sealed to maintain an IP66 rating; or shall be constructed of clear, flat (for lamps over 3,200 lumens), tempered glass. The glass shall be thermal-resistant and impact-resistant. The lens shall be sealed to the door frame with continuous silicone gasketing. The door shall have an easy-access, quick-release safety latch. The door shall have aluminum or stainless-steel quick-release hinge pins for tool-less or one-hand easy and secure opening. When the door is closed, the electrical component compartment and the optical chamber shall be completely sealed.

4. Electrical Components. All components shall be listed for wet locations by Underwriters Laboratory (UL), ETL or by an Occupational Safety and Health Administration Nationally Recognized Testing Laboratory (OSHA NRTL). Luminaires shall operate from 120 to 277 VAC or be adaptable to the type of power distribution system to be used. All internal wiring and quick disconnects shall be rated for at least 600 VAC and insulated for 302°F. The dimmable driver shall be easily removed from the luminaire housing without the use of tools. The following components shall be per corresponding sections of ANSI C136.37:

   A. Wiring and grounding electrodes;

   B. Terminal blocks for incoming AC lines;

   C. 7-pin Photocontrol receptacle; and

   D. Latching and hinging.

(b) Roadway Luminaires. Roadway luminaires shall be Light Emitting Diode (LED) type with integral driver, flat lens, aluminum housing, and be UL or ETL listed for wet locations. All luminaires for the project shall be the same type and design unless the plans specify otherwise.

1. The luminaire and all components shall be UL or ETL listed for wet location and shall have minimum ingress protection rating of IP66.

2. The light source shall be composed of LED modules connected to a non-integrated driver and be ready for connection to a production line luminaire. Luminaires utilizing integrated driver LED light sources, screw-based products, or panel retrofit products shall not be used.

3. The luminaire shall have a Type II, III, or IV distribution for non-median mounted luminaires, and Type II, III, IV or V distribution for median mounted luminaires.

4. Transmissive optical components shall be applied per LED manufacturer's Original Equipment Manufacturer (OEM) design guidelines to ensure suitability for the environment where the luminaire is installed.

5. Luminaires shall utilize an adjustable slipfitter-type mounting system for installation on 1.25-inch (1.66-inch outer diameter (o.d.)) to 2-inch (2.375-inch o.d.) diameter pipe tenons. Slipfitter shall consist of a two-piece clamp and four 9/16-inch hex bolts. Slipfitter shall allow for a vertical tilt adjustment of plus or minus 5 percent in order to mount luminaire plumb to foundation for a U0 rating (no uplight). Luminaires shall be equipped with integrated leveling bubble.

6. Access to all internal parts requiring replacement shall not require tools ("tool-less entry").

7. The luminaire housing shall be constructed of aluminum alloy.

8. The power supply and driver shall be provided in compliance with subsection 715.05. The dimming driver shall be internal and thermally separated from the LED compartment.

9. The dimming 7-pin photocell receptacle shall conform to subsection 715.04(d) below.

10. The luminaire finish shall be corrosion resistant super triglycidyl isocyanurate (TGIC) polyester powdercoat. The color shall be gray or as specified per the project.

    A. Powder coat: super TGIC polyester powder coat 2.5 mil nominal thickness.

    B. Finish shall exceed a rating of 6 per ASTM D1654 after 1,000 hours of testing per ASTM B117.

    C. The coating shall exhibit no greater than 30 percent reduction of gloss per ASTM D523, after 500 hours of ultraviolet (UV) testing at ASTM G154.

11. The effective projected area (EPA) for wind-loading calculations shall be no greater than 1.2 square feet.

12. The luminaire weight shall not exceed 45 pounds.

13. The luminaire shall be tested per IES LM-79 and TM-21 certifying photometric performance and rated life, respectively. IES LM-79 (performance) and TM-21 (predicted life at 55°C) testing shall both be for the same luminaire's operating drive current.

14. The luminaire shall have a maximum Backlight rating as shown in Table 715-1, an Uplight rating of U0, and a maximum Glare rating as shown in Table 715-1.

15. The luminaire system efficacy shall not be less than 85 luminaire lumens per input watt.

16. The luminaire shall have an external label per ANSI C136.15 and internal label per ANSI C136.22.

(c) Light Sources. LED luminaires shall not be retrofit to existing luminaire housing; the Contractor shall replace the housing along with the luminaire as a single unit. Light sources shall be compatible with dimmable drivers supplied with the luminaires where they are to be installed. The same manufacturer shall provide all light sources of a similar type.

LED light sources shall meet or exceed the following requirements:

1. CCT, CRI and Flux:

    A. Correlated Color Temperature (CCT) – All LED light sources shall emit white light and have a CCT no greater than 3,400K nominal per ANSI C78.277.

    B. Color Rendering Index (CRI) – All LED light sources shall have a minimum Color Rendering Index (CRI) of 70 per the IES LM-79 test results.

    C. Luminous Flux – LED light sources shall not exceed the junction temperature recommended by the LED manufacturer. Luminous flux differences between LEDs shall not exceed 10 percent.

2. LEDs shall have a minimum rated life of 70,000 hours per IES TM-21 at 55 °C at the normal operating driver current for the specific luminaire. The lumen output shall be maintained at 70 percent of initial rated lumens (L70) or greater at the rated life of the luminaire.

3. LEDs shall be temperature rated for operation and storage within the range of -40 °C to +50 °C and shall withstand low and high frequency vibration (ANSI C136.31 Vibration Level 3G) over the rated life of the light source.

4. Cooling System

   A. Mechanical design of protruding external surfaces (heat sink fins) shall facilitate hose-down cleaning and discourage debris accumulation.

   B. The cooling system must be passive utilizing heat sinks, convection or conduction.

   C. Fans, diaphragms, pumps, or liquids shall not be used.

(d) Photocontrol Receptacle. Each roadway luminaire shall be furnished with a 7-pin multi-contact twist-lock outdoor lighting dimming receptacle per ANSI C136.41.

715.05 LED Drivers. LED drivers shall conform to the following:

(a) Dimming signal protocols are 0-10V direct current (DC) or Digital Addressable Lighting Interface (DALI).

(b) The operating voltage shall be 120/277-volt at 50/60 Hz, and the driver shall operate normally with input voltage fluctuations of plus or minus 10 percent, consistent with NEMA SSL-1, Electronic Drivers for LED Devices, Arrays or Systems.

(c) The minimum power factor (PF) shall be 0.90 at full input power and across specified voltage range.

(d) The maximum total harmonic distortion (THD) shall be 20 percent at full input power and across specified voltage range.

(e) The factory-set drive current shall be 700A or less unless approved by the Project Engineer. If higher drive currents are proposed, the submittal must be accompanied with IES LM-79 and TM-21 test results for higher operating drive current.

(f) Drivers shall be at a minimum Restriction of Hazardous Substances (RoHS) 1 compliant.

(g) The rated case temperature for operation and storage shall be rated for up to plus 85 °C. The LED driver shall be rated for an ambient operating temperature within the range of minus 40 °C to plus 50 °C

(h) All electronics of the power supply shall be protected from all electrical surges with an elevated(10kV) electrical immunity rating including, but not limited to, lightning strikes and stray current in rebar and concrete. Surge protection shall be integral to the LED power supply.

(i) The luminaire, including driver, shall consume no more than 4 watts in the off state power.

1. Electrical immunity (including surge protection): The luminaire shall meet the “Elevated” 10kV/5kA requirements per IEEE/ANSI C136.2. The manufacturer shall indicate whether failure of the electrical immunity system can possibly result in disconnection of power from the luminaire.

2. Electromagnetic interference: The driver shall comply with Federal Communications Commission (FCC) 47 Code of Federal Regulations (CFR) part 15 non-consumer radio frequency interference (RFI) and electromagnetic interference (EMI) standards.

715.06 Alternative Power Sources. Electrical power systems not connected to an electrical power grid shall be one of the following:

(a) General. Alternative power source systems shall conform to the following:

1. The assembly shall be UL or ETL listed for wet location and shall have a minimum ingress protection rating of IP66.
2. The assembly shall withstand low and high frequency vibration (ANSI C136.31 Vibration Level 3G) over the rated life the assembly.

(b) Battery. All batteries shall conform to the following and shall be approved by the Project Engineer:

1. General
   A. The battery shall have an extended operating temperature rated for operation and storage within the range of minus 40 °C to plus 85 °C.
   B. The nominal voltage shall be 12V.
   C. Shall have no less than 80 percent capacity after 12 months of storage at 25 °C.
   D. Batteries used for roadway luminaires shall have a minimum rated capacity for three days autonomy without charge, at full light output for the three-day duration.
   E. Batteries shall be rated for a 5-year design life.

(c) Solar Panel. Solar panels shall be n-type, mono crystalline silicon, with greater than or equal to 20 percent efficiency at 25 °C. All solar panels shall be approved by the project Engineer.

(d) Wind Turbine. All wind turbines shall conform to the following and be approved by the Project Engineer.

1. Shall consist of an axial flux coreless permanent magnet synchronous generator.

2. Blade materials shall be reinforced polyamide.

3. Shall include anti-vibration mounts.

4. Shall include regulation to stop turbine from rotating when system is fully charged, or wind gusts are above design speeds.

5. The noise generated by the entire assembly shall be less than 55dBA at the adjacent edge of right of way.

715.07 Conduit. Unless otherwise specified, conduit shall be rigid metallic or semi-rigid plastic electrical conduit. Metallic conduit shall be clean, free of burrs, and galvanized.

Plastic conduit shall be a semi-rigid type currently recommended and UL listed for the proposed use. Underground plastic conduit for street lighting shall conform to ASTM F441 schedule 80. Fittings shall be the type used outside the conduit. Fittings shall connect the conduit in a manner that makes the joints watertight.

Junction boxes used in structures shall be galvanized steel, 6 inches square by 4 inches deep, with weatherproof covers.

Pull boxes and splice boxes shall be a minimum of 13 inches by 24 inches and 12 inches deep, sized per NEC 314 and CDOT Standard S-613-3. Pull and splice boxes shall have heavy-duty weatherproof covers rated for roadway applications. The housing shall be resistant to sunlight exposure, weathering, and chemicals; it shall be unaffected by freeze/thaw cycles. Covers shall fit flush to the sidewalk, turf area, or roadway surface. Hardware and inserts shall be stainless-steel. The cover for street lighting circuits shall be marked “ELECTRICAL” or “STREET LIGHTING”. The cover shall list the minimum HS load rating of 22,500 psi.

715.08 Lighting Circuitry and Wiring. All wiring shall be copper with 600-volt insulation, rated for outdoor use. Wire sizes #14 AWG through #10 AWG shall be solid copper. Wire sizes #8 AWG and larger shall be stranded copper; except, service ground conductors to grounding electrodes shall be #4 stranded, insulated copper. All conductor sizes shall be, at minimum, sized to the breaker amperage feeding the circuit per NEC Table 310.16.

A breakaway submersible, in-line fuse holder and fuse for each hot conductor and breakaway submersible connector shall be installed on the neutral if a neutral is required. The grounding wires shall not be fused or breakaway.

Fuse connectors shall be installed in the phase wires of their respective circuits at the junction box located as a back box to the luminaire or within the pole base or transformer base. The Contractor shall provide sufficient excess conductor length to allow withdrawal of the connected fuse holder from the hand hole. Fuses and fuse holders shall be UL listed and shall be installed in such a manner that the fuse stays with the load side when holder is separated. The Contractor shall form loops in the leads on each side of the fuse holders and so position the fuse holders that they may be easily removed or inserted through the opening of hand hole. All electrical apparatus used in the lighting system shall be rated to adequately handle the necessary loads and shall conform to power source requirements.

Bonding and grounding electrodes shall conform to the requirements of subsection 613.08.

715.09 Secondary Service Pedestals, Lighting Control Centers, and Meter Power Pedestal. Secondary Service Pedestals, Lighting Control Centers, and Meter Power Pedestals shall be metal conforming to ANSI C47.12.28, Pad Mounted Enclosure Integrity Standard and shall be the nominal size and dimensions shown in the Contract.

The cabinets shall be constructed of 12-gauge corrosion-resistant steel with hoods and covers constructed of 14-gauge corrosion-resistant steel. Cabinets shall be MEMA 3R or NEMA 4 construction and shall be UL listed as “Enclosed Industrial Control Equipment” (UL508A). Cabinets shall be vandal resistant dead-front enclosures.

The cabinet’s external finish shall be polyurethane industrial grade powder paint of 1.7 mil minimum thickness. The cabinet's internal finish shall be polyurethane industrial grade powder paint of 1.7 mil minimum thickness or bare aluminum.

All external fasteners, rivets, screws and bolts shall be stainless-steel. Fasteners, except sealing screws, shall not be removable by external access. Hinges shall be stainless-steel continuous piano hinge type hinges.

External nameplates shall be permanently attached to the cabinet. A stainless-steel handle shall be provided on the front exterior of each cabinet door or hood. Cabinet shall be equipped with a three-point latch. All handles shall be pad lockable per CDOT Maintenance requirements.

The cabinet shall have separate isolated sections for metering equipment (if required), utility termination, and CDOT equipment. All sections must be sealed and pad lockable. The metering section shall have a hinged swing back hood with an integral hinged polycarbonate sealable window for visual access to meters. The utility termination section shall be sealed and securable with a padlock. The section shall have a lift off cover with a stainless-steel handle. Sufficient clearance shall be provided for a 4-inch diameter conduit for utility cables. Utility landing lugs shall be UL listed and shall accommodate 6, #350 kcmil conductors. An optional meter fusible disconnect ahead of the meter shall be provided for utility companies that require them.

The CDOT compartment door shall be sealed and securable with a padlock. The compartment door shall be anchorable in an open position. There shall be a print pocket on the inside of the door. The print pocket shall hold all wiring schematics and instructions in a clear weatherproof sleeve with a side opening. Required UL labeling shall be located on the inside of the CDOT door. Distribution and control equipment shall be behind an internal dead-front door with a quarter-turn securing latch and be hinged to open more than 90 degrees. The dead-front door shall be hinged on the same side as the CDOT section door.

Pedestal mounting bolts shall not be visible or accessible externally. Pedestal mounting shall include pedestal mounting base and hardware. Pad mounting shall include concrete pad mounting base, anchor bolt kit and hardware.

Secondary service pedestals, lighting control centers, and meter power pedestals shall be rated for 600 VAC, installed with protection against damage from greater currents. The pedestals and centers shall be grounded with grounding electrodes in conformance with the current edition of the National Electric Code (NEC). The following equipment is for a typical installation and may or may not be required as shown on the plans:

(1) Fusible meter disconnect ahead of meter (optional per utility company requirements).

(2) Service meter pedestal or a meter socket. The Project Engineer per the CDOT region requirements shall confirm location of meter. The meter shall confirm to the utility company requirements.

(3) Service main circuit breaker that is installed in a circuit load center as sized on the plans.

(4) Circuit load center with an all-copper bus for CDOT loads.

(5) Circuit breakers.

(6) Ground fault circuit interrupter receptacle (GFCI) (20 amp, 120 VAC NEMA 5-20R).

(7) Multiple pole light contactors.

(8) Test switch.

(9) Photoelectronic control with exterior mounted 3-prong twist-lock receptacle.

(10) Mounting pans or false backs for circuit breakers, contactors, relays, switches, transformers, and other types of electrical equipment mounted inside the cabinet.

(11) 18” snow skirt (floor stand kit), optional per the Project Engineer’s requirements.

(12) Cabinet style HVAC unit (heating, ventilation, and air-conditioning), optional per the Project Engineer’s requirements.

The internal wiring of cabinets shall be assembled by a UL listed facility or by a licensed master electrician, using UL listed components. Cabinets shall conform to one or more of the following standards where appropriate: UL 50, Cabinets and Boxes; UL 67, Panel Boards; UL 869A, Service Equipment; and UL 508A Standard for Industrial Control Panels.

Circuit breakers and equipment shall be labeled with an engraved permanent label on the dead-front panel to indicate the circuit controlled.

Multiple Pole Light Contactors shall be "lighting" type, specifically rated for the type of lighting load specified. The contactors shall have a 600-Volt rating. All multiple pole light contactors shall be unenclosed, single phase with the number of poles specified on plans; they shall be open type lighting contactors with the rating shown or specified. Contactors shall be constructed for surface mounting on a false back or bracket within a weatherproof cabinet. The contactor coil shall operate on 120 Volt for 120/240 Volt circuits and 277 Volt for 277/480 Volt circuits. Contact material shall be designed for LED driver loads and require no maintenance such as filing, burnishing, or dressing at any time the contactor is in service.

A 277 VAC rated test switch or hand-off auto (HOA) switch shall be installed in the control cabinets if shown. The test switch shall be a heavy-duty single pole switch or circuit breaker rated at 20 amps and shall be installed in the control cabinet as a roadway lighting test switch. The switch shall be wired to shunt the photoelectric control relay power contactor and energize the lighting circuit contactors. The HOA switch shall be single or double pole, double throw, center off with 15A contacts. The HOA switch shall be wired to the photocell control when switch is in the Auto position, lighting contactor(s) shall close when photocell in in low light closure. HOA shall be wired to energize the lighting contactor(s) closure when the HOA is in the Hand position. The HOA's off position will turn off the control circuit.

All components of the photoelectric control relays shall be housed in a weatherproof, locking, non-rusting container. The photoelectric control relay shall be rated for long life LED loads and attach to a three-prong locking receptacle by a twisting motion.

The photoelectric control relay shall meet or exceed the requirements of ANSI C136.10. The photoelectric control shall be factory set to turn on lights when ambient lighting levels fall to 1.4 foot-candles plus or minus 0.2 foot-candles when operated at 120 VAC. When operated at 250 VAC, turn on shall not change more than plus or minus 0.3 foot-candles from the 120 VAC value. The maximum off to on ratio shall be 1.5:1. The photoelectric control shall be a cadmium sulfide photoelectric control encapsulated for humidity protection, or a silicon junction type phototransistor. The photoelectric control shall be designed for normal operation at a dual voltage of 105 V and 285 V. Power consumption shall be less than 1 watt. At the designated voltage, the photoelectric control shall be capable of controlling a minimum load of 1000 watts. Minimum operating temperature range shall be from minus 40 °C to plus 65°C. A time delay control circuit shall prevent false turn offs by transient lighting conditions. The unit shall include a failsafe circuit for the lighting load such that the lighting systems remain energized if any functional failure of the photoelectric control circuit occurs.

715.10 Heavy Duty Safety Switch. All switches shall be heavy duty rated. Switchblades and jaws shall be fixable and plated copper. Switches shall have a pad lockable handle. Switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position (except for double-throw switches). Defeater mechanism shall be front accessible. Switches shall have deionizing arc chutes. Switch assembly and operating handle shall be an integral part of the enclosure base.

Switches rated 30 A to 600 A shall have reinforced, rejection type fuse clips. Switchblades shall be readily visible in the "ON" and "OFF" position. Switch operating mechanism shall be non-teasible, positive quick-make/quick-break type. Bail type mechanisms are not acceptable. Fusible switches shall be suitable for service entrance equipment (except for 4-pole switches and 1200 A when used on 480Y/277 wye systems). Switches shall have line terminal shields (except for non-fusible double throw switches).

Switches shall be suitable for systems capable of 200 kA at 480 V with Class J, L, R, or T fusing as applicable for single-throw switches; 100 kA at 600 V for double-throw switches. Embossed or engraved ON-OFF indication shall be provided. Double-make, double-break switchblade feature shall be provided. Fuse pullers shall be provided on all NEMA 3R, 4X and 12 switches through 200 A. Renewal parts data shall be shown on the inside of the door.

All enclosures shall be NEMA 3R unless otherwise noted. Other types, where noted, shall be NEMA 4X watertight corrosion-resistant 316 stainless-steel or NEMA 12 dust-tight and oil-tight special industry (dual NEMA 12/3R rating through 800 A). All enclosures shall have a factory installed ground terminal block. Nameplate shall be front cover mounted, containing a permanent record of switch type, ampere rating, and maximum voltage rating. 30 A to 100 A, NEMA 4X or NEMA 12 enclosures shall be provided with draw-pull latches.

SECTION 716
WATER LINE MATERIALS

716.01 Cast Iron Pipe. Cast iron pipe shall conform to the requirements of Federal Specification WW-P-421, Class 150 with Type III mechanical joints.

716.02 Welded Steel Pipe. Welded steel pipe shall be of the length, diameter and metal thickness shown on the plans and shall conform to the following:

(1) Pipe shall conform to the applicable requirements of AWWA Standard C 200, Section 3, manufactured from steel sheets conforming to ASTM A1011, Grade 33 or 36, plates conforming to ASTM A283 Grade C or D, or ASTM A572 Grade 42; or it shall be manufactured to meet the requirements of ASTM A53, Grade B or ASTM A139 Grade B or C.

(2) Surface Preparation and Coating. Inside and outside surfaces shall be blast cleaned with sand, steel grit, steel Shot or a combination of steel grit and steel shot to remove mill scale and rust, per subsection 509.24(b). Pipe that is cement mortar lined per AWWA Standard C205 shall not be blast cleaned. Paint and coating schedule for pipe larger than 10 inch shall conform to Table 716-1.

TABLE 716-1
FOR PIPES CARRYING POTABLE WATER

Pipes to be disinfected after installation, per AWWA Standards

Buried Pipe		Exposed Pipe	
Interior	**Exterior**	**Interior**	**Exterior**
Lined with cement mortar per AWWA Standard C 205	80 mil thickness tape coating systems for the exterior of steel water pipelines per AWWA Standard C 214	Lined with cement mortar per AWWA Standard C 205 or coal tar epoxy per Corps of Engineers C 200	Subsections 509.24 and 509.29

TABLE 716-2
FOR PIPES CARRYING NON-POTABLE WATER AND FOR SEWERS

Buried Pipe		Exposed Pipe	
Interior	**Exterior**	**Interior**	**Exterior**
Lined with cement mortar per AWWA Standard C 205 or coal tar epoxy per Corps of Engineers C 200	80 mil thickness tape coating systems for the exterior of steel water pipelines per AWWA Standard C 214	Lined with cement mortar per AWWA Standard C 205 or coal tar epoxy per Corps of Engineers C 200	Subsections 509.24 and 509.29

Type of pipe and its coating for pipe 10 inch and smaller shall be as shown on the plans.

Bell and spigot ends with rubber gaskets, flanges, mechanical couplings, or field-welded joints may be used, as conditions require to join the pipe.

All field welds shall conform to Section 509 and shall have linings and coatings replaced equal to the original coating. Wire brushing shall be used where necessary to clean the pipe.

Where cement mortar lining is used with welded joints or bell and spigot ends with rubber gaskets, the joint cut back shall be mortared after the pipe has been laid. This cement mortar lining and application shall conform to AWWA Standard C 205.

On buried pipe coated with a tape coating system conforming to AWWA Standard C 214, the field joints shall be cleaned, primed, and wrapped with two thicknesses of 35-mil cold applied elastomeric joint tape conforming to AWWA Standard C 209, Type 11.

Damage to the pipe lining or coating due to the Contractor's operation shall be repaired at the Contractor's expense.

716.03 Galvanized Pipe. Galvanized pipe and fittings shall conform to the requirements of ASTM A53.

716.04 Copper Pipe. Copper pipe shall conform to the requirements of ASTM B88, Type "K" and shall be annealed. Pipe shall be supplied with solder type fittings.

716.05 Plastic Pipe. Polyethylene pipe (PE) shall conform to the requirements of ASTM D2104 when size, type, and schedule or series are designated or ASTM D2239 when size and pressure ratings are designated. Polyvinyl Chloride pipe (PVC) shall conform to the requirements of ASTM D1785 when size and schedule are designated or ASTM D2241 when size and pressure ratings are designated.

All plastic pipe used as water pipe must bear the National Sanitation Foundation (NSF) seal of approval.

716.06 (unused)

716.07 Valves and Valve Boxes. Valves shall be designed to exceed the required working pressure of the water line but shall not be less than the values.

(a) Gate Valves.

1. General. Valves shall have non-rising stems, unless otherwise specified, with inside screw and shall open to the left or counterclockwise. Valves shall be equipped with double O-ring stem seals conforming to AWWA C500. All valves shall have the manufacturer's names, catalog number and working pressure molded or stamped thereon. Valves shall be painted as specified in AWWA C500, Section 27, and shall be furnished complete with all accessories. Ends of valve shall fit the pipe or fitting where attached (push-on, mechanical, bell-and-spigot or flanged).

   Gate valves shall be for buried service; however, they shall be protected against freezing above the frost line.

2. Valves Smaller than 3 Inch. Valves shall be of the wedge-disc type with non-rising stem, screw ends and bronze body. Metal composition of the body, centerpiece and other cast parts shall be cast bronze meeting the requirements of ASTM B62. All packing shall have each ring cut to fit, with staggered joints. Continuous (spiraled) packing shall not be used. Valves shall be provided with handwheels and stuffing box glands. Unless otherwise specified, valves shall be for 200-pound water service.

3. Valves 3 Inch and Larger. Valves 3 inch and larger shall conform to AWWA C500, except that they may be furnished with 2-inch square operating nuts or hand-wheels.

   Bypasses, when required, shall conform to the details shown on the plans or established.

   The intended position of the valve in the water line (either horizontal or vertical) shall be as shown on the plans.

(b) Other Valves. Butterfly valves, globe valves, air relief valves, check valves, tapping valve and sleeve and other appurtenances shall be as shown on the plans.

(c) Valve Boxes. Unless otherwise specified or shown on the plans, valve boxes shall be of the adjustable screw type, complete with drop cover.

SECTION 717
REST AREA AND BUILDING MATERIALS

717.01 General. All materials and equipment shall be new and shall be of recognized standard quality.

717.02 Masonry and Masonry Wall Reinforcement.

(a) Masonry. Concrete blocks or concrete ornamental blocks shall be lightweight aggregate concrete blocks conforming to ASTM C129, Type 1. Corner block shall be installed at all wall openings. All block shall be uniform in color and be smooth textured. Ornamental block shall be of the type as scheduled on the plans.

Structural glazed tile shall be of the types, color, and sizes shown on the plans.

Face brick shall be 2 1/4 inch x 3 5/8 inch x 7 5/8 inch (nominal 8 inch) modular size brick. Brick required at ends of rowlock shall be solid brick (no holes). All face brick shall conform to ASTM C216, Grade SW Type FBS (rough). The style of brick to be used shall be as scheduled on the plans.

(b) Masonry Wall Reinforcement. Masonry wall reinforcement for curtain walls, shelter wall panels and information center wall panels shall be ladder type for 6-inch wall, 9 gauge, galvanized, with deformed side rods.

"Z" ties for cavity walls of building shall be 3/16 inch x 6-inch galvanized rod.

Corrugated wall ties shall be 7/8 inch x 7-inch x 20 gauge galvanized steel.

717.03 Mortar for Masonry and Structural Glazed Tile. Mortar shall conform to subsection 704.04. Coloring shall be added to the mortar for the face brick to yield a mortar compatible with or approximating the color of the face brick.

Remixing or retempering of mortar will not be permitted.

Waterproofing compound shall be used in all mortar. Mixing waterproofing compound with mortar shall be in strict accordance with the manufacturer's instructions.

717.04 Metal Specialties.

(a) Metal Toilet Stalls. Metal compartments for toilet rooms shall be of the type and style as scheduled on the plans.

Each toilet compartment shall be furnished with a cast alloy chrome plated Combination Coat Hook and Bumper and a chrome plated, single-fold type toilet paper dispenser.

(b) Mirrors. Mirrors shall have clear anodized aluminum or stainless-steel vandal-proof frames with finish similar to #44 satin stainless-steel. Corners shall be mitered and reinforced. Mirror glass shall be 1/4 inch thick, #1 quality polished plate, 18-inch-wide x 24-inch-high, of the type and style as scheduled on the plans.

717.05 Sanitary Napkin Disposal. Sanitary napkin disposal shall be of the type and style as scheduled on the plans.

717.06 Doors, Frames and Windows. General. All steel doors, door frames and windows shall be as scheduled on the plans.

All doors shall be full flush type, with no exposed seams.

(a) Frame and Window Construction. All frames shall be No. 16-gauge steel, with 2-inch face, 1/2 inch or 5/8 inch integral stops and 5 1/2 inch or 5 3/4 inch depth.

Window frames and door frames shall be shipped as "set up," when welded units are used, with all comers and intersections welded and ground smooth. Frames may be knocked-down when units with steel tabs are furnished. Window frames shall have bottom panels of heights shown on the plans.

Hinge jambs shall be mortised for 4 1/2 inches x 4 1/2 inches template hinges and prepared for the ANSI Universal lock strike or approved equal.

(b) Door Hardware. Hardware shall be reinforced and completely prepared for field attachment into drilled and tapped holes.

All hardware, whether specifically mentioned or not, required to fully complete the work as shown on the plans and in the specifications, shall be included and of the same type and quality as that specified.

All hardware shall be as scheduled on the plans. Lockset shall conform to Federal Specification FF-H-00106b, Series 86C-4 where applicable and shall be mortise type. Finish of all hardware shall be U.S. 10 as identified in Fed. Spec. FF-H-00106b, Section 6.8, Table II.

(c) Hardware Sets. For hardware locations refer to the door schedule on the plans.

(d) Keying. All doors shall be keyed alike. Three keys shall be furnished per building.

717.07 Ceramic Tile. Unless otherwise specified, all tile shall conform to ASTM C126.

All floor tile shall be delivered to the job in unopened, sealed containers. They shall be accompanied with a certificate of grade signed by the manufacturer and the Contractor, together with adequate identification of the containers.

Ceramic floor tile shall be of unglazed tile of the style and pattern as scheduled on the plans. Ceramic tile for the Mosaic shall be 1-inch x 1-inch squares and part squares. The colors and placement shall be as shown on the plans.

The Contractor shall submit samples to the Engineer for approval, in duplicate, of each kind of tile proposed for use. When approved, one sample shall be retained for comparison with the finished work.

717.08 Roofing, Flashing and Roof Insulation. General. All roofing materials shall bear the manufacturer's label on sealed packages. All insulation shall be marked for proper identification.

Asphalt for applying roofing shall conform to ASTM D312, Types I, and III.

Felt for roofing shall be Type II (30-pound type) (not perforated) for the base sheet, and Type I (15-pound type) (perforated) for additional layers. Felt shall conform to ASTM D226.

Roofing aggregate shall meet the quality requirements of subsection 703.02 and shall be graded uniformly with 100 percent passing the 19.0 mm (3/4 inch) screen and 100 percent retained on the 4.75 mm (No. 4) screen.

Lumber shall be construction grade or better, Douglas Fir, Larch or Hemlock.

Shingles shall be good grade (No. 2) cedar shingles, with a weight of at least 36 pounds per bundle.

All membrane roofing shall be four ply. Lumber roofing shall be as shown on the plans.

All joints shall be sealed with a two-component type, polysulfide-base synthetic rubber sealant or an approved equal. Sealant shall meet the requirements of ANSI A116.1, Class B. Primer shall conform to the requirements of the manufacturer of the sealant used.

Joint filler used as back up for sealant shall be plastic foam joint filler.

Care shall be taken to ensure that back-up material shall not contain any asphalt. (Asphalt is incompatible with this type sealant).

717.09 Carpentry. Ceiling panels, adhesive for panels, moldings to conceal joints, corners and intersections of panels and walls, color and style of panels shall be as scheduled on the plans.

717.10 Interior Insulation. All insulation, except that required for roof or in frame walls, shall be expanded polystyrene having a “K” factor of 0.26 (average) at a mean temperature of 70 ˚F and a Perm rating of 1.2 or less, with thicknesses as shown on the plans. Adhesive for bonding the insulation to the masonry walls shall be an asphalt emulsion material that is acceptable to the manufacturer of the insulation. Insulation required for underside of roof or in-frame walls shall be blanket-type fiberglass, thickness as shown on the plans with a density of 3/4 pound per cubic foot and shall have a vapor barrier of the embossed vinyl, scrim reinforced, aluminum foil type.

717.11 Glass and Glazing. All glass shall be obscure type, 1/4 inch thick, rough one side and polished one side or as called for on the plans.

All glass shall bear the identifying label of the manufacturer.

717.12 Trash Receptacles. The trash receptacles shall be of the type and style as scheduled on the plans. Each receptacle shall be furnished with 25 disposable polyethylene liners.

Receptacles shall be painted with baked enamel finish, Metallic Gray bottom and Sea Mist top.

717.13 Paint and Special Coating. The special makes of prepared paints, sealant or special coatings that may be specified or otherwise required must be delivered in the original package with the seals unbroken and labels attached.

717.14 Plumbing. The sanitary drainage system within the building and to the septic tank or sanitary hookup shall be made of standard weight cast iron soil pipe. The pipe shall be furnished in standard lengths with inner and outer surfaces concentric, smooth inside and free from defects. Any pipe cracked in cutting shall be removed.

Cast iron pipe, including bell, shall weigh at least the following average weights per 5-foot of length:

Table 717-1

PIPE WEIGHT PER 5-FOOT LENGTH

2-inch	20 pounds
3-inch	30 pounds
4-inch	40 pounds
6-inch	65 pounds

Fittings for cast iron pipe shall be standard design fittings of the same inside diameter as the pipe with which they are used, and of equal quality and weight in all parts.

Cast iron pipe and fittings shall conform to Commercial Standard CS 188 for Standard Weight Cast Iron Soil Pipe and Fittings.

Lead for caulking joints in cast iron pipe shall be soft pig. All oakum shall be pitched. Use 12 ounces of lead for each 4-inch diameter of pipe used.

All hot and cold-water piping and supply lines above grade shall be Type L, copper pipe with sweated and brazed fittings. Pipe, valves and fittings shall be of Bridgeport, Case or Mueller, or an approved equal. Connections involving different metals shall require a dielectric union. Solder shall be 95.5 tin and antimony and shall be applied as per manufacturer's instructions.

Underground water lines under concrete slab of the building shall be ASTM B88, Type “K” hard drawn copper pipe with brazed fittings. Brazing material shall be silver solder.

Pipe for sewage vent lines shall conform to the Colorado Plumbing Code. A suitable vent screen shall be provided for each vent line.

Underground water line to building, sanitary station and trailer pad shall be 100-psi pressure rated, virgin polyethylene pipe.

Fittings shall be of polyethylene or nylon with stainless-steel clamps. All pipe and fittings shall be approved by the National Sanitation Foundation and shall bear that mark.

717.15 Heating and Ventilating.

(a) Heaters. The wall heaters shall be of the make and model scheduled on the plans.

The forced air furnace shall be of the make and model scheduled on the plans with adjustable pulley type belt drive blower. Motor shall be 120 V/60 cycle single phase. Furnace shall be complete with cabinet, electric heating section, blower, filters, motor, belt drive, adjustable pulley on motor, safety controls, relays, and all other items as may be incidentally required for a complete and ready to operate installation. Capacity shall be as indicated on the plans.

(b) Grills. Grill location, model, style and sizes shall be as shown on the plans.

(c) Thermostat. Thermostats shall be as specified under electrical work in subsection 717.16.

(d) Exhaust Fan and Curb. Exhaust fan shall be of the make and model scheduled on the plans. Fan shall be mounted on a prefabricated curb equipped with automatic back draft damper. Fan shall be operated by a timer. Fasten curb directly on top of sheathing.

(e) Duct Work. Duct work shall be fabricated from galvanized steel sheets per recommended practice as outlined in the current edition of the American Society of Heating, Refrigeration and Air Conditioning Engineering Guide. Aluminum may be used at the Contractor's option and shall conform to gauge shown in the table below. All duct work shall be fabricated from the one material selected by the Contractor.

The following sheet gauges and thicknesses shall be used throughout:

Table 717-2

DUCT WORK SHEET GAUGES AND THICKNESS

Maximum Side (Inch)	Steel U.S. Gauge	Aluminum Thickness (Inch)	Type Of Transverse Joint*	Bracing
Up to 12	26	.020	S, Drive Pocket or Bar Slips, on 7"-10" centers	None
13 to 18	24	.025		None
19 to 30	24	.025		1" x 1" x 1/8" at 60"

* Other joint connections of equivalent mechanical strength and air tightness may be used.

The flat side of all ducts shall be cross broken.

All horizontal ducts are to be supported with angle iron hangers secured to the construction above, at intervals not to exceed 7 feet 10 inches. All vertical riser ducts shall be supported at floor and ceiling with angle iron rests secured to the ducts.

(f) Outlets, Inlets and Vents. All outlets, inlets and vents shall be of the type and style called for on the plans, or an approved equal.

717.16 Electrical.

(a) Conduit. Conduit below grade, finish floor elevation, or embedded in concrete shall be rigid steel, hot dipped, sherardized or galvanized, unless otherwise specified. Each length of conduit shall be stamped with the name or trademark of the manufacturer and shall bear the Underwriter's Laboratories, Inc. label.

Thin wall electrical metallic tubing conduit will be permitted above grade, unless otherwise noted on the plans.

(b) Conduit Fittings. Conduit fittings shall be compatible with the conduit furnished, with cast covers and where installed exposed to the elements, shall have vellum or fiber gaskets.

(c) Conductors. All 120 and 220-volt wire and cable shall be single conductor, soft drawn, copper wire with 600-volt insulation. Type TW shall be used for overhead runs. Type THW shall be used in runs under floor slab inside building.

Cable serving water wells may be one cable of three conductors, Type USE; three single conductors, Type USE, placed in the same trench; or two conductors Type UF, with ground wire. The wire size shall be as shown on the plans with no splices below ground.

Cable serving outdoor lighting may be one cable of two conductors Type USE or two single conductors, Type USE placed in the same trench. The wire size shall be as shown on the plans with no splices below ground.

Main service cables shall be Type USE. Wire size shall be as shown on the plans for direct burial type. Cable sheathing and insulation shall conform to ASTM D4227. Splices will not be allowed between the utility pole and the main circuit breakers at building.

All wire smaller than #10 AWG, shall be solid copper and all wire #10 AWG and larger shall be stranded copper wire.

Aluminum wire will not be allowed. Wire size not shown on the plans shall be sized according to the requirements of the National Electric Code.

(d) Thermostat. Thermostat for controlling furnace or wall heaters shall be of the low voltage type.

Thermostat for operating emergency light shall be 32-90 ˚F range, heavy duty, line voltage type, to make contact on temperature drop.

(e) Emergency Light. The emergency light shall be weatherproof, with guard, red glass globe, gasket and 6 volt, 25 watt, medium base extended service lamp.

(f) Device Plates. Device plates in Utility room shall be pressed steel to suit the device to be covered. Device plate in restrooms shall be stainless-steel type 430.

(g) Emergency Battery Charger. The charger shall be 6 volt, 50-amp hour rated, operating on 110-120-volt AC, 60 cycle, without lights, mounted on a bracket supplied by the manufacturer, complete with fast charge ammeter, trickle charge millimeter, test switch and pilot lights. The battery shall be 6-volt plastic or glass jar lead acid type. All shall be mounted in a 20-gauge minimum steel cabinet, adequately ventilated by louvers.

(h) Disconnect Switches. All safety switches shall be S/N, fused, and Type "ND" construction as prescribed by the National Electrical Code. Weather-proof housing for exterior switches shall be provided.

(i) Timer. Timer for exhaust fan shall be 10 ampere, SPDT, 120 V for intermittent operation. A 24-hour dial with 96 tabs to permit 15-minute switching changes shall be provided.

(j) Miscellaneous. Lighting switches, receptacles, hand dryers, photoelectric cells, contactors, switches, panels, lighting fixtures, area luminaires and poles shall be the style, type and color as scheduled on the plans. Note: The Contractor shall furnish the Engineer three portfolios (bound copies) containing names of manufacturers, cuts and curves of all lighting fixtures to be used on the project within 30 days after approval of all materials has been made. The portfolios shall be made on 8 1/2 inch x 11 inch sheets, with cuts glued on and fixtures identified by number as per specifications. These portfolios will not be returned and will become the property of the Department.

717.17 Sewer, Septic Tank, Leaching Field, Sanitary Station and Sewer Lift Station. Concrete reinforcing steel, concrete pipe and sewer piping (vitrified clay, plastic, and cast iron) and associated construction methods shall be as specified under the appropriate subsections of Section 600 or 700.

Cast iron manholes and waterstops for septic tanks and water tower and hatch for trailer sanitary station shall be the type and size as scheduled on the plans.

The gravel material used for leaching fields shall be crushed stone, crushed or natural gravel meeting the following grading requirements:

Table 717-3

LEACH FIELD GRAVEL MATERIAL GRADATION

Sieve Size	Mass Percent Passing Square Mesh Sieves
25.0 mm (1 inch)	100
19.0 mm (3/4 inch)	95-100
4.75 mm (No. 4)	0-5