

**SECTION 700  
MATERIALS DETAILS**

**SECTION 701  
HYDRAULIC CEMENT**

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

<b>Type</b>	<b>Specification</b>
Masonry Cement	ASTM C 91
Portland Cement	ASTM C 150
Blended Hydraulic Cement	ASTM C 595
Hydraulic Cement	ASTM C 1157

In addition to the standard chemical requirements for portland cement in ASTM C 150, the maximum percent of equivalent alkalis ( $\text{Na}_2\text{O} + 0.658 \text{K}_2\text{O}$ ) shall not exceed 0.90 percent.

Where either Type I or Type II portland cement is required, blended hydraulic cement conforming to ASTM C 595 Type IP or Type IP(MS) may be used, except that the blended cement shall consist of no less than 70 percent portland cement. Where Type II portland cement is required, blended hydraulic cement conforming to ASTM C 595 Type IP(MS) may be used, except that the blended cement shall consist of no less than 70 percent portland cement. Where blended hydraulic cement is used the substitution of fly ash for the blended hydraulic cement is not allowed.

For concrete where Class F fly ash is required, blended hydraulic cement conforming to ASTM C 595 Type IP or Type IP(MS) may be used, except that the blended cement shall consist of no less than 70 percent portland cement and no less than 20 percent Class F fly ash by weight. The weight of blended hydraulic cement must equal the weight of portland cement plus fly ash.

Where either Type I or Type II portland cement is required, hydraulic cement conforming to ASTM C 1157 Type GU or Type MS may be used. Where Type II portland cement is required, hydraulic cement conforming to ASTM C 1157 Type MS may be used.

Where Type V portland cement is required one of the following may be used:

- (1) Type II portland cement with no more than 5.0 percent  $\text{C}_3\text{A}$  content and no more than 25.0 percent  $[\text{C}_4\text{AF} + 2(\text{C}_3\text{A})]$ .
- (2) Type II portland cement with no more than 0.040 percent expansion at 14 days when tested in accordance with ASTM C 452.
- (3) Type II portland cement with at least 15 percent of the cement replaced with an approved Type F fly ash.
- (4) ASTM C 595 Type IP(MS) blended hydraulic cement consisting of no less than 70 percent portland cement and at least 15 percent Type F fly ash.
- (5) ASTM C 1157 Type HS hydraulic cement.

701.01

Cement shall be from a preapproved source listed on the Department's Approved Products List. The cement intended for use on the project shall have been tested and accepted prior to its use. Certified Test Reports showing that the cement meets the specification requirements and supporting this statement with actual test results shall be submitted to the Engineer.

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 insure that the material meets the specifications.

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which, for any reason, has become partially set or which contains lumps 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 C 618, Class C or Class F. All chemical requirements of ASTM C 618 Table 1 shall apply with the following exceptions:

- (1) Footnote A shall not apply.
- (2) Loss on Ignition shall not exceed 3.0 percent.

Class C fly ash will not be permitted in concrete where Type V portland cement is required.

Fly ash shall be from a preapproved source listed on the Department's Approved Products List. The fly ash intended for use on the project shall have been tested and accepted prior to its use. Certified Test Reports showing that the fly ash meets the specification requirements and supporting this statement with actual test results shall be submitted to the Engineer.

Preapproval shall include submission of a report from the supplier documenting the results of testing the fly ash from that source in accordance with 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 insure that the material meets the specifications.

**701.03 Silica Fume.** Silica fume for concrete shall conform to the requirements of ASTM C 1240.

Silica Fume shall be from a preapproved source listed on the Department's Approved Products List. The silica fume intended for use on the project shall have been tested and accepted prior to its use. Certified Test Reports showing that the silica fume meets the specification requirements and supporting this statement with actual test results shall be submitted to the Engineer. The certification for silica fume shall state the solids content if the silica fume admixture is furnished as slurry.

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 insure that the material meets the specifications.

702.01

**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 Provisional Standard MP1)

**Table 702-1  
SUPERPAVE PERFORMANCE GRADED BINDERS**

PROPERTY	REQUIREMENT FOR PG BINDER					AASHTO Test No.
	58-28	58-34	64-22	64-28	76-28	
<b>Original Binder Properties</b>						
Flash Point Temp., °C, minimum	230	230	230	230	230	T 48
Viscosity at 135 °C, Pa•s, maximum	3	3	3	3	3	TP 48
Dynamic Shear, Temp. °C, where $G^*/\sin \delta @ 10 \text{ rad/s} \geq 1.00 \text{ kPa}$	58	58	64	64	76	TP 5
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	50	-	T 51
Toughness, joules (inch-lbs)	-	-	-	12.4 (110)	-	CPL-2210
Tenacity, joules (inch-lbs)	-	-	-	8.5 (75)	-	CPL-2210
Acid or Alkali Modification (pass-fail)						CPL-2214
<b>RTFO Residue Properties</b>						
Mass Loss, percent maximum	1.00	1.00	1.00	1.00	1.00	CP-L 2215
Dynamic Shear, Temp. °C, where $G^*/\sin \delta @ 10 \text{ rad/s} \geq 2.20 \text{ kPa}$	58	58	64	64	76	TP 5
Elastic Recovery, 25 °C, percent min.	-	-	-	-	50	CPL-2211
Ductility, 4 °C (5 cm/min.), cm minimum	-	-	-	20	-	T 51
<b>PAV Residue Properties, Aging Temperature 100 °C</b>						
Dynamic Shear, Temp. °C, where $G^* \cdot \sin \delta @ 10 \text{ rad/s} \leq 5000 \text{ kPa}$	19	16	25	22	28	TP 5
Creep Stiffness, @ 60 s, Test Temperature in °C	-18	-24	-12	-18	-18	
S, maximum, MPa	300	300	300	300	300	TP 1
m-value, minimum	0.300	0.300	0.300	0.300	0.300	TP 1
**Direct Tension, Temperature in °C, @ 1 mm/min., where failure strain $\geq 1.0 \%$	-18	-24	-12	-18	-18	TP 3
**Direct tension measurements are required when needed to show conformance to AASHTO MP 1.						

Samples of the PG binder for acceptance shall be sampled on the project as stated in the Schedule of 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 D 449, and the asphaltic primer shall conform to the requirements of ASTM D 41.

**702.02 Liquid Asphaltic Materials.** Liquid asphaltic materials shall conform to the requirements of AASHTO M 81, M 82, and ASTM D 2026 for the designated types and grades.

Primer for dampproofing shall meet the requirements of ASTM D 41.

RC-800 (Rubberized) shall be a blend of asphalt cement, rubber, and cutter stock. The asphalt cement shall be blended with a minimum of 1½ percent by weight of rubber prior to adding cutter stock. The final product shall meet the requirements of Table 702-2.

**Table 702-2**

Property	Requirement		AASHTO Test No.
	Min.	Max.	
Flash point °C (°F)	27 (80)		T 79
Kinematic viscosity, 60 °C, mm <sup>2</sup> /s (140 °F, centistokes)	800 (800)	1600 (1600)	T 201
Distillation test:			
Distillate, percent by volume of total distillate to 360 °C (680 °F)			
To 225 °C (437 °F)	15		
To 260 °C (500 °F)	45		
To 316 °C (600 °F)	75		
Residue from distillation to 360 °C (680 °F):			
Volume percent of sample by difference	75		T 78

**702.03 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 seal coats shall be sampled and will be tested for information only according to CP-L 2213, Chip Seal Compatibility.

- (a) Polymerized emulsions for seal coat shall conform to the following requirements for CRS-2P (Cationic, Polymerized) or HFRS-2P (Anionic,

702.03

Polymerized, High Float). CRS-2P or HFRS-2P shall be an emulsified blend of polymerized asphalt, water, and emulsifiers. The asphalt cement shall be polymerized prior to emulsification and shall contain a minimum of 3.0 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. The emulsified blend shall conform to the requirements listed in Table 702-3.

**Table 702-3**

Property		CRS-2P	HHFRS-2P	AASHTO Test No.
<b>Tests on Emulsion:</b>				
Viscosity, at 50°C, Sabolt-Furol, s	min	50	50	T 59
	max	450	450	
Storage stability, 24 hr, % max		1.0	1.0	T 59
Particle charge test		Positive		T 59
Sieve test, % max		0.10	0.10	T 59
Demulsibility, % min		40	40	T 59
Oil Distillate by volume, % max or range		3.0	3.0	T-59
Residue by distillation/ evaporation <sup>2</sup> , % min		65 <sup>2</sup>	65 <sup>2</sup>	T 59/ CP-L 2212 <sup>1</sup>
<b>Tests on residue:</b>				
Penetration, 25 °C, 100g, 5s, min		70	70	T 49
Penetration, 25 °C, 100g, 5s, max		150	150	
Ductility, 25 °C, 5 cm/min, cm, min			75	T 51
Solubility, in trichloroethylene% min		97.5	97.5	T 44
Elastic Recovery, 25 °C min			58	CP-L 2211
Float Test, 60 °C, s min			1200	T 50
Toughness, in-lbs, min		70		CP-L 2210
Tenacity, in-lbs, min		45		CP-L 2210
<sup>1</sup> 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 accordance with AASHTO T-59 to determine acceptability.				
<sup>2</sup> For high float emulsions the distillation and evaporation tests will be in accordance with AASHTO T-59 or CP-L 2212 respectively with modifications to include 205 ± 5°C (400 ± 10°F) maximum temperature to be held for 15 minutes.				

- (b) *Emulsion for Prime Coat.* Emulsion for prime coat shall conform to the following requirements for either Asphalt Emulsion Prime in Table 702-4, or Penetrating Priming Stabilizer in Table 702-5.

**Table 702-4  
FOR ASPHALT EMULSION PRIME**

Property	Requirement	AASHTO Test No.
Viscosity, Saybolt Furol, at 50 °C (122 °F), s	15-150	T 59
Settlement	1% max.	T 59
% Residue	65% min.	T 59 to 260 °C (500 °F)
Oil Distillate by Volume, %	7% max.	T 78
<b>Tests on Residue from Distillation:</b>		
Solubility in Trichloroethylene, %	97.5 min.	T 44
<b>Tests on Residue from Cutback Distillation to 360 °C (680 °F):</b>		
Viscosity, 60 °C, mm/s (140 °F, centistokes)	3,000 (3000) min.	T 202

**Table 702-5  
FOR PENETRATING PRIMING STABILIZER**

Property	Requirement		AASHTO Test No.
	Max.	Min.	
Flash (T.O.C.), °C (°F)	38 (100)		T 79
Saybolt Furol Viscosity at 50 °C (122 °F), s	30	100	T 72
Kinematic Viscosity at 60 °C, mm <sup>2</sup> /s (140 °F, centistokes)	60	212	T 201
Residue by evaporation, %	55		T 59
<b>Tests on residue:</b>			
Penetration, 25 °C (77 °F), 100 g, 5 sec, mm		25	T 49
Softening Point Ring & Ball, °C (°F)		71 (160)	T 53

- (c) *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 prior to emulsification, and shall contain a minimum of three 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.

702.03

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 No.
	Max.	Min.	
<b>Tests on Emulsion:</b>			
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
Asphalt Content, % Residue	65		T 59
Oil distillate by volume, %	1	7	T 59
<b>Tests on Residue:</b>			
Penetration, 25 °C (77 °F), 100g, 5 sec	150	300*	T 49
Float Test, 60 °C (140 °F), sec	1200		T 150
Solubility in TCE, %	97.5		T 44
Elastic Recovery, 4 °C (39.2 °F), %	50		CPL 2211
*When approved by the Engineer, Emulsified Asphalt (HFMS-2sP) with a residual penetration greater than 300 mm 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 mm 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
	Max.	Min.	
<b>Tests on Emulsion:</b>			
Viscosity @ 25 °C, SFS	15	85	ASTM D 244
Pumping Stability	Pass		GB Method <sup>1</sup>
Sieve Test, %w		0.1	ASTM D 244 <sup>2</sup>
Cement Mixing, %w		2.0	ASTM D 244
Particle Charge		Positive	ASTM D 244
Conc. of Oil Phase	60		ASTM D 244 <sup>3</sup>
<b>Tests on Residue:</b>			
Viscosity @ 60 °C , CST	1000	4000	ASTM D 2170
Flash Point, COC, °C (° F)	232		ASTM D 92
<b>Volatility</b>			
IBP, °C	163		ASTM D1160, 10mm
2%V, °C	204		”
5%V, °C	221		”
RTF-C Weight Change, %W		2	ASTM D 2872
Saturates, %w		28	ASTM D 2007
RTF-C Ratio		2.5	ASTM D 2872
Specific Gravity	0.98	1.02	ASTM D 70
<sup>1</sup> 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 (¼ inch) inlet and outlet. The emulsion passes if there is no significant separation after circulating ten minutes. <sup>2</sup> Test procedure identical with ASTM D 244 except that distilled water shall be used in place of two percent sodium oleate solution. <sup>3</sup> ASTM D 244 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.			

**702.04 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.

**Table 702-8**  
**ASPHALT REJUVENATING AGENT**

Property	Test Method	Requirement
Viscosity, S.F., @ 25 °C (77 °F), s	ASTM D244	15-40
<sup>1</sup> Residue, % min.	ASTM D244	60-65
<sup>2</sup> Miscibility Test	ASTM D244	No coagulation
<sup>3</sup> Sieve Test, % max.	ASTM D244	0.10
Particle Charge Test	ASTM D244	Positive
ASTM D244 (Mod):		
Viscosity, 60 °C (140 °F), mm <sup>2</sup> /s	ASTM D445	100-200
Asphaltenes, % max.	ASTM D4124	0.75
<sup>4</sup> Maltenes Dist. Ratio $\frac{PC+A_1}{S+A_2}$	ASTM D4124	0.3-0.5

<sup>1</sup> 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 cool immediately and calculate results.

<sup>2</sup> Test procedure identical with ASTM D244 except that .02 Normal Calcium Chloride solution shall be used in place of distilled water.

<sup>3</sup> Test procedure identical with ASTM D244 except that distilled water shall be used in place of 2% sodium oleate solution.

<sup>4</sup> In the Maltenes Distribution Ratio Test by ASTM Method D4124.

PC = Polar Compounds  
A<sub>1</sub> = First Acidaffin  
A<sub>2</sub> = Second Acidaffins  
S = Saturates

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 3.0 percent styrene-butadiene solution polymer. The finished product shall conform to the physical requirements listed in Table 702-8A below.

**Table 702-8A**  
**ARA 1P**

<b>Test on Emulsion</b>	<b>Test Method</b>	<b>Min</b>	<b>Max</b>
Viscosity, Saybolt-Furol @ 77 °F, s	ASTM D 244	15	100
Residue @ 350 °F, %	ASTM D244 Modified	60	
Sieve Test, %	ASTM D244		0.10
Oil distillate, %	ASTM D244		2.0
<b>Test on Residue</b>	Residue from D244 Modified		
Penetration @ 39.2 °F, 50g, 5s	ASTM D-5 Modified	300	
Asphaltenes, %	ASTM D4124		15
Rotational Viscosity @ 275 °F, #21 spindle, 150 rpm, cps	ASTM D4402	20	100

**702.05 Recycling Agents.** Asphalt recycling agents shall conform to the physical and chemical requirements of Table 702-9.

**Table 702-9**  
**APHALT RECYCLING AGENT**

<b>Property</b>	<b>Test Method</b>	<b>Requirement</b>
Viscosity @ 60 °C (140 °F), mm <sup>2</sup> /s (cSt)	ASTM D2170	200-800 (200-800)
Specific Gravity	ASTM D 70	Report
Flash Point C.O.C., °C (°F) min.	ASTM D 92	204 (400)
Oven Weight Change, 5 hrs. @ 163 °C (325 °F), % max.	ASTM D1754	4
*Viscosity Ratio, % max.	ASTM D2170	3
Saturates, % max.	ASTM D4124	30
*Viscosity Ratio = $\frac{\text{Viscosity after oven wt. change test, measured @ 60 °C (77°F)}}{\text{Original Viscosity @ 60 °C (77 °F)}}$		

**702.06 Hot Poured Joint and Crack Sealant.** Hot poured material for filling joints and cracks shall conform to the requirements of ASTM D 6690, Type I or II. ASTM D 1985 mortar blocks shall be used for concrete bond test. ASTM D 6690 material must pass asphalt compatibility test, Section 9, ASTM D 5329.

Sealant material shall be supplied preblended, prereacted, 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 pretested by the Department prior to use and subsequently placed on the Colorado Approved Products List.

703.00

### SECTION 703 AGGREGATES

All sieve sizes and designations described in this section refer to laboratory sieves having square openings and conforming to ASTM E 11.

Where the Contract refers to a nominal size aggregate, the nominal size shall conform to the gradation in Table 703-1 below.

**Table 703-1  
DEFINITION OF NOMINAL AGGREGATES**

Nominal Size	Material passing the designated sieve by weight		
	100%	90% to 100%	No more than 90%
50 mm (2")	63 mm (2½")	50 mm (2")	37.5 mm (1½")
37.5 mm (1½")	50 mm (2")	37.5 mm (1½")	25.0 mm (1")
25.0 mm (1")	37.5 mm (1½")	25.0 mm (1")	19.0 mm (¾")
19.0 mm (¾")	25.0 mm (1")	19.0 mm (¾")	12.5 mm (½")
12.5 mm (½")	19.0 mm (¾")	12.5 mm (½")	9.5 mm (⅜")
9.5 mm (⅜")	12.5 mm (½")	9.5 mm (⅜")	4.75 mm (#4)

The grading and composition requirements for coarse and fine aggregates for concrete are set forth in Table 703-2.

**Table 703-2**  
**CONCRETE AGGREGATE GRADATION TABLE**  
 Percentage Passing Designated Sieves and Nominal Size Designation

Sieve Size	Coarse Aggregates (from AASHTO M 43)										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 4.75 mm (1 1/2" to #4)	19.0 mm to 4.75 mm (1 1/2" to 3/4")	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 150µm (#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	40-70	85-100	100		
4.75 mm (#4)	0-5	0-5	0-5	0-5	0-10	0-5	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		
600µm (#30)									25-60		
300µm (#50)									10-30		
150µm (#100)									2-10		

703.00

703.01

**703.01 Fine Aggregate for Concrete.** Fine aggregate for concrete shall conform to the requirements of AASHTO M 6. The amount of material finer than 75 µm (No. 200) sieve shall not exceed three percent by dry weight of fine aggregate, when tested in accordance with AASHTO T 11 or Colorado Procedure 31, Method D, unless otherwise specified. The minimum sand equivalent, as tested in accordance with AASHTO T 176 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, except that the percentage of wear shall not exceed 45 when tested in accordance with AASHTO T 96. Coarse aggregate shall conform to the grading in Table 703-2. Sizes 357 and 467 shall each be furnished in two separate sizes and combined in the plant in the proportions necessary to conform to the grading requirements. Compliance with grading requirements will be based on the combination and not on each individual stockpile.

**703.03 Aggregate for Bases.** Aggregates for bases shall be crushed stone, crushed slag, crushed gravel, natural gravel, or crushed reclaimed concrete or asphalt material which conforms 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 No. 40 sieve fraction, stated in 2.2.2 of AASHTO M 147, shall not apply. The requirements for the Los Angeles wear test (AASHTO T 96) shall not apply to Class 1, 2, and 3. Aggregate for bases shall meet the grading requirements of Table 703-3 for the class specified for the project, unless otherwise specified.

The liquid limit shall be as shown in Table 703-3 and the plasticity index shall not exceed six when the aggregate is tested in accordance with AASHTO T89 and T 90 respectively.

**Table 703-3  
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
100 mm (4")		100					
75 mm (3")		95-100					
60 mm (2½")	100						
50 mm (2")	95-100			100			
37.5 mm (1½")				90-100	100		
25 mm (1")					95-100		100
19 mm (¾")				50-90		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.

**703.04 Aggregates for Hot Mix Asphalt.** Aggregates for hot plant mix bituminous pavement (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. For Gradings S, SX, and SG, a percentage of the aggregate retained on the 4.75 mm (No. 4) sieve shall have at least two mechanically induced fractured faces when tested in accordance with 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. 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 in accordance with AASHTO T 90. The material shall not contain clay balls, vegetable matter, or other deleterious substances.

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

**Table 703-4  
MASTER RANGE TABLE FOR HOT MIX ASPHALT**

Sieve Size	Percent by Weight Passing Square Mesh Sieves		
	Grading SX	Grading S	Grading SG
37.5 mm (1½")			100
25.0 mm (1")		100	90 - 100
19.0 mm (¾")	100	90 - 100	
12.5 mm (½")	90 - 100	*	*
9.5 mm (⅜")	*	*	*
4.75 mm (#4)	*	*	*
2.36 mm (#8)	28 - 58	23 - 49	19 - 45
1.18 mm (#16)			
600 µm (#30)	*	*	*
300 µm (#50)			
150 µm (#100)			
75 µm (#200)	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 in accordance with 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 (½ inch) and shall be non-plastic when tested in accordance with AASHTO T 90.

703.04

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

- (1) No more than 30 percent when tested in accordance with 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 in accordance with 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		
	9.5 mm ( $\frac{3}{8}$ " nominal)	12.5 mm ( $\frac{1}{2}$ " nominal)	19.0 mm ( $\frac{3}{4}$ " nominal)
19.0 mm ( $\frac{3}{4}$ "			100
12.5 mm ( $\frac{1}{2}$ "	100	100	85 – 95
9.5 mm ( $\frac{3}{8}$ "	90 – 100	85 – 95	55 – 75
4.75 mm (#4)	30 – 55	24 – 32	24 – 32
2.36 mm (#8)	20 – 42	16 – 24	16 – 24
1.18 mm (#16)			
600 $\mu$ m (#30)	12 – 25	10 – 16	10 – 16
300 $\mu$ m (#50)			
150 $\mu$ m (#100)			
75 $\mu$ m (#200)	8 – 12	8 – 12	8 – 12

**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) Percentage of wear, Los Angeles Abrasion Test (AASHTO T 96), not more than 35.
- (2) When blast-furnace slag is used, weight per cubic foot shall be at least 70 pounds.
- (3) 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 in accordance with Colorado Procedure 45.
- (4) 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 in accordance with 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 2000 g.

**Table 703-6  
GRADATION SPECIFICATIONS FOR COVER COAT AGGREGATE**

Sieve Size	Percent by Weight Passing Square Mesh Sieve		
	9.5 mm (3/8") Type I	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	70-100	60-80
4.75 mm (#4)	0-15	0-4	
75 µm (#200)	0-1.0	0-1.0	0-1.0

\*Type IV shall be used only with light 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:

Sieve Size	Mass percent passing
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.

**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:

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

**703.08 Structure Backfill Material.**

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

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 of 35 or less and a plasticity index of 6 or less 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 I structure backfill, it will be paid for in accordance with subsection 104.03.

**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 703-7.

**Table 703-7  
GRADITION 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 (1½")		100	
19.0 mm (¾")	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 in accordance with AASHTO T 96, shall not be more than 70. The grading requirements shall be as follows:

703.10

<b>Sieve Size</b>	<b>Mass Percent Passing Square Mesh Sieves</b>
63 mm (2½ inch)	100
50 mm (2 inch)	95-100
19.0 mm (¾ inch)	0-15

704.01

**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 C 55.

**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 C 139, or, for hollow blocks, to ASTM C 90. 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 C 270.

**SECTION 705**  
**JOINT, WATERPROOFING,**  
**AND BEARING MATERIALS**

**705.01 Joint Fillers.**

- (a) *Joint Sealant with Backer Rod.* The joint sealant material shall be a silicone that is on the Department's Approved Products List. The silicone materials shall be stored and applied in accordance with 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 prior to joint sealant shall be constructed of closed cell polyethylene strand as approved.
- (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 where called for 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 (unused)**

**705.03 Gaskets.** Rubber gasketed joints shall conform to the requirements of AASHTO M 315 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 C 425.

**705.06 Bearing Materials**

**Table 705-1**  
**POLYISOPRENE (NATURAL RUBBER) ELASTOMER**

Specimen Properties	ASTM Test Procedure	Requirements		
		50 Duro	60 Duro	70 Duro
<b>Physical Properties</b>				
Hardness	D 2240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa min (psi).	D 412	15.5 (2250)	15.5 (2250)	15.5 (2250)
Ultimate Elongation, % min.	D 412	450	400	300
<b>Heat Resistance, 70 Hr/70 °C (158 °F)</b>				
Change in Durometer Hardness, Max. Points		+10	+10	+10
Change in Tensile strength, % max.	D 573	-25	-25	-25
Change in Ultimate Elongation, % max.	D 573	-25	-25	-25
Compression Set, % max. 22 Hr./100 °C (212 °F)	D 395 Method B	25	25	25
Ozone Resistance, 20% strain 100 ppm Ozone in Air by Vol. 38 ± 1 °C (100 °F ± 2 °F)/48 Hr. Mounting Procedure ASTM D 518, Procedure A	D 1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made During Vulcanization, N/mm (Lb. Per Inch)	D 429, 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)	D 746 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)	D 1043	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)	ASTMD 4014 Quad Shear Test as described in Annex A	2 3	2 3	2 3
<sup>1</sup> Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F). <sup>2</sup> 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 ¼ cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next ½ cycle of loading. <sup>3</sup> ASTM D 1043 refers to the “Modulus of Rigidity” while ASTM D 4014 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
<b>Physical Properties</b>				
Hardness	D 2240	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, MPa min (psi).	D 412	17.2 (2500)	17.2 (2500)	17.2 (2500)
Ultimate Elongation, % min.	D 412	400	350	300
<b>Heat Resistance, 70 Hr/70 °C (158 °F)</b>				
Change in Durometer Hardness, Max. Points		+15	+15	+15
Change in Tensile strength, % max.	D 573	-15	-15	-15
Change in Ultimate Elongation, % max.	D 573	-40	-40	-40
Compression Set, % max. 22 Hr./100 °C (212 °F)	D 395 Method B	35	35	35
Ozone Resistance, 20% strain 100 ppm Ozone in Air by Vol. 38 ± 1 °C (100 °F ± 2 °F)/48 Hr. Mounting Procedure ASTM D 518, Procedure A	D 1149	No Cracks	No Cracks	No Cracks
Adhesion Bond Made During Vulcanization, N/mm (Lb. Per Inch)	D 429, 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)	D 746 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)	D 1043	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)	ASTMD4014 Quad Shear Test as described in Annex A	2 3	2 3	2 3
<sup>1</sup> Stiffness at test temperature shall not exceed 4 times the stiffness measured at 23 °C (73 °F). <sup>2</sup> 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 ¾ cycle of strain shall be discarded and the stiffness shall be determined by the slope of the force deflection curve for the next ½ cycle of loading. <sup>3</sup> ASTM D 1043 refers to the “Modulus of Rigidity” while ASTM D 4014 refers to the “Shear Modulus Stiffness”. The word “stiffness” is used to describe both terms.				

705.06

- (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 not less than 60 percent by volume of the total compound.

- (b) *Sheet Lead.* Sheet lead shall conform to the requirements of ASTM B 29 for common desilverized lead.

- (c) *Polytetrafluoroethylene (PTFE) Sheets.* PTFE resin shall be virgin material conforming to the requirements of ASTM D 4894 or D 4895. The specific gravity shall be 2.13 to 2.19 and the melting point shall be 623 °F ± 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 (min.)	ASTM D 4894 or D 4895	2800 psi
Elongation (min.)	ASTM D 4894 or D 4895	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:

<b>Mechanical</b>	<b>ASTM Method</b>	<b>15% Glass Fiber</b>	<b>25% Carbon</b>
Tensile Strength (min.)	D 4894 or D 4895	2000 psi	1300 psi
Elongation (min.)	D 4894 or D 4895	150%	75%
<b>Physical</b>	<b>ASTM Method</b>	<b>15% Glass Fiber</b>	<b>25% Carbon</b>
Specific Gravity (min.)	D 4894 or D 4895	2.20	2.10
Melting Point	D 4894 or D 4895	621 °F ± 18 °F	621 °F ± 18 °F

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

Bearing Pressure	500 psi	2000 psi	3000 psi
Unfilled PTFE	0.08	0.06	0.04
Filled PTFE	0.12	0.10	0.08

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

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 gage minimum thickness and shall conform to ASTM A 240, 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 -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:

- (1) Overall Vertical Dimensions
 

Average Total Thickness 1/4 inches or less	-0, +1/8 inch
Average Total Thickness over 1/4 inches	-0, +1/4 inch

705.06

(2) Overall Horizontal Dimension	
36 inches and less	-0, +1/4 inch
Over 36 inches	-0, +1/2 inch
(3) Thickness of Individual Layers of Elastomer (Laminated Bearings Only)	±1/8 inch
(4) 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
(5) Position of Exposed Connection Members	±1/8 inch
(6) Edge Cover of Embedded Laminates or Connection Members	-0, +1/8 inch
(8) 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 either in 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 in accordance with Colorado Procedure L-2202:

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 lbs

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:

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 requirements of ASTM D 6690 Type 2, except that blocks for the bond test shall be as described in ASTM D 1985.

The membrane material shall be pretested by the Department prior to use. The batch or lot of the product will be placed on the Department's Approved Product List.

**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.

706.01

**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 prior to 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 8 feet apart. Joints for this pipe shall come equipped with steel rings and rubber gaskets conforming to ASTM C 361 and as described in Bureau of Reclamation Specifications for Type R-2 joints.

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 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.

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 prior to 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 prior to 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 prior to 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 in accordance with 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.

707.01

## **SECTION 707 METAL PIPE**

**707.01 Ductile Iron Pipe.** This pipe shall conform to the requirements of ASTM A 716 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 with 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 to which 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 ½ inch 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 prior to any handling or backfilling operations.

Special fittings and elbows for conduits shall be of the same gage as the conduit to which they are joined.

When aramid fiber bonded corrugated steel pipe is specified the pipe shall conform to ASTM A 885 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 therein 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.

707.05

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 prior to any handling or backfilling operations.

Special fittings and elbows for underdrains shall be of the same gage as the conduit to which 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 metal or alloy, unless otherwise shown on the plans.

**707.09 Repair of Damaged Coating.** Units on which 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 which 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.

## SECTION 708 PAINTS

**708.01 General.** This specification covers ready-mixed paint. Paint shall be easily mixed. The mixed paint shall be free from agglomerates, skins and foreign matter and shall be of suitable consistency for the method of application. Paint shall have satisfactory spreading qualities and give a smooth, continuous coating free from breaks or sags. Paint shall be able to withstand one year of storage without detrimental deterioration. In a  $\frac{3}{4}$  full, tightly closed container, paint shall show no skinning after 48 hours.

Color where designated by number refers to Federal Standard 595B. All proportions specified herein shall be by weight.

### 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 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 3 mils.

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

The top coat shall be an approved high-build polyurethane enamel with a minimum dry film thickness of 3 mils. To prevent bubbling, a mist coat shall be applied prior to application of the top coat.

**708.04 Aluminum Paint.** The paint shall be supplied ready-mixed in the proportion of (ASTM D 962, 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  $\frac{1}{2}$  to

708.04

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 Paint.** Pavement marking paint shall conform to the requirements listed in the table below. All proportions are by weight. Pigment composition and vehicle composition shall not vary by more than 1.0 percent of each amount specified.

Finished Paint Pigment (White and Yellow) ..... 49.0% to 52.0%

(a) <i>Pigment Composition.</i>	<b>White</b>	<b>Yellow</b>
Titanium Dioxide, ASTM D 476, Type III	27.0%	
Yellow Pigment		35.0%*
Calcium Carbonate, ASTM D 1199, Type GC-II	18.0%	53.3%
Magnesium Silicate ASTM D 605	54.3%	11.0%
Pigment Suspending Agents (see below)	0.7%	0.7%

\*The pigment for yellow paint shall consist of a blend of organic yellow pigment and other pigments and fillers as are necessary to result in a colorfast paint complying with all provisions of this specification. The paint shall contain no lead or other material such that the dry film could be considered a hazardous waste under EPA or Colorado Department of Health Regulations.

(b) <i>Vehicle Composition.</i>	<b>White &amp; Yellow</b>
Alkyd Resin Solution, AASHTO M 248, Type F	70.0%
VM&P Naphtha, Fed. Spec. TT-N-95, Type I	
Driers, ASTM D 600 cl. B, and Anti-Skinning Agent, Methanol	30.0%

(c) *Pigment Suspending Agent.*  
Organo-montmorillonite conforming to subsection 708.06(b) shall be added to achieve the desired storage and stability requirements.

(d) *Properties of Finished Paint.*  
The paint at the time of container filling shall be free of skins, pigment agglomerates and foreign matter and shall meet the following requirements:

- (1) Fineness of grind, Hegman, minimum 2
- (2) Consistency, Krebs-Stormer, K.U. @ 25 °C (77 °F) 70-80
- (3) Drying time, a wet film of paint 380 micrometers thick tested according to ASTM Method D 711, minutes maximum 30
- (4) Reflectance. The white paint shall have a daylight 45°, 0° luminous directional reflectance of not less than 80% when compared to magnesium oxide.
- (5) Color. The color of the yellow paint shall visually match color chip No. 33538 of Federal Standard 595B. In case of dispute, the color shall be within the green and red tolerance limits when compared with the standard color chips of the Standard Yellow for Highway Signs and Markings - U.S. Department of Transportation, Washington, D.C. The manufacturer shall

supply test data showing that the yellow pavement marking paint will retain the yellow color within these limits for a period of one year under outdoor sunlight exposure.

#### 708.06 Materials - Specifications

(a) *Paint Pigments.*

Chromium Oxide, (Green)	ASTM D 263
Magnesium Silicate	ASTM D 605
Titanium Dioxide	ASTM D 476, Class IV
Red Iron Oxide	ASTM D 3721
Black Iron Oxide	ASTM D 769
Yellow Iron Oxide	ASTM D 768

- (b) *Organo-montmorillonite.* Organo-montmorillonite shall be an organo 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 D 12
Mineral Spirits	ASTM D 235
Driers - Cobalt and/or manganese	ASTM D 600
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 hrs.
Dry Hard	18 hrs. 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.

708.07

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, prior to 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 on the basis of 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.

**MINIMUM PHYSICAL PROPERTIES**

Solids by Weight	48 percent (Without texturing agent)
Solids by Volume	36 percent (Without texturing agent)
Weight per gallon	8.3 lbs./gal. (Without texturing agent)
Texturing Agent	3.2 to 3.8 lbs./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 in accordance with 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 therein, 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 A 615
Axle-steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A 996
Low-Alloy Steel Deformed Bars for Concrete Reinforcement [to be Welded]	ASTM A 706
Fabricated Deformed Steel Bar Mats for Concrete Reinforcement	ASTM A 184
Steel Welded Wire Fabric, Plain, for Concrete Reinforcement	AASHTO M 55
Steel Welded Wire Fabric, Deformed for Concrete Reinforcement	AASHTO M 221
Epoxy Coated Reinforcing Bars	AASHTO M 284

Unless otherwise designated, bars conforming to ASTM A 615 & ASTM A 996 shall be furnished in Grade 60 for # 5 bars and larger and Grade 40 or 60 for bars smaller than # 5.

In ASTM A 184, bar material conforming to ASTM A 616 will not be permitted.

**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 M 284 and shall be grade 40, epoxy-coated, and deformed. Bar size shall be as designated on the Standard Plan M-412-1.

Dowel bars for transverse joints shall conform to AASHTO M 254 for the coating and to ASTM A 615, grade 60 for the core material and shall be epoxy-coated, smooth, and lightly greased, pre-coated 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.

710.01

## **SECTION 710 FENCE AND GUARDRAIL**

**710.01 Barbed Wire.** Steel barbed wire shall conform to the requirements of ASTM A 121, Class I. Aluminum barbed wire shall be manufactured in accordance with ASTM B 211 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 A 116, coating Class I.

Aluminum coated steel woven wire shall conform to the requirements of ASTM A 116, 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 A 392, Class I; and aluminum coating for steel fabric to ASTM A 491, Class I.

**710.04 Snow Fence.** Wire-bound picket fence shall conform to the requirements of ASTM F 537. Posts shall conform to the requirements of AASHTO M 281.

**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 be either 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 damaged either 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 Sound 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 American Wood Preserver’s Association (AWPA) standards, Sections C1 and C2 (Soil contact for posts, above ground for balance of fence). A treatment report is required from the treatment plant.
- (5) Preservative. Section P5 of AWPA standards.

All lumber shall be manufactured in accordance with 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 in accordance with

710.07

AASHTO M 133 and AWPA C14. 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 in accordance with 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 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.
- (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 in accordance with AASHTO M 232, Class C, or AASHTO M 298, Class 50, Type 1. All other fittings shall be galvanized in accordance with AASHTO M 111. Bolts, nuts, and washers for corrosion resistant guard rail shall be of corrosion resistant material and conform to or exceed the requirements of ASTM A 307.

Where high strength bolts are required, they shall conform to the requirements of ASTM A 325.

**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	AASHTO M 148
Sheet Materials for Curing Concrete	AASHTO M 171

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 which 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 which have been frozen will be rejected in accordance with subsections 106.08 and 106.09.

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

Admixtures which have been frozen will be rejected.

712.01

## **SECTION 712 MISCELLANEOUS**

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

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

**712.03 Hydrated Lime.** Hydrated lime for aggregate pretreatment shall conform to the requirements of ASTM C 207, Type N. In addition, the residue retained on a 75  $\mu\text{m}$  (No. 200) sieve shall not exceed 10 percent when determined in accordance with ASTM C 110. (Drying of the residue in an atmosphere free from carbon dioxide will not be required.)

**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 in accordance with 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 in accordance with 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 A 536. 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 A 47. 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 (unused)**

**712.08 Geosynthetics.** Geosynthetic rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall furnish to the Engineer a certified test report from the producer, containing all data required to verify compliance with the specifications listed in the appropriate table.

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 for various applications are given in Tables 712-1 through 712-8. Unless otherwise stated, all property values represent minimum average roll values (MARV) in the weakest principle direction (i.e., average test results from any sampled roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values in the Tables). Stated values are for non-critical, non-severe conditions. Lots shall be sampled in accordance with ASTM D 4354.

- (a) *Geomembrane.* Geomembrane shall be manufactured for stopping seepage loss. The lining shall consist of virgin polyvinyl chloride (PVC) resins, plasticizers, stabilizers, and such materials that, when compounded, will meet the physical requirements for the thickness specified as listed 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 ½ 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 D 1593
Tensile Strength, kN/m (lbs./in.) width	3.50 (20)	8.75 (50)	12.25 (70)	ASTM D 882, Method B
Modulus @ 100% Elongation, kN/m (lbs./in.)	1.58 (9)	3.50 (20)	5.25 (30)	ASTM D 882, Method B
Ultimate Elongation, %	350	350	350	ASTM D 882, Method A
Tear Resistance: N (lbs)	18 (3.2)	29 (6.5)	38 (8.5)	ASTM D 1004
Low Temperature Impact, °C (°F)	-23 (-13)	-26 (-15)	-29 (-20)	ASTM D 1790
Volatile loss, % max.	1.5	0.9	0.7	ASTM D 1203, Method A
Pinholes, No. Per 8 m <sup>2</sup> (No. Per 10 sq. Yds.) max.	1	1	1	
Bonded Seam Strength, % of tensile strength	80	80	80	

- (b) *Geotextiles for Erosion Control, Drainage, and Silt Fence.* Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages.

Geotextiles for erosion control shall conform to the physical requirements of Table 712-2 for the appropriate class.

Geotextiles for drainage applications shall be nonwoven and shall conform to the physical requirements of Table 712-3.

Geotextiles for silt fence applications shall conform to the physical requirements of Table 712-4.

**Table 712-2  
PHYSICAL REQUIREMENTS FOR  
EROSION CONTROL GEOTEXTILES**

<b>Property</b>	<b>Class A<sup>1</sup></b>	<b>Class B<sup>2</sup></b>	<b>Test Method</b>
Grab Strength, N (lbs)	900 (200)	400 (90)	ASTM D 4632
Elongation, % min.	15	15	ASTM D 4632
Seam Strength, N (lbs) <sup>3</sup>	800 (180)	360 (80)	ASTM D 4632
Puncture Strength, N (lbs)	360 (80)	180 (40)	ASTM D 4833
Trapezoid Tear, N (lbs)	225 (50)	135 (30)	ASTM D 4533
Apparent Opening Size (AOS) US Std Sieve	AOS less than 0.297 mm (greater than No. 50 sieve)		CW 002215 ASTM D 4751
Permeability, cm/s <sup>4</sup>	k fabric >k soil for all classes		ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes		ASTM D 4355

<sup>1</sup> Class A erosion control geotextiles are used where installation stresses are more severe than for Class B applications.

<sup>2</sup> Class B erosion control geotextiles are used in structures or under conditions where the fabric is protected by a sand cushion or by “zero drop height” placement of stone. Stone placement depth should be less than 3 feet and stone weights should not exceed 250 pounds.

<sup>3</sup> Values apply to both field and manufactured seams, if required.

<sup>4</sup> A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.

**Table 712-3**  
**PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILES**

<b>Property</b>	<b>Class A<sup>1</sup></b>	<b>Class B<sup>2</sup></b>	<b>Test Method</b>
Grab Strength, N (lbs)	800 (180)	360 (80)	ASTM D 4632
Seam Strength, N (lbs) <sup>3</sup>	710 (160)	310 (70)	ASTM D 4632
Puncture Strength, N (lbs)	360 (80)	110 (25)	ASTM D 4833
Trapezoid Tear, N (lbs)	225 (50)	110 (25)	ASTM D 4533
Apparent Opening Size (AOS) US Std Sieve	AOS less than 0.297 mm (greater than No. 50 sieve)		ASTM D 4651
Permeability, cm/s <sup>4</sup>	k fabric >k soil for all classes		ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes		ASTM D 4355
<p><sup>1</sup> Class A drainage geotextiles are used where installation stresses are more severe than for Class B applications, i.e. very coarse sharp angular aggregate is used, a heavy degree of compaction (95% AASHTO T 99) is specified or depth of trench is greater than 10 feet)</p> <p><sup>2</sup> Class B drainage geotextiles are used with smooth graded surface having no sharp angular projections and sharp angular aggregate is not used; compaction requirements are light (&gt;95% AASHTO T 99), and trenches are less than 10 feet) in depth</p> <p><sup>3</sup> Values apply to both field and manufactured seams, if required.</p> <p><sup>4</sup> A nominal coefficient of permeability may be determined by multiplying permittivity value by nominal thickness. The k value of the fabric should be greater than the k value of the soil.</p>			

**Table 712-4  
PHYSICAL REQUIREMENTS FOR  
TEMPORARY SILT FENCE GEOTEXTILES**

<b>Property</b>	<b>Wire Fence Supported Requirements</b>	<b>Self Supported Requirements</b>	<b>Test Method</b>
Tensile strength, N (lbs)	400 (90) minimum	400 (90) minimum	ASTM D 4632
Elongation at 50% minimum tensile strength	N/A	50 maximum	ASTM D 4632
Permittivity <sup>1</sup> s-1	0.01 minimum	0.01 minimum	ASTM D 4491
Apparent Opening Size (AOS), mm <sup>1</sup>	0.84 maximum	0.84 maximum	ASTM D 4751
Ultraviolet Degradation at 500 hours	minimum 70% Strength Retained	minimum 70% Strength Retained	ASTM D 4355
<sup>1</sup> Permittivity and AOS do not relate directly to filtration performance of silt fence fabrics. Values presented reflect minimum criteria of products currently used. Performance tests such as VTM-51 (from Virginia Highway Research Council) may be used to evaluate silt fence performance if deemed necessary by the engineer.			

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 712-5A and B may be used as a guide for Comparing the permeability coefficient of the fabric with that of the in-place soil.

**Table 712-5A  
TYPICAL VALUES OF PERMEABILITY COEFFICIENTS<sup>1</sup>  
(TURBULENT FLOW)**

<b>Type of Material</b>	<b>Particle Size Range Millimeters (Inches)</b>		<b>Effective Size</b>	<b>Permeability Coefficient-k cm/s</b>
	<b>D max</b>	<b>D min</b>	<b>D 20 mm (Inches)</b>	
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
<sup>1</sup> Basic Soils Engineering, R.K. Hough, 2nd Edition, Ronald Pess Co.; 1969, Page 76.				

**Table 712-5B TYPICAL VALUES OF PERMEABILITY  
COEFFICIENTS<sup>1</sup> (LAMINAR FLOW)**

Type of Material	Particle Size Range Millimeters (Inches)		Effective Size	Permeability Coefficient-k cm/s
	D max	D min	D 10 mm	
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 & GRAVEL	10	0.05	0.1	0.01
Uniform, fine SAND	0.25	0.05	0.06	40 x 10 <sup>-4</sup>
Well-graded, silty SAND & GRAVEL	5	0.01	0.02	4 x 10 <sup>-4</sup>
Silty SAND	2	0.005	0.01	1.0 x 10 <sup>-4</sup>
Uniform SILT	0.05	0.005	0.006	0.5 x 10 <sup>-4</sup>
Sandy CLAY	1.0	0.001	0.002	0.05 x 10 <sup>-4</sup>
Silty CLAY	0.05	0.001	0.0015	0.01 x 10 <sup>-4</sup>
CLAY (30% to 50% clay sizes)	0.05	0.0005	0.0008	0.001 x 10 <sup>-4</sup>
Colloidal CLAY (-2 μm 50%)	0.01	10	40	10 <sup>-9</sup>

<sup>1</sup> Basic Soils Engineering, R.K. Hough, 2nd Edition, Ronald Pess Co.; 1969, Page 76.

- (c) *Paving Geotextile*. The paving geotextile shall be constructed of nonwoven synthetic fibers; resistant to chemical attack, mildew, and rot; and shall conform to the physical requirements of Table 712-6.

**Table 712-6  
PHYSICAL REQUIREMENTS FOR PAVING GEOTEXTILES**

Property	Requirements	Test Method
Tensile Strength, N (lbs.)	450 (100)	ASTM D 4632
Mass per Area, g/m <sup>2</sup> (oz./sq. yd..)	140 (4)	ASTM D 3776
Elongation-at-Break, %, min.	50	ASTM D 4632
Asphalt Retention, L/m <sup>2</sup> (gal./sq. yd.)	0.9 (0.2)	Texas DOT Item 3099
Melting Point, °C (°F)	149 (300)	ASTM D 276

- (d) *Weed Barrier Geotextile*. Geotextile for weed barrier shall be a nonwoven, spunbound polypropylene polyester or polyolefin extruded in such a manner as to form a mat and shall conform to the physical requirements of Table 712-7.

**Table 712-7**  
**PHYSICAL REQUIREMENTS FOR WEED BARRIER**

Property	Requirements	Test Method
Grab Strength, N (lbs.)	310 (70)	ASTM D 4632
Puncture Strength, N (lbs.)	135 (30)	ASTM D 4833
Trapezoid Tear, N (lbs.)	110 (25)	ASTM D 4533
Water Flow Rate, L/s/m <sup>2</sup> (gal./sq. yd./min.)	110 (160)	ASTM D 4491
Ultraviolet Degradation at 150 hours	45% strength retained	ASTM D 4355

- (e) *Separator Geotextile.* Geotextile separator material shall consist of permeable sheets of polymeric yarn or fiber oriented into a woven or non-woven stable network which retains its relative structure during handling, placement and long-term service. The geotextile shall meet or exceed the properties shown in Table 712-8.

**Table 712-8**  
**PHYSICAL REQUIREMENTS FOR SEPARATOR<sup>1</sup>**

Property	Class A		Class B		Test Method
	Elongation < 50% <sup>2</sup>	Elongation > 50% <sup>2</sup>	Elongation < 50% <sup>2</sup>	Elongation > 50% <sup>2</sup>	
Grab Strength, N (lbs.)	1200 (270)	800 (180)	800 (180)	510 (115)	ASTM D 4632
Puncture Resistance, N (lbs.)	445 (100)	310 (70)	310 (70)	180 (40)	ASTM D 4833
Trapezoidal Tear Strength, N (lbs)	445 (100)	335 (75)	310 (70)	180 (40)	ASTM D 4533
Apparent Opening Size, mm (US Sieve Size) Permittivity, sec <sup>-1</sup>	AOS < 0.3 mm (US Sieve Size No. 50) 0.02 default value, must also be greater than that of soil				ASTM D 4751
Permeability, cm/sec	k fabric > k soil for all classes				ASTM D 4491
Ultraviolet Degradation at 500 hours	50% strength retained for all classes				ASTM D 4355

<sup>1</sup> Strength values are in the weaker principle direction  
<sup>2</sup> As measured in accordance with ASTM D 4632

**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 gage (U.S.), soft temper.

712.09

Wire mesh for Slope Mattress (cage thickness up to 10 inches) shall be 14 gage (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 ½ 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 gages lighter.

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

- (a) *Mesh Openings.* 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 prior to the date of letting.
- (c) *Non-raveling.* The mesh for both gabions and slope mattresses shall show no raveling beyond the mesh opening in which 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 gages 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 FOR MINIMUM STRENGTH  
TESTS FOR GABION BASKETS ONLY**

<b>Part</b>	<b>Minimum Strength (pounds per foot)</b>
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:

	<b>Stone Size</b>
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, min. 40 pounds per yard.
  - (2) Size 2 inch steel pipe conforming to ASTM A 53 either black or galvanized.
  - (3) Size 3 inch x 3 inch x  $\frac{3}{8}$  inch structural steel angles conforming to ASTM A 709 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

**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 C 881.

**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.

The drainage geotextile shall conform to the physical requirements of subsection 712.08, Table 712-3, for the Geotextile (Drainage) (Class B). 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 712-9.

**Table 712-9  
PHYSICAL REQUIREMENTS FOR DRAINAGE CORE**

Property	Value	Test Method
Compressive Strength, kPa (lbs./sq. in.)	140 (20)	ASTM D 1621
In-Plane Flow Capacity L/s/m (gal./min./ft.), minimum	2.12 (10)	ASTM D 4716
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:

*Ribbed Type:* AASHTO Interim Specifications Bridges, Section 18, Soil Thermoplastic Pipe Interaction Systems; material specifications are ASTM F 894 for polyethylene pipe, and ASTM F 794 for poly (vinyl) chloride pipe. Couplings shall be as recommended by the manufacturer.

*Corrugated Type:* AASHTO M 294.

*Smooth Type:* ASTM F 679. Couplings shall be as recommended by the manufacturer.

**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**

Application	Aluminum		Steel
	ASTM Designation	Alloy NO. Temper	ASTM Designation
Sign panels	B 209	6061-T6 5052-H36 5052-H38	*A 653
Traffic controller cabinets	B 209	6061-T6	709 Grade 36
Clip bolts	B 211	2024-T4	
Locknuts or steel nuts and bolts	B 211	2017-T4	*A 307
Clips and backing angles	B 221	6061-T6	
* Steel sheets shall have a Z600 zinc coating in accordance with ASTM A 653 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  $\frac{1}{3}$  inch, and the dimensions of the opposing sides shall be within  $\frac{1}{16}$  inch.

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

**713.03 (unused)**

**713.04 Sign Panel Backgrounds.** Reflective sheeting background material used shall be of the type as specified on the plans and shall conform to the requirements specified in subsection 713.10.

713.04

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

The aluminum sign blanks shall receive a chemical treatment conforming to ASTM B 449, Class 2 prior to placement of reflective sheeting.

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

**713.06 Messages.** Letter design shall be in accordance with the following:

Letter design for commercial legend shall be Series “E” for capitals, and Series “E Modified” for upper and lower case letters and numbers. The “E Modified” legend shall have an increased stroke width of 20 percent of the required legend height. The Inter-letter spacing shall be “Colorado Improved” in accordance with the Colorado Supplement to the Standard Highway Signs.

Silk screen process figures shall be in accordance with the plans and series figures described in the current editions of “Standard Alphabets for Highway Signs” and “Standard Highway Signs”, published by the FHWA, and the “Colorado Supplement to Standard Highway Signs”.

For overhead signs, the legend and borders shall be VIP sheeting or equivalent. The background retroreflective sheeting shall be Type III.

**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 grommetted mounting hole. The delineator unit shall withstand the combined corrosion test described in ASTM B 117.

**713.08 Glass Beads for Traffic Markings.** Glass beads for Traffic Paint shall conform to AASHTO M 247, Type 1 or Type 2, non-flotation grade.

Glass beads for Thermoplastic Pavement Marking shall conform to AASHTO M 247, Type 1.

Glass beads for epoxy pavement marking shall conform to AASHTO M 247, Type 1. The beads shall be silicon treated to meet the requirements of Section 4.4.2 of AASHTO M 247.

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

Glass beads for methyl methacrylate pavement marking shall conform to AASHTO M 247, type 1 non-floatation and shall be applied by the first bead applicator. Glass beads applied by the second bead applicator shall be AASHTO M 247, type 1 silane coated (AC-02) floatation beads.

**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 which 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 in accordance with AASHTO T 257, with an observation angle of 0.1 degrees.

Entrance Angle Degrees	Specific IntensityCandlepower per Foot-Candle			
	Crystal	Yellow	Red	Green
0	110	50	33	22
20	60	30	18	12

713.10

- 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.

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 D 788, Grade 8. The reflectors shall meet test requirements of Colorado Procedure L-2115, Sec. 3.2 and 3.3.

- (b) *Retroreflective Sheeting*. Reflective sheeting for traffic control devices shall conform to the requirements of ASTM D 4956.

**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 IMSA.

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

Pull rope shall be  $\frac{1}{8}$  inch nylon.

Messenger cable (span wire) shall be  $\frac{3}{8}$  inch diameter (minimum), seven wire stranded, common galvanized, utilities grade, rated at 11,500 pounds, in accordance with ASTM A 475.

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

Max. 35 watts,  $\pm 5$  watts for 12 inch ball

Max. 30 watts,  $\pm 5$  watts for 8 inch ball

Max. 15 watts,  $\pm 5$  watts for 12 inch arrow

Max. 15 watts,  $\pm 5$  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 assure 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  $-40$  °F and  $+165$  °F

(6) Lens

Shall be replaceable, polycarbonate (UV stabilized "Lexan") convex lens; meet ITE color standards; minimum of  $\frac{1}{8}$  inch thickness; and minimum light

713.11

transmittance of 92 percent, free from bubbles, flaws and other imperfections. Non-polycarbonate tinted lenses will be accepted provided that these meet ITE color standards. Chromacity shall be measured uniform across the face of the lens. Non-polycarbonate lenses shall also meet 3½ 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 D 4505, Type I, Class B, C, D or E, and shall have a minimum thickness of 60 mils.

**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 insure a color similar to Federal Highway White, Color Number 17886, conforming to Federal Standard 595. Yellow - Sufficient yellow pigment shall be used to insure a color similar to Federal Highway Yellow, Color Number 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 E 303.
  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

713.15

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 in accordance with 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.

Color	White		Yellow	
	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 in accordance with 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 in accordance with 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 D 4592, Type I, and shall be  $4 \pm 0.1$  inches wide.

**713.17 Epoxy Pavement Marking Material.** Only 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 certified test report (CTR). The CTR shall confirm that the material meets all CDOT requirements and is the same material that was preapproved in the product evaluation process.

- (a) *Formulation.* 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:

	<b>White:</b>	<b>Yellow:</b>
<b>Pigments</b>	Min % by weight 18% Titanium Dioxide, (ASTM D 476, Type II)	% by weight 21-27%
<b>Epoxy Resin</b>	75-82%	73-79%

The pigment for yellow 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) *Epoxy Number.* The epoxy number of the epoxy resin shall be  $0.38 \pm 0.05$  as determined by ASTM D 1652 for white and yellow component A on pigment free basis.
- (d) *Amine Number.* The amine number on the curing agent (component B) shall be  $410 \pm 50$  per ASTM D 2071.
- (e) *Toxicity.* Upon heating to application temperature, the material shall not produce fumes which are toxic or injurious to persons or property.
- (f) *Color and Weather Resistance.* The mixed epoxy compound, both white and yellow, when applied to 3 inch x 6 inch aluminum panels at  $15 \pm \frac{1}{2}$  mils of thickness with no glass beads and exposed in the Q.U.V. Environmental Testing

713.17

Chamber as described in ASTM G 154, shall conform to the following minimum requirements. (The test shall be conducted for 75 hours at 122 °F, 4 hours humidity, and 4 hours U.V., in alternating cycles. The prepared panels shall be cured at 77 ° F for 72 hours prior to exposure.) The color of the white epoxy system shall not be darker than Federal Standard No. 595B-17778. The color of the yellow epoxy system shall conform to Federal Standard No. 595B-13538. The gloss values of both samples shall not be less than 70° after the test.

- (g) *Drying Time.* The 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 epoxy material shall be capable of fully curing under the constant surface temperature condition of 25 °F and above.
- (i) *Adhesion to Concrete.* The catalyzed epoxy pavement marking material, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified (4000 psi minimum) concrete surface that there shall be a 100 percent concrete failure in the performance of this test.
- (j) *Hardness.* The epoxy pavement marking materials, when tested according to ASTM D 2240, shall have a Shore D Hardness between 75 and 100. Samples shall be allowed to cure at room temperature,  $75 \pm 2$  °F for a minimum of 12 hours and a maximum of 48 hours prior to performing the indicated test.
- (k) *Abrasion Resistance.* The abrasion resistance shall be evaluated on Taber Abrader with a 1000 gram load and CS-17 wheels. The duration of the test shall be 1000 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 70. The tests shall be run on cured samples of material which have been applied at film thickness of  $15 \pm \frac{1}{2}$  mils to code S-16 stainless steel plates. The samples shall be allowed to cure at  $75 \pm 2$  °F for a minimum of 48 hours prior to performing the indicated tests.
- (l) *Tensile Strength.* When tested according to ASTM D 638, the epoxy pavement marking materials shall have a tensile strength of not less than 6000 psi. The Type IV Specimens shall be cast in a suitable mold and pulled at the rate of  $\frac{1}{4}$  inch per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature ( $75 \pm 2$  °F) for a minimum of 12 hours and a maximum of 48 hours prior to performing the indicated tests.
- (m) *Compressive Strength.* When tested according to ASTM D 695, the catalyzed epoxy pavement marking materials shall have a compressive strength of not less than 12,000 psi. The cast sample shall be conditioned at room temperature,  $75 \pm 2$  °F, for a minimum of 12 hours and a maximum of 48 hours prior to performing the tests. The rate of compression of these samples shall be no more than  $\frac{1}{4}$  inch per minute.

**713.18 Raised Pavement Marker.** Raised pavement marker shall be not less than 3.5 inches nor 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 not less than 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:

Observation AngleDegrees	Entrance AngleDegrees	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.

714.01

**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' in accordance with 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 prior to 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 Anchorages 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.

## SECTION 715 LIGHTING MATERIALS

**715.01 General.** Materials shall be of a standard line from a name brand manufacturer, or must be approved. Electrical material shall be approved by the Underwriters' Laboratories, Inc., and shall conform to the recommendations and requirements of the National Electrical Code.

Material shall be the same as, or compatible with, that used by the local utility, provided it meets the above requirements.

All lighting materials and all electrical materials shall be subject to inspection and approval and may be rejected as unsuitable at the project site. Samples may be taken or manufacturer's certification may be accepted in lieu of samples.

**715.02 Concrete Foundation Pads.** Concrete shall be Class "B" conforming to Section 601.

Anchor bolts shall be designed by the Contractor's Engineer and shown on the working drawings. The threaded ends of the anchor bolts and the nuts and washers shall be galvanized in accordance with ASTM A 153. Galvanizing for anchor bolts shall extend from 2 to 4 inches beyond the threads.

Reinforcing steel shall conform to the requirements of Section 602.

Grounding wire cast in the foundation shall be No. 6 AWG, soft drawn bare copper or better.

**715.03 Light Standards.**

- (a) *General.* All 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 90 MPH wind velocity, in accordance with AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," unless otherwise shown on the plans.

All breakaway bases and couplers shall meet the breakaway requirements as specified in AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, Section 7.1.7.2. 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, or as specified.

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

715.03

All metal poles shall be tapered and shall be supplied with pole caps.

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	Alloy No.
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 conforming to ASTM B 313 (excluding pressure and burst tests) alloy 5086-H34.

Aluminum mast arms shall be tapered and trussed as shown on the plans.

Steel mast arms and trusses shall be made of Schedule 40 standard steel pipe conforming to ASTM A 53.

All steel poles, mast arms and base flanges shall be hot-dip galvanized in accordance with ASTM A 123. Units on which 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 herein.

Base flanges for aluminum poles and transformer bases shall be aluminum castings of material conforming to ASTM B 26 alloy SG70A-T6 or an acceptable equivalent.

All transformer bases shall have vandal resistant, removable access doors.

- (c) Hardware used with steel standards shall be either cadmium plated, hot dip galvanized 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.

**715.04 Luminaires and Lamps.** A luminaire shall be a complete pre-wired lighting device specifically manufactured for the purpose of roadway lighting. A luminaire unit shall consist of housing, lens, reflector, ballast, lamp holder,

photoelectric control, mounting slip-fitter, and all necessary internal wiring. Luminaires shall be adaptable to the type of power distribution system to be used. Luminaires shall have a noncorrosive housing, a portion of which, by means of a hinge with a safety catch and a latch, may be opened to provide access to all internal components. Lamp holder shall be glazed porcelain. Screw shell shall be nickel plated or equal. Luminaires shall also conform to the following requirements:

- (a) Roadway luminaires shall be of the high pressure sodium type. Units for the project shall all be of the same type and design.

The luminaire light distribution shall be IES Type II, unless otherwise specified on the plans.

When luminaires are furnished for continuous roadway lighting, the manufacturer's photometric charts showing utilization curves and isolux lines shall be furnished to the Engineer to verify:

1. The average initial illumination on the traveled way will be at least 0.8 foot-candle.
2. The initial foot-candle value at the point of least illumination on the pavement area will be at least one fourth the average initial illumination.

- (b) Wall type luminaires for use under overpass structures shall be complete pre-wired lighting devices. Each luminaire shall be weatherproof, corrosion resistant and shall consist of a housing, reflector, shrouded porcelain socket, refractor, door, integral ballast and lamp.

Detail requirements are as follows:

1. The housing shall be cast aluminum.
2. The door shall be a cast aluminum frame with stainless steel hinges and latch containing a thermal shock resistant prismatic refractor.
3. Reflector shall be aluminum and shall be asymmetric.
4. Socket shall be for horizontal lamp position.
5. Integral ballast shall be rated to the circuit voltage and size of lamp specified.
6. Main beam angle setting shall be adjustable from 60° to 70°.
7. Manufacturer's photometric charts corresponding to the luminaire be installed shall be furnished to the Engineer upon request. The charts will be

715.04

used to verify that the luminaire will meet the following illumination requirements:

- A. The average initial illumination on the traveled way will be at least 0.8 foot-candle.
- B. The initial foot-candle value at the point of least illumination on the traveled way will be at least 0.05.

For the purpose of making the above calculations:

- (1) Traveled way is defined as the portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes; and limited to a 70 foot length of roadway measured 35 feet each way from the luminaire station.
  - (2) The luminaire is considered to be located 15 feet from the nearest edge of the traveled way and mounted 15 feet above the roadway surface. The luminaire shall be designed to permit either wall or pendant mounting as required.
- (c) *Lamps.* Lamps for roadway lighting shall be high pressure sodium of the wattage shown on the plans. Minimum lumens for each specific wattage shall be as follows:

Watts	Min. Lumens
100	8 500
150	12 000
250	25 000
400	50 000
1000	130 000

**715.05 Ballasts.** Ballasts shall be of the magnetic regulator type specifically manufactured for use with high pressure sodium lamps, and shall operate at a minimum of 90 percent power factor. Operation shall be suitable with a line voltage variation of  $\pm 10$  percent. Satisfactory starting operation shall be obtained with an ambient temperature of  $-20$  °F.

**715.06 Conduit.** Unless otherwise specified, conduit shall be rigid metallic or semirigid plastic electrical conduit. Metallic conduit shall be clean, free of burrs, and shall be galvanized.

Conduit threads, when used in damp or wet locations, or when buried in the earth, or buried in concrete which is in contact with the earth, shall be completely covered with a coating of white lead. Coatings having insulating qualities will not be permitted.

Plastic conduit shall be a semirigid type currently recommended and approved by Underwriters' Laboratories, Inc. for the proposed usage. Underground plastic conduit for traffic signals shall conform to the requirements of ASTM F 441 schedule 80.

Fittings shall be of the type used outside the conduit and shall be secured to the conduit in such manner that the joints are watertight.

Concrete and plastic pull boxes shall be as shown on the plans.

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

Pull boxes shall be a minimum of 16 inches by 12 inches and 6 inches deep, or as shown on the plans, and shall have weatherproof covers.

**715.07 Direct Burial Cable.** Direct burial cables shall consist of 7-strand concentric Class B stranding. If not otherwise specified in the Contract, the conductors shall be a minimum of No. 6 AWG copper.

The cables shall have conductors insulated with 60 mils of cross-linked polyethylene.

Compact stranding will not be permitted. A separator shall be applied on conductors to provide free stripping. The void areas between conductors may or may not be filled with a non-hygroscopic material. Cables shall be bound with binding tape. The bound conductors shall be covered with interlocked galvanized (inside and outside) steel tape armor and covered with 50 mils of polyvinyl chloride (PVC), or the armor may be a 10 mil thick corrugated bronze tape, helically applied with a minimum overlap of 12.5 percent or three corrugations, whichever is greater. The completed cable shall be marked "Type USE or RHH or RHW". The outside diameter of the completed cable shall not be more than 1.10 inches.

Cable assembly in polyethylene pipe will be allowed as an alternative to direct burial cable. Conductor size as shown in the Contract shall be in appropriate size polyethylene pipe as shown in the following table.

Conductor Size	Pipe Size (Inch)
#6	1
#4	1¼
#2	1¼
#1	1½

Polyethylene pipe shall be medium or high density and shall meet all provisions of NEMA standard publication No. TC7.

The requirements for conductors shall be the same as those specified for buried cable.

When crossing under roadway, all conductors, regardless of type, shall be run in rigid metal conduit or schedule 80 plastic conduit.

715.08

**715.08 Lighting Circuitry and Wiring.** Lighting systems shall be photoelectrically controlled. Photo cells shall be of the hermetically sealed, cadmium sulfide type and shall be preaged. Photoelectric units shall have a turn-on setting of 2.0 foot-candles, maximum. The ratio of the turn-off to turn-on setting shall be 3:1, maximum.

All electrical apparatus used in the lighting system shall be of ratings adequate to handle the necessary loads and shall conform to power source requirements.

Unless otherwise shown on the plans, copper wires and copper conductors shall be used and shall meet the minimum specifications and sizes as required by the National Electrical Code.

**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 A 1011, Grade 33 or 36, plates conforming to ASTM A 283 Grade C or D, or ASTM A 572 Grade 42; or it shall be manufactured to meet the requirements of ASTM A 53, Grade B or ASTM A 139 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, in accordance with subsection 509.24(b). Pipe that is cement mortar lined in accordance with 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, in accordance with AWWA Standards

<b>BURIED PIPE</b>		<b>EXPOSED PIPE</b>	
<b>INTERIOR</b>	<b>EXTERIOR</b>	<b>INTERIOR</b>	<b>EXTERIOR</b>
Lined with cement mortar in accordance with AWWA Standard C 205	80 mil thickness tape coating systems for the exterior of steel water pipelines in accordance with AWWA Standard C 214	Lined with cement mortar in accordance with AWWA Standard C 205 or coal tar epoxy in accordance with Corps of Engineers C 200	Subsections 509.24 and 509.29

**FOR PIPES CARRYING NON-POTABLE WATER AND FOR SEWERS**

<b>BURIED PIPE</b>		<b>EXPOSED PIPE</b>	
<b>INTERIOR</b>	<b>EXTERIOR</b>	<b>INTERIOR</b>	<b>EXTERIOR</b>
Lined with cement mortar in accordance with AWWA Standard C 205 or coal tar epoxy in accordance with Corps of Engineers C 200	80 mil thickness tape coating systems for the exterior of steel water pipelines in accordance with AWWA Standard C 214	Lined with cement mortar in accordance with AWWA Standard C 205 or coal tar epoxy in accordance with 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.

716.02

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 A 53.

**716.04 Copper Pipe.** Copper pipe shall conform to the requirements of ASTM B 88, 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 D 2104 when size, type, and schedule or series are designated or ASTM D 2239 when size and pressure ratings are designated. Polyvinyl Chloride pipe (PVC) shall conform to the requirements of ASTM D 1785 when size and schedule are designated or ASTM D 2241 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 herein.

(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 with 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 to which 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, center-piece and other cast parts shall be cast bronze meeting the requirements of ASTM B 62. All packing shall have each ring cut to fit, with staggered joints. Continuous (spiralled) 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 with 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.

717.01

**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 light-weight aggregate concrete blocks conforming to ASTM C 129, 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  $2\frac{1}{4}$  inch x  $3\frac{5}{8}$  inch x  $7\frac{5}{8}$  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 C 216, 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  $\frac{3}{16}$  inch x 6 inch galvanized rod.

Corrugated wall ties shall be  $\frac{7}{8}$  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  $\frac{1}{4}$  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, ½ inch or 5/8 inch integral stops and 5 ½ inch or 5 ¾ 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 ½ inches x 4 ½ 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 herein.

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, Sec. 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 C 126.

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.

717.07

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 D 312, 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 D 226.

Roofing aggregate shall meet the quality requirements of subsection 703.02 and shall be graded uniformly with 100 percent passing the 19.0 mm ( $\frac{3}{4}$  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 not less than 36 pounds per bundle.

All membrane roofing shall be 4 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 A 116.1, 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 fiber glass, thickness as shown on the plans with a density of  $\frac{3}{4}$  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,  $\frac{1}{4}$ " 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 not less than the following average weights per 5 foot of length:

2 inches	20 pounds
3 inches	30 pounds
4 inches	40 pounds
6 inches	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

717.14

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 B 88, 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. 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.

- (a) *Grills.* Grill location, model, style and sizes shall be as shown on the plans.
- (b) *Thermostat.* Thermostats shall be as specified under electrical work in subsection 717.16.
- (c) *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.
- (d) *Duct Work.* Duct work shall be fabricated from galvanized steel sheets in accordance with 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:

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'-10". All vertical riser ducts shall be supported at floor and ceiling with angle iron rests secured to the ducts.

- (e) *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. 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 trade mark of the manufacturer and shall bear the Underwriter's Laboratories, Inc. label.

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

- (a) *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.
- (b) *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 3 conductor, Type USE; three single conductors, Type USE, placed in the same trench; or 2 conductor Type UF, with ground wire. The wire size shall be as shown on the plans with no splices below ground.

717.16

Cable serving outdoor lighting may be one cable of 2 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 D 4227. 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.

- (c) *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.

- (d) *Emergency Light.* The emergency light shall be weatherproof, with guard, red glass globe, gasket and 6 volt, 25 watt, medium base extended service lamp.
- (e) *Device Plates.* Device plates in Utility room shall be pressed steel to suit the device to be covered. Device plate in Men and Women's rooms shall be stainless steel type 430.
- (f) *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 milliammeter, 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 gage minimum steel cabinet, adequately ventilated by louvers.
- (g) *Disconnect Switches.* All safety switches shall be S/N, fused, and Type "ND" construction as prescribed by the National Electrical Code. Weather-proofhousing for exterior switches shall be provided.
- (h) *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.
- (i) *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 ½ 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 or crushed or natural gravel meeting the following grading requirements:

Passing 25.0 mm (1 inch) Sieve	100%
Passing 19.0 mm (¾ inch) Sieve	95%-100%
Passing 4.75 mm (No. 4) Sieve	0%-5%