PART X — MATERIALS

Section No. Page No.

Section 1001
Portland Cement and Cementitious Materials

1001.01 PORTLAND CEMENT. Use portland cement from the Approved Materials List and comply with AASHTO M 85. Alkali content calculated as sodium oxide equivalent shall not exceed 0.60 percent by weight.

1001.02 BLENDED HYDRAULIC CEMENT. Use blended hydraulic cement Type IP, Type IS, or Type IL from the Approved Materials List and comply with AASHTO M 240. The alkali content of blended hydraulic cement calculated as sodium oxide equivalent shall not exceed 0.60 percent by weight.

Type IP may contain up to 30 percent by weight of fly ash or up to 30 percent by weight of bottom ash, provided that the bottom ash is interground with the cement clinker. Fly ash and bottom ash shall comply with AASHTO M 295, Class C or F.

Type IS cement may contain up to 50 percent by weight of ground granulated blast-furnace slag. Grade 100 and Grade 120 ground granulated blast-furnace slag (slag cement) shall comply with AASHTO M 302.

Type IL portland limestone cement shall not be treated as blended cement for purposes of cement material substitution with fly ash and slag.

1001.03 MASONRY CEMENT AND MORTAR CEMENT. Comply with ASTM C91 for masonry cement. Comply with ASTM C1329 for mortar cement. Mix mortar cement in accordance with ASTM C270 or use pre-blended dry mortar cement complying with ASTM C1714 and mix according to the manufacturers recommendations.

1001.04 FLY ASH AND NATURAL POZZOLANS. Use fly ash from the Approved Materials List. Comply with AASHTO M 295 for Class C and Class F. Comply with ASTM C618 for Class N. Alkali content calculated in accordance with DOTD TR 531 shall not exceed 2.5 percent by weight. Fly ash and natural pozzolans with alkali contents greater than 1.5 percent may only be used with innocuous (non-reactive) aggregates.

1001.05 GROUND GRANULATED BLAST-FURNACE SLAG (SLAG CEMENT). Use Grade 100 or Grade 120 ground granulated blast-furnace slag from the Approved Materials List and comply with AASHTO M 302.

1001.06 MICROSILICA (SILICA FUME). Use microsilica (silica fume) from the Approved Materials List and comply with AASHTO M 307.

Section 1002
Asphalt Cement, Emulsions, and Additives

1002.01 ASPHALT MATERIALS. Asphalt cement and emulsions shall be from the Approved Materials List. Asphalt shall be prepared by the refining of petroleum. Asphalt shall be uniform in character, free from water, and shall not foam when heated to 350°F (177°C).

Refinery or supplier storage tanks, piping, retorts, booster tanks, and other equipment used in delivering, storing, or handling asphalt materials shall be kept clean and in good operating condition and shall be operated as to avoid contamination of the contents with foreign materials.

Final test results for asphalt materials will be applied to the proper table in this Section for conformance to specifications.

Samples taken at the refinery or supplier shall comply with specification requirements. When the refinery or supplier sample fails to meet these requirements, the material will be rejected and shall not be shipped to the jobsite.

When asphalt materials sampled at the point of delivery do not comply with specification requirements, and in the opinion of the engineer have resulted in an unsatisfactory product based on an investigation, the materials shall be removed and replaced or otherwise corrected at no direct pay. Payment adjustment, when required, shall apply to the quantity of material represented by the sample. If no specific pay item exists, then the invoice price for the material will be used.

1002.02 ASPHALT MATERIAL ADDITIVES.

1002.02.1 Anti-Strip: Anti-strip additives for asphalt materials shall be from the Approved Materials List. Anti-strip additives shall be tested in accordance with DOTD TR 317.

1002.02.2 Crumb Rubber: Waste Tire Rubber must be pre-qualified by the Materials Laboratory. The maximum size of rubber particles shall be 30 mesh crumb (90-100 percent passing the No. 30 sieve) with a maximum replacement of 10 percent by weight of asphalt material. No cryogenic crumb rubber is allowed.

1002.02.3 Polymers: Polymer additives that are pre-blended with the asphalt material will be allowed. In-line blending may be allowed with approval from the Materials Engineer Administrator.

1002.02.4 Warm Mix Additives (WMA): A WMA is foamed water or a chemical additive that allows for asphalt to be mixed and placed at a

lower temperature, while maintaining or enhancing the ease of compaction. WMA shall be from the Approved Materials List.

1002.02.5 Fibers: A cellulose or mineral fiber, used to prevent draindown or to serve as filler must be pre-approved by the Department.

1002.02.5.1 Cellulose Fiber: Comply with the following:

Table 1002-1
Cellulose Fiber Properties

Property	Requirements
Fiber Length	6 mm, max.
Passing No. 100 (150 µm) Sieve[1]	60% - 80%
Ash Content[2]	13% - 23%
pH[3]	6.5 – 8.5
Oil Absorption[4]	4 to 6 times fiber weight
Moisture Content[5]	<5% by weight

[1] Sieve Analysis: This test is performed using an Alpine Air Jet Sieve (Type 200 LS). A representative five gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 11 psi. The portion remaining on the screen is weighed. Alternate methods may be allowed if approved by the Materials Engineer Administrator.

[2] Ash Content: A representative 2-3 gram sample of fiber is placed in a tared crucible and heated between 1100ºF and 1200ºF (595ºC and 650ºC) for not less than two hours. The crucible and ash are cooled in a desiccator and reweighed.

[3] pH Test: Five grams of fiber are added to 100 ml of distilled water, stirred and let sit for 30 minutes. The pH is determined with a probe calibrated with pH 7.0 buffer.

[4] Oil Absorption Test: Five grams of fiber are accurately weighed and suspended in an excess of mineral spirits for not less than five minutes to ensure total saturation. It is then placed in a screen mesh strainer (approximately 0.5-square millimeter hole size) and shaken on a wrist action shaker for ten minutes (approximately 1-1/4-inch motion at 240 shakes/minute). The shaken mass is then transferred without touching, to a tared container and weighed. Results are reported as the amount (number of times its own weight) the fibers are able to absorb.

[5] Moisture content: Ten grams of fiber are weighed and placed in a 250 ºF (121ºC) forced air oven for two hours. The sample is then reweighed immediately upon removal from the oven.

1002.02.5.2 Mineral Fiber: When mineral fiber is used, a cationic sizing will be required. Introduce the cationic sizing at rates recommended by the manufacturer to ensure proper dispersion of the fibers. Comply with the following:

Table 1002-2
Mineral Fiber Properties

Property	Requirements
Fiber Length[1]	6 mm maximum
Fiber Thickness[2]	0.005 mm maximum

[1] The Fiber Length is determined according to the Bauer McNett fractionation or alternate approved by the Materials Engineer Administrator.
[2] Mean Value of at least 200 fibers in a phase contrast microscope. An alternate method may be allowed if approved by the Materials Engineer Administrator.

Table 1002-3
Performance Graded Asphalt Cements

Property	AASHTO Test Method	PG82-22rm[1,7]	PG76-22m[7]	PG70-22m[7]	PG67-22	PG58-28
		Spec.	Spec.	Spec.	Spec.	Spec.
Tests on Original Binder:						
Rotational Viscosity @ 135°C, Pa·s [2]	T 316	3.0	3.0	3.0	3.0	3.0
Dynamic Shear, 10 rad/s, G*/Sin Delta, kPa	T 315	1.00+ @ 82°C	1.00+ @ 76°C	1.00+ @ 70°C	1.00+ @ 67°C	1.00+ @ 58°C
Dynamic Shear, 10 rad/s, Phase Angle, °	T 315	—	75° @ 76°C	—	—	—
Flash Point, °C	T 48	232+	232+	232+	232+	232+
Solubility, % [3]	T 44	N/A	99.0+	99.0+	99.0+	99.0+
Separation of Polymer, 163°C, 48 hours, degree C difference in R & B from top to bottom [4]	ASTM D7173 AASHTO T 53	—	2-	2-	—	—
Tests on Rolling Thin Film Oven Residue:	T 240					
Mass Change, %	T 240	1.00-	1.00-	1.00-	1.00-	1.00-
Dynamic Shear, 10 rad/s, G*/Sin Delta, kPa	T 315	2.20+ @ 82°C	—	—	2.20+ @ 67°C	2.20+ @ 58°C
Elastic Recovery, 25°C, 10 cm elongation, %[5]	T 301	60+	—	—	—	—
Multiple Stress Creep Recovery (MSCR), 67ºC, Jnr(3.2 kPa)	T 350	—	0.5-	2.0-	—	—
Multiple Stress Creep Recovery (MSCR), 67ºC, % Recovery (3.2 kPa)	T 350	—	Meets curve[6]	Meets curve[6]	—	—
Ductility, 25°C, 5 cm/min, cm	T 51	—	—	—	90+	—
Tests on Pressure Aging Vessel Residue:	R 28					
Dynamic Shear, @ 26.5°C, 10 rad/s, G* Sin Delta, kPa	T 315	5000-	6000-	6000-	5000-	5000- @ 19°C
Bending Beam Creep Stiffness, S, MPa @ -12°C.	T 313	300-	300-	300-	300-	300- @ -18°C
Bending Beam Creep Slope, m value,@ -12°C	T 313	0.300+	0.300+	0.300+	0.300+	0.300+ @ -18°C

[1]Tank mixers are required. Submit written documentation of tank cleaning annually to the Materials Laboratory. Submit written certificates of analysis from the asphalt binder supplier confirming rubber source and size distribution of rubber used. Furnish to the Materials Laboratory.

[2]The rotational viscosity will be measured to determine product uniformity. The rotational viscosity measured by the supplier shall be noted on the Certificate of Delivery. A binder having a rotational viscosity of 3.0 Pa·s or less will typically have adequate mixing and pumping capabilities. Binders with rotational viscosity values higher than 3.0 Pa·s should be used with caution and only after consulting with the supplier as to any special handling procedures and guarantees of mixing and pumping capabilities.

[3]Not all polymers are soluble in the specified solvents. If the polymer modified asphalt digested in the solvent will not pass the filter media, a sample of the base asphalt used in making the polymer modified asphalt should be tested for solubility. If the solubility of the base asphalt is at least 99.0%, the material will be considered as passing.
[4]Prepare samples per ASTM D7173. Determine softening point of top and bottom per AASHTO T 53. Not required when crumb rubber is used. Separation may be waived for plant blending with the approval of the Materials Engineer.
[5]AASHTO T 301 except elongation shall be 10 cm.
[6]As defined in AASHTO M 332
[7] Use a maximum 10 % crumb rubber.

Table 1002-4
Emulsified Polymerized Asphalt[1]

Property	AASHTO Test Method	Percent of Contract Unit Price							
		CRS-2P			CSS-1hP			Polymer Emulsion Tack (PET)	
		Specs	Deviations		Specs	Deviations		Specs	Deviations
		100	80	50 or Remove[2]	100	80	50 or Remove[2]	100	50 or Remove and Replace[2]
Viscosity, Saybolt Furol @ 50°C, s	T 59	100 – 400	—	—	—	—	—	—	—
Viscosity, Saybolt Furol @ 25°C, s	T 59	—	—	—	20 – 100	—	—	20 – 100	—
Storage Stability,24Hr.,%	T 59	1.0-	—	—	1.0-	—	—	—	—
Settlement, 5-day, %	T 59	5.0-	—	—	—	—	—	—	—
Identification Test	T 59	Pass	—	Fail	—	—	—	—	—
Particle Charge	T 59	Pos.	—	Neg.	Pos.	—	Neg.	—	—
Residue by Distillation, % by wt. [3]	T 59	65+	61-64	60-	62+	57-61	56-	63+	62-
Oil Distillate by Volume, %	T 59	3.0-	—	—	—	—	—	—	—
Sieve Test, % (Retained on 850 µm)	T 59	0.1-	—	—	0.1-	—	—	—	—
Tests on Residue by Distillation:									
Penetration, 25°C, 100 g, 5 s, dmm	T 49	100 – 200	80–99 201–225	79- 226+	40 – 90	30–39 91–100	29- 101+	60 – 150	59- 151+
Softening Point (Ring & Ball), °C	T 53	38.0	32.1-37.9	32.0	57+	51.1- 56.9	51-	—	—
Solubility, %	T 44	97.5+	—	—	97.5+	—	—	97.5+	—
Ductility, 25°C 5 cm/min, cm	T 51	—	—	—	70+	56–69	55-	—	—
Tests on Residue by Evaporation[4]:									
Force Ductility Ratio, (f_2/f_1, 4°C, 5 cm/min, f_2 at Second peak)	T 300	0.30+	0.21-0.29	0.20-	—	—	—	—	—
Elastic Recovery, 10°C @ 20 cm elongation, %	T 301	58+	51–57	50-	—	—	—	58+	

[1] The Department does not allow the addition of latex, rubber or other additives to emulsified polymerized asphalt.

[2] At the Chief Engineer's option.

[3] For CSS-1hP, hold the temperature for the Distillation test below 280°F (138°C). Higher temperatures may cause the polymers to break down.

[4] Obtain residue asphalt for force ductility and elastic recovery by evaporation (Oven) rather than distillation (Aluminum-alloy Still).

Table 1002-5
Non-Tracking Tack Coats – Cold Applied

Property	AASHTO Test Method	NTSS-1HM		CBC-1H	
		100% Pay	**50% Pay or Remove and Replace[1]**	**100% Pay**	**50% Pay or Remove and Replace[1]**
Viscosity, Saybolt Furol @ 25°C, s	T 59	15 - 100	—	15 - 100	—
Storage Stability, 24 Hour, %	T 59	1.0-	—	1.0-	—
Settlement, 5 Days, %	T 59	5.0-	—	—	—
Residue by Distillation[3], %	T 59	50+	49-	58+	57-
Oil Distillate, %	T 59	1.0-	—	—	—
Sieve Test, (Retained on the 850 µm), %[2]	T 59	0.3-	—	0.1-	—
Tests on Residue					
Penetration @ 25°C, 100g, 5s, d_{mm}	T 49	20-	—	40 - 90	39- 91+
Softening Point, Ring and Ball, °C	T 53	65+	64-	49+	48-
Solubility, %	T 44	97.5+	—	—	—
DSR @ 82°C; G*/Sin δ, 10 rad / s, kPa	T 315	1.0+	—	—	—

[1] At the Chief Engineer's option.
[2] Sieve tests may be waived if no application problems are present in the field.
[3] For CBC-1H only: Exception to T59 Distillation – Bring the temperature on the lower thermometer slowly to 350°F. Maintain at this temperature for 20 minutes. Complete total distillation in 60 +/- 5 minutes from the first application of heat.

Table 1002-6
Cationic Emulsified Asphalt (CSS-1h)

Property	AASHTO Test Method	CSS-1h		
		Specifications	Deviations	
		100	80	50 or Remove and Replace[1]
Viscosity, Saybolt Furol @ 50°C, s	T 59	—	—	—
Viscosity, Saybolt Furol @ 25°C, s	T 59	20 – 100	—	—
Residue by Distillation, % by wt.	T 59	57+	52 – 56	51-
Oil Distillate by Volume, %	T 59	—	—	—
Particle Charge	T 59	Pos.	—	Neg.
Sieve Test, % (Retained on 850 µm)	T 59	0.1-	—	—
Settlement, 5-day, %	T 59	5.0-	—	—
Tests on Residue by Distillation:				
Penetration, 25°C, 100 g, 5 s, dmm	T 49	40 – 90	30 – 39 91 – 100	29- 101+
Solubility, %	T 44	97.5+	---	---
Ductility, 25°C 5 cm/min, cm	T 51	40+	26 – 39	25-
Viscosity, 135°C, Pa·s	T 316	—	—	—

[1] At the Chief Engineer's option.

Table 1002-7
Anionic Emulsified Asphalt (SS-1h)

Property	AASHTO Test Method	SS-1h		
		Specifications	Deviations	
		100	80	50 or Remove and Replace[1]
Viscosity, Saybolt Furol @ 25°C, s	T 59	20 – 100	—	—
Residue by Distillation, % by wt.	T 59	57+	52 – 56	51-
Sieve Test, % (Retained on 850 µm)	T 59	0.1-	—	—
Cement Mixing	T 59	2-	—	—
Settlement, 5-day, %	T 59	5.0-	—	—
Tests on Residue by Distillation:				
Penetration, 25°C, 100 g, 5 s, dmm	T 49	40 – 90	30 – 39 91 – 100	29- 101+
Solubility, %	T 44	97.5+	—	—
Ductility, 25°C, 5 cm/min, cm	T 51	40+	26 – 39	25-

[1] At the Chief Engineer's option.

Table 1002-8
MC Cutback Asphalt

Property	AASHTO Test Method	MC-30			MC-70		
		Specifications		Deviations	Specifications		Deviations
		100	80	50 or Remove[1]	100	80	50 or Remove and Replace[1]
Flash Point, Open Tag, °C	T 79	38+	—	—	38+	—	—
Viscosity, Saybolt Furol @ 25°C, s	T 72	75 - 150	58 – 74 151 - 167	57- 168+	—	—	—
Viscosity, Saybolt Furol @ 60°C, s	T 72	—	—	—	35 – 70	24 – 34 71 – 80	23- 82+
Distillation Test, Distillate Percentage by Volume of Total Distillate to 360°C	T 78						
To 225°C		0.0- 25.0	—	—	0.0- 20.0	—	—
To 260°C		40.0- 70.0	—	—	20.0- 60.0	—	—
To 316°C		75.0- 93.0	—	—	65.0- 90.0	—	—
Residue from Distillation to 360°C, Volume % of Sample by Difference	T 78	50.0+	45.1-49.9	45.0-	55.0+	50.1-54.9	50.0-
Tests on Residue by Distillation:							
Penetration, 25°C, 100 g, 5 s, dmm	T 49	120 – 250	102 - 119 251 - 268	101- 269+	120 - 250	102 – 119 251 – 268	101- 269+
Solubility, %	T 44	99.0+	98.6–98.9	98.5-	99.0+	98.6–98.9	98.5-
Ductility, 25°C for Residues To 200 Penetration 5 cm/min, cm	T 51	100+	76 - 99	75-	100+	76 – 99	75-
Ductility, 15.5°C for Residues of 200 – 300 Penetration, 5 cm/min, cm	T 51	100+	76 - 99	75-	100+	76 - 99	75-

[1] At the Chief Engineer's option.

Table 1002-9
Asphalt Emulsion Prime (AEP)

	AASHTO Test Method	Percent of Contract Unit Price		
		Specification		Deviations
		100	80	50 or Remove and Replace [1]
Viscosity, Saybolt Furol @ 50°C, s	T 59	15-100	10-15 101-200	9- 201+
Residue by Evaporation, % by wt.	T 59	50+	46-49	45-
Oil Distillate by Volume, %	T 59	25.0-	—	—
Sieve Test (retained on 850 µm), %	T 59	0.1-	—	—
Storage Stability, 24 h, %	T 59	1.0-	—	—
Settlement, 5 Days, %	T 59	5.0-	—	—
Test on Residue by Evaporation:				
Penetration, 25°C, 100 g, 5 s, dmm	T 49	250+	—	—
Solubility, %	T 44	97.5+	—	—

[1] At the Chief Engineer's option.

Table 1002-10
Cationic Emulsified Petroleum Resin (EPR-1)

	AASHTO Test Method	Percent of Contract Unit Price		
		Specification		Deviations
		100	80	50 or Remove and Replace[1]
Viscosity, Saybolt Furol @ 25°C, s	T 59	15- 100	10-15 101-150	9- 151+
Residue by Evaporation, % by wt.	T 59	57+	52-56	51-
Particle Charge	T 59	Pos.	—	Neg.
Sieve Test (Retained on 850 µm), %	T 59	0.1-	—	—
Settlement, 5 Days, %	T 59	5.0-	—	—

[1] At the Chief Engineer's option.

Table 1002-11
Hot Applied Modified Asphalt Cements for Asphalt Surface Treatment (PAC 15)

Property	AASHTO Test Method	PAC 15	
		Spec.	Deviation
		100	90 or Remove and Replace[1]
Penetration @ 25°C, 100 g., 5 s, dmm	T 49	75-125	74- 126+
Viscosity, @ 60°C, Pa·s	T 202	150+	149-
Rotational Viscosity @ 135°C, Pa·s[2]	T 316	3.0-	3.1+
Force Ductility Ratio, f_2/f_1, 4°C, 5cm/min, f_2 @ 30 cm elongation[3]	T 300	0.30+	0.29-
Softening Point, °C	T 53	45+	44-
Flash Point, °C	T 48	230+	228-
Separation of Polymer, 163°C, 48 hours difference in R & B from top to bottom sample, °C [4]	ASTM D 7173 AASHTO T 53	2-	—
Tests on Residue from Rolling Thin Film Oven Test:	T 240		
Elastic Recovery, 25°C, 10 cm elongation, % [5]	T 301	55+	54-
Penetration Retention 25°C, RTFO/Original	T 49	0.60+ 1.00-	0.59- 1.01+

[1] At the Chief Engineer's option.
[2] Measure rotational viscosity to determine product uniformity. The supplier shall note his measured rotational viscosity on the Certificate of Delivery. A binder having a rotational viscosity of 3.0 Pa·s or less will typically have adequate mixing and pumping capabilities. Use binders with rotational viscosity values higher than 3.0 Pa·s with caution and only after consulting with the supplier as to any special handling procedures and guarantees of mixing and pumping capabilities.
[3] AASHTO T 300 except the second peak (f_2) shall be defined as the stress at 30 cm elongation.
[4] Prepare samples per ASTM D7173. Determine softening point of top and bottom per AASHTO T 53.
[5] AASHTO T 301 except the elongation shall be 10 cm.

Table 1002-12
Non-Tracking Hot Applied Polymer (NTHAP) Tack Coat

TYPICAL PHYSICAL PROPERTIES

PARAMETER	TEST METHOD	MIN	MAX
Rotational Viscosity @ 149 °C, Pa·s	AASHTO T316	—	3.0*
Penetration @ 25 °C , dmm	ASTM D5	—	25
Softening Point, °C	ASTM D36	70	99
Original DSR @ 82 °C , G*/sin δ, kPa	AASHTO T315	1.0	—
Creep Stiffness, m-value @ 0 °C on original binder	AASHTO T313	0.285	—

* Rotational viscosity shall be waived if material can be successfully applied in the field.

Section 1003
Aggregates

1003.01 GENERAL. All aggregates shall be environmentally acceptable for the intended use and shall be from an approved SiteManager® Producer/Supplier. Additionally stone, gravel, slag, lightweight aggregates, and coarse and manufactured sand sources shall be from the Approved Materials List. Recycled portland cement concrete (RPCC), reclaimed asphalt pavement (RAP), blended calcium sulfate (BCS), and fine natural sand are required to be from an approved Producer/Supplier. For source approval, comply with the requirements in this subsection and any other appropriate section. Provide global positioning coordinates (GPS) for the aggregate source site location.

Unless otherwise defined, coarse aggregates have material predominately retained on the No. 4 (4.75 mm) sieve; fine aggregates have material predominately passing the No. 4 (4.75 mm) sieve.

An aggregate material stockpile is either a dedicated stockpile or a working (non-dedicated) stockpile. A dedicated stockpile is a stockpile, which has been sampled and tested by the Department representative. Once approved, it shall not be altered unless the additional material has been sampled, tested, and approved. For non-dedicated or working stockpiles, the contractor may add or remove material as needed, provided the quality and gradation is maintained.

1003.01.1 Test Methods: The following test methods apply:

Table 1003-1
Aggregate Test Procedures

Property	Test Procedure
Deleterious Materials	DOTD TR 119
Flat and Elongated Particles	ASTM D4791
Magnesium Sulfate Soundness	AASHTO T 104
Los Angeles Abrasion	AASHTO T 96
Alkali-Silica Reactivity (Chemical Method)	ASTM C289
Alkali Reactivity (Mortar-Bar Method)	ASTM C1260
Reactivity of Concrete Aggregates	AASHTO PP65-11
Alkali Reactivity of Carbonate Rocks (Rock-Cylinder Method)	ASTM C586
Organic Impurities	AASHTO T 21
Unit Weight	AASHTO T 19
Specific Gravity & Absorption of Fine Aggregate	AASHTO T 84
Specific Gravity & Absorption of Coarse Aggregate	AASHTO T 85
Polish Value	AASHTO T 278 and T 279
Amount of Material Finer than the No 200 (75 µm) Sieve	DOTD TR 112
Sieve Analysis (Gradation)	DOTD TR 113
pH of Soil and Water	DOTD TR 430
pH of Aggregates	DOTD TR 122
Atterberg Limits (LL, PL, & PI)	DOTD TR 428
Organic Content	DOTD TR 413
Percent Crushed	DOTD TR 306
Mechanical Analysis of Extracted Aggregate	DOTD TR 309
Sand Equivalent	DOTD TR 120
Fine Aggregate Angularity	DOTD TR 121
Micro-Deval	AASHTO T 327
Moisture Sensitivity (TSR)	DOTD TR 322
Mortar Strength	AASHTO T 71
Methylene Blue	AASHTO TP 57-99

1003.01.2 General Material Properties: All aggregates shall comply with these material properties.

1003.01.2.1 Deleterious Materials: Conform to the following deleterious materials table for source approval and/or project acceptance:

Table 1003-2
Deleterious Materials in Aggregates

Property	Percent, Max
Wood	0.05
Clay Lumps	0.5
Clay Lumps and Friable Particles	3.0
Coal and Lignite	1.0[1]
Flat and Elongated Particles (5:1)	15.0[2]
Flat and Elongated Particles (3:1)	25.0[3]
Glassy Particles	10.0
Iron Ore	2.0[1]
Total: Wood, Clay Lumps, Friable Particles, Iron Ore, Lignite and Other Foreign Matter	5.0

[1] For bridge railing aggregate, maximum is 0.00.
[2] For source approval, maximum is 15.0. For Superpave asphalt aggregates and asphalt surface treatment, maximum is 10.0. For stone matrix asphalt (SMA) aggregates, maximum is 5.0.
[3] Applies only to thin lift asphalt coarse mix, thin lift asphalt Open Graded Friction Course (OGFC) and SMA.

1003.01.2.2. Magnesium Sulfate Soundness: For source approval coarse natural aggregates and recycled portland cement concrete (RPCC), the maximum soundness loss is 15 percent when subjected to 5 cycles of the magnesium sulfate soundness test.

1003.01.2.3. Los Angeles Abrasion: For coarse natural aggregates and RPCC source approval, maximum Los Angeles abrasion loss is 40.0 percent.

1003.01.2.4. Friction Rating: A friction rating is assigned for coarse aggregate (stone and lightweight aggregate) during source approval in accordance with Table 1003-3. The assigned friction rating is available from the Materials and Testing Section. Coarse gravel will only be evaluated for friction rating if the percent double face crushed is at least 75 percent; otherwise, it is assigned a rating of III.

Table 1003-3
Aggregate Friction Rating

Friction Rating[1]	Polish Value
I	> 37
II	35 to 37
III	30 to 34
IV	< 30

[1]The Materials Engineer Administrator may adjust friction rating based upon pavement friction test results.

1003.01.3 Recycled, Reclaimed and Synthetic Aggregates:

1003.01.3.1 Recycled Portland Cement Concrete, (RPCC):

RPCC shall be from an approved source listed in the SiteManager® Producer/Supplier List. RPCC shall be crushed portland cement concrete screened and/or graded to meet the requirements of the specification for the intended use. For source approval, the raw material feedstock, the crushing operation, the quality control program, and the stockpiles will be inspected and approved by the District Laboratory Engineer. Quality must be maintained in order to retain source approval status. RPCC used for Interstate projects shall be stored in dedicated stockpiles used solely for one specific project. The RPCC for non-Interstate projects shall be stored in working stockpiles that are separate, identifiable, and have a minimum quantity of 5000 cubic yards. Stockpiles shall be reasonably free of asphalt concrete overlay material, reinforcing steel, joint material, base course material and other debris. If the Project Engineer certifies that the stockpile contains RPCC exclusively from DOTD pavements or structures, the Magnesium Sulfate soundness testing may be waived by the Materials Engineer Administrator.

1003.01.3.2 Reclaimed Asphalt Pavement, (RAP): RAP shall be from an approved source listed in the SiteManager® Producer/Supplier List. Mill or crush RAP in accordance with Section 509 and store in working stockpiles. Stockpiled materials shall be uniform and reasonably free of lightweight aggregate, debris, soil, and other foreign matter.

1003.01.3.3 Blended Calcium Sulfate, (BCS): BCS, a synthetic aggregate, shall be from an approved source listed in the SiteManager® Producer/Supplier List. The quality control program shall be approved by the Materials and Testing Section. The source shall provide documentation as evidence that the Department of Environmental Quality has given environmental clearance specifically for the intended use. Material pH shall

be a minimum of 5.0 when tested in accordance with DOTD TR 122. BCS may be blended at the source with an approved limestone or lime to meet pH requirements. The blended material shall be non-plastic and reasonably free from organic and foreign matter. Samples shall be taken from a dedicated stockpile at the point of origin and tested for gradation in accordance with DOTD TR 113.

1003.01.4 Properties for Portland Cement Concrete Aggregates: For source approval, aggregates will be evaluated for both alkali silica and alkali carbonate reactivity.

1003.01.4.1 Alkali Silica Reactivity (ASR) of Sands and Gravels in Portland Cement Concrete: For source approval, aggregates for use in portland cement concrete are tested for alkali silica reactivity properties in accordance with ASTM C289. Aggregates categorized as "innocuous" (non-reactive) are allowed without restriction. Aggregates categorized as "potentially deleterious" or "deleterious" by ASTM C289 may be further appraised by ASTM C1260 testing, modified to use a minimum 0.53 water cement ratio and a portland cement from the Department's Approved Materials List. If ASTM C1260 then designates aggregates as "potentially deleterious," (less than 0.2 percent expansion) then use the maximum cementitious material substitutions as allowed in Section 901 for mixes incorporating these "potentially deleterious" aggregates. If a fly ash binary mix is selected, the fly ash must be class F. Alternatively, AASHTO PP65-11 may be applied to define ASR potential for gravel and sand for concrete mixtures. Concrete mixtures shall refrain from incorporating aggregates designated as "ASR deleterious."

1003.01.4.2 Alkali Carbonate Reactivity (ACR) and Alkali Silica Reactivity (ASR) of Limestone in Portland Cement Concrete: For source approval, limestone aggregates for use in portland cement concrete will be evaluated for alkali carbonate reactivity (ACR) and alkali silica reactivity (ASR) utilizing AASHTO PP65-11. Aggregates determined to be innocuous (non-reactive) are allowed without restriction. For those aggregates determined to be potentially "ASR reactive," use the maximum cementitious material substitutions as allowed in Section 901 for mixes incorporating these ASR reactive aggregates. If a fly ash binary mix is selected, the fly ash must be class F. Concrete mixtures shall refrain from incorporating limestone aggregates designated as "ASR deleterious." Concrete mixtures shall not incorporate aggregates designated as "ACR reactive."

1003.01.4.3 Organic Impurities in Fine Aggregate for Portland Cement Concrete: For source approval, fine aggregate for portland cement concrete is tested for organic impurities in accordance with AASHTO T 21. If the color is darker than the Organic Color No. 3 when tested, the fine aggregate is then tested in accordance with AASHTO T 71 for mortar strength. The measured compressive mortar strength shall be at least 95 percent of the referenced compressive mortar strength.

1003.02 NONPLASTIC EMBANKMENT. The maximum organic content is 4.0 percent when tested in accordance with DOTD TR 413.

1003.02.1 Sand: Sand embankment shall be nonplastic material with at least 75 percent passing the No. 4 (4.75 mm) sieve and not more than 15 percent passing the No. 200 (75 μm) sieve when tested in accordance with DOTD TR 112 and DOTD TR 113.

1003.02.2 Stone: Stone shall be a coarse stone from the Approved Materials List. Comply with the following gradation:

Table 1003-4
Gradation for Nonplastic Embankment, Stone

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
2 inches (50 mm)	100
1 inch (25.0 mm)	55 - 100
3/4 inch (19.0 mm)	35 - 88
No. 4 (4.75 mm)	0 - 10

The maximum dry-rodded unit weight (mass) is 95 pounds per cubic foot (1520 kg/cu m) when tested in accordance with AASHTO T 19.

1003.02.3 Blended Calcium Sulfate, (BCS): Comply with the following gradation:

Table 1003-5
Gradation for Nonplastic Embankment, BCS

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 1/2 inches (50 mm)	60 - 100
1 inch (25.0 mm)	40 - 80
3/4 inch (19.0 mm)	30 - 70
No. 4 (4.75 mm)	20 - 65
No. 200 (75 μm)	0 - 25

1003.03 BASE COURSE AGGREGATES.

1003.03.1 Stone: Use stone from the Approved Materials List, and comply with the following gradation:

Table 1003-6
Gradation for Base Course Aggregates, Stone

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	100
1 inch (25 mm)	90 - 100
3/4 inch (19.0 mm)	70 - 100
No. 4 (4.75 mm)	35 - 65
No. 40 (425 µm)	12 - 32
No. 200 (75 µm)	5 - 12

For material passing the No. 40 (425 µm) sieve, comply with the following requirements:

Liquid Limit (Max.)	25
Plasticity Index (Max.)	5

1003.03.2 Recycled Portland Cement Concrete: Comply with the following gradation:

Table 1003-7
Gradation for Base Course Aggregates, RPCC

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	100
1 inch (25.0 mm)	90 - 100
3/4 inch (19.0 mm)	70 - 100
No. 4 (4.75 mm)	35 - 65
No. 40 (425 µm)	12 - 32
No. 200 (75 µm)	0 - 8

Material passing the No. 40 (425 µm) sieve shall be non-plastic.

1003.03.3 Blended Calcium Sulfate, BCS: Comply with the following gradation:

Table 1003-8
Gradation for Base Course Aggregates, BCS

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
2 inches (50 mm))	100
1 ½ inches (37.5 mm)	85 - 100
1 inch (25.0 mm)	80 - 100
3/4 inch (19.0 mm)	60 - 100
No. 4 (4.75 mm)	10 - 40
N0. 40 (425 µm)	0 - 20
No. 200 (75 µm)	0 - 15

1003.03.4 Permeable Base: For permeable asphalt base and permeable concrete base, use 100 percent crushed stone from the Approved Materials List, and comply with the following:

Table 1003-9
Gradation for Permeable Base Aggregates (Stone)

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 inch (25 mm)	100
3/4 inch (19.0 mm)	90 - 100
3/8 inch (9.5 mm)	20 - 55
No. 4 (4.75)	0 - 10
No. 8 (2.36)	0 - 5

1003.04 AGGREGATE FOR SUBGRADE LAYER.

1003.04.1 Stone or Recycled Portland Cement Concrete: For stone or recycled portland cement concrete comply with 1003.03.

1003.04.2 Blended Calcium Sulfate: Comply with the following gradation:

Table 1003-10
Gradation for Subgrade Layer, BCS

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 inch (25.0 mm)	90 - 100
3/4 inch (19.0 mm)	70 - 100
No. 4 (4.75 mm)	25 - 75
No. 200 (75 μm)	0 - 25

1003.05 AGGREGATES FOR SURFACE COURSE.

1003.05.1 Stone, Recycled Portland Cement Concrete: For stone and/or recycled portland cement concrete, comply with the following:

Table 1003-11
Gradation for Surface Course Aggregates, Stone/RPCC

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	100
3/4 inch (19.0 mm)	50 - 100
No. 4 (4.75 mm)	35 - 65
No. 40 (425 μm)	10 - 32
No. 200 (75 μm)	3 - 15

For material passing the No. 40 (425 μm) sieve, comply with the following requirements:

Liquid Limit (Max.)	25
Plasticity Index (Max.)	5

1003.05.2 Sand-Clay-Gravel: This material shall be a mixture of sand, clay, and either siliceous gravel, stone, or recycled portland cement concrete. The mixture shall be reasonably free from foreign matter as determined by visual inspection.

The mixture, prior to treatment shall comply with the following:

Table 1003-12
Gradation for Surface Course Aggregates, Sand-Clay-Gravel

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	95 - 100
No. 4 (4.75 mm)	40 - 65
No. 200 (75 µm)	10 - 25

For material passing the No. 40 (425 µm) sieve, comply with the following after lime treatment:

Liquid Limit (Max.)	40
Plasticity Index	4-15

1003.05.3 Reclaimed Asphalt Pavement (RAP): Comply with the following:

Table 1003-13
Gradation for Surface Course Aggregates, RAP

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
2 inches (50 mm)	100
No. 4 (4.75)	35 - 75

1003.06 AGGREGATES FOR ASPHALT MIXTURES.

Use only stone, gravel, slag, lightweight aggregates, and coarse and manufactured sand sources from the Approved Materials List. RAP and fine natural sand are required to be from an approved Producer/Supplier. All coarse aggregates for Stone Matrix Asphalt (SMA) shall be clean and durable crushed stone. Fine aggregate for SMA shall be 100 percent crushed stone manufactured sand.

Coarse aggregate is all material retained on or above the No. 4 (4.75 mm) sieve. Fine aggregate is all material passing the No. 4 (4.75 mm) sieve.

Comply with 1003.01.

1003.06.1 Coarse: For coarse aggregate stockpiles, determine Coarse Aggregate Angularity in accordance with DOTD TR 306 (Double Face), and determine Flat and Elongated in accordance with ASTM D4791.

1003.06.2 Fine: For fine aggregate stockpiles, determine Fine Aggregate Angularity in accordance with DOTD TR 121, and Sand Equivalent (SE) in accordance with DOTD TR 120. SE is not required for

manufactured sands (screenings), nor for fine aggregate stockpiles having 25 percent or more passing the No. 200 (75 μm) sieve.

1003.06.3 Natural Sand: Natural sand is non-plastic material consisting of clean, hard, durable, siliceous grains graded from coarse to fine and reasonably free from vegetative matter, clay balls, clay lumps, or other deleterious materials. Comply with Tables 1003-1 and 1003-2. The gradation shall have a maximum of 25 percent passing the No. 200 (75 μm) sieve. Clay lumps shall not exceed 0.5 percent by weight (mass) when sampled from the stockpile and tested in accordance with DOTD TR 119.

1003.06.4 Manufactured Sand: Manufactured sand (screenings) is the fine aggregate material generated during the crushing and processing of coarse aggregates. Sand Equivalent testing is not required; fine aggregate angularity testing is required.

1003.06.5 RAP: RAP shall be approved either at the time of removal from the roadway or in stockpiles. Make all stockpile quality control records available at the Project Engineer's request. The records shall include RAP quantities and delivery date, quantities delivered to projects, daily moisture contents, weekly asphalt cement content, and weekly RAP G_{se}. Before feeding RAP into the plant, crush or screen all pieces that are larger than 2 inches (50 mm).

1003.06.6 Mineral Filler: Mineral filler shall be from the Approved Materials List, and shall consist of limestone dust, pulverized hydrated lime, portland cement, cement stack dust, or lime kiln dust. Mineral dust collected in bag houses or by other dust collectors at asphalt concrete plants is not classified as mineral filler. Cement stack dust shall consist of material collected from waste rotary kiln gases discharged through a collector of a cement plant. Comply with the following:

Table 1003-14
Gradation for Asphalt Aggregates, Mineral Filler

U. S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
No. 30 (600 mm)	100
No. 80 (180 mm)	95 - 100
No. 200 (75 μm)	70 - 100
No. 270 (53 μm)	60 - 100

1003.06.7 Lightweight Aggregate: Lightweight aggregate shall consist of cubical fragments which are of uniform density and are free from an excess of foreign matter.

1003.07 AGGREGATES FOR ASPHALT SURFACE TREATMENT. Use crushed gravel, crushed stone, or lightweight aggregate from the Approved Materials List and comply with 1003.01.

Crushed gravel Size 1 and Size 2 shall have 60 percent minimum crushed retained on the No. 4 (4.75 mm) sieve. Crushed gravel Size 3 shall have 75 percent crushed retained on the No. 4 (4.75 mm) sieve. Determine the percent crushed in accordance with DOTD TR 306.

Comply with the following gradation:

Table 1003-15
Gradation for Asphalt Surface Treatment

		Size 1		Size 1A	Size 2	Size 3
U. S. Sieve	Metric Sieve	Slag or Stone Aggregate (Size No. 5)	Crushed Gravel[1] or Lightweight Aggregate	Slag or Stone Aggregate	All Aggregate	All Aggregate
1 1/2 inch	37.5 mm	100	100	100	—	—
1 inch	25.0 mm	90-100	95-100	100	—	—
3/4 inch	19.0 mm	20-55	60-90	85-100	100	—
1/2 inch	12.5 mm	0-10	—	25-40	95-100	100
3/8 inch	9.5 mm	0-5	0-15	5-15	60- 80	95-100
No. 4	4.75 mm	—	0-5	—	0-5	20-50
No. 8	2.36 mm	—	—	—	0-2	0-2
No. 200[2]	75 µm[2]	0-1	0-1	0-1	—	—

[1] Uncrushed gravel may be used for Size 1 aggregate if more than one application of Asphalt Surface Treatment is required.
[2] If the material passing the No. 200 (75 µm) sieve consists of only dust from crushing and handling, and is essentially free of clay, then the percentage passing the No. 200 (75 µm) sieve shall be 0 - 2 percent.

1003.08 AGGREGATES FOR PORTLAND CEMENT CONCRETE AND MORTAR. Use aggregates from the Approved Materials List in portland cement concrete and mortar.

1003.08.1 Fine Aggregate: Sand shall be natural silica sand.

For fine aggregate used in all portland cement concrete except Types B and D gradations, conform to the following gradation:

Table 1003-16
Gradation for Portland Cement Concrete Sand

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	95 - 100
No. 16 (1.18 mm)	45 - 90
No. 50 (300 μm)	7 - 30
No. 100 (150 μm)	0 - 7
No. 200 (75 μm)	0 - 3

Table 1003-17
Gradation for Mortar Sand

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	95 - 100
No. 100 (150 μm)	0 - 25
No. 200 (75 μm)	0 - 10

1003.08.2 Coarse Aggregate:

For bridge decks, use coarse aggregates with a Friction Rating of I, II, or III as defined in 1003.01.2.4.

1003.08.2.1 Uncrushed Coarse Aggregate:

For uncrushed coarse aggregate used in all portland cement concrete except Types B and D gradations, comply with Table 1003- 18.

Table 1003-18
Gradation for Portland Cement Concrete, Uncrushed Aggregates

Percent Passing				
US Sieve	Metric Sieve	Size 57M	Size 89M	Size 67
2 1/2 inch	63 mm	—	—	—
2 inch	50 mm	—	—	—
1 1/2 inch	37.5 mm	100	—	—
1 inch	25.0 mm	90-100[1]	—	100
3/4 inch	19.0 mm	—	100	90-100
1/2 inch	12.5 mm	25-60	90-100	—
3/8 inch	9.5 mm	—	—	20-55
No.4	4.75 mm	0-10	15-60	0-10
No.8	2.36 mm	0-5	0-30[2]	0-5
No. 16	1.18 mm	—	0-5	—
No. 200	75 µm	0-1	0-1	0-1

[1] ASTM C33 No. 57 designation requires 95 – 100.
[2] ASTM C33 No. 89 designation requires 0 – 15.

1003.08.2.2 Crushed Coarse Aggregate: For crushed coarse aggregate used in all portland cement concrete, except Types B and D gradations, comply with the uncrushed coarse aggregate gradation of 1003.08.2.1, except that when the material finer than the No. 200 (75 µm) sieve consists of the dust fraction from crushing, essentially free of clay, this percentage shall be 0-2 percent. When the total material passing the No. 200 (75 µm) sieve from the coarse and fine aggregates does not exceed 5 percent, the percent passing the No. 200 (75 µm) sieve from the crushed coarse aggregate may be increased to 3 percent.

1003.08.3 Portland Cement Concrete Aggregates - Combined Gradations: For the combined aggregates for the proposed portland cement concrete combined gradation mix, the percent retained based on the dry weight (mass) of the total aggregates shall meet the requirements of Table 1003-19 for the type of concrete specified in Table 901-3.

Table 1003-19
Combined Gradations for Portland Cement Concrete Aggregates

U.S. Sieve	Metric Sieve	Percent Retained of Total Combined Aggregates	
		Gradation Type	
		Type B	Type D
2 1/2 inch	63 mm	0	0
2 inch	50 mm	0	0-20
1 1/2 inch	37.5 mm	0-20	0-20
1 inch	25.0 mm	0-20	5-20
3/4 inch	19.0 mm	5-20	5-20
1/2 inch	12.5 mm	5-20	5-20
3/8 inch	9.5 mm	5-20	5-20
No. 4	4.75 mm	5-20	5-20
No. 8	2.36 mm	5-20	5-20
No. 16	1.18 mm	5-20	5-20
No. 30	600 µm	5-20	5-20
No. 50	300 µm	0-20	0-20
No. 100	150 µm	0-20	0-20
No. 200	75 µm	0-5	0-5
Note: For the sieves in the shaded areas, the sum of any two adjacent sieves shall be a minimum of 12 percent of the total combined aggregates.			

Sample and test each type of aggregate stockpile to be used in the proposed mixture individually. Mathematically determine the percent of total combined aggregates retained using the proportions of the combined aggregate blend. Base all gradation calculations on percent of dry weight (mass).

1003.09 GRANULAR MATERIAL. Granular material shall be non-plastic siliceous material complying with 1003.01 and the following gradation:

Table 1003-20
Gradation for Granular Material

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1/2 inch (12.5 mm)	100
No. 10 (2.00 mm)	75 - 100
No. 200 (75 µm)	0 - 10

1003.10 BEDDING MATERIAL. Bedding materials shall consist of stone, recycled portland cement concrete, or a mixture of either recycled portland cement concrete, gravel, crushed slag, or stone combined with granular material. Stone shall be from the Approved Materials List.

1003.10.1 Stone or Recycled Portland Cement Concrete:
Comply with 1003.03.

1003.10.2 Sand-Aggregate:

The sand-aggregate material shall be a natural or artificial mixture of sand and gravel, recycled portland cement concrete, or other approved aggregate listed in this subsection. Material passing the No. 40 (425 μm) sieve shall be non-plastic. The mixture shall be free of foreign matter as determined by visual inspection. Comply with the following gradation prior to placement.

Table 1003-21
Gradation for Bedding, Sand-Aggregate

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	90 - 100
3/4 inch (19.0 mm)	70 - 85
3/8 inch (9.5 mm)	40 - 60
No. 4 (4.75 mm)	15 - 40
No. 16 (1.19 mm)	3 - 15
No. 200 (75 μm)	0 - 5

1003.10.3 Mixtures: Mix recycled portland cement concrete, gravel, or stone with 35±5 percent granular material by volume. Verify the mixture quantities by proof of material deliveries.

1003.10.3.1 Gravel: Comply with the following gradation.

Table 1003-22
Gradation for Bedding, Gravel

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	95 - 100
No. 4 (4.75 mm)	0 - 15
No. 200 (75 μm)	0 - 2

1003.10.3.2 Recycled Portland Cement Concrete or Stone: Comply with the following gradation:

Table 1003-23
Gradation for Bedding, (RPCC or Stone)

U.S. (Metric) Sieve Size	Percent Passing By Weight (Mass)
1 ½ inches (37.5 mm)	95 - 100
3/4 inch (19.0 mm)	40 - 85
No. 4 (4.75 mm)	0 - 15

1003.10.3.3 Granular Material: Comply with 1003.09.

1003.11 BACKFILL. Stone shall comply with 1003.03.1. Recycled portland cement concrete, RPCC, shall comply with 1003.03.2. Reclaimed asphalt pavement, RAP, shall comply with 1003.05.3. For source approval, comply with 1003.01.

Section 1004
Landscaping Materials

1004.01 FERTILIZER. Fertilizer shall be a commercial type complying with the commercial fertilizer laws in effect as regulated by the Louisiana Department of Agriculture and Forestry. The chemical composition shall be as specified and shall be designated by a 3-number sequence representing minimum percentages by weight, respectively, of nitrogen (N), available phosphoric acid (P_2O_5) and soluble potash (K_2O).

Fertilizer supplied in granular, pellet, or tablet form shall be packaged in moisture proof containers.

Fertilizer tablets shall be an approved brand containing nitrogen fixing and phosphorus solubilizing bacteria, slow-release nitrogen, natural organic nutrients, and humic acid. For backfill mix, fertilizer tablets shall be controlled release tablets, 21 gram, 20-10-5 (N-P-K) with calcium, sulfur and iron.

1004.02 AGRICULTURAL LIME. Agricultural lime shall consist of ground limestone or seashells containing at least 90 percent calcium carbonate equivalent ($CaCO_3$) when tested in accordance with ASTM C602. The material shall be ground so that a minimum of 90 percent passes a No. 10 sieve and 25 percent passes a No. 100 sieve.

1004.03 SEED. Seed shall comply with requirements of Louisiana law. The minimum percentage of pure live seed and the maximum percentage of weed seed permitted shall be in accordance with Table 1004-1.

Table 1004-1
Seed Requirements

Variety	Minimum Percent of Pure Live Seed (Purity Times Germination Including Hard Seed by Count)	Maximum Percent of Weed Seed, by Count
Hulled Bermuda	83	1
Pensacola Bahia	81	2
Crimson Clover	78	1
Kentucky 31 Fescue	80	1
Unhulled Bermuda	80	1
Ball Clover	80	1
Vetch (Common)	80	1
Annual Rye	80	1
Browntop Millet	80	1

Each variety of seed shall be furnished and delivered in separate bags or other containers. Each bag or container shall bear an analysis tag which is a minimum No. 6 standard shipping tag having all information required by the Louisiana Seed Law, arranged as shown in Table 1004-2.

Table 1004-2
Seed Analysis Tag

Kind & Variety			
Where Grown		Net Wt.	Lot No.
Pure Seed	%	Germination	%
Inert Matter	%	Hard Seed	%
Crop Seed	%	Total Germ. & Hard Seed	%
Weed Seed	%	Date of Test	
Name & No. of Noxious Weed Seed per lb (kg).			
Name			
Address			

Seed furnished shall be the previous season's crop (the last crop year for the crop kind in question) and the date of analysis shown on each tag is

within 5 months (excluding the month in which the test is completed) of the time of delivery to the project.

1004.03.1 Noxious Weeds: Noxious weeds shall be interpreted to mean that list of weeds, except Bermuda, which has been adopted by the Louisiana Seed Commission as being noxious in Louisiana. Noxious weed seeds shall not exceed the limitations prescribed in the regulations and in no case shall they exceed 500 seeds per pound.

Analysis tags shall be removed from each bag or container only by the engineer or an authorized representative.

1004.03.2 Test Report: For each lot of seed, submit a copy of the official service laboratory test report as defined by the Louisiana Department of Agriculture and Forestry to the engineer. The DOTD will accept test reports from the Agricultural Departments of other states provided the requirements of these specifications are met. Ensure that the lot number on the analysis tag matches the laboratory test report lot number.

1004.04 MULCH. Mulch shall consist of either tacked vegetative mulch or fiber mulch product complying with the following:

1004.04.1 Tacked Vegetative Mulch: Vegetation for tacked vegetative mulch shall consist of pine straw, stems or stalks of oats, rye, rice,; or other approved straws. Also, hay obtained from various legumes and grasses such as clover, vetches, soybeans, Bermuda, Dallis, carpet sedge, fescue, or other approved legumes or grasses of any combination thereof may be used. Straw or hay shall be reasonably dry and free from mold, Johnson grass or other noxious weeds. The tacking agent for vegetative mulch shall be from the Approved Materials List. For source approval, the minimum allowable vegetative density of tacked vegetative mulch shall be 70 percent for clay soils and 60 percent for sandy soils when evaluated in accordance with the Texas Transportation Institute (TTI) Field Performance Testing Procedure of Selected Erosion Control Products.

1004.04.2 Fiber Mulch Products: Use fiber mulch products from the Approved Materials List that consist of organic fiber mulches. Fiber mulch products may consist of the fiber only, or a prepackaged blend of fiber mulch and tackifier. For fiber mulch products packaged without tackifier, use a tackifier from the Approved Materials List. For source approval, the minimum allowable vegetative density of fiber mulch products shall be 70 percent for clay soils and 60 percent for sandy soils when evaluated in accordance with the Texas Transportation Institute (TTI) Field Performance Testing Procedure of Selected Erosion Control Products.

1004.05 WATER MANAGEMENT GEL. Water management gel shall consist of an acrylamide copolymer gel with the ability to retain and release available water to the root zone. Mix the manufacturer's recommended amount of water management gel with the required amount of backfill soil per plant before backfilling.

1004.06 MYCORRHIZAL INOCULANT. Mycorrhizal inoculant shall consist of live spores and/or root fragments or mycelium of Vesicular-Arbuscular (VA) Endomycorrhizal fungi and Ectomycorrhizal fungus and beneficial bacteria which have been chosen based on their ability to survive and influence plants over a broad pH range. Rhododendrons, Azaleas, and Laurels require ericoid Mycorrhizae. Each Endomycorrhizal Inoculant shall carry a supplier's guarantee of numbers of propagules per unit weight or volume of bulk material. If more than one fungal species is claimed by the supplier, the label shall include a guarantee for each species of Mycorrhizal fungus claimed. The Project Engineer will verify that the expiration date or shelf life of each container has not expired before approving its use.

Section 1005
Joint Materials for Pavements and Structures

1005.01 PREFORMED JOINT FILLERS.

1005.01.1 Resilient Bituminous Types: Comply with AASHTO M 2l3.

1005.01.2 Wood Fillers: Bottom boards shall be clear heart redwood. Top boards shall be any type of wood which is free from defects and meets dimensional requirements. Occasional medium surface checks will be permitted provided the board is free of defects that will impair its usefulness.

Boards shall not vary from specified dimensions in excess of the following tolerances:

	Tolerance, inches	Tolerance, mm
Thickness	-0, +1/16	-0, +2
Depth	±1/8	±3
Length	±1/4	±6

The load required to compress the material in an oven-dry condition to 50 percent of its original thickness shall not exceed 1750 psi (12 MPa).

1005.01.3 Bituminous Type: Comply with ASTM D994.

1005.01.4 Asphalt Ribbon: Filler shall consist of preformed strips of bitumen and inert filler material conforming to the following requirements:

Thickness, mm	3-5
Depth tolerance, mm	±3
Weight, kg/100 sq m, Min.	245
Tensile Strength, kg/100 mm width, Min.	90
Bitumen, % by wt (ASTM D545), Min.	60

The tensile strength is determined by pulling a 25-by-150-mm sample at a 500-mm/min separation rate.

This material shall be resistant to cracking, tearing, or permanent deformation under normal handling and installation procedures. It shall be sufficiently rigid to enable it to form a straight joint.

Backer material of the appropriate size shall comply with ASTM D5249, Type 3.

1005.01.5 Closed Cell Polyethylene Joint Filler: Comply with ASTM D7174, Type I. This material shall be used with an adhesive-lubricant. Joint fillers and adhesive-lubricants shall be from the Approved Materials List.

1005.01.6 Rubber: Comply with AASHTO M 153, Type IV.

1005.02 POURED AND EXTRUDED JOINT SEALANT. Provide all materials in containers labeled with the name and address of the manufacturer, the trade name of the sealant, classification of the sealant (i.e., non-sag or self-leveling), batch number, manufacture date, and expiration date.

1005.02.1 Hot Poured Rubberized Asphalt Type: Comply with ASTM D6690, Type II. The sealant shall be from the Approved Materials List. Backer materials of the appropriate size shall comply with ASTM D5249, Type I.

1005.02.2 Polyurethane Sealants: The system shall be either a 1- or 2-component, pourable or extrudable sealant, with required primers and backer material. It shall cure to a solid rubber-like material able to withstand both tension and compression. Sealant shall comply with the requirements of Table 1005-1.

The system shall be from the Approved Materials List. A backer material of the appropriate size shall comply with ASTM D5249, Type 2 without the heat resistant requirement or Type 3.

Table 1005-1
Polyurethane Sealants

Property	Test Method	Requirement
Flow @ 60°C, 5 hr., mm, Max	ASTM D5329	3.0
Tack-Free Time, h, Max	ASTM C679	72
Bond, Defects, mm, Max	ASTM D5893	6.0
Resilience, %, Min.	ASTM D5329	75
Ball Penetration	ASTM D5329	5 – 20
Resilience (after heat aging @ 70 +/- 1°C for 24 +/- 2h), %, Min.	ASTM D5329	75
Artificial Weathering	ASTM D5893	Pass
Ozone Resistance (Exposure to 100 pphm ozone for 100 h @ 40°C, sample under 20% strain or bent loop)	ASTM D1149	No Cracks
Weight (mass) Loss, %, Max.	ASTM C792	10
Infrared Charts	DOTD TR610	
Activator		Pass
Base		Pass

[1]All specimens shall be cured at standard laboratory conditions for a minimum of 72 hours prior to beginning any test.

1005.02.3 Silicone Sealant (Single Component): Comply with ASTM D5893. The system shall be from the Approved Materials List.

1005.02.4 Silicone Sealant (Two Component - Rapid Cure): Comply with ASTM D5893 and meet the requirements for single component sealants when mixed and prepared in accordance with the manufacturer's recommendations. The system shall be from the Approved Materials List.

A backer material of the appropriate size shall conform to ASTM D5249, Type 3.

1005.03 PREFORMED ELASTOMERIC COMPRESSION JOINT SEALS.

1005.03.1 Seals: The system shall be from the Approved Materials List. The uncompressed depth of the seal shall be equal to or greater than the uncompressed width of the seal. The actual width of the seal shall not be less than the nominal width of the seal.

The system shall comply with ASTM D2628, except that the ozone resistance may be determined by the bent loop test method.

1005.03.2 Adhesive-Lubricant: The adhesive-lubricant shall comply with ASTM D4070 and shall be from the Approved Materials List.

1005.04 COMBINATION JOINT FORMER/SEALER.

1005.04.1 Description: This joint former/sealer is intended for use in simultaneously forming and sealing a weakened plane in portland cement concrete pavements.

The material shall consist of an elastomeric strip permanently bonded either mechanically or chemically at the top of each of two rigid plastic side frames or mechanically bonded at the top of the two rigid plastic side frames and covered with a removable plastic top cap. The side frames shall be of such configuration that when the sealer is inserted into fresh concrete and vibrated, a permanent bond forms between side frames and concrete.

1005.04.2 Material Requirements:

1005.04.2.1 Elastomer: The elastomer strip portion of the material shall be manufactured from vulcanized elastomeric compound using polymerized chloroprene as the base polymer, and shall comply with the requirements of Table 1005-2.

Table 1005-2
Elastomer for Combination Joint Former / Sealer

Property	ASTM Test Method	Requirements	
		Polymerized Chloroprene	Thermoplastic Vulcanizate
Tensile Strength, kPa, Min.	D 412	12,400	7,400
Elongation at Break, % Min.	D 412	200	400
Hardness, Shore A	D 2240	65 ± 10	65 ± 10
Properties after Aging, 70 h @ 100°C	D 573		
Tensile Strength, % Loss, Max.		20	20
Elongation, % loss, Max.		25	25
Hardness, pts. increase, Max.		10	10
Ozone Resistance, 20% strain or bent loop, 300 pphm in air, 70 h @ 40°C	D 1149	no cracks	no cracks
Oil Swell, IRM 903, 70 h@ 100°C, wt change, % Max.	D 471	45	75

1005.04.2.2 Bond of Elastomer to Plastic: The force required to shear the elastomer from the plastic shall be a minimum of 5.0 pounds per linear inch of sealer when tested in accordance with DOTD TR 636.

1005.04.2.3 Bond of Plastic to Cement Mortar: The force required to separate the cement mortar from the plastic shall be a minimum of 5.0 pounds per linear inch of sealer when tested in accordance with DOTD TR 636.

1005.05 FABRICATED SEALS AND TROUGHS.

1005.05.1 Preformed Neoprene Joint Seal: Provide an extruded neoprene material conforming to ASTM D2628 with the following exceptions:

1. Ozone resistance may be determined by the bent loop method.
2. Omit the recovery and the compression-deflection tests.

1005.05.2 Preformed Silicone Joint Seal: Comply with Tables 1005-3 and 1005-4.

Table 1005-3
Preformed Silicone Joint Seal Properties

Preformed Silicone Seal Property	ASTM Test Method	Value
Durometer (Shore A)	D2240	55 +/- 5
Tensile Strength	D412	1000 psi. minimum
Elongation	D412	400% minimum
Tear Strength (Die B)	D624	100 ppi. minimum
Compression set at 212°F, 70 hrs.	D395	30% maximum
Heat Aged at 212°F, 70 hrs.		
Durometer (Shore A)	D573	5 max. points loss
Tensile Strength	D573	10 max. % loss
Elongation	D573	10 max. % loss
U.V. Radiation Resistance	C793	No cracking, ozone chalking or degradation

The locking adhesive shall be non-sag, high modulus silicone adhesive conforming to the following specifications:

Table 1005-4
Adhesive Properties

Adhesive Property	ASTM Test Method	Value
Durometer (Shore A)	C661	25 +/- 5
Peel Adhesion to Substrates after 7 days water immersion	C794	13 pli.
Tensile Strength	D412	200 psi. minimum
Elongation	D412	450% minimum
Tack Free Time	C679	30 minutes maximum
Cure Time 1/4" Bead (through 1/4" thickness) at 75°F, 50% R.H.	C679	16 hours maximum
U.V. Radiation Resistance	C793	No cracking, ozone chalking or degradation

1005.05.3 Fabricated Troughs and Membranes: Provide troughs and membranes consisting of reinforced elastomeric virgin polychloroprene (neoprene) with excellent environmental resistance to weather, salts, chlorides, oxygen, ozone, ultraviolet radiation, water, and common roadway substances such as gasoline and products of combustion.

Provide troughs and membranes having 1/4 inch minimum thickness. Elastomeric sheets shall be internally reinforced with synthetic or natural fabric. Fabric shall consist of either a single layer of 14.6 ounce woven nylon

fabric, or the equivalent in multiple layers of woven nylon fabric, laminated between two or more layers of neoprene.
Conform to the following:

Table 1005-5
Elastomeric Sheet Properties

Elastomeric Sheet Property	ASTM Test Method	Value
Durometer (Shore A)	D2240	60 +/- 5
Tensile Strength	D412	2000 psi. minimum
Elongation at Break	D412	250% minimum
Heat Aged at 212°F, 70 hrs.		
Durometer (Shore A)	D573	+10, -0 point change
Tensile Strength	D573	20 max. % loss
Elongation at Break	D573	20 max. % loss
Tear Strength (Die C)	D624	120 ppi. minimum
Oil Swell at 212°F, 70 hrs. using ASTM Oil No. 3		
Change in Weight	D471	45 maximum % gain
Change in Volume	D471	120 maximum % gain
Change in Tensile Strength	D471	70 maximum % loss
Change in Elongation at Break	D471	55 maximum % loss
Ozone Resistance at 100°F, 100 hrs., 100 PPHM Ozone, under 20% strain	D1149	No cracks when tested with Method "B"
Breaking Strength of Finished Fabric: Take sample transverse to trough centerline, or random sample from curtain.	D5034	700 ppi. minimum

1005.06 JOINT MATERIALS FOR TRANSVERSE EXPANSION JOINT (TYPE EJ-1 1/2 Inches).

1005.06.1 Type EJ-1 1/2 Inches: System shall be an approved product listed on the Approved Materials List and comply with ASTM D7174, Type I.

1005.06.2 Type EJ-4 Inches: System shall comply with ASTM D7174, Type I, with the following exceptions. The material shall be a preformed polyurethane (or other approved equal) foam, and the preformed cross section shall be semi-open cell, homogenous without laminations. The load required to compress test specimens by 25 percent (to 75 percent of original thickness) shall not be less than 3 psi (21 kPa).

Dimensional tolerances shall be:

	Tolerance, inches (mm)	
Thickness:	+/- 5%	(+/- 5%)
Depth:	+/- 0.4	(+/- 10)
Length:	+3.0, -0	(+80, -0)

The cross section shape shall allow easy installation in the pavement joint with parallel sides and shall be sufficiently self-locking to prevent the material from floating out of the joint. The molded polyurethane foam shall be free of defects and internal voids greater than 1/2 inch (13 mm). When the joint filler is used to form the joint, the self-locking feature will not be required and the joint filler will extend full depth.

Use lubricant-adhesive recommended by the joint filler manufacturer and apply according to the manufacturer's directions.

1005.07 WATERSTOPS.

1005.07.1 Copper Waterstops: Comply with ASTM B370, soft temper.

1005.07.2 Polyvinyl Chloride (PVC) Waterstops: Comply with U. S. Army Corps of Engineers' Specification CRD-C 572.

1005.07.3 Rubber Waterstops: Comply with U. S. Army Corps of Engineers' Specification CRD-C 513.

Section 1006
Thermoplastic Pipe

1006.01 GENERAL. Thermoplastic pipe and joint systems for cross drains, storm drains, and side drains shall be from the Approved Materials List. Thermoplastic pipe for underdrains and yard drains shall be perforated or non-perforated, as specified, and shall be from the Approved Materials List. Perforations, if specified, shall comply with AASHTO M 252.

1006.02 Polyvinyl Chloride Pipe (PVCP). PVCP and gasket materials shall comply with AASHTO M 278 or ASTM D3034, SDR 35.

1006.03 Ribbed Polyvinyl Chloride Pipe (RPVCP). RPVCP may be either open profile or dual wall construction in accordance with the specified ASTM standards. Pipe and gasket materials shall comply with ASTM F794 or ASTM F949, Series 46 with UV inhibitors. The resin shall have a minimum cell classification of 12454-C in accordance with ASTM D1784.

1006.04 Corrugated Polyethylene Pipe Single Wall (CPEPSW). CPEPSW shall be perforated and shall comply with AASHTO M 252, Type C. Perforations shall comply with AASHTO M 252. Do not use CPEPSW as shoulder outlet underdrain pipe.

1006.05 Corrugated Polyethelene Pipe Double Wall (CPEPDW).

When used for storm, cross, or side drains, CPEPDW pipe and gasket materials shall comply with AASHTO M 294, Type S, with a minimum resin cell classification of 435400C in accordance with ASTM D3350.

When used for plastic underdrain pipe, the pipe and joint system shall comply with AASHTO M 252.

When used for yard drain pipe, the pipe and joint system shall comply with AASHTO M 252, Type S, with a minimum resin cell classification of 424420C in accordance with ASTM D3350, or AASHTO M 294, Type S, with a minimum resin cell classification of 435400C in accordance with ASTM D3350.

1006.06 Joint Systems for Thermoplastic Pipe. Use pipe and joint systems from the Approved Materials List. Joint systems shall comply with 1018.03. A Type 2 or 3 joint system may be substituted for a Type 1 joint system; a Type 3 joint system may be substituted for a Type 2 joint system.

When using split coupling bands, use one piece that is composed of the same material as the pipe. The bands shall be the same thickness as the base pipe. The width of the band shall be equal to one-half the diameter of the pipe but a minimum of 12 inches wide.

Section 1007
Metal Pipe

1007.01 CORRUGATED STEEL PIPE AND PIPE ARCH. Metal pipe shall be qualified products as determined by the Construction Fabrication Unit. Comply with the requirements of Type I (culvert pipes, circular section) and Type II (culvert pipes, other than circular section) of AASHTO M 36 amended as follows:

1. Pipe and pipe arch shall be galvanized in accordance with AASHTO M 218.
2. Elbows, tees, and other in-line fittings shall be fabricated from sheets of the same thickness and coating material as the pipe or pipe arch to which they are joined. Flared end sections shall be as specified.
3. Shop-formed elliptical pipe and shop-strutted pipe shall be furnished when specified.
4. For helical pipe, no coil splices at pipe manufacturing plants will be allowed for pipe 30 inches in diameter or less.
5. Helical pipe shall have annular ends and shall have the ends of seams welded a minimum of 2 inches. Helical pipe ends shall be rerolled a minimum of two full standard corrugations to the same corrugation depth as the pipe when used with the appropriate jointing system.
6. Pipe arch dimensions shall comply with AASHTO M 245 and Table 1007-1 of this section.
7. A minimum of two approved lifting lugs shall be provided on pipe larger than 30 inches in diameter, pipe arch larger than 30 inches in equivalent diameter, and any diameter of pipe or pipe arch longer than 30 feet.
8. Damaged metallic coating shall either be recoated or shall be repaired with a cold galvanizing repair compound from the Approved Materials List.

1007.02 BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCH. These conduits shall be coated in accordance with AASHTO M 190 amended as follows:

1. AASHTO M 36 is amended in accordance with 1007.01
2. Coating shall be Type A, fully bituminous coated.

1007.03 BITUMINOUS COATED CORRUGATED STEEL UNDERDRAIN PIPE. Pipe and coupling bands shall comply with the requirements of Type III (underdrain pipes) of AASHTO M 36. The pipe shall be coated with a bituminous material in accordance with AASHTO M 190, Type A coating, except the minimum coating thickness shall be 0.03 inch The specified minimum diameter of perforations shall apply after coating. Minimum sheet thickness shall be 0.064 inch (16 gage).

1007.04 STRUCTURAL PLATE FOR PIPE, PIPE ARCH AND ARCH. Comply with AASHTO M 167 for steel, and AASHTO M 219 for aluminum.

1007.05 CORRUGATED ALUMINUM PIPE AND PIPE ARCH. Comply with AASHTO M 196 with the following exceptions:

1. Helical pipe shall have annular ends and shall have the ends of seams welded a minimum of 2 inches. Helical pipe ends shall be rerolled a minimum of two full standard corrugations to the same corrugation depth as the pipe when used with the appropriate jointing system.
2. Pipe arch dimensions shall comply with Table 1007-1.
3. A minimum of two approved lifting lugs shall be provided on pipe larger than 30 inches diameter, pipe arch larger than 30 inches equivalent diameter, and any diameter of pipe or pipe arch longer than 30 feet.
4. Aluminum alloy sheet used in fabricating pipe shall conform to the applicable requirements of AASHTO M 197 for Alclad Alloy 3004-H34 for annular pipe, and Alclad Alloy 3004-H32 for helical pipe.

1007.06 CORRUGATED ALUMINUM UNDERDRAIN PIPE. Pipe and coupling bands shall comply with the requirements of Type III (underdrain pipes) of AASHTO M 196. Minimum sheet thickness shall be 0.060 inch (16 gage).

1007.07 PIPE ARCH DIMENSIONS. Pipe arch dimensions shall comply with Table 1007-1. Pipe arch tolerances shall comply with the plans.

Table 1007-1
Metal Pipe Arch Dimensions (Inches)

	Steel & Aluminum	Steel
Round Equivalent (Inches)	2 2/3 in. by 1/2 in. Corrugation	3 in. by 1 in. or 5 in. by 1 in. Corrugation
15	17 x 13	—
18	21 x 15	—
21	24 x 18	—
24	28 x 20	—
30	35 x 24	—
36	42 x 29	40 x 31
42	49 x 33	46 x 36
48	57 x 38	53 x 41
54	64 x 43	60 x 46
60	71 x 47	66 x 51
66	77 x 52	73 x 55
72	83 x 57	81 x 59
78	—	87 x 63
84	—	95 x 67
90	—	103 x 71
96	—	112 x 75
102	—	117 x 79
108	—	128 x 83
114	—	137 x 87
120	—	142 x 91

1007.08 PIPE JOINT SYSTEMS. Metal pipe joint systems shall comply with 1018.03 and shall be as shown on the plans. A Type 2 or 3 joint system may be substituted for a Type 1 joint system; a Type 3 joint system may be substituted for a Type 2 joint system. For Type 1 joints, provide at least one line of approved gasket material under the band on each pipe end.

1007.08.1 Coupling Bands: Coupling bands for joining metal conduit shall be approved by the DOTD Materials Engineer Administrator and shall comply with AASHTO M 36 for steel conduit and AASHTO M 196 for aluminum conduit with the following modifications:

Bands shall be of an approved design and shall be fabricated from metal sheets of the same material as the conduit. The band thickness shall be the same as the conduit thickness with a maximum of 12 gage. Coating shall be the same as used on the conduit. Minimum band width shall be 12 inches.

1007.08.2 Steel Banding Rods: Comply with AASHTO M 270, Grade 36 (M 270M, Grade 250). Welding of rods will not be permitted. No more than two splices will be allowed.

1007.08.3 Hardware: Hardware shall be galvanized in accordance with ASTM A153 or B633, Class Fe/Zn 25 or an approved mechanical galvanizing process complying with ASTM B695 that provides the same coating thickness.

1007.08.4 Gaskets: Gaskets for pipe joint systems shall be from the Approved Materials List.

1007.08.4.1 Rubber Gaskets: Comply with ASTM C443. Each rubber gasket shall be identified with a batch or lot number. Gasket cross section shall be the following:

For pipe 36 inches in diameter or less, gasket cross section shall be 13/16-inch.

For pipe greater than 36 inches in diameter, with 1/2-inch deep corrugations, gasket cross section shall be 7/8-inch.

For pipe greater than 36 inches in diameter with 1-inch deep corrugations, gasket cross section shall be 1 3/8-inches.

1007.08.4.2 Preformed Flexible Gaskets: Comply with ASTM C990. Gasket material shall be a minimum of 1 inch for 1/2-inch corrugation depth, and a minimum of 1 1/2 inches for 1-inch corrugation depth.

1007.09 CAST IRON SOIL PIPE AND FITTINGS. Comply with ASTM A74. Joints shall be made with rubber gaskets complying with ASTM C564.

1007.10 DUCTILE IRON PIPE. Comply with ANSI A 21.51.

1007.11 BLACK AND GALVANIZED WELDED AND SEAMLESS STEEL PIPE. Steel pipe for ordinary uses shall comply with ASTM A53.

Section 1008
Paints

1008.01 GENERAL. Paints shall be delivered in clean, unopened shipping containers complying with Surface Transportation Board (STB) requirements.

Each paint container shall bear a label containing the following information: name and address of manufacturer, trade name or trademark, kind of paint, color of paint, number of gallons (L), batch number, and date of production.

The material shall not show skinning, settling, color change, thickening, or livering that cannot be eliminated by normal mixing procedures. Store, mix, and apply according to manufacturer's recommendations. Discard paint after the manufacturer's recommended shelf life has expired. DOTD's test results are valid for 12 months.

1008.02 ZINC PAINT SYSTEMS. The zinc paint system shall be from the Approved Materials List. Each system will be tested in accordance with AASHTO R 31. Zinc paint systems shall conform to the specification requirements of AASHTO R 31. All zinc paint systems shall meet the performance requirements listed in the latest Northeast Protective Coating Committee (NEPCOAT) Acceptance Criteria for New and 100 percent Bare Existing Steel for Bridges. The latest acceptance criteria can be found on the NEPCOAT website at www.nepcoat.org under the Qualified Products for Protective Coatings for New and 100 percent Bare Existing Steel for Bridges document.

Paint used on projects will be sampled and tested and shall comply with the following requirements:

Table 1008-1
Zinc Paint System Properties

Property	Test Method	Tolerance[1]
Pigment Content.	ASTM D2698	±2.0%
Density	ASTM D1475	±0.25 lbs/gal (±0.03 kg/l)
Solids Content	ASTM D2369	±2.0%
Non-volatile in Vehicle Content	ASTM D2698	±2.0%
Viscosity, Ku	ASTM D562	±5KU
Dry to Touch	ASTM D1640	±10%
Dry Through	ASTM D1640	±10%
Sag, Lenetta	ASTM D4400	±10%
Infrared Spectrum	DOTD TR 610	Match Original[2]

[1]Target Values shall be established by the Materials and Testing Section upon qualification of the paint system.
[2]Standards for infrared spectrum shall be kept on file and compared to project samples for acceptance purposes.

The topcoat shall be tinted to match federal color # 36463 from Federal Standard 595C for non-weathering steel and tinted to match federal color # 30045 from Federal Standard 595C for weathering steel, unless otherwise specified.

1008.03 ASPHALTIC VARNISH.

1008.03.1 Material: Asphaltic varnish shall be composed of hard native asphalts or asphaltites (gilsonite, for example), run (fluxed) and blended with properly treated drying oils, and thinned with suitable solvents with the necessary amount of dryers.

1008.03.2 Appearance: The film sample will be poured on a clean, clear glass plate, and then placed in a vertical position until the excess varnish drains off. The sample is then examined by transmitted light. A smooth and homogeneous sample is acceptable.

1008.03.3 Color: Color shall be jet black when examined by reflected light.

1008.03.4 Solids Content: Solids content shall not be less than 40 percent by weight (mass) when tested in accordance with ASTM D2369.

1008.03.5 Drying of Film:

1008.03.5.1 Set to Touch: Film shall set to touch in not more than 8 hours when tested in accordance with ASTM D1640.

1008.03.5.2 Dry Through: Film shall dry through in not more than 36 hours when tested in accordance with ASTM D1640.

1008.03.6 Working Properties and Appearance of Dried Film: Varnish shall have good brushing, flowing, covering, and leveling properties. Dried film shall be jet black, smooth, and free from brush marks, blisters, pinholes, and other defects.

1008.03.7 Water Resistance: Film shall show no whitening, dulling, or other defects after a dried film is immersed in water for 18 hours and air dried for 2 hours.

1008.04 COAL TAR EPOXY-POLYAMIDE PAINT. Comply with SSPC-Paint 16.

1008.05 COLD GALVANIZED REPAIR COMPOUND. Use a product from the Approved Materials List. The material shall be supplied from the manufacturer in unopened aerosol cans or unopened friction top cans. The cans shall be labeled with the manufacturer's name, product name, batch number, and expiration date. The pigment shall contain a minimum of 90 percent metallic zinc. Dried film shall be relatively smooth, and free from blisters, pinholes, sags, and other defects. A minimal amount of brush marks is acceptable.

Test panels coated with the compound will be tested in a salt fog apparatus in accordance with ASTM B117 for 1500 hours. The panels shall show no signs of rusting, blistering, undercutting, delamination, or other deleterious conditions.

1008.06 CORROSION INHIBITING ALKYD PAINT SYSTEM. Use a three-coat paint system which is compatible with basic lead silico chromate paint. The corrosion inhibiting pigment shall be calcium borosilicate. The primer and the intermediate coats shall be tinted for color contrast. Use aluminum topcoat in accordance with SSPC-Paint 101, Type I for both systems.

1008.06.1 Specific Requirements: Comply with the following:

Table 1008-2
Corrosion Inhibiting Alkyd Paint System Properties, Primer

Property	Test Method	Min	Max
Pigment, % by wt	ASTM D2371	53	—
Vehicle, % by wt	ASTM D2372	—	47
Density, lbs/gal	ASTM D1475	11.4	—
Water, %		—	0.25
Coarse Particle and Skins (Total Residue Retained on No. 325 Sieve Based on Paint), %	ASTM D185	—	1.0
Fineness of Grind (North Std)	ASTM D1210	5	—
Viscosity (Stormer-Krebs Units) @ 77°F	ASTM D562	75	85
Dry Through, Hours	ASTM D1640	—	18
Non-volatile in Vehicle, % by wt	ASTM D2369 & ASTM D2372	57	—

Table 1008-3
Corrosion Inhibiting Alkyd Paint System Properties, Intermediate Coat

Property	Test Method	Min	Max
Pigment, % by wt	ASTM D2371	44	—
Vehicle, % by wt	ASTM D2372	—	56
Density, lbs/gal	ASTM D1475	10.2	—
Water, %		—	0.25
Coarse Particle and Skins (Total Residue Retained on No. 325 Sieve Based on Paint), %	ASTM D185	—	1.0
Fineness of Grind (North Std)	ASTM D1210	5	—
Viscosity (Stormer-Krebs Units) @ 77°F	ASTM D562	75	85
Dry Through, Hours	ASTM D1640	—	-10
Non-volatile in Vehicle, % by wt	ASTM D2369 & ASTM D2372	45	—

Table 1008-4
Corrosion Inhibiting Alkyd Paint System Chemical Requirements, Prime

Pigment	Test Method	Min	Max
Calcium Boro-Silicate	ASTM D4288	80.0%	—
Synthetic Iron Oxide, Class I	ASTM D84	16.0%	18.0%
Organo Montmorillonite		1.0%	2.0%
VEHICLE			
Alkyd Resin Solution, Type I, Class A	Fed. Spec TT-R-266	43.0%	50.0%
Linseed Oil	ASTM D234	20.0%	27.0%
Mineral Spirits, Type II[1]	Fed. Spec TT-T-291E		28.0%
Driers		1.0%	2.0%

[1]Small quantities of alcohols or alcohol/water mixtures may replace some mineral spirits where such materials are used as polar additives for the suspending aid.

Table 1008-5
Corrosion Inhibiting Alkyd Paint System Chemical Requirements, Intermediate Coat

Pigment	Test Method	Min	Max
Calcium Boro-Silicate	ASTM D4288	80.0%	—
Synthetic Iron Oxide, Class I	ASTM D84	17.5%	18.5%
Organo Montmorillonite		1.5%	2.5%
Lampblack		—	2.0%
VEHICLE			
Alkyd Resin Solution, Type I, Class A	Fed. Spec TT-R-266	65.0%	—
Mineral Spirits, Type II[1]	Fed. Spec TT-T-291E	—	34.0%
Driers		1.0%	1.5%

[1]Small quantities of alcohols or alcohol/water mixtures may replace some mineral spirits where such materials are used as polar additives for the suspending aid.

1008.08 MAINTENANCE OVERCOATING OF STEEL BRIDGES.

Use an overcoat system from the Approved Materials List. For source approval, a field trial is required, which consists of a three year side-by-side comparison between the new overcoat system and a corrosion inhibiting alkyd paint "control" system. Both systems shall overcoat a red lead paint system and/or approved alternate system. The new overcoat paint system shall perform as well or better than the control system in the areas of blistering, rusting, fading, chalking, and adhesion. Alternate testing programs such as NTPEP and NEPOVERCOAT will be allowed if approved by the Materials Engineer Administrator.

Paint used on projects will be sampled and tested and shall comply with the following requirements:

Table 1008-6
Paint Overcoat System Properties

Property	Test Method	Tolerance[1]
Pigment Content	ASTM D2698	±2.0%
Density	ASTM D1475	±0.25 lbs/gal (±0.03 kg/l)
Total Solids Content	ASTM D2369	±2.0%
Non-volatile in Vehicle Content	ASTM D2698	±2.0%
Viscosity, Ku	ASTM D562	±5KU
Dry to Touch	ASTM D1640	±10%
Dry Through	ASTM D1640	±10%
Sag, Lenetta	ASTM D4400	±10%
Infrared Spectrum	DOTD TR 610	Match original[2]

[1]Target values shall be established by the Materials and Testing Section upon qualification of the paint system.
[2]Standards for infrared spectrum shall be kept on file and compared to project samples for acceptance purposes.

The topcoat shall be tinted to match federal color # 36463 from Federal Standard 595C for non-weathering steel and tinted to match federal color # 30045 from Federal Standard 595C, for weathering steel, unless otherwise specified.

Section 1009
Reinforcing Steel, Strand, and Wire Rope

1009.01 REINFORCING STEEL. Comply with the "Buy America Provisions" in 106.04.

Use reinforcing steel for concrete complying with the following unless otherwise specified. Use Grade 60 reinforcing steel in bridge structures and other structures. Grade 40 may be used in portland cement concrete pavement (PCCP) structures. Comply with specifications below, as applicable.

Use rebar chairs, ties, and miscellaneous accessories compatible with the reinforcement.

1009.01.1 Billet-Steel: Deformed and plain bars shall comply with ASTM A615 and shall be from the Approved Materials List.

1009.01.2 Rail-Steel and Axle-Steel: Deformed and plain bars shall comply with ASTM A996.

1009.01.3 Cold-Drawn Steel Wire: Plain wire shall comply with ASTM A1064 with the following amendment: For material testing over 110,000 psi tensile strength in high strength applications such as spirals and ties, reduce the 25 percent minimum reduction in area by 5 percent for each 10,000 psi increment of tensile strength exceeding 110,000 psi.

Deformed wire shall comply with ASTM A1064.

1009.01.4 Steel Welded Wire Reinforcement: Comply with ASTM A1064. Use deformed reinforcement for bridge structures.

1009.01.5 Stainless Deformed Reinforcing Steel: Conform to ASTM A955, Type 316LN UNS Designation S31653, UNS Designation S31803, or UNS Designation S32304.

1009.01.6 Galvanized Deformed Reinforcing Steel: Comply with ASTM A767.

1009.01.7 Epoxy Coated Reinforcing Steel and Patching Materials: Use products from the Approved Materials List and comply with ASTM A775.

1009.02 BAR SUPPORTS AND TIE WIRES. Bar supports (chairs) shall be metal wire. The bottom of bar supports shall be coated with an acceptable epoxy or plastic material for a minimum distance of 2 inches from the point of contact with the forms. Metal chairs in contact with the metal forms shall be hot-dipped galvanized, electroplated with zinc (GS Grade), epoxy coated, or stainless steel.

Metal tie wires and bar supports shall be coated fully with an acceptable epoxy, plastic or nylon material if using epoxy coated steel.

1009.03 DOWEL BARS.

1009.03.1 PAVEMENT DOWEL BARS: Steel dowel bars shall comply with 1009.01.1, 1009.01.2, or 1009.01.3. Dowels shall have a uniformly round cross section and shall be saw cut, smooth and free of burrs, projections and deformations.

Coated dowel bars shall be undercoated with an adhesive and given an outer coat of polypropylene or polyethylene. Coated dowel bars shall comply with AASHTO M 254. For PCCP, place coated dowel bars in approved dowel bar assemblies in accordance with the plans.

1009.04 STEEL STRAND FOR PRE-STRESSING AND POST-TENSIONING. Strand shall comply with ASTM A416. The strand manufacturer shall submit to the Construction Section three copies of Certificates of Analysis of all test results as stipulated in ASTM A416, and as part of this certificate, shall provide the modulus of elasticity of that particular mill heat of strand. The Department reserves the right to conduct inspections at the site of manufacture and to have all tests witnessed by its inspector. The data from the manufacturer's typical curve shall be used when computing the required elongation for each strand.

1009.05 ANCHORAGES AND HARDWARE FOR PRESTRESSING. Anchorages, including hold down and miscellaneous hardware, shall be sampled in accordance with the Materials Sampling Manual and submitted to the Construction Fabrication Engineer for acceptance after evaluation or testing.

1009.06 WIRE ROPE. Wire rope shall comply with Federal Specifications RR-W-410G or the latest federal specifications and the following:

Comply with Table 1009-1 when selecting the type and classification of wire rope.

When wire joints are necessary, they shall be electrically butt-welded; and in the stranding operation, no two joints in any strand shall be closer than 25 feet, except for filler wires.

Table 1009-1
General Wire Rope Classification and Usage

Type	Classification	Usage
I	1. (6x7)	Haulage rope, for use where strength and durability are desirable, but not much bending is required. May be used as single line for pulling load, but not suitable for sheave work.
	2. (6x19)	Most widely used for cranes, derricks, dredges, draglines and scrapers. This classification is very rugged, withstands abrasion well and is generally suited for all-around use.
	3. (6x37)	For hoisting rope where maximum flexibility is required; for instance, hoisting rope that runs over small sheave on draglines.
II	1. (8x19)	High speed elevator rope.
III (Marine)	1. (6x6)	Deck lashing ropes.
	2. (6x12)	Running ropes.
	3. (6x24)	Mooring lines.
	4. (6x3x7)	Spring lay.
	5. (6x3x19)	Spring lay.
	6. (6x42)	Tiller or hand control rope.
IV (Special)	1. (18x7)	Nonrotating (for drill rigs)

1009.07 WIRE ROPES FOR MOVABLE BRIDGES. See Sections 821.07.31, 821.07.32, and 821.07.33.

Section 1010
Fence and Guard Rail

1010.01 BARBED WIRE. Comply with the "Buy America Provisions" in 106.04.

Barbed wire shall be either steel or aluminum alloy and shall be 12 1/2 gage.

1010.01.1 Steel Barbed Wire. Comply with ASTM A121.

1010.01.2 Aluminum Alloy Barbed Wire. Comply with ASTM B211, Alloy 5052-O for line wire and Alloy 5052-H38 for barbs.

1010.02 WOVEN WIRE. Comply with one of the following Design Numbers and Grades of ASTM A116.

Design No.	Grade
939-6-11	60
939-6-12 1/2	60
939-6-14 1/2	125
939-6-12 1/2	125

1010.03 POSTS AND BRACES FOR FIELD AND LINE TYPE FENCE. Posts and braces shall be either steel or treated timber.

1010.03.1 Treated Timber Posts and Braces: Posts shall be round. Braces shall be either round or square. Comply with Section 1014.

1010.03.2 Steel Posts and Braces: Steel posts and braces shall be equipped with corrugations, knobs, notches, holes, or studs so placed and constructed as to engage a substantial number of fence wires in proper position. Posts may be punched with holes in such position and of such size as will not unduly impair the strength of the posts. Posts with punched tabs used for fastening wires are not acceptable. Corner, end, and bracing posts shall be supplied with necessary holes and with galvanized bolts of standard commercial quality or other satisfactory substitute, such as castings, for fastening braces to the posts.

Line posts, anchor plates, and braces shall comply with ASTM A702, except that a hardness test may not be substituted for the tensile test. Steel posts, anchor plates, and braces shall be galvanized in accordance with ASTM A123.

1010.04 STAPLES AND NAILS. Staples and nails shall be made of galvanized steel wire. Minimum galvanized coating shall be not less than 0.20 ounce per square foot when tested in accordance with ASTM A90.

1010.05 METAL FASTENERS FOR STEEL POSTS. Metal fasteners for steel posts shall be galvanized steel-wire fasteners or clamps and shall be satisfactory for use with the type of steel post furnished. Wire shall be not less than 0.120 inch diameter. Galvanized coating shall not be less than 0.20 ounce per square foot when tested in accordance with ASTM A90.

1010.06 GATES FOR FIELD AND LINE TYPE FENCE.

1010.06.1 Gates: Steel used in fabricating gates shall be galvanized in accordance with ASTM A653 Coating Designation G60.

1010.06.2 Posts:

1010.06.2.1 Treated Timber: Comply with Section 1014.

1010.06.2.2 Metal: Metal posts shall be made of galvanized steel pipe, standard weight, complying with ASTM A53.

1010.06.3 Hardware: Hinges, washers, nails, staples, welded chains, and latches shall be galvanized, of acceptable quality, and of satisfactory type for use with the gate and posts selected.

1010.06.4 Gate Stops:

1010.06.4.1 Treated Timber: Gate stops shall be timber complying with 1010.03.1 treated in the same manner as posts.

1010.06.4.2 Metal: Gate stops shall be acceptable galvanized steel suitable for welding to the post.

1010.06.5 Stop Posts: Stop posts for double swinging driveway gates shall be treated timber complying with Section 1014.

1010.07 CHAIN LINK FENCE, GATES AND APPURTENANCES. Comply with AASHTO M 181 except for the following.

Wire ties, fabric ties, hog rings, and tension wire for Type I, II, or III fencing shall be aluminum alloy, galvanized ductile steel, or aluminum-coated ductile steel wire.

1010.07.1 Wire Ties: Wire ties, fabric ties, and hog rings shall have 20,000 psi minimum tensile strength, and 10 percent minimum elongation. Steel shall be coated with at least 0.60 ounce of zinc or 0.40 ounce of aluminum alloy per square foot of uncoated wire surface. Wire ties shall be AWG No. 9. Fabric ties and hog rings shall be AWG No. 12.

1010.07.2 Tension Wire: Galvanized and aluminum-coated steel tension wire shall be AWG No. 9 wire having at least 75,000 psi tensile strength with at least 0.70 ounce of zinc or 0.40 ounce of aluminum alloy per square foot of uncoated wire surface.

Aluminum alloy tension wire shall be AWG No. 6 wire having at least 42,000 psi tensile strength, 35,000 psi yield strength, and 10 percent elongation.

Barbed wire used with chain link fence shall comply with 1010.01.

Padlocks shall be solid jacket, extruded brass metal with interchangeable cores and 1 3/4-inches cases. All padlocks shall be keyed alike. Furnish two keys for each padlock.

1010.08 GROUNDING. Ground rod assemblies suitable for grounding fences and other applicable grounding requirements shall meet the following requirements:

1010.08.1 Ground Rods: Ground rods shall be a minimum 5/8 inch nominal diameter copper weld steel rod with a minimum length of 8 feet.

1010.08.2 Ground Wire: Ground wire shall be an AWG No. 6 solid copper conductor firmly attached in such a manner that fence fabric, barbed wire, metal post and ground rod are electrically connected.

1010.08.3 Mechanical Connectors: Mechanical connectors will only be allowed where exothermic welds cannot be achieved. Mechanical connectors for attaching ground wire to ground rods is not allowed. Mechanical connectors for attaching ground wire to fence fabric, barbed wire and metal posts shall be solid copper alloy UL approved. Coated steel hardware will not be permitted.

1010.09 METAL BEAM FOR HIGHWAY GUARD RAIL. Rail elements shall be corrugated sheet steel beams from the Approved Materials List. Guard rail elements, terminal sections, and fittings shall be interchangeable with similar parts, regardless of source or manufacturer.

Guard rail, terminal sections, and appurtenances shall comply with AASHTO M 180 and the DOTD standard plans.

The fabricator shall annually file a Brand Registration and Guarantee with the DOTD Materials Engineer Administrator.

1010.10 GUARD RAIL POSTS AND BLOCKOUTS. Railing posts shall be either timber or steel. Furnish the same kind of posts on a structure. Furnish timber post blockouts or an approved alternate material that is approved by the Federal Highway Administration and also complies with

NCHRP 350 or the latest edition of the AASHTO Manual for Assessing Safety Hardware (MASH).

1010.10.1 Timber Posts and Blockouts: Timber and preservative treatment shall comply with Section 1014.

1010.10.2 Steel Posts:

Comply with AASHTO M 270, Grade 36 galvanized in accordance with ASTM A123. Furnish Certificates of Analysis (Mill Test Reports) together with a Fabricator's Material Statement and Certificate of Compliance in accordance with 1013.01. Field welding is not allowed unless specifically required by the plans.

1010.10.3 Guard Rail Attachments:

Concrete for guard rail attachments shall comply with Section 901 Class A1. Reinforcement shall comply with Section 1009.

1010.11 GUARD RAIL HARDWARE. For non-proprietary systems and components bolts shall comply with ASTM A307, Grade A and nuts shall comply with ASTM A563, Grade A
(Property Class 5). Washers shall comply with ANSI B18.22 for regular Type B series.

Fittings, bolts, washers, and other accessories for steel guard rail shall be galvanized after fabrication in accordance with Section 811.

1010.12 WIRE ROPE AND FITTINGS FOR HIGHWAY GUARD RAIL. Comply with AASHTO M 30.

Section 1011
Concrete Curing Materials, Admixtures, and Special Finishes

1011.01 CURING MATERIALS.

1011.01.1. Liquid Membrane-Forming Compounds: This material shall comply with ASTM C309 and shall be from the Approved Materials List. Allowable types are Type 2 white-pigmented or Type 1-D, clear or translucent with a fugitive dye, as specified.

1011.01.2 Moist Cure Materials:

1011.01.2.1 Sheet Material: Use sheet materials for curing concrete meeting the physical and performance requirements of ASTM C171.

1011.01.2.2 Burlap Cloth: Use burlap cloth made from Jute or Kenaf complying with AASHTO M 182, Class 3.

1011.02 ADMIXTURES.

1011.02.1 Physical Requirements: Use concrete admixtures from the Approved Materials List, which comply with Table 1011-2 when tested in accordance with DOTD TR 224.

1011.02.2 Chemical Requirements: The contribution of chloride ion resulting from the addition of admixtures to the concrete shall not exceed 0.02 pound per cubic yard of concrete, when tested in accordance with DOTD TR 643.

1011.02.3 Acceptance Testing: The admixture shall be tested by analytical infrared (IR) spectroscopy in accordance with DOTD TR 610. The IR spectrum shall compare favorably to the standard IR spectrum of the original material tested and on file at the Materials and Testing Section. The percent solids by weight, determined in accordance with DOTD TR 524, shall not deviate more than ±10 percent from that of the original approved material and shall not exceed the manufacturer's stated limits. Tests to determine rate of hardening, compressive strength or other properties may be made at any time during the work to ensure continued compliance with these specifications.

1011.03 SPECIAL FINISH FOR CONCRETE. Use material from the Approved Materials List. The material shall provide a uniform-textured finish complying with these specifications. Follow the manufacturer's recommendation for method of mixing, method of application, and rate of

application, except that the rate shall not exceed 60 square feet per mixed gallon. Modifications to the manufacturer's recommendations will not be permitted.

Use a one-component coating system containing pigments, sand and resins. The coating shall contain fungicides to prevent the growth of mildew, mold, etc. Color and texture of the material when applied to the test panel shall closely match that of the standard "Louisiana Gray" color chip on file (similar to federal color # 36440 from Federal Standard 595C) at the Materials and Testing Section.

For project samples, comply with Table 1011-1.

Table 1011-1
Special Finish Sample Acceptance

PROPERTY	TEST METHOD	SPECIFICATIONS ACCEPTANCE[1]
Density	ASTM D1475	Target Value ±0.25 lbs/gal
Viscosity	ASTM D562	Target Value ±5 KU
Dry to Touch	ASTM D1640	Target Value ±10%
Dry Through	ASTM D1640	Target Value ±10%
Solids percent	ASTM D2369	Target Value ±2%
Volatile percent	ASTM D2369	Target Value ±2%
Infrared Spectrum	DOTD TR 610	[2]

[1]Target Values shall be established by the Materials Section upon qualification of the paint system.
[2]Standards for infrared spectrum shall be kept on file and compared to project samples for acceptance purposes.

For source approval, comply with the following:

1. The average number of cycles to failure shall be not less than 50 cycles when tested in accordance with ASTM C666, Method A. Test specimens shall show no flaking, cracking, spalling or loss of bond.

2. The material shall be unaffected except for slight chalking or discoloration when exposed to 1000 hours of accelerated weathering using UV-B lamps in accordance with ASTM G154.

Table 1011-2
Physical Requirements for Admixtures

Property	Test Method	Water-Reducing			High Range Water Reducing		Set Accelerating	Specific Performance
		Air Entraining	Normal Set	Set Retarding	Normal Set	Set Retarding		
Unit Water Content,								
Max. % of Control		90	95	95	88	88	---	---
Min. % of Control		—	89	89	---	---	---	---
Air Content, %, Total	DOTD TR 202	5 ± 1	0 to 3	0 to 3	0 to 3	0 to 3	0 to 3	---
Time of Setting, allowable deviation from control, hr:min.	AASHTO T 197							
Initial: at least		—	—	1:30 later	—	1:30 later	1:00 earlier	1:00 earlier
not more than		—	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later	3:30 later	3:30 earlier	1:30 later
Final: at least		—	—	—	—	—	1:00 earlier	1:00 earlier
not more than		—	1:00 earlier or 1:30 later	3:30 later	1:00 earlier or 1:30 later	3:30 later	—	1:30 later
Compressive Strength, Min. % of Control	DOTD TR 230							
1 Day		—	—	—	140	125	125	—
3 Days		—	—	—	125	125	100	90
7 Days		85	105	105	115	115	100	90
28 Days		85	105	105	110	110	100	90
6 Months		—	—	—	100	100	—	90
1 year		—	—	—	100	100	—	90
Flexural Strength, Min. % of Control	AASHTO T 97							
3 Days		—	—	—	110	110	—	90
7 Days		—	—	—	100	100	100	90
28 Days		—	—	—	100	100	100	90
Relative Durability Factor, Min. % of Control	AASHTO T 161	—	—	—	100	100	100	80

Section 1012
Vacant

Section 1013
Metals

1013.01 STRUCTURAL STEEL. Comply with the "Buy America Provisions" in 106.04.

Obtain all applicable physical and chemical tests and furnish the Construction Section five copies of the Certificates of Analysis (Mill Test Reports) together with a Fabricator's Material Statement and Certificate of Compliance. This form will be furnished by the Department upon request.

Structural steel shall comply with AASHTO M 270.

The main load-carrying structural member components that are subject to tensile stress shall meet the longitudinal Charpy V-Notch requirements for Temperature Zone 1 contained in the AASHTO M 270 Supplemental Requirements for Non-Fracture Critical Impact Test Requirements and for Fracture Critical Impact Test Requirements. Sampling and testing procedures shall be in accordance with AASHTO T 243 and AASHTO T 244.

1013.02 RIVET STEEL.

1013.02.1 Structural Rivet Steel: Comply with ASTM A502, Grade 1.

1013.02.2 High Strength Rivet Steel: Comply with ASTM A502, Grade 2.

1013.03 COPPER BEARING STEEL. Copper bearing steel shall contain at least 0.2 percent copper.

1013.04 STEEL FORGINGS AND STEEL SHAFTING.

1013.04.1 Carbon and Alloy Steel Forgings: Steel forgings shall comply with ASTM A668. Class C forgings shall be furnished except in cases specified below:

1013.04.1.1 Forged Shafts: Comply with ASTM A668, Class F.

1013.04.1.2 Forged Trunnions: Comply with ASTM A668, Class G.

1013.04.2 Alloy Steel Forgings for Pinions and Reduction Gears: Comply with ASTM A291, Class 3 or 3A.

1013.04.3 Cold Finished Steel Shafting: Cold finished carbon steel shafting shall comply with ASTM A108. Cold finished alloy steel shafting shall comply with ASTM A331.

1013.05 STEEL CASTINGS.

1013.05.1 Steel Castings for Highway Bridges: Comply with ASTM A27, Grade 70-36.

1013.05.2 High Strength Steel Castings: Comply with ASTM A148.

1013.05.3 Chromium Alloy Steel Castings: Comply with ASTM A743, Grade CA-15. Galvanizing for steel castings used for frames, grates, and covers shall be in accordance with ASTM A123.

1013.06 CAST IRON CASTINGS. Castings shall be true to pattern in form and dimensions and free from pouring faults, sponginess, cracks, blowholes, and other defects in positions affecting strength and value for the service intended. Castings shall be boldly-filleted at angles, and rises shall be sharp and perfect. Castings shall be sandblasted or otherwise effectively cleaned of scale and sanded to a smooth, clean and uniform surface.

1013.06.1 Gray Iron and Ductile Castings: Comply with AASHTO M 306.

1013.06.2 Malleable Castings: Comply with ASTM A47, Grade 32510. Castings weighing more than 1,000 pounds shall be ultrasonically tested for voids. If voids are found, the casting will be rejected.

1013.06.3 Ductile Iron Castings: Comply with ASTM A536, Grade 60-40-18.

1013.07 BRONZE OR COPPER ALLOY BEARING AND EXPANSION PLATES.

1013.07.1 Bronze Bearing and Expansion Plates: Comply with ASTM B22, Alloy C 91100.

1013.07.2 Rolled Copper-Alloy Bearing and Expansion Plates: Comply with ASTM B100, Alloy C 51000.

1013.08 BOLTS, NUTS, WASHERS, AND HARDWARE. If galvanizing is required, comply with Section 811.

1013.08.1 Carbon Steel Bolts, Nuts, and Washers: When high strength bolts are not required, bolts shall comply with ASTM A307 Grade A, and nuts shall comply with ASTM A563. Unless otherwise specified, any appropriate steel washers can be used and the washer coating must be similar to the bolts and nuts coating. Machine bolts may have either square or hex heads and nuts.

1013.08.2: ASTM A325 and A490 have been replaced by ASTM F3125. References to A325 and A490 are to be taken to mean ASTM F3125,

Grade A325 and A490 respectively. Bolts, nuts, and washers shall have plain surface finish unless otherwise specified.

1. High strength bolts shall comply with ASTM F3125, Grade A325 (formally ASTM A325) or Grade A490 (formally ASTM A490), as specified. For ASTM A325 bolts, Type 1 bolts shall be used; except that Type 3 bolts shall be used with unpainted AASHTO M 270, Grade 50W and 70W steels.

2. For Type 1 bolts, the nuts shall comply with ASTM A563, Grade DH or ASTM A194 Grade 2H. For Type 3 bolts, the nuts shall comply with ASTM A563, Grade DH3.

3. Circular washers for high strength bolts shall comply with ASTM F436.

4. Direct Tension Indicators shall comply with ASTM F959 and shall match the material type of the bolt, nut, and washer used in the same assembly.

1013.08.3 Stainless Steel Bolts, Nuts, and Washers: Stainless steel bolts and nuts shall comply with ASTM A320, Grade B 8, annealed or approved equal. Washers shall comply with ASTM F436 and shall be fabricated from stainless steel material with equal or better corrosion resistance as the bolt.

1013.08.4 Anchor Bolts, Nuts, and Washers: Steel anchor bolts shall comply with ASTM F1554. Steel hex nuts shall comply ASTM A563 or ASTM A194 and shall comply with the grade, surface finish, and style recommendations of ASTM F1554. Steel washers shall comply with ASTM F436, Type 1.

Stainless steel anchor bolts and hex nuts shall comply with ASTM F593, Group 2, Alloy 316. For high strength applications, comply with F593, Group 7, Alloy 630. Washers shall comply with ASTM F436 and shall be fabricated from stainless steel material with equal or better corrosion resistance as the bolt.

1013.08.5 Hardware: The minimum corrosion protection for bridge hardware is galvanization in accordance with ASTM A153 or ASTM A123 or an approved mechanical galvanizing process complying with ASTM B695 that provides the same coating thickness.

Eyebolts shall comply with ASTM A489.

1013.09 STEEL H PILES. Comply with AASHTO M 270, Grade 36.

1013.10 SHEET PILES. Steel sheet piles shall comply with ASTM A328 or ASTM A572. Substitution of ASTM A588 for A572 may be allowed with

approval of the Bridge Engineer Administrator. Steel sheet pile shall be hot rolled with a ball-and-socket type interlocking joint. Aluminum sheet piles shall comply with ASTM B221, Alloy 6061-T6 or Alloy 6063-T6 or ASTM B209 Alloy 3064-H34.

1013.11 STEEL PIPE PILES. Comply with ASTM A252, Grade 2.

1013.12 SHEET COPPER. Comply with ASTM B152.

1013.13 SHEET LEAD. Comply with ASTM B29.

1013.14 SHEET ZINC. Comply with ASTM B69, Type II.

1013.15 COLD-ROLLED STEEL. Cold-rolled steel shall be cold-finished steel complying with ASTM A108.

1013.16 BRONZE.

1013.16.1 Center Discs for Movable Bridges: Comply with ASTM B22, Alloy C91300.

1013.16.2 Trunnion and Similar Bearings for Movable Bridges: Comply with ASTM B22, Alloy C91100.

1013.16.3 Shafts and Ordinary Bearings: Comply with ASTM B22, Alloy C90500.

1013.16.4 Gears, Nuts Transmitting Motion, and Other Parts Involving Stresses Other Than Compression: Comply with ASTM B22, Alloy C90500.

1013.17 BABBITT METAL. Comply with ASTM B23, Alloy 3.

1013.18 STEEL FOR CENTER DISCS (Movable Bridges). Comply with ASTM A668, Class F.

1013.19 STEEL FOR KEYS (Movable Bridges). Comply with 1013.15 or ASTM A668, Class D.

1013.20 SEAMLESS STEEL PIPE AND TUBING FOR HYDRAULIC LINES. Carbon steel pipe for hydraulic lines shall comply with ASTM A106, Grade B. Fittings for hydraulic lines shall comply with ASTM A105. Stainless steel tubing shall be seamless austenitic stainless steel and shall comply with ASTM A269.

1013.21 GALVANIZED STEEL PIPE RAILINGS.

1013.21.1 Galvanized Steel Pipe: Galvanized steel pipe shall be standard weight complying with ASTM A53.

1013.21.2 Fittings and Castings: Fittings and castings for steel pipe shall be malleable iron or cast steel complying with ASTM A47, Grade 32510 or ASTM A27, Grade 70-36. Fittings and castings shall be galvanized in accordance with ASTM A153. Make repairs to galvanized surfaces in accordance with 811.08.

For each heat or foundry pour of iron or steel post casting, the Certificates of Analysis shall give chemical and physical test results, including the ounces per square foot of galvanized coating applied. These results shall be on file and accessible for review by the Department if requested.

1013.22 STEEL PIPE AND TUBING FOR BRIDGE RAILING. Steel pipe shall be standard weight ASTM A53, Grade B pipe. Rectangular tubing sections shall be ASTM A500, Grade B or ASTM A501, Grade B. Other railing components shall meet the requirements of AASHTO M270, Grade 50 except that the maximum tensile strength requirement will be waived.

1013.23 ALUMINUM FOR BRIDGE RAILING. Aluminum pipe, tubing, and structural shapes shall conform to ASTM B221 or ASTM B429, Alloy 6061-T6. Base plates and post caps shall conform to ASTM B209, Alloy 6061-T6.

1013.24 STEEL FOR OPEN GRID BRIDGE FLOORING. Comply with 1013.01.

1013.25 DUCTILE CAST IRON BEARINGS. Comply with ASTM A536.

1013.26 SHEAR CONNECTORS. Shear connector studs shall be Type B studs complying with ANSI/AASHTO/AWS D 1.5, Bridge Welding Code.

1013.27 CONCRETE ANCHOR STUDS. Concrete anchor studs used for end dam plates, bearing plates or other concrete anchorage shall be Type A studs complying with the latest edition of ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

1013.28 STEEL FOR STAY-IN-PLACE FORMS. Comply with ASTM A653 with a minimum G 165 coating for non-corrosive environments, G235 for corrosive environments and G235 with polymer coating for coastal environments.

Section 1014
Timber, Timber Connectors, and Preservatives

1014.01 STRUCTURAL TIMBER AND LUMBER. Structural timber and lumber shall be qualified products as determined by the Construction Fabrication Unit. For species and grade of structural timber and lumber comply with AASHTO M 168 and the following requirements.

1014.01.1 Southern Pine. For Southern Pine lumber, comply with the latest version of the Standard Grading Rules for Southern Pine Lumber published by the Southern Pine Inspection Bureau (SPIB). Use the appropriate grade of lumber as designated in the plans or specifications.

1. Caps, stringers, decking, and bridge rails shall be Grade No. 1 Dense Timbers.

2. Items other than caps, stringers, decking, and bridge rail shall be Grade No. 1 Timbers.

1014.01.2 Douglas Fir. For Douglas Fir lumber, comply with the latest version of the Standard Grading Rules for Western Lumber published by the West Coast Lumber Inspection Bureau (WCLB) or Western Lumber Grading Rules published by Western Wood Products Association (WWPA). Use the appropriate grade of lumber as designated in the plans or specifications. Comply with the following:

1. Caps, stringers, decking, and bridge rail shall be composed of "Select Structural" members.

2. Items other than caps, stringers, decking, and bridge rail shall be composed of Grade 1 members.

1014.01.3 Structural Glued Laminated Timber (GLULAM). Structural glued laminated timber (glulam) shall be qualified products as determined by the DOTD Construction Fabrication Unit. Glulam shall comply with AASHTO M-168 and meet the requirements of ANSI A190.1

1014.02 TIMBER PILES, POLES, POSTS, AND BRACES.

1014.02.1 Timber Piles: Timber piles shall be Class B Southern Yellow Pine or Douglas Fir and shall comply with ASTM D25.

1014.02.2 Timber Poles: For timber poles, use Southern Pine or Douglas Fir and comply with ANSI 05.1.

1014.02.3 Timber Posts and Braces: Posts and braces shall be cut from sound trees (not limbs) and shall not contain any unsound knots. Sound knots will be permitted if the diameter of the knot does not exceed 1/3 the diameter of the piece at the point where it occurs. Posts and braces shall be free from decayed wood, rot, and red heart. Ring shakes and season checks

which penetrate more than 1/4 inch will be cause for rejection. Posts and braces shall show at least four annular rings per inch and at least 1/3 summer wood, "dark bands."

Fence posts shall be peeled for their full length; all outer and inner bark shall be removed. Knots shall be trimmed close to the surface of the post before treatment. A line drawn from center of top to center of butt shall neither fall outside the body of the posts nor at any point exceed more than 1 inch from the geometric center of the post. Posts and braces shall be free from short or reverse crook. Excessive bow, camber, twist, or other such defects in posts and brace will be cause for rejection. Ends shall be sawn square.

Guard rail posts and blockouts shall be treated timber of Southern Pine Grade No. 1 or Douglas Fir Dense No. 1. Posts and blockouts shall be fabricated before treatment.

When round timber posts are specified or shown in the plans for guard rail, the posts shall be 7 1/4 inches in diameter plus or minus 1/8 inch at any point, as determined by a circumference-diameter tape. The length shall not vary more than 1 inch from plan length. The round timber post top shall be domed approximately hemispherical in shape and the radius of the dome shall be 4 inches. The dome shall be smooth, and the distance from the top of the dome to the base of the dome shall not vary more than 3/4 inch at any location. All round timber posts shall be smooth shaved by machine and no "ringing" will be permitted. All outer and inner bark shall be removed during the shaving process. All knots and knobs shall be trimmed smooth and flush with the surface of the post. Each post shall have minimum sapwood depth of 1 inch measured at any location within the circumference. The maximum diameter of any single knot shall not exceed 3 inches. The sum of the diameters of all knots greater than 0.5 inch in any 1-foot section shall not exceed 8 inches. A straight line drawn from the center of the top to the center of the butt of any post shall not deviate from the centerline of the post more than 1/4 inch at any point. Splits or ring shakes are not permitted in the top for round post. Splits are not permitted in the butt. A single shake is permitted in the butt, provided it is not wider than one half the butt diameter.

Guard rail timber species (blockouts/braces) shall be the same as those furnished for the timber posts. The actual finished size of blockouts for round timber posts shall be 5 3/4 inch square, with a tolerance of 1/8 inch plus or minus. Each of the four corners of each block shall be machined down to provide a flat 1 inch surface the entire length of the block with a tolerance of 1/4 inch plus or minus. Each block shall be machine concaved to a radius of 3 5/8 inches, and to a depth of 3/4 inch. The size and hole location shall be

as shown on the plans. Blockouts shall be of medium grain, at least 4 rings per inch, and free from splits, shakes, compression wood or decay in any form. Individual knots, knot clusters or knots in the same cross section of a face are permitted, provided they are sound or firm, and are limited in cumulative width (when measured between lines paralleled to the edges) to no more than one third the width of the face. Grain deviation is limited to 1 inch in 6 inches. The material may be sawn or surfaced.

1014.02.4 Glulam Poles, Posts, and Braces. Glulam poles shall comply with ANSI 05.2. Glulam posts and braces shall comply with ANSI 05.3. Glulam is not to be used for pile applications.

1014.03 TIMBER PRESERVATIVES. The type preservatives to be used are as follows:

1014.03.1 Creosote (CR): For creosote used for land and fresh and coastal water applications, comply with AWPA P1/P13.

1014.03.2 Creosote Solutions (CR-S): For creosote solutions for fresh and coastal water applications, comply with AWPA P2.

1014.03.3 Pentachlorophenol-Petroleum Solution (Penta): Comply with AWPA P35.

1014.03.4 Copper Naphthenate (CuN): Comply with AWPA P8/P9.

1014.03.5 Chromated Copper Arsenate (CCA): Comply with AWPA P23, Type C.

1014.03.6 Ammoniacal Copper Zinc Arsenate (ACZA): Comply with AWPA P22.

1014.03.7 Alkaline Copper Quat (ACQ): Comply with AWPA P26 for Type A (ACQ-A). Comply with AWPA P27 for Type B (ACQ-B). Comply with P28 for Type C (ACQ-C).

1014.03.8 Copper Azole (CA): Comply with AWPA P32 for Type B (CA-B). Comply with AWPA P48 for Type C (CA-C).

1014.03.9 Field Repairs: Comply with AWPA M4 and product manufacturer's recommendations. Repair any surface that is exposed by damage or field fabrication by treating with copper naphthenate containing a minimum of 2.0 percent copper metal. Apply solution to these exposed surfaces until absorption stops. Remove excess preservative. Bored holes for connectors or bolts may be treated by pumping coal-tar roofing cement meeting ASTM D5643 into holes using a grease gun or similar device.

1014.04 TREATMENT.

1014.04.1 General: Materials shall be treated according to current AWPA U1 Standard Specifications for Preservative Treatment and used in the appropriate application.

1014.04.2 Amount of Preservative: The amount of preservative shall be the minimum specified in Table 1014-2 herein determined by assay. The assay zone shall be as specified in AWPA T1 Standards. All sample holes shall be filled with a tightly-fitted pressure-treated plug. All treated wood products shall meet all penetration requirements of AWPA Standards. The treating plant shall provide treating reports to the Department's inspector upon request. At the Department's discretion the treating reports may be used for acceptance of small miscellaneous charges of material.

1014.04.3 Painting: When painting of treated material is required, use a paint system that is compatible with the wood treatment process, and in accordance with manufacturer's recommendations

1014.05 TIMBER CONNECTORS. Connectors for treated timber structures, except those of malleable iron, shall be galvanized in accordance with ASTM A123.

1014.05.1 Split Ring Connectors: Split rings of 2 1/2 inches, 4 inches and 6 inches inside diameter shall be manufactured from hot-rolled, low-carbon steel conforming to ASTM A711, Grade 1015. Each ring shall form a closed true circle with an outside cylindrical surface parallel to the axis of the ring. The inside surface, except for the 6-inch ring, shall be beveled from the median line toward the edges. It shall be cut through in one place in its circumference to form a tongue and slot.

Connector grooves in timber shall be cut concentric with the bolt hole and have the dimensions shown in Table 1014-1.

Table 1014-1
Split Ring Timber Connector Dimensions, Inches

Nominal Ring Size	Inside Diameter	Groove Width	Groove Depth
2 1/2	2.56	0.18	0.37
4	4.08	0.21	0.50
6	6.12	0.27	0.62

1014.05.2 Toothed-Ring Connectors: Toothed-ring connectors shall meet the following requirements:

1. Stamp cold from 0.060 inch thick rolled sheet steel.
2. Comply with ASTM A711, Grade 1015.
3. Bend cold to form a circular, corrugated, sharp-toothed band and circle.
4. Be parallel to the axis of the ring.
5. The central band shall be welded to fully develop the strength of the band.
6. All sizes shall have an overall depth of 0.94 inch and depth of fillet of 0.25 inch.

1014.05.3 Shear Plate Connectors: Shear plate connectors shall be of the following types:

1014.05.3.1 Pressed Steel Type: Pressed steel shear plates of 2 5/8 inches in diameter shall be manufactured from steel complying with ASTM A711, Grade 1015. Each plate shall be a true circle with a flange around the edge, extending at right angles to the face of the plate and extending from one face only. The plate portion shall have a central bolt hole and two small perforations on opposite sides of the hole and midway from the center and circumference.

1014.05.3.2 Malleable Iron Type: Malleable iron shear plates of 4-inch diameter shall be manufactured according to ASTM A47, Grade 32510. Each casting shall consist of a perforated round plate with a flange around the edge extending at right angles to the face of the plate and projecting from one face only. The plate portion shall have a central bolt hole reamed to size with an integral hub concentric to the bolt hole and extending from the same face as the flange.

1014.05.4 Claw-Plate Connectors: Claw-plate connectors of 2 5/8 inches, 3 1/8 inches, and 4 inches in diameter shall be malleable iron, manufactured according to ASTM A47, Grade 32510. Each claw-plate shall consist of a perforated circular flanged plate with three-sided teeth arranged about the perimeter of one face. The male plate shall have integral cylindrical hubs on both faces concentric to a bolt hole through the center of the plate. The female plate shall be flat on the side opposite the teeth, but shall have an integral cylindrical hub concentric to the central bolt hole and on the face with the teeth.

1014.05.5 Spike-Grid Connectors: Spike-grid connectors shall be manufactured according to ASTM A47, Grade 32510. They shall consist of four rows of opposing spikes forming a 4 1/8 inch square grid with 16 teeth held in place by fillets. Fillets for the flat grid in cross section shall be diamond shaped. Fillets for single and double curve grids shall be increased

in depth to allow for curvature and shall maintain a thickness between sloping faces on fillets equal to the width of the fillet.

1014.06 HARDWARE AND STRUCTURAL SHAPES. Washers shall be cast ogee gray iron or malleable castings. Use a standard washer under heads of lag screws. Nails shall be cut or round wire of standard form. Spikes shall be cut wire or boat spikes. Structural shapes shall comply with Section 1013 for the type of metal used.

1014.07 QUALITY ASSURANCE. Inspection shall be in accordance with AWPA M2. Quality control shall be in accordance with AWPA M3. Care of the treated wood products shall be in accordance with AWPA M4. Treated timber and piles to be supplied from a DOTD certified plant and inspected and stamped by DOTD Construction prior to shipment. Notify DOTD Construction prior to treatment.

Table 1014-2
Minimum Retention of Preservative
(Pounds per Cubic Foot of Wood)

	CR[1]	CR-S	Penta	CuN (Cu as Metal)	CCA[2] and ACZA	ACQ-B ACQ-C ACQ-D	CA-B CA-C	MCA[4]
Timber & Lumber								
Above Ground: (UC3B) SP	SP 8.0	SP 8.0	SP 0.40	SP 0.04	SP 0.25	SP 0.25 B,C 0.15 D	SP 0.10 B 0.06 C	SP 0.06
Land & Fresh Water (UC4C) SP DF	SP/DF 12.0	SP/DF 12.0	SP/DF 0.50	SP/DF 0.075	SP/DF 0.60	SP/DF 0.60	SP/DF .031	SP/DF 0.23
Coastal Water (UC5C) SP DF	SP/DF 25.0	SP/DF 25.0	N/A	N/A	N/A	N/A	N/A	N/A
Piles Non-Foundation[3]								
Land & Fresh (UC4C) SP DF	SP 19.0 DF 12.0	N/A	SP 0.45 DF 0.60	N/A	SP 0.60 DF 0.60	N/A	SP 0.31 DF N/A	SP 0.23 DF N/A
Coastal Water (UC5C) SP DF	SP/DF 16.0	SP/DF 16.0	N/A	N/A	SP/DF 1.5 outer 0.9 inner	N/A	N/A	N/A
Piles Foundation[3]								
Land & Fresh Water (UC4C) SP DF	N/A	N/A	N/A	SP 0.10 DF.14	SP 0.80 DF N/A	SP 0.80 C DF N/A	SP 0.41 DF N/A	N/A
Coastal Water (UC5C) SP DF	SP/DF 25.0	SP/DF 25.0	N/A	N/A	SP/DF 1.5 inner	N/A	N/A	N/A
Poles								
(UC4C) SP DF	SP 9.0 DF 12.0 outer 6.0 inner	N/A	SP 0.45 DF 0.60 outer 0.30 inner	SP 0.13 DF 0.150 outer 0.175 inner	SP N/A DF 0.60	SP/DF 0.60 B	SP 0.31 DF N/A	N/A
Fence (UC4A)								
Gate Posts/Braces	N/A	N/A	N/A	0.055	N/A	0.40	0.21 B 0.15 C	0.15
Guard Rail Posts/Blockouts (UC4B)	10.0	10.0	0.50	0.069	0.50	0.50	0.25	0.23
Bridge Rails, Dead End Road Installations, Pedestrian Bridges: Rails & Posts								
Above Ground (UC3B) SP DF	N/A	N/A	N/A	N/A	N/A	0.25 B, C 0.5 D	0.10 B 0.06 C	0.06
Land & Fresh Water (UC4C) SP DF	N/A	N/A	N/A	N/A	N/A	0.60	0.31	0.23

[1]Timber, blockouts, poles and dead end road installations treated with creosote shall be steam flashed for a minimum of 1 hour at 240ºF after treatment

.[2]Material treated with CCA shall be conditioned by kiln drying prior to treatment.

[3]A building foundation pile is embedded in the ground and capped with concrete. A structure foundation pile is a fender system pile or any structure pile, except for those used for pile-supported approach slabs. Pile supported approach slab piles are classified as non-foundation.

[4]Micronized copper azole.

Section 1015
Signs and Pavement Markings

1015.01 GENERAL REQUIREMENTS. Signs and pavement markings materials shall comply with these specifications, the plans and the MUTCD. When directed, the contractor shall furnish and prepare samples for testing in accordance with Department instructions.

1015.02 METALS.

1015.02.1 Ferrous Metals:

1015.02.1.1 Structural Steel: Structural steel for posts, stringers, framing and miscellaneous steel shall comply with AASHTO M 270, Grade 36. Steel shall be galvanized in accordance with 811.12.

1015.02.1.2 Steel Pipe: Steel pipe or tubing for structures shall be Schedule 40 (STD) complying with ASTM A53, Type E or Type S Grade B, or hot formed tubing complying with ASTM A36 and ASTM A501.

1015.02.1.3 U-Channel Steel Posts for Small Signs, Markers, and Delineators: Posts shall be steel of the flanged channel type shown on the plans, galvanized after fabrication in accordance with 811.12. Before fabrication, posts shall be within 3.5 percent of the specified weight.

Posts shall be fabricated from steel complying with either ASTM A499, Grade 60 with chemical properties conforming to ASTM A1 for 91 lb/yd or heavier rail steel, or ASTM A576, Grade 1080 with 0.10 to 0.20 percent silicon. Holes 3/8 inch in diameter shall be drilled or punched through the middle of each post on one inch centers for the full length of the post.

1015.02.1.4 Square Tubing for Small Signs, Markers, and Delineators: Use 2 inches x 2 inches square tubing.

The square tubing shall conform to ASTM A1011, Grade 50 for hot rolled carbon steel, structural quality. The average minimum tensile strength after cold-forming is 60,000 psi. The cross section of the square tubing shall be a square tube formed and carefully rolled to size and shall be welded by high frequency resistance welding and externally scarfed to agree with corner radii and dimensional tolerances shown in the DOTD Roadside Traffic Sign Standard Details. It shall be manufactured from hot-dipped galvanized steel conforming to ASTM A653, G90, Structural Quality, Grade 50, Class 1. The weld shall be hot zinc coated after the scarfing operation. The steel shall be coated with a chromate conversion coating and a clear organic polymer topcoat.

Perforated sign posts shall be 2 inches x 2 inches square tubing for the upright sign post and 2 1/4 inches x 2 1/4 inches x 3 feet shall be used for anchoring into soil using wet concrete in accordance with the Roadside Traffic Sign Standard Plans.

1015.02.1.5 Square Tubing Breakaway Supports, Hardware and Related Accessories: These items shall meet the specifications in DOTD Roadside Traffic Sign Standard Details. The breakaway support shall be a Kleen-Break Model 425 post coupler manufactured by Xcessories Squared.

1015.02.2 Aluminum Alloy: Structural members shall be aluminum complying with ASTM B221 or ASTM B429, Alloy 6061-T6. Miscellaneous aluminum shall comply with ASTM B209, Alloy 6061-T6.

1015.02.3 Connectors:

1015.02.3.1 Structural Bolts, Nuts and Washers: High strength bolts shall comply with ASTM A325, and other bolts shall comply with ASTM A307, Grade A or Grade B. Bolts shall have hexagonal heads and include two flat washers and one lock washer and one hexagonal-head nut. Bevel washers, where required, shall be wrought steel. Bolts, nuts and washers shall be galvanized in accordance with ASTM A153 or by an approved mechanical galvanizing process complying with ASTM B695 that provides the same coating thickness.

Anchor bolts shall comply with ASTM F1554. Anchor bolts shall be hot dip galvanized in accordance with ASTM A153.

Stainless steel bolts shall comply with ASTM F593, alloy groups 1, 2, or 3 (except alloys 303 or 303 Se), with a minimum tensile strength of 70,000 psi.

1015.02.3.2 Fasteners: Use vandal resistant aluminum alloy fasteners with brasier heads complying with ASTM B316, Alloy 2024-T4, to attach Interstate, Louisiana, and U.S. shields to the sign panel.

1015.03 FLEXIBLE POSTS. Flexible posts for delineators shall be from the Approved Materials List.

1015.04 SIGN PANELS. Flat sign panels shall be marked on the front bottom edge with MUTCD code, initials of the manufacturer and the date. Extruded panels shall be marked on the back in accordance with the standard plans.

1015.04.1 Permanent Sign Panels: New and recycled flat panels shall be aluminum sheets or plates complying with ASTM B209, Alloy 6061-T6 or Alloy 5052-H38. New and recycled extruded aluminum panels

shall comply with ASTM B221, Alloy 6063-T6 and after fabrication, shall have a flatness equal to or less than 0.031 inch per foot of length and 0.004 inch per inch of width. The traceability paperwork shall be maintained and available from the fabricator for 7 years.

1015.04.2 Temporary Sign Panels: Substrate for barricade panels shall be rigid thermoplastic. Substrate for portable signs shall be new or recycled aluminum, wood or plastic. Substrate for post mounted signs shall be new or recycled aluminum, wood, rigid thermoplastic or aluminum clad low density polyethylene plastic.

1015.04.2.1 Aluminum: Aluminum sheeting shall be 0.080 inch thickness complying with ASTM B209, Alloy 6061-T6 or Alloy 5052-H38.

1015.04.2.2 Wood: Plywood sheeting of exterior type Grades either High Density Overlay or Medium Density Overlay are acceptable for use provided the following requirements are met.

Panels shall be a minimum of 5/8 inch thick, shall comply with the latest American Plywood Association specifications, and shall be identified with the APA edge mark or back stamp to verify inspection and testing. Prior to application of reflective sheeting, the surface shall be abraded with steel wool or fine sandpaper, and wiped thoroughly clean. The surface shall dry a minimum of 8 hours prior to application of sheeting. Cut edges of plywood panels shall be sealed with an approved aluminum pigmented polyurethane sealer.

1015.04.2.3 Plastic: Plastic substrate for barricade panels and signs shall be as follows:

1015.04.2.3.1 Fiber Reinforced Vinyl (PVC): The substrate shall have a nominal composite thickness of 0.04 inches and be bonded to an approved retroreflective material by the manufacturer.

1015.04.2.3.2 Rigid Thermoplastic: Rigid thermoplastic substrate shall consist of either High Density Polyethylene (HDPE) or High Density Polycarbonate (HDPC). The rigid thermoplastic for barricade panels shall be hollow core HDPE or HDPC with a minimum thickness of 0.625 inch. The thermoplastic for sign panels shall be 0.40 inch thick thin wall, fluted substrate or 0.625 inch thick blow molded substrate. Substrates shall be sufficiently rigid to maintain a flat face and shall be capable of attachment to the sign mounting in such a manner as not to crush or otherwise deform the substrate. Reflectorized sheeting applied to rigid thermoplastic shall have its manufacturer's approval for use on the substrate.

1015.04.2.3.3 Aluminum Clad Low Density Polyethylene (AL/LDPE) Plastic: The aluminum clad low density polyethylene plastic substrate shall be 0.080 inch thick. The substrates shall be sufficiently rigid

to maintain a flat face and shall be capable of attachment to the sign mounting in such a manner as not to crush or otherwise deform the substrate. Reflectorized sheeting applied to aluminum clad low density polyethylene shall have its manufacturer's approval for use on this substrate.

1015.05 REFLECTIVE SHEETING.

1015.05.1 Permanent and Temporary Standard Sheeting: Reflective sheeting shall be one of the following standard types as specified on the plans and complying with ASTM D4956 except as modified herein. Permanent warning, regulatory, guide and supplemental guide sign sheeting shall meet the requirements of DOTD Type X as described below and detailed in 1015.05.3. Reflective sheeting for temporary signs and devices shall meet the requirements of ASTM D4956 Type III except as noted in 1015.05.6. Reflective sheeting for delineators shall meet the requirements of ASTM D4956 Type III or Type V, including Supplemental Requirements S2. Reflective sheeting shall be from the Approved Materials List.

Type III - A high-intensity retroreflective sheeting. This sheeting is typically encapsulated glass-bead retroreflective material.

Type V - A "super high-intensity" retroreflective sheeting, typically used for delineators. This sheeting is typically a metalized microprismatic retroreflective element material.

Type VI - An elastomeric, high-intensity retroreflective sheeting without adhesive. This sheeting is typically a vinyl microprismatic retroreflective material.

DOTD Type X - A super high-intensity retroreflective sheeting having highest retroreflectivity characteristics at medium distances. This sheeting is typically an unmetalized microprismatic retroreflective element material.

1015.05.2 Fluorescent Pink Retroreflective Sheeting: Signs for temporary control of traffic through incident management areas shall be Type VI fluorescent pink retroreflective sheeting and shall comply with the MUTCD. Temporary traffic control signs for incident management shall be placed to notify motorists of upcoming incidents on the roadway, and shall be removed from public view once the incident has been managed. Physical properties shall comply with ASTM D4956. Photometric properties shall be as follows.

1015.05.2.1 Retroreflectivity: Minimum Coefficients of Retroreflection shall be as specified in Table 1015-1.

Table 1015-1
Coefficients of Retroreflection for Fluorescent Pink Sheeting[1]

Observation Angle, degrees	Entrance Angle, degrees	Fluorescent Pink
0.2	-4	180
0.2	+30	72
0.5	-4	81
0.5	+30	31

[1]Minimum Coefficient of Retroreflection (R_A) (cd $lx^{-1}m^{-2}$)

1015.05.2.2 Color and Daytime Luminance: Color Chromaticity Coordinates and Daytime Luminance Factors shall be as specified in Table 1015-2.

Table 1015-2
Fluorescent Pink Color Specifications Limits (Daytime)

Chromaticity Coordinates (corner points) [1]										Luminance Factor, min.
1		2		3		4		5		Y%
x	y	x	y	x	y	x	y	x	y	20
0.600	0.340	0.450	0.332	0.430	0.275	0.536	0.230	0.644	0.290	

[1]The five pairs of chromaticity coordinates measured with CIE 2° Standard Observer and 45/0 (0/45) geometry and CIE D65 Standard Illuminant.

1015.05.3 DOTD Type X Retroreflective Sheeting: Physical properties shall comply with ASTM D4956. Color shall conform to ASTM D4956, Table 11. Luminance shall conform to ASTM D4956, Table 2. Retroreflectivity properties shall be as follows:

1015.05.3.1 Retroreflectivity: Minimum Coefficients of Retroreflection shall be as specified in Table 1015-3.

Table 1015-3
Coefficients of Retroreflection for DOTD Type X Sheeting[1]

Observation Angle, (degrees) Entrance Angle, (degrees)	0.2 -4	0.2 +30	0.5 -4	0.5 +30
White	560	280	200	100
Yellow	420	210	150	75
Orange	210	105	75	37
Green	56	28	20	10
Red	84	42	30	15
Blue	28	14	10	5.0
Brown	17	8.4	6.0	3.0
Fluorescent Yellow-Green	450	220	160	80
Fluorescent Yellow	340	170	120	60
Fluorescent Orange	170	84	60	30

[1]Minimum Coefficient of Retroreflection (R_A) (cd $lx^{-1}m^{-2}$)

1015.05.4 Adhesive Classes: The adhesive required for retroreflective sheeting shall be Class 1 (pressure sensitive) as specified in ASTM D4956.

1015.05.5 Accelerated Weathering: Reflective sheeting, when processed, applied, and cleaned in accordance with the manufacturer's recommendations, shall perform in accordance with the accelerated weathering standards in Table 1015-4.

Table 1015-4
Accelerated Weathering Standards[1]

Type	Retroreflectivity[2]				Colorfastness[3]	
	Orange/ Fluorescent Orange		All colors, except Orange/ Fluorescent Orange		Orange/ Fluorescent Orange	All colors, except Orange/ Fluorescent Orange
III	1 year	80[4]	3 years	80[4]	1 year	3 years
III (for drums)	1 year	80[4]	1 year	80[4]	1 year	1 year
V	1 year[5]	80[6]	3 years[5]	80[6]	1 year[5]	3 years[5]
VI	1/2 year	50[7]	1/2 year	50[7]	1/2 year	1/2 year
DOTD X	1 year	80[8]	3 years	80[8]	1 year	3 years

[1]At an angle of 45° from the horizontal and facing south in accordance with ASTM G7 at an approved test facility in Louisiana or South Florida.
[2]Percent retained retroreflectivity of referenced table after the outdoor test exposure time specified.
[3]Colors shall conform to the color specification limits of ASTM D4956 after the outdoor test exposure time specified.
[4]ASTM D4956, Table 4.
[5]If outdoor weathering data is not available, artificial weathering according to ASTM D4956, Supplemental Requirement S3 may be used.
[6]ASTM D4956, Table 6.
[7]ASTM D4956, Table 7.
[8]Table 1015-3.

Reflective sheeting for signs, when processed, applied, and cleaned in accordance with the manufacturer's recommendations shall perform outdoors in accordance with the performance standards in Table 1015-5.

Table 1015-5
Reflective Sheeting Performance Standards

Type	Retroreflectivity[1] — Durability[2]				Colorfastness[3]
	Orange/ Fluorescent Orange		All colors, except Orange/Fluorescent Orange		
III	3 years	80[4]	10 years	80[4]	3 years
DOTD X	3 years	80[5]	10 years	80[5]	3 years

[1]Percent retained retroreflectivity of referenced table after installation and the field exposure time specified.

[2]All sheeting shall maintain its structural integrity, adhesion and functionality after installation and the field exposure time specified.

[3]All colors shall conform to the color specification limits of ASTM D4956 after installation and the field exposure time specified.

[4]ASTM D4956, Table 4.

[5]Table 1015-3.

1015.05.6 Temporary Signs, Barricades, Channelizing Devices, Drums and Cones: Reflective sheeting for temporary signs, barricades, and channelizing devices shall meet the requirements of ASTM D4956, Type III, except that temporary warning construction signs used on the mainline of freeways and expressways shall be fluorescent orange and meet the requirements of DOTD Type X.

Reflective sheeting for vertical panels shall meet the requirements of ASTM D4956, Type III.

Reflective sheeting for drums shall be a minimum of 6 inches (150 mm) wide and shall meet the requirements of ASTM D4956, Type III, and the Supplementary Requirement S2 for Reboundable Sheeting as specified in ASTM D4956. Reflective sheeting for traffic cone collars shall meet the requirements of ASTM D4956, Type III or Type VI.

1015.05.7 Sheeting Guaranty: The contractor shall provide the Department with a guaranty from the sheeting manufacturer stating that if the retroreflective sheeting fails to comply with the performance requirements of this subsection, the sheeting manufacturer shall do the following:

Table 1015-6
Manufacturer's Guaranty-Reflective Sheeting

Type	Manufacturer shall restore the sign face in its field location to its original effectiveness at no cost to the Department if failure occurs during the time period[1] as specified below		Manufacturer shall replace the sheeting required to restore the sign face to its original effectiveness at no cost to the Department if failure occurs during the time period[1] as specified below
	Orange/ Fluorescent Orange	All colors, except Orange/ Fluorescent Orange	All colors, except Orange/Fluorescent Orange
III	<3 years	<7 years	7 - 10 years
DOTD X	<3 years	<7 years	7 - 10 years

[1] From the date of sign installation.

Replacement sheeting for sign faces, material, and labor shall carry the unexpired guaranty of the sheeting for which it replaces.

The sign fabricator shall be responsible for dating all signs with the month and year of fabrication at the time of sign fabrication. This date shall constitute the start of the guaranty obligation period.

1015.06 NONREFLECTIVE SHEETING.

1015.06.1 General Requirements: Nonreflective sheeting film shall consist of an extensible, pigmented, weather-resistant plastic film. Face side of film shall be supported and protected by a paper liner which is readily removable after application without the necessity of soaking in water or other solvents. Colors shall match visually and be within the limits shown in Table 11 of ASTM D4956.

1015.06.2 Adhesive Requirements: Sheeting shall have a pre-coated pressure sensitive adhesive backing, which may be applied without additional coats on either sheeting or application surface. Adhesive shall comply with ASTM D4956, Class 1 (pressure sensitive).

1015.06.3 Physical Characteristics: The film shall be readily cut by normal fabricating methods without cracking, checking or flaking. Applied film shall be free from ragged edges, cracks, and blisters. The material shall have demonstrated its ability to withstand normal weathering without checking, cracking, or excessive color loss.

1015.07 SIGN ENAMELS, PAINTS, SILK SCREEN PASTE, AND OVERLAY FILM.

1015.07.1 Sign Enamels and Paints: These shall be applied in accordance with the sheeting manufacturer's recommendations. Final appearance as well as materials used shall be subject to approval.

1015.07.2 Silk Screen Paste: Silk screen paste shall be mixed at the factory, well ground to a uniform consistency and smooth texture, and shall be free from water and other foreign matter. It shall dry within 18 hours to a film that does not run, streak, or sag. Paste which has livered, hardened, or thickened in the container, or in which pigment has settled out so that it cannot be readily broken up with a paddle to a uniform usable consistency, will be rejected. Thinner shall be used in accordance with the sheeting manufacturer's recommendations.

Paste shall have proper pigmentation and consistency for use in silk screen equipment. The material shall produce the desired color and the same retroreflectivity values as required for reflective sheeting of the same type and color when applied on reflective sheeting background. Paste shall meet the quality and test requirements for appearance, coarse particles, and moisture and water resistance as specified for sign paints.

1015.07.3 Overlay Film: Transparent electronic cuttable overlay film shall produce the desired color and the same reflectivity values as required for reflective sheeting of the same type and color when applied on reflective sheeting background.

1015.08 TEMPORARY PAVEMENT MARKINGS.

1015.08.1 Temporary Tape: Temporary tape shall comply with ASTM D4592, Type I (removable) or Type II (non-removable) and shall be from the Approved Materials List.

1015.08.2 Painted Stripe: Paint shall be an approved traffic paint complying with 1015.12. Glass beads for drop-on application shall comply with 1015.13.

1015.08.3 Temporary Raised Pavement Markings for Asphalt Surface Treatment: Temporary raised pavement markers for asphalt surface treatment shall be flexible reflective tabs having a nominal width of 4 inches. The markers shall be yellow with amber reflective area on both sides. The body of the marker shall consist of a base and vertical wall made of polyurethane or other approved material and shall be capable of maintaining a reasonable vertical position after installation. The initial minimum Coefficient of Luminous Intensity at an entrance angle of -4

degrees and an observation angle of 0.2 degrees shall be 230 mcd/lx when measured in accordance with ASTM E810.

The reflective material shall be protected with an easily removable cover of heat resistant material capable of withstanding and protecting the reflective material from the application of asphalt at temperatures exceeding 325°F.

1015.09 RAISED PAVEMENT MARKERS. Markers shall be either non-reflectorized or reflectorized, as specified. Markers shall be from the Approved Materials List.

1015.09.1 Non-Reflectorized Markers:

1015.09.1.1 Description: Non-reflectorized markers shall consist of an acrylonitrile butadiene styrene polymer or other approved material, and shall be approximately 4 x 6-inches.

1015.09.1.2 Physical Requirements: Markers shall comply with the compressive strength requirements of ASTM D4280. The color shall be in accordance with the plans and the MUTCD.

1015.09.2 Reflectorized Markers: Reflectorized markers shall comply with ASTM D4280, Designation H and Designation F. The type and color shall be in accordance with the plans and the MUTCD. The markers shall be either standard having minimum base dimensions of 3 x 3-inches and a maximum height of 0.80 inches or low profile having minimum base dimensions of 3 x 2-inches and a maximum height of 0.60 inches.

1015.09.3 Adhesive:

1015.09.3.1 Epoxy Adhesive: Epoxy adhesive shall be Type I or II epoxy resin system complying with 1017.03.

1015.09.3.2 Bituminous Adhesive: The adhesive shall conform to ASTM D4280 (any type) for asphalt surfaces and D4280 Type II or Type III for concrete surfaces and shall be from the Approved Materials List.

1015.10 THERMOPLASTIC PAVEMENT MARKINGS.

1015.10.1 Description: This specification covers hot-sprayed, hot-extruded, and preformed thermoplastic compound for pavement markings on asphalt or portland cement concrete pavement. Thermoplastic marking material applied to asphalt surfaces shall consist of an alkyd based formulation. Thermoplastic marking material applied to portland cement concrete surfaces shall consist of an alkyd based formulation. Non-preformed material shall be manufactured so as to be applied by spray 40 mils thick or extrusion 90 mils thick or greater to pavement in molten form, with internal and surface application of glass spheres, and upon cooling to

normal pavement temperature, shall produce an adherent, reflectorized pavement marking of specified thickness and width, capable of resisting deformation. Preformed thermoplastic shall be a minimum of 125 mils thick prior to application. Black thermoplastic pavement markings shall require skid-resistant filler in lieu of glass beads.

For yellow thermoplastic material, the type and amount of yellow pigment shall be at the option of the manufacturer, providing all other requirements of this specification are met. However, the pigment for yellow thermoplastic shall be lead free and shall meet the regulatory level of non-hazardous waste as defined by 40 CFR § 261.24 when tested in accordance with EPA Method 1311, Toxicity Characteristics Leaching Procedures. The manufacturer shall provide certification that the material provided meets these requirements.

1015.10.2 Suitability for Application: Thermoplastic material shall be a product especially compounded for pavement markings. Markings shall maintain their original dimension and placement and shall not smear or spread under normal traffic at temperatures below 140°F. Markings shall have a uniform cross section. Glass beads shall be uniformly distributed to ensure that the full width of the line is visible at night. Pigment shall be evenly dispersed throughout the material thickness. The exposed surface shall be free from tack and shall not be slippery when wet. Material shall not lift from pavement in freezing weather. Cold ductility of material shall be such as to permit normal movement with the pavement surfaced without chipping or cracking.

1015.10.3 Standard (Flat) 90 mil or Greater Thermoplastic Pavement Markings: White and yellow thermoplastic shall be from the Approved Materials List and comply with AASHTO M 249 as modified herein. All other colors are not required to be from the Approved Materials List.

1015.10.3.1 Color:

1015.10.3.1.1 Laboratory Performance: The yellow thermoplastic shall comply with the requirements of Table 1015-7 when tested in accordance with ASTM E1349.

Table 1015-7
Color Specification Limits (Daytime)

Color	1		2		3		4	
	X	y	x	y	x	y	x	y
Yellow	0.4756	0.4517	0.4985	0.4779	0.5222	0.4542	0.4919	0.4354

(The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with Standard 2° Observer and Standard Illuminant D65.)

1015.10.3.1.2 Field Performance: The Department may take initial daytime color and luminance factor (Y%) readings, as required by the engineer, within 7 to 30 days after installation to verify compliance with ASTM D6628.

1015.10.3.2 Whiteness Index: White thermoplastic shall have a minimum whiteness index of 40 when tested according to ASTM E313.

1015.10.3.3 Retroreflectivity: All retroreflectivity readings shall be measured with a geometry of 1.05 degrees observation angle and 88.76 degrees entrance angle as detailed in ASTM E1710.

For 90 mil thermoplastic, the initial retroreflectance for the in-place 4 inch lines marking shall have a minimum value of 375 mcd/lux/sq m for white and 250 mcd/lux/sq m for yellow. The Department may take readings on 4 inch lines before the expiration of the Guarantee Period in accordance with 104.05. Readings shall be at least 325 mcd/lux/sq m or greater for white and 200 mcd/lux/sq m or greater for yellow.

Only white and yellow markings require reflectivity testing.

In lieu of measurements, the engineer shall determine by visual nighttime inspection that stop bars, cross walks, chevrons, hash marks, legends and symbols have sufficient reflectance. For 8 inch lines for gores and turn lanes, the initial retroreflectance for the in-place marking shall meet 250 mcd/lux/sq m for white.

1015.10.4 Standard (Flat) 40 mil Thermoplastic Pavement Markings: Materials shall comply with AASHTO M 249 as modified herein. The meltdown temperature for all laboratory tests shall be 375°F ± 3°F.

1015.10.4.1 Composition: The material shall meet the following composition requirements:

	White	Yellow
Binder	25 percent minimum	25 percent minimum
Glass Spheres	30 percent minimum	30 percent minimum

% by weight

The intermixed glass spheres contained in the thermoplastic material shall conform to AASHTO M 247 Type I.

1015.10.4.2 Color:

1015.10.4.2.1 Laboratory Performance: The yellow thermoplastic shall comply with the requirements of Table 1015-7, "Color Specification Limits (Daytime)" when tested in accordance with ASTM E1349.

1015.10.4.2.2 Field Performance: The Department may take initial daytime color and luminance factor (Y%) readings, as required by the engineer, within 7 to 30 days after installation to verify compliance with ASTM D6628.

1015.10.4.3 Softening Point: After heating the marking compound for 4 hours ± 5 min. at 375°F ± 3°F and testing in accordance with ASTM E28, the material shall have a minimum softening point of 190°F as measured by the ring and ball method.

1015.10.4.4 Indentation Resistance: The material, when tested in accordance with ASTM D2240, Shore Durometer, A2, shall not exceed 40 when tested at 115°F ± 3°F.

1015.10.4.5 Retroreflectivity: All retroreflectivity readings shall be measured with a geometry of 1.05 degrees observation angle and 88.76 degrees entrance angle as detailed in ASTM E1710.

For 40 mil thermoplastic, initial retroreflectance for the in-place marking shall have a minimum of 250 mcd/lux/sq m for white and 175 mcd/lux/sq m for yellow. The Department may take readings before the expiration of the Guarantee Period in accordance with 104.5. Readings shall be at least 200 mcd/lux/sq m or greater for white and 125 mcd/lux/sq m or greater for yellow.

1015.10.5 Preformed Thermoplastic Pavement Markings:

White and yellow preformed thermoplastic shall be from the Approved Materials List and comply with AASHTO M 249 as modified herein. All other colors are not required to be Approved Materials List products.

1015.10.5.1 Color:

1015.10.5.1.1 Laboratory Performance: Yellow preformed thermoplastic shall comply with the requirements of ASTM D6628.

1015.10.5.1.2 Field Performance: The Department may take initial daytime color and luminance factor (Y%) readings, as required by the engineer, after 7 days and within 30 days after installation to verify compliance with ASTM D 6628.

1015.10.5.2 Softening Point: After heating the preformed thermoplastic material and testing in accordance with AASHTO T 250, the material shall have a minimum softening point of 200° F.

1015.10.5.3 Skid Resistance: Preformed thermoplastic markings shall have a minimum initial friction resistance number of 45 BPN when tested in accordance with ASTM E303.

1015.10.5.4 Retroreflectivity: All retroreflectivity readings shall be measured with a geometry of 1.05 degrees observation angle and 88.76 degrees entrance angle as detailed in ASTM E1710.

In lieu of measurements, the engineer shall determine by visual nighttime inspection that preformed thermoplastic pavement markings have sufficient reflectance.

1015.11 PREFORMED PLASTIC PAVEMENT MARKING TAPE.

1015.11.1 General: Preformed plastic pavement marking tape shall be from the Approved Materials List and shall comply with ASTM D4505 Retroreflectivity Level I or Level II, except as modified herein. The marking tape shall be Class 2 or 3. The type and color shall be in accordance with the plans and the MUTCD.

1015.11.2 Thickness: All preformed plastic pavement marking tape shall have a minimum overall thickness of 0.060 inches when tested without the adhesive.

1015.11.3 Friction Resistance: The surface of the Retroreflectivity Level II preformed plastic pavement marking tape shall provide a minimum friction resistance value of 35 British Polish Number (BPN) when tested according to ASTM E303. The surface of the Retroreflectivity Level I preformed plastic pavement marking tape shall provide a minimum friction resistance value of 45 BPN when tested according to ASTM E303. Friction values will be calculated for the Retroreflectivity Level I material with a raised surface pattern as defined in ASTM D4505 by averaging values taken at downweb and at a 45 degrees angle from downweb.

1015.11.4 Retroreflective Requirements: The preformed plastic pavement marking tape shall have the minimum initial specific luminance values shown in Table 1015-8 when measured in accordance with ASTM D4061.

Table 1015-8
Specific Luminance of Preformed Plastic Tape

Type	Observation Angle, degrees	Entrance Angle, degrees	Specific Luminance (mcd/sq m/lx)	
			White	Yellow
Retroreflectivity Level I	1.05	88.76	500	300
Retroreflectivity Level II	1.05	88.76	250	175

1015.11.5 Durability Requirements: The Retroreflectivity Level I preformed plastic pavement marking tape shall show no appreciable fading, lifting or shrinkage for at least 4 years after placement for longitudinal lines and at least 2 years after placement for symbols and legends.

The Retroreflectivity Level I preformed plastic pavement marking tape shall also retain the following reflectance values for the time period detailed in Table 1015-9.

Table 1015-9
Retained Specific Luminance for Retroreflectivity Level I Preformed Plastic Pavement Marking Tape

Time	Observation Angle, degrees	Entrance Angle, degrees	Specific Luminance (mcd/sq m/lx)	
			White	Yellow
1 year	1.05	88.76	400	240
4 years (2 years for symbols and legend)	1.05	88.76	100	100

1015.11.6 Plastic Pavement Marking Tape Guaranty (Retroreflectivity Level I): If the plastic pavement marking tape fails to comply with these performance and durability requirements within 4 years for Retroreflectivity Level I, the manufacturer shall replace the plastic pavement marking material at no cost to the Department.

1015.12 TRAFFIC PAINT. The contractor shall use water-borne traffic paint. Each paint container shall bear a label with the name and address of manufacturer, trade name or trademark, type of paint, number of gallons, batch number and date of manufacture.

Paints shall be from the Approved Materials List. Paints shall show no excessive settling, caking or increase in viscosity during 6 months of storage, and shall be a suitable consistency for standard spray gun application.

An infrared curve shall be generated in accordance with DOTD TR 610 and compared with the standard curve made during the initial qualification process.

For yellow paint material, the manufacturer shall determine the type and the amount of yellow pigment, providing the final product meets all of the requirements of this specification. However, the pigment for yellow paint shall be lead free and shall meet the regulatory level of non-hazardous waste as defined by 40 CFR § 261.24 when tested in accordance with EPA Method 1311, Toxicity Characteristics Leaching Procedures. The manufacturer shall provide certification that the material provided meets these requirements.

1015.12.1 Water Borne Traffic Paint: This material shall be a rapid setting waterborne compound suitable for use with hot application equipment. The paint shall contain Dow Fastrack HD-21A, Arkema DT-400 acrylic emulsion, or approved equal. The material shall meet the requirements of Table 1015-10 and Table 1015-11.

Table 1015-10
Water Borne Traffic Paint Physical Properties

Property	Test Method	Requirements Min.	Max.
pH	ASTM E70	9.9	—
Viscosity, at 25°C Krebs Unit	ASTM D562	78	95
Drying Time, minutes[1]	ASTM D711	—	10
Total Solids, % by mass	ASTM D2369	73	79
Percent Pigment[2]	ASTM D3723	55	62
Non-volatiles in Vehicle, % by weight	ASTM D215	43	—
Weight per Gallon, lb/gal	ASTM D1475	—	—
White		13.7	—
Yellow		13.1	—
Daylight Reflectance, %	ASTM E1349		
White		80	—
Yellow		50	—
Fineness of Grind	ASTM D1210	3	—
Color	[3]	Pass	
Shelf Life, months		12	—
Pigment Composition	[4]	Pass	
Infrared Spectroscopy (IR)	DOTD TR 610	Pass	

[1]Drying time to no track - Paint applied at 15 mils (375 μm) wet on the road surface with paint heated to 120-150°F (50-65°C) shall not show tracking when a standard size automobile crosses in a passing maneuver at 3 minutes.

[2] Do not apply any theoretical empirical factors in determining the percent of the paint. Do not calculate percent pigment by adding back the burned-off organic constituents of the pigment.

[3]Color (without glass beads) - Yellow paint shall comply with the requirements of Table 1015-11 when tested in accordance with ASTM E1349. White shall be a clean, bright, untinted binder.

[4]The white paint shall contain a minimum of 1.0 pound per gallon (120 g/L) of rutile titanium dioxide (Ti02) as determined using DOTD TR 523. The rutile titanium dioxide shall comply with ASTM D476.

Table 1015-11
Water Borne Traffic Paint Color Specification Limits (Daytime)

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow	0.493	0.473	0.518	0.464	0.486	0.428	0.469	0.452

(The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with Standard 2° Observer and Standard Illuminant D65.)

1015.12.2 Initial Retroreflectivity: All retroreflectivity readings shall be measured with a geometry of 1.05 degrees observation angle and 88.76 degrees entrance angle as detailed in ASTM E1710.

For traffic paint, initial retroreflectance shall have a minimum of 250 mcd/lux/sq m for white and 175 mcd/lux/sq m for yellow. Glass beads shall be uniformly distributed to ensure that the full width of the line is visible at night.

1015.12.3 Initial Daytime Color and Luminance Factor: For traffic paint, test the initial daytime color and luminance factor (Y%) according to ASTM D6628. The Department may take readings 7 to 30 days after installation to verify compliance with ASTM D6628.

1015.13 GLASS BEADS FOR PAVEMENT MARKINGS. Glass beads for use with painted traffic striping and flat thermoplastic striping shall conform to the specification requirements of AASHTO M 247, as modified herein.

1015.13.1 Moisture Resistance - Flow Characteristics: The beads shall not absorb moisture in storage. They shall remain free of clusters and lumps and shall flow freely from the dispensing equipment.

1015.13.2 Gradation: Glass beads shall meet the gradation requirements of AASHTO M 247 for the specified Type, when tested in accordance with ASTM D1214.

1015.13.2.1 Painted Traffic Striping: Glass beads for permanent painted traffic striping shall meet the gradation requirements of AASHTO M 247 Type 3. For temporary painted traffic striping, the contractor may determine which beads to use provided the line is reflective for the expected line life. Table 1015-12, "Gradation of 1.9 Refractive Index Glass Beads" may be used as an alternate on chip seal.

Table 1015-12
Gradation of 1.9 Refractive Index Glass Beads

U.S. SIEVE (METRIC SIEVE)	PERCENT PASSING
No. 18 (1.00 mm)	95-100
No. 20 (850 µm)	85-95
No. 30 (600 µm)	40-85
No. 40 (425 µm)	20-45
No. 50 (300 µm)	0-5

1015.13.2.2 Flat Profile Thermoplastic Striping: Drop-on beads for flat profile thermoplastic striping shall meet the gradation requirements of Table 1015-13 as determined by the thickness of the striping specified.

Table 1015-13
Types of AASHTO M 247 Glass Beads used for Flat Profile Thermoplastic Striping[1]

THICKNESS	NUMBER OF BEAD DROPS	APPLICATION #1	APPLICATION #2
40 mil spray	Single Drop	AASHTO M247 Type 2 or Table 1015-12 or contractors discretion[2]	Not required
90 mils or greater	Double Drop	AASHTO M247 Type 4	AASHTO M 247 Type 1 or Table 1015-12 or Contractors discretion[2]

1. Materials not designated in AASHTO M 247 require approval from the engineer.
2. Materials used at the contactors discretion shall meet the retroreflectance requirements.

1015.13.3 Roundness: Beads shall have a minimum of 75 percent true spheres when tested according to ASTM D1155, Method A. AASHTO M247 Type 3 and 4 beads shall have a minimum of 80 percent true spheres when tested by ASTM D1155, Method A.

1015.13.4 Angular Particles: The beads shall have no more than 3 percent angular particles per screen.

1015.13.5 Refractive Index: The beads shall have a minimum refractive index of 1.50 when tested by the liquid immersion method. Beads conforming to Table 1015-12 shall have a minimum refractive index of 1.90.

1015.13.6 Glass Bead Coating: All beads except Type 1 shall be coated with an adhesion assuring coating when tested in accordance with AASHTO M 247. The smaller AASHTO M 247 Type 1 beads shall also be coated to provide free flowing characteristics when tested in accordance with AASHTO M 247.

1015.13.7 Packaging and Marking: The beads shall be packaged in moisture proofed containers. Each container shall be stamped with the following information: Name and address of manufacturer, shipping point, trademark or name, the wording "Embedment Coated Glass Beads," type, weight, lot number and the month and year of manufacture.

1015.13.8 Heavy Metal Limits: Glass beads shall not contain more than 75 parts per million of inorganic arsenic when tested using EPA Method 6010B in conjunction with EPA Method 3052 for sample preparation.

Section 1016
Concrete Pipe and Precast Reinforced Concrete Drainage Units

1016.01 CONCRETE PIPE AND PRECAST DRAINAGE UNITS. Concrete drainage units include box culverts, three-sided structures, manholes, junction boxes, catch basins, and safety ends. Use concrete pipe and precast drainage units that are on the Approved Materials List and are from Certified Plants. All shop drawings must be approved by the Project Engineer before fabrication can begin.

Cementitious materials shall comply with Section 1001. Substitutions for cement are allowed in accordance with 901.07. Admixtures shall comply with 1011.02, except that chloride-type accelerators are not allowed. Class A1 concrete shall comply with Section 901. The addition of synthetic fibers will only be allowed upon approval of the Construction Fabrication Engineer.

1016.01.1 Joint Systems and Gaskets: Joint systems shall comply with 1018.03. A Type 2 or 3 joint system may be substituted for a Type 1 joint system; a Type 3 joint system may be substituted for a Type 2 joint system. Use gaskets from the Approved Materials List.

Rubber gaskets for pipe joints shall comply with ASTM C443. Each rubber gasket shall be identified with a batch or lot number.

Flexible sealants for pipe joints shall comply with ASTM C990.

1016.01.2 Curing: Concrete pipe and box culverts shall be cured by one of the methods listed in ASTM C76 or ASTM C1577, as applicable. No other combination or methods will be allowed.

Precast manholes, catch basins, junction boxes, and safety ends shall be cured in accordance with 805.06 or 805.09.4.

For curing concrete three-sided structures that are wet-cast products, keep forms in place for one curing day in accordance with 805.07. When structures are manufactured using the dry-cast method, follow curing procedures in ASTM C1504.

1016.01.3 Lots: A lot is one day's production.

1016.01.4 Compressive Strength: Compressive strength shall comply with the applicable ASTM specification for the product.

For each lot, five compressive strength cylinders shall be made and field-cured in accordance with DOTD TR 227 and broken in accordance with DOTD TR 230. The ASTM C497 core test may be used in lieu of cylinder tests, with approval of the Construction Fabrication Engineer. For pipe, the

ASTM C497 three-edge bearing test (3EB) may be used in lieu of cylinders. The Department reserves the right to have any concrete pipe tested at no cost to the Department to ultimate load using 3EB. The 3EB test is required yearly to retain plant certification.

Compressive strength must be verified by cylinders, cores or 3EB before shipping.

1016.01.5 Precast Unit Markings: Identifying information shall be indented into the concrete or painted thereon with waterproof paint on each unit on the inside and outside of the unit in such a manner as to be legible at time of delivery. Information shall include the name or trademark of the manufacturer, the date of casting, and the structure number or the station number as shown on the plans.

1016.01.6 Pipe Connections to Precast Units: For concrete pipe connections, use resilient connectors conforming to ASTM C923 or use grout connection. For grout connections each opening shall be 4±1/2 inches larger than the outside diameter of the pipe for which it is provided.

For connecting plastic and metal pipe to precast units use resilient connectors conforming to ASTM C923.

1016.02 REINFORCED CONCRETE PIPE (RCP). Comply with ASTM C76, amended as follows:

1. Unless otherwise specified, use Class III, Wall A, B, or C pipe.

2. When extra strength pipe is required, use either Class IV or Class V as specified. Use Wall A, B, or C.

3. For pipe sizes not included in ASTM C76, the area of reinforcement shall be designed in accordance with ASTM C655. Provide fabrication drawings and design calculations reflecting compliance with these specifications prior to pipe fabrication.

4. If allowed, modified designs require review and approval from the DOTD Hydraulics and Construction Fabrication Units. Minor modifications to facilitate fabrication processes may be used with the Construction Fabrication Engineer's approval.

1016.03 REINFORCED CONCRETE PIPE ARCH, (RCPA). Comply with ASTM C506, amended as follows:

1. Unless otherwise specified, use Class III pipe arch.

2. For pipe arch sizes not included in ASTM C506, the area of reinforcement shall be designed in accordance with ASTM C655. Provide fabrication drawings and design calculations reflecting compliance with these specifications prior to pipe fabrication.

3. If allowed**,** modified designs require review and approval from the DOTD Hydraulics and Construction Fabrication Units. Minor modifications to facilitate fabrication processes may be used with the Construction Fabrication Engineer's approval.

1016.04 PRECAST REINFORCED CONCRETE BOX CULVERTS. Comply with ASTM C1577 amended as follows:

1. Use Table 1.
2. Provide concrete with a Surface Resistivity at 28 days of 22 (kΩ-cm).
3. If allowed, modified designs require review and approval from the DOTD Hydraulics and Construction Fabrication Units. Minor modifications to facilitate fabrication processes may be used with the Construction Fabrication Engineer's approval.
4. When approved, minor surface cavities or irregularities which do not impair the service value of the unit and which can be corrected without marring its appearance shall be pointed with patching material from the Approved Materials List as soon as forms are removed.

1016.05 CONCRETE THREE-SIDED STRUCTURES. Comply with ASTM C1504.

1016.06 PRECAST REINFORCED CONCRETE MANHOLES, CATCH BASINS, JUNCTION BOXES, AND SAFETY ENDS. Comply with the dimensions shown on the plans, and the following:

Circular precast concrete manholes shall comply with ASTM C478, except that Class A1 concrete shall be used.

Square or rectangular precast concrete catch basins, junction boxes and drain manholes shall comply with ASTM C858, except that Class A1 concrete shall be used.

Precast safety ends shall comply with 702.04.3.

Portland cement concrete shall attain a minimum compressive strength of 4500 psi before shipping of the units.

Castings for frames, grates and covers shall comply with 1013.05 for steel and shall comply with 1013.06 for gray iron or malleable iron castings. Galvanization shall conform to ASTM A123.

1016.06.1 Casting Concrete: When multiple castings are to be made using the same forms, the use of metal non-panel forms are required. Concrete shall be placed into each sectional unit without interruption and shall be consolidated to force the concrete into the corners of forms and prevent formation of stone pockets or cleavage planes.

1016.06.2 Reinforcement: Reinforcement shall be as shown on the plans, and shall not vary more than 1/4 inch from the positions shown, except at pipe connections. Cover on reinforcement shall not be less than that shown on the plans.

Section 1017
Epoxy Resin Systems

1017.01 GENERAL. This section covers the material requirements for Epoxy Resin Adhesives (General Use) and Epoxy Resin Adhesives (Traffic Markers).

For anchoring application, the epoxy resin systems shall comply with ASTM C881 (with the exception of the gel time requirement) and ICC-ES AC 308. For crack injection, the minimum gel time shall be 15 minutes.

1017.02 EPOXY RESIN ADHESIVES (GENERAL USE).

1017.02.1 General: Epoxy Resin Adhesives shall comply with AASHTO M 235 (ASTM C881) and the additional requirements of Table 1017-1. Use two component systems in accordance with the manufacturer's recommendations. Epoxy resin adhesives shall be from the Approved Materials List.

1017.02.2 Classifications: Epoxy Resin Adhesives shall be classified by Type, Grade and Class.

1017.02.2.1 Types:

1. *Type I*- Use in non-load-bearing application for bonding hardened concrete to hardened concrete and other materials, and as a binder in epoxy mortars or epoxy concretes.
2. *Type II*- Use in non-load-bearing applications for bonding freshly mixed concrete to hardened concrete.
3. *Type III*- Use in bonding skid-resistant materials to hardened concrete, and as a binder in epoxy mortars or epoxy concretes used on traffic-bearing surfaces (or surfaces subject to thermal or mechanical movements).
4. *Type IV*- Use in load-bearing applications for bonding hardened concrete to hardened concrete and other materials and as a binder for epoxy mortars and concretes.
5. *Type V*- Use in load-bearing applications for bonding freshly mixed concrete to hardened concrete.
6. *Type VI*- Use for bonding and sealing segmental precast elements, as in segment-by-segment erection and for span-by-span erection when temporary post tensioning is applied.
7. *Type VII*- Use as a non-stress-carrying sealer for segmental precast elements when temporary post tensioning is not applied, as in span-by-span erection.

Note 1—Epoxy resin systems will adhere to a wide variety of materials, including wood, metals, masonry, and most plastics. Polyethylene, TFE-fluorocarbon, cellophane, and greased or waxed surfaces are among the few materials to which these systems will not adhere.

1017.02.2.2 Grades: Three grades of systems are defined according to their flow characteristics and are distinguished by the viscosity and consistency requirements of AASHTO M 235, Table 1.

Grade 1 - Low viscosity.

Grade 2 - Medium viscosity.

Grade 3 - Non-sagging consistency.

1017.02.2.3 Classes: Classes A, B, and C are defined for Types I through V, and Classes D, E, and F are defined for Types VI and VII, in accordance with the range of temperatures for which they are suitable.

Class A - Use below 40°F (4°C), with the lowest allowable temperature to be defined by the manufacturer of the product.

Class B - Use between 40 and 60°F (4 and 15°C).

Class C - Use above 60°F (15°C), with the highest allowable temperature to be defined by the manufacturer of the product.

Class D - Use between 40 and 65°F (4 and 18°C) for Type VI and VII applications.

Class E - Use between 60 and 80°F (15 and 30°C) for Type VI and VII applications.

Class F - Use above 75°F (25°C) for Type VI and VII applications, with the highest allowable temperature to be defined by the manufacturer of the product.

Table 1017-1
Epoxy Resin Adhesives

		Type I		Type II		Type III		Type IV		Type V		Type VI & Type VII	
Property	**Test Method**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Compressive Strength, 24 hr, psi (MPa)	**DOTD TR 705**	**5000 (34)**	**—**	**—**	**—**	**3000 (20)**	**—**	**5000 (34)**	**—**	**—**	**—**	**—**	**—**
Tensile Bond Strength, psi (MPa)	**DOTD TR 706**												
24 hours (dry cure)		**350 (2.4)**	**—**	**—**	**—**	**250 (1.7)**	**—**	**350 (2.4)**	**—**	**—**	**—**	**—**	**—**
72 hours (moist cure)		**—**	**—**	**150 (1.0)**	**—**	**—**	**—**	**—**	**—**	**150 (1.0)**	**—**	**—**	**—**

1017.03 EPOXY RESIN ADHESIVES (TRAFFIC MARKERS).

1017.03.1 General: Epoxy Resin Adhesives for bonding traffic markers shall comply with AASHTO M 237, Type I and Type II, and the requirements of Table 1017-2. Use two component systems in accordance with the manufacturer's recommendations. Use epoxy resin adhesives from the Approved Materials List.

1017.03.2 Classifications: Epoxy Resin Adhesives shall be classified by Types.

1017.03.2.1 *Types:*

Type I- Rapid Setting, High Viscosity, Epoxy Adhesive. This type of adhesive provides rapid adherence of traffic markers to the surface of the pavement.

Type II- Standard Setting, High Viscosity, Epoxy Adhesive. This type of adhesive is recommended for adherence of traffic markers to pavement surfaces when rapid set is not required.

Table 1017-2
Epoxy Resin Adhesives for Bonding Traffic Markers

		Type I Rapid		Type II Standard	
Property	Test Method	Min.	Max.	Min.	Max.
Consistency: Component A (Resin) TD Spindle at 5 RPM, poises (Pa·s)	AASHTO T 237	1000 (100)	3500 (350)	1000 (100)	3500 (350)
Component B (Hardener) TD Spindle at 5 RPM, poises (Pa·s)		1000 (100)	3500 (350)	1000 (100)	3500 (350)
Shear Ratio (each component)		2.0	—	2.0	—
Gel Time, Minutes[1]	AASHTO T 237	6	10	6	10
Tensile Bond Strength to reach 170 psi (1.17 kPa), minutes	AASHTO T 237	—	40	—	210
Diagonal Shear Bond Strength 24 hour, psi (MPa)	AASHTO T 237	1000 (7.0)	—	2000 (14.0)	—
24 hour, plus 7 day water soak, psi (MPa)		800 (5.5)	—	1500 (10.0)	—

[1]The gel time for mixtures that are mixed and dispensed by hand shall be a minimum of 7 minutes to a maximum of 13 minutes.

Section 1018
Miscellaneous Materials

1018.01 WATER. Water shall be suitable for human consumption or shall comply with the following when tested in accordance with AASHTO T 26:

	Percent by Weight (Max.)
Alkali	0.1
Solids (Organic)	0.1
Solids (Inorganic)	0.4
Salt (NaCl)	0.5
Sugar, Oil, or Acid	0.0

1018.02 LIME. For hydrated lime and quicklime, use products from the Approved Materials List. Comply with AASHTO M 216 with the following exceptions:

1. Maximum free moisture shall be 1.50 percent for hydrated lime.
2. Quicklime shall contain no more than 8 percent MgO by weight of total material. The quicklime shall be protected from contact with moisture prior to testing, and shall be free flowing and graded so that 100 percent will pass a 3/8 inch sieve. When the quicklime is to be used in slurry, a minimum of 95 percent shall pass the 3/4 inch sieve.

1018.03 JOINT SYSTEMS FOR PIPE AND PRECAST CONCRETE DRAINAGE UNITS.

1018.03.1 General: All pipe joint systems and materials shall be approved by the Materials Engineer Administrator. For source approval on all pipes exceeding 12 inches in diameter and for all concrete drainage units, joint types are determined by hydrostatic joint testing in accordance with Table 1018-1, with the modifications of 1018.03.2

Table 1018-1
Joint Type Determination

Type of Pipe	Test Method
Concrete Pipe and Drainage Units	ASTM C443
Metal Pipe	AASHTO M 36
Plastic Pipe - CPEPDW	AASHTO M 294
Plastic Pipe - PVCP	AASHTO M 278 or ASTM D3034
Plastic Pipe - RPVCP	ASTM F794 or ASTM F949

1018.03.2 Testing: Using water as the pressure medium and starting with a straight pipe joint alignment, pipe is tested in horizontal alignment, and manholes in vertical alignment. The evaluation may be performed as a continuous test rather than considering each level individually.

1018.03.2.1 Type 1 Joints (T1): Type 1 pipe joints shall be soil tight and shall not leak when the pipe joint assembly is filled with water.

1018.03.2.2 Type 2 Joints (T2): Type 2 pipe joints shall not leak when subjected to 5 psi hydrostatic pressure for 10 minutes.

1018.03.2.3 Type 3 Joints (T3): Type 3 pipe joints shall not leak when subjected to 10 psi hydrostatic pressure for 10 minutes. Also, concrete pipe shall not leak when then deflected to create a position 1/2 inch wider than the assembled position on one side and subjected to hydrostatic pressure for an additional 10 minutes. Flexible pipe shall not leak when then deflected by 5 percent of the original diameter and subjected to 10 psi hydrostatic pressure for an additional 10 minutes.

1018.04 NON-SHRINK GROUT. Non-shrink grout shall comply with ASTM C1107 and shall be from the Approved Materials List.

1018.05 HARDWARE CLOTH. Hardware cloth shall comply with the requirements of ASTM A740, shall have a minimum wire diameter of 0.041 inch, and shall be constructed of 1/2 inch x 1/2 inch mesh galvanized in accordance with ASTM A153.

1018.06 FORM RELEASE AGENT. Form release agent for concrete shall be from the Approved Materials List.

1018.07 SACKS FOR SACKED CONCRETE REVETMENT. Sacks for sacked concrete revetment shall be suitable new burlap bags. Burlap shall comply with AASHTO M 182.

1018.08 CONCRETE ANCHOR SYSTEMS. Concrete anchor systems shall consist of mechanical anchor devices, epoxy systems or other approved methods for anchoring fasteners to hardened concrete. Use systems from the Approved Materials List.

1018.09 ROOFING PITCH. Comply with ASTM D4586.

1018.10 MIX RELEASE AGENT FOR ASPHALT CONCRETE. Mix release agent for asphalt concrete shall be from the Approved Materials List. Do not use diesel as a mix release agent.

1018.11 ELECTRICAL CONDUIT AND CONDUCTORS. Rigid metal electrical conduit shall comply with ANSI C 80.1 or ANSI C 80.5.

Electrical conductors shall comply with IPCEA Publication No. S-19-81, IPCEA Publication S-66-524, and IPCEA Publication S-61-402.

1018.12 MASONRY UNITS.

1018.12.1 Sewer Brick: Sewer brick shall be made from clay, shale or concrete.

Brick made from clay or shale for use in junction boxes, catch basins, arches, manholes and for backings shall comply with AASHTO M 91, Manhole Brick, Grade MM.

Concrete brick shall comply with ASTM C139, except that the minimum thickness of each unit shall not be less than 3 5/8 inches.

1018.12.2 Building Brick:

1. Building brick made from clay or shale for use in brick masonry shall comply with ASTM C62, Grade SW.

2. Concrete building brick for use in masonry buildings shall comply with ASTM C55.

1018.12.3 Concrete Building Block: Concrete hollow load-bearing building block shall comply with ASTM C90.

1018.12.4 Cellular Concrete Blocks: Cellular concrete blocks shall be manufactured by machines employing high vibratory compaction. The blocks shall comply with ASTM C90, except the oven-dry weight of concrete shall be at least 130 pounds per cubic foot based on bulk specific gravity. Permissible block dimension variations will be as directed.

1018.13 BARRICADE WARNING LIGHTS.

1018.13.1 General: Unless otherwise designated in the plans, barricade warning lights shall be Type A/C (switchable combination low-intensity flashing and steady burn), Type B (high-intensity flashing), or Type D (360-degree steady burn), and all bulbs shall be LED-type. Barricade warning lights shall be from the Approved Materials List, and comply with the MUTCD.

These lights are not for warning gates or barriers for moveable bridges.

1018.13.2 Markings: Each light submitted for approval and each light placed on a project shall have a permanently attached identification plate or other permanent markings with the following information:

1. Manufacturer's name
2. Model number
3. Type
4. Lens manufacturer and identification number
5. Circuit manufacturer and identification number
6. Bulb number
7. Minimum operating voltage required to conform to minimum intensity requirements
8. Year of manufacture

1018.13.3 Certification: Prior to installation, furnish the engineer with the following information:

1. Material certification (Certificate of Compliance)
2. Proposed number of warning lights to be used
3. Type
4. Trade name
5. Manufacturer's name and model number

The certification shall also state that each light assembly has been tested, is functioning properly and will be maintained in satisfactory working order.

1018.14 ELASTOMERIC BRIDGE BEARING PADS.

1018.14.1 General: Elastomeric bridge bearing pads shall be either plain, consisting of elastomer only, or laminated, consisting of layers of elastomer separated by non-elastic laminates. The elastomer portion of the compound used for bearings shall be 100 percent virgin chloroprene stock. Natural rubber, vulcanized rubber (natural or synthetic) or other synthetic rubber-like materials will not be acceptable.

Non-elastic laminates shall be a nominal 1/16 inch thickness rolled steel sheets with a minimum yield strength of 33,000 psi.

Elastomeric bridge bearing pads shall be from the Approved Materials List.

1018.14.2 Physical Properties of Elastomer: The elastomer compound for plain and laminated bearings shall be a virgin, low temperature Grade 2, polychloroprene complying with AASHTO M 251. In addition, the pad shall comply with acceptance criteria of AASHTO M251, except that the sample quantity shall be one per lot, and the lot size shall be no more than 100 pads. All tests shall be made on the finished product. Special molded or prepared specimens, where required, shall comply with the specimen preparation requirements of the test involved.

For laminated bearings, each bearing shall be subjected to an average compression test loading of 1,500 psi by the manufacturer. The performance of each bearing will be considered satisfactory if there is no visible evidence of bond failure or other damage to the bearing because of this loading. The Department may verify that pads meet this requirement by means of random testing.

1018.14.3 Manufacturing Requirements: Components of laminated bearing pads shall be molded into an integral unit. Edges of the nonelastic laminations shall be covered by a minimum of 1/8 inch of elastomer. The laminates shall be parallel with the bottom surface of the bearing, subject to the tolerances that follow.

The preparation of elastomer compound prior to placement in the mold shall be such as to result in a homogeneous, finished bearing pad free of voids, blisters, cracks, folds, cuts, non-fills and any appearance of layers or ply separation on the surface or within the pad. Plain bearing pads may be molded individually or cut to length from previously molded strips or slabs. No pads shall be formed from the lamination of previously cured sheets or slabs. Finish of cut surfaces shall be at least as smooth as ANSI No. 250 finish.

Each bearing pad shall be marked with the manufacturer's identification number in such manner as to remain legible until the bearing pad is placed in the structure. This number shall identify the batch from which it was produced. A batch is defined as the quantity of compound produced from each separate mixture of ingredients.

1018.14.4 Appearance and Dimensions: The flash tolerance and appearance shall comply with Drawing RMA F3-T.063 of the RMA Rubber Products Handbook as published by the Rubber Manufacturers Association, Inc.

For both plain and laminated bearings, the permissible variations from specified dimensions and configuration shall be in accordance with AASHTO M 251.

	Tolerance Inches
Variation from Plane Parallel to Theoretical Surface	
Individual Nonelastic Laminates (determined by measurements at edges of bearing)	±1/8
Thickness of Nonelastic Laminates	-0, +1/16

1018.14.5 Certification: Prior to installation, furnish the Materials Engineer Administrator with a notarized material Certificate of Analysis and a list showing:

1. Proposed number of laminated bearing pads to be used itemized by type and size.
2. Manufacturer's name and identification number.
3. State project number.

The certification shall also state that each bearing pad shipped has been load tested and found to comply with these requirements. It shall also state that the steel laminates in each laminated pad are aligned as required in 1018.14.4.

1018.15 SILT FENCING, EROSION CONTROL MATTING, AND HARDWARE.

1018.15.1 Silt Fencing: Silt fencing shall be either wire-supported or self-supported.

1018.15.1.1 Wire-Supported Silt Fencing: Wire-supported silt fencing shall consist of standard woven livestock wire, and minimum of 14-gage wire, a minimum of 36 inches in height with a maximum wire spacing of 6 inches. Posts shall be either wood or steel installed a minimum of 2 feet in the ground. Filter material shall be burlap weighing approximately 7 1/2 ounces per square yard, approved jute fabric or approved geotextile fabric. Geotextile fabric shall comply with Section 1019, Class F.

1018.15.1.2 Self-Supported Silt Fencing: Self-supported silt fencing shall consist of an approved geotextile fabric suitably attached to posts of either wood or steel installed in accordance with plan details. Geotextile fabric shall comply with Section 1019, Class G.

1018.15.2 Erosion Control Matting, and Hardware: Erosion control systems shall consist of approved hydraulically applied fiber mulch

systems, or rolled erosion control products (mats) including hardware and installation plan.

Use erosion control systems from the Approved Materials List. Comply with the performance requirements in Table 1018-2 when evaluated in accordance with the Department's Qualification Procedure for erosion control systems.

Table 1018-2
Erosion Control Systems

Slope Protection			
Type[1]	Test Site Conditions for Evaluations	Maximum Sediment Loss, lb/100 ft^2	Minimum Vegetation Density, %
A	3:1 Slope	7.89	80
B	2:1 Slope	7.89	80
Flexible Channel Liners			
Type[1]	Test Site Conditions for Evaluation	Maximum Average Sediment Loss, lb/100 ft^2	Minimum Vegetation Density, %
C	Shear Stress Range 0 to 2 psf	350	70
D	Shear Stress Range 0 to 4 psf	500	70
E	Shear Stress Range 0 to 6 psf	620	70
F	Shear Stress Range 0 to 8 psf	800	70

[1]Types are listed in increased order of protection within each category.

The manufacturer's installation plan shall include a description of all hardware and shall comply with the installation procedure used during the evaluation of source approval. Furnish a copy of the approved installation plan with each shipment.

Section 1019
Geotextile Fabric and Geocomposite Systems

1019.01 GEOTEXTILE FABRIC.

1019.01.1 General Requirements: The geotextile fabric shall be composed of at least 85 percent by weight of polyolefins, polyesters, or polyamides. The geotextile fabric shall be resistant to chemical attack, rot and mildew and shall have no tears or defects which adversely alter its physical properties. When required, the geotextile fabric shall contain stabilizers and/or inhibitors added to the base material to make filaments resistant to deterioration due to ultraviolet and heat exposure. Edges of geotextile fabric shall be finished to prevent the outer yarn from pulling away from the fabric. Fibers of other composition may be woven into the geotextile fabric for reinforcing purposes. Durability of these fibers shall be equivalent to that of the geotextile fabric.

Geotextile fabric rolls shall be furnished with an opaque, waterproof wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged with the manufacturer's name, date of manufacture, batch number, and name of product.

Unless otherwise specified on the plans or in the project specifications, the geotextile fabric shall be from the Approved Materials List.

1019.01.2 Detailed Requirements: The geotextile fabric shall comply with the requirements in Table 1019-1 and utilized as follows unless otherwise specified:

Use	Classes
1. Drainage:	
Underdrains	A, B, C or D
Pipe and Precast Manhole Joints	A, B, C or D
Weep Holes	A, B, C or D
Bedding Fabric	B, C, or D
Approach Slabs	B, C, or D
Fabric for Geocomposite Drainage Systems[1]	B, C, or D
2. Stabilization:	
Bulkheads	C or D
Flexible Revetments	C or D

Rip Rap	D
Railroad Crossings	D
Base Course	D
Subgrade Layer	D
Soil Stabilization	C, D, or S

3. Paving Fabric[2]:	B or C (modified)

4. Silt Fencing:	
Wire Supported	F
Self-Supported	G

[1]Refer to 1019.02 for additional requirements.
[2]Refer to 1019.03 for additional requirements.

Table 1019-1
Geotextile Fabrics

Property	Test Method	Requirements Classes						
		A	B	C	D	S	F	G
AOS, Metric Sieve, µm, Max.	ASTM D4751	300	300	300	212	600	850	850
Grab Tensile, N, Min.	ASTM D4632	330	400	580	800	800	400	400
% Elongation @ Failure, Min.	ASTM D4632	–	—	50	50	—	—	—
% Elongation @ 200 N, Max.	ASTM D4632	–	—	—	—	—	—	50
Burst Strength, N, Min.	ASTM D3787	440	620	930	1290	1390	—	—
Puncture, N, Min.	ASTM D4833	110	130	180	330	330	—	—
Trapezoid Tear Strength, N, Min.	ASTM D4533	110	130	180	220	220	—	—
Permittivity, $Sec.^{-1}$, Min.	ASTM D4491	1.0	1.0	1.0	1.0	0.2	0.01	0.01
Grab Tensile Strength Retained after weathering 150 h, UVA lamps, %, Min	ASTM D4632 ASTM G154	70	70	70	70	70	—	—
Grab Tensile Strength Retained after weathering 500 h, UVA lamps, %, Min	ASTM D4632 ASTM G154	—	—	—	—	—	70	70

1019.02 GEOCOMPOSITE DRAINAGE SYSTEMS. The geocomposite fabric drain shall consist of a nonwoven geotextile fabric and a core as specified below with the geotextile completely enveloping the core. Fittings shall be as recommended by the manufacturer. The geotextile fabric shall be sufficiently secured to the core to prevent separation of the geotextile fabric and intrusion of the backfill material during installation. The geocomposite drainage system shall be from the Approved Materials List.

1019.02.1 Geotextile Fabric: The fabric shall meet the requirements for Class B, C, or D geotextile fabric of 1019.01 with the following modifications:

Property	Test Method	Requirements
Elongation, %, Min.	ASTM D4632	20
Sewn Seam Strength (Fabric to Fabric), kN/m width, Min.	ASTM D4437	2600

1019.02.2 Cores for Wall Drains (Single Sided): The core shall be a flexible, solid-backed, rectangular design made of a polyolefin material not sensitive to moisture. The geocomposite design shall allow drainage of water from one side only. The core shall consist of supports having a minimum height of 5/16 inch upon which the fabric shall be securely fastened. The cross section open area of the core which will allow the passage of water shall be a minimum of 40 percent.

The core shall meet the following requirements:

Property	Test Method	Requirements
Compressive Strength, kPa @ 20% Max. Deflection, Min.	ASTM D1621	380

1019.03 PAVING FABRIC. In addition to the specifications for Class B or C geotextile fabric of 1019.01, the paving fabric shall also comply with the following requirements:

Property	Test Method	Requirements
Asphalt Retention, L/sq m	AASHTO M 288	0.9
Change in Area at 135°C, %, Max.	AASHTO M 288	15.0

Section 1020
Traffic Signals

1020.01 TRAFFIC SIGNAL HEADS.

1020.01.1 General Requirements: Traffic signal sections, beacon sections, and pedestrian signal sections shall be of the adjustable type. Materials and construction of each section shall be the same.

Signals shall be constructed with 12-inch lenses in accordance with the plans. Signal sections can be polycarbonate or aluminum. All signal sections, visors and associated brackets shall be black color. Aluminum sections shall be finished both inside and out with a thick, black powder coating or with two (2) coats of high grade black enamel. Each coat shall be independently baked to resist peeling and chipping. Edges shall be deburred and smooth with no sharp edges.

1020.01.2 Housing, Housing Doors, and Visors: Only Traffic Signal Heads on the Traffic Operations Approved Products List will be accepted.

1020.01.2.1 Optical Unit for Programmable Head: The optical unit shall include a light emitting diode (LED). The optical unit and visor shall be designed as a unit to eliminate the return of outside sunlight from entering the unit from above the horizontal (known as sun phantom). The optical unit shall be designed and assembled so that no light can escape from one indication to another.

1020.01.2.2 12-Inch LED Traffic Signal Module (Mast Arm and Span Wire Mount): Only 12-Inch LED Traffic Signal Lamp Units on the Traffic Operations Approved Products List will be accepted.

1020.01.3 Pedestrian Signals: Only LED Countdown Pedestrian Signal Heads (LED modules and housings) listed on the Traffic Operations Approved Products List will be accepted.

1020.01.4 Brackets: Brackets for the assembly of 2-way, 3-way, and 4-way signal sections shall have the center of the attachment points arranged on a 8-inch radius. Attachment to signal head shall be made with 1 1/2-inch conduit or 3-bolt type fittings with a bolt length 1 1/2 inches. Fittings at the center of the bracket shall have a removable lower plate for access to the wireway.

The bracket at the supported end of the signal section shall be 1 1/2-inch conduit for wiring and a fitting with cover for access to the wire-way. The bracket at the opposite end of the section may be either the same as the top or solid. A set screw engaging a drilled hole shall be provided at each joint

on the bracket where conduit type joints are used or an equivalent locking device shall be provided.

The attachment point for mounting on the bracket shall be a 2-inch opening. When slip-fit is used, the section shall come complete with the necessary nuts and washers for 1 1/2-inch conduit. Provisions shall be made for a positive lock to prevent accidental bracket rotation. Locking may be accomplished by means of serrations, detents, set screws, or similar devices. Friction locking will not be acceptable. An acceptable alternative to the 1 1/2-inch conduit will be a tri-stud type fitting with washer. Tri-stud length shall be 1 1/2 inches.

Unused openings of signal sections shall be closed with a standard waterproof plug for a 1 1/2-inch opening. The minimum length of the plug shall be 1 1/2-inches. The exposed portions of plugs shall be painted to match the color of the signal heads.

Carbon steel components shall be galvanized in accordance with ASTM A153.

Apply paint or powder coat to match the color of the signal heads.

1020.01.5 Signal Mounts: Signal sections and beacon sections shall be as shown on the plans and shall be suitable for one of the following standard mounts. The type mount for each will be specified in the plans.

1020.01.5.1 Support Cable Mount: Support cable mounted signals shall come with a disconnect hanger and clamp described in 1020.07. Signs shall be mounted with a Span Wire Sign Bracket approved on the Traffic Operation Approved Product List.

1020.01.5.2 Pedestal Mount: Pedestal mounts shall be furnished with a slip fitting for placement on a 4-inch inside diameter pipe pedestal having set screws for correct alignment of the signal. Provisions for the entrance of signal cables shall be incorporated into the design of the bracket assembly.

The bracket assembly shall incorporate a weatherproof terminal compartment or box with a removable cover allowing complete access. The box shall be a suitable size to accommodate, and shall come equipped with, a terminal strip with terminals equal to the number of signal indications in the signal heads plus one or more for common and for equipment ground. The terminal compartment shall be neat in appearance and shall be adjacent to or near the pedestal mount. In no case shall feed wires be required to pass through a signal section or face to reach the terminal compartment. A terminal compartment integral with the bracket will be permitted.

Apply paint or powder coat to match the color of the signal heads.

1020.01.5.3 Mast Arm Mount: This mount shall be furnished and installed. Only Signal Head Mast Arm Brackets on the Traffic Operations Approved Products List will be accepted. Signs shall be mounted with a Mast Arm Traffic Sign Mounting Bracket listed on the Traffic Operation Approved Product List.

1020.01.5.4 Side Mount: This mount shall be furnished for attaching brackets to vertical supports as shown on the plans. The bracket mounting hub shall accept 1 1/2-inch conduit and provide for a wire opening equivalent to a 1 1/2-inch condulet. For timber pole installation, the side mounts shall have a vertical entrance for 1-inch conduit.

Apply paint or powder coat to match the color of the signal heads.

1020.01.5.5 Flashing Beacon Signal Mount: The flashing beacon signal shall attach to the support cable by a bracket as shown on the plans. The bracket shall be provided with a cable entrance adapter with provisions for balancing and securing the signal.

Apply paint or powder coat to match the color of the signal heads.

1020.01.6 Backplates: Only backplates listed on the Traffic Operations Approved Products List will be accepted.

1020.01.7 Disconnect Hanger for Traffic Signal Head: The hanger shall provide a means for connecting and disconnecting the signal head electrically and mechanically from signal support cable and span wire without use of tools.

The hanger, with top and bottom attachments and clamps, shall not increase signal height from the span wire to the bottom of the signal by more than 6 inches.

Apply paint or powder coat to match the color of the signal heads.

The hanger shall be as shown on the plans and shall conform to the requirements of the clamp, housing and terminal block, plug, and adapter.

1020.01.7.1 Clamp: The clamp shall be capable of attaching to a 1/4-inch to 7/16-inch support cable and shall attach to or be integral with a balance adjusting device and a suitable weatherproof entrance for signal cable. The support cable clamp shall utilize a minimum of two “J” or “U” type bolts 3/8-inch or larger. A 5/8-inch clevis type suspension clamp shall be provided with a 5/8-inch diameter. The balance adjustor shall be suitable for mating with a clevis-type clamp having a horizontal clearance of 5/8 inch and pin of 5/8-inch. All steel shall be galvanized in accordance with ASTM A153.

1020.01.7.2 Housing: Only Traffic Signal Heads on the Traffic Operations Approved Products List will be accepted. The housing and accessories shall be high-strength aluminum alloy and shall be equipped with

a door of similar material. The door shall be held shut by a device operable with one hand without use of tools and shall not be easily removable. The door, when open, shall provide complete access to the interior of the housing and shall include a device to hold the door open while working inside the hanger if it will not remain open.

The housing shall be equipped with two or more weatherproofed openings for signal cable entrance. The openings shall be equipped with suitable bushings for cable protection. Cable entrances shall be capable of accommodating three signal cables 11/16-inch in diameter. The housing shall be provided with a permanently mounted clamping device to prevent the cable from twisting. The clamping device shall not damage the cable jacket, insulation, or break wires.

The housing shall be provided with a 3 1/2-inch-by-3 1/2-inch cast aluminum flange adaptor as shown on the plans for connecting to the signal head or bracket.

1020.01.7.3 Terminal Block and Plug: An easily accessible pressure type terminal block shall be located in the housing and shall accommodate from twelve or eighteen separate lines, as specified. Each terminal shall be permanently numbered for identification, shall accommodate a minimum of two AWG No. 12 conductors, and shall be sufficiently rugged to permit tightening for proper electrical connection without damaging the wire.

The terminal block shall be wired to a multi-circuit female jack connector mounted in the housing and aligned in accordance with the plans.

A minimum size No. 18 AWG wire, with 600-volt polyethylene or polyvinylchloride insulation, shall be used between the terminal strip and the jack connector. The numbered terminals on the terminal strip shall be wired to the corresponding numbered pin in the jack connector.

A suitable male plug with clamp for the corresponding female jack connector shall be furnished and shall be equipped with 4 feet of cabled leads for connection to the signal heads. Wire shall be No. 18 AWG, 600-volt polyethylene or polyvinylchloride insulated and neatly cabled.

1020.02 TRAFFIC DETECTORS AND ASSOCIATED EQUIPMENT.

1020.02.1 Loop Detectors: Detector units for signalized intersections are included as part of DOTD Traffic Control Standard 18A. Detector units required at remote vehicle detection locations shall comply with NEMA TS1, Section 15, with or without delay and extension timing as specified.

The two types of inductive detector units are specified are those with and those without the ability to delay and extend a call, NEMA Type 1 and Type 1T.

Detector units shall be suitable for accurate detection of vehicles from motorcycles to tractor-trailer combinations which ordinarily travel public streets and highways with sufficient conductive material, suitably located to permit recognition and response by the detector system.

Detector units shall also comply with NEMA TS1, Section 15.2.6.

1020.02.1.1 Size and Case: The amplifier case shall be constructed of rugged metallic material with a protective coating. A hand-tool-removable cover shall be provided to allow access to internal circuitry.

1020.02.1.2 Connectors, Switches, and Fuses: Switches, connectors, and fuses shall be located on the front of the unit.

1. Permanently label each switch to identify its function. Permanently label each position to identify its mode of operation. Each mode of operation shall be simple to program with one switch position assigned to each function.

2. Provide a single connector on the front of the unit to comply with NEMA TS1, Section 15.2.28.1. This connector shall mate with cable connections MS 3106A-18-1S.

3. Plug wiring shall be as follows.

PIN[1]	**FUNCTION**
Pin A	AC (-)
Pin B	Relay Common
Pin C	AC (+)
Pins D & E	Loop Leads
Pin F	Relay (N.O.)
Pin G	Relay (N.C.)
Pin H	Chassis Ground
Pin I	Spare
Pin J	Delay Override

[1]No pins shall be used for any other purpose than those listed above.

4. Permanently label fuse holders to identify the size of the fuse.

1020.02.1.3 Electrical Characteristics

1. Detector unit outputs shall be a relay type as referenced in NEMA TS1, Section 15.2.29.1. The output operation shall be indicated by a high intensity light emitting diode.

2. Color coding for the wire shall be as follows:

Function	**Color Code**
Detector Wiring	Not Specified
AC(+)	Black
AC(-)	White
Relay Common	White/Black Stripe
Ground	Green

3. The operation of the detector unit shall comply with NEMA TS1, Section 15.2.1. In addition, the detector unit shall retune to a new inductance value following an excessively large inductance change.

4. When sensor loop and loop lead-in network falls outside the specifications in NEMA TS1, Section 15.2.13, the detector shall generate a failsafe continuous output in both presence and pulse modes. The continuous output shall remain until the memory is cleared by removing power or resetting.

5. When specified, the detector unit shall have the ability to delay and extend a call to the controller. The Delay/Extension operations shall comply with NEMA TS1, Section 15.2.24. The delay time shall begin when a vehicle enters the detection area until the call relay is closed representing activation and shall be selectable in the range between 0 and 30 seconds. The extension time shall begin timing when the vehicle leaves the detection area, continuing the activation for the selected time. The time shall be selectable in the range of 0 to 7 1/2 seconds.

6. The detector unit shall have at least three selectable frequencies which shall be visible at all times on the front of the detector unit.

7. The Sensitivity Control shall comply with NEMA TS1, Section 15.2.14 and Section 15.2.15. There shall be at least three selectable sensitivity ranges located on the front of the detector unit. The sensitivities shall be nominally 0.02 percent, 0.08 percent, and 0.32 percent change in total loop inductance.

8. The modes of operation shall comply with NEMA TS1, Section 15.2.17. There shall be two presence modes and one pulse mode. The selected mode shall be indicated at all times on the front of the detector unit.

Long presence mode shall continue to detect the same vehicle within the detection area for at least 3 1/2 minutes for a Class 1 type test vehicle.

Medium presence mode shall continue to detect the same vehicle within the detection area for at least 20 seconds for a Class 1 type test vehicle.

1020.02.1.4 Fail Safe: The detector shall operate with the sensor loop shorted to ground or of poor quality. The unit shall generate a continuous call when returning failed sensor loop, failed detector unit, or power failure.

1020.02.1.5 Loop Detector Sealants: Comply with Table 1020-1:

Table 1020-1

Loop Detector Sealants

Physical Property	Test Method	Hot Applied	Cold Applied					
			Single Component		Two Component			
					Rapid Set		Slow Set	
			Self Leveling	Non-Sag	Self Leveling	Non-Sag	Self Leveling	Non-Sag
Total Solids by weight,%, Min.	ASTM D2834		60	60	60	60	60	60
Tack Free Time, hr, Max.	ASTM C679		4	4	2	2	4	4
Rheological Properties	ASTM C639 Type 1		Smooth surface		Smooth surface		Smooth surface	
Slump, mm	ASTM D2202			7.6		7.6		7.6
Extrusion Rate, mL/min, Min.	ASTM C1183		50	50				
Hardness shore A, Min.	ASTM D2240		10	10	10	10	10	10
Penetration @ 25°C, Min.	ASTM D5	60						
Softening Point, °C, Min.	ASTM D36	82						
Asphalt Compatibility[1]	ASTM D5329	pass	pass	pass	pass	pass	pass	pass
Pot Life, minutes, Min.	ASTM C881				12	12	30	30
Dielectric Strength, 60 Hz, Short Time test, Electrode 1 in air @ 25°C kV/mm, Min.	ASTM D149	13.8	13.8	13.8	13.8	13.8	13.8	13.8
Flex @-7°C, inch, 90° Bend	ASTM D5329	pass	pass	pass	pass	pass	pass	pass

[1]Not applicable when used to seal portland cement concrete pavement

1020.02.2 Video Detection System: A Video Detection System (VDS) monitors vehicles on a roadway via processing of video images and provides detector outputs to a traffic controller or similar device.

1020.02.2.1 System Function Requirement: The system shall provide flexible detection zone placement anywhere within the combined field of view of the image sensors. Presence detector configurations shall be lines or boxes placed across lanes of traffic or lines placed in-line with lanes of traffic. A single detector shall be able to replace one or more conventional detector loops. Detection zones shall be able to be fully overlapped. In

addition, detection zones shall have the capability of implementing "AND" and "OR" logical functions including presence, extension and delay timing. These logical functions may be excluded if provisions are made to bring each detector separately into the controller and the controller can provide these functions.

The system shall produce accurate detector outputs under all roadway lighting conditions, regardless of time of day.

The system shall be capable of providing 64 or more detector outputs from up to 8 camera/video processor units. The VDS processor system should provide compressed color video through the DB-9 RS-232 data stream with active detection zones overlaid.

The system shall have a modular electrical design. It shall be powered by 89-135 VAC, 60 Hz single-phase. Power to the system shall be from the transient protected side of the AC power distribution system in the traffic control cabinet in which the system is installed. If the VDS processor is located in the controller cabinet, then, the system shall be powered by 12-24 VDC and draw less than 2 amperes.

The system software shall be able to detect either approaching or departing vehicles in multiple traffic lanes. Each zone and output shall be user-definable through interactive graphics by placing lines and/or boxes in an image on a video monitor or personal computer. The user shall be able to redefine previously defined detection zones. Detection zones shall be provided that are sensitive to the direction of vehicle travel. The direction to be detected by each detection zone shall be user programmable.

The Windows software shall be able to display the traffic parameters on the video monitor per vehicle for each detection zone by lane. It shall be possible to view and sort the stored data for selected time intervals. When the monitoring equipment is directly connected to the VDS processor unit, it shall be possible to view vehicle detections in real-time.

The field communications wiring between each camera and the traffic controller cabinet shall meet VDS factory requirements.

1020.02.2.2 VDS Processor: The processor is an electronic unit that converts the video image provided by the cameras, generates vehicle detection for defined zones and collects vehicular data as specified.

The VDS processor may be housed in either the cabinet or camera housing. The processor shall fit directly into NEMA TS1 and TS2 type detector racks or equipment manufacture supplied racks. The video output from the unit shall be in color with active detection zones overlaid on full motion video.

The processor unit shall be capable of providing the following detection zones: count, presence, directional presence, speed, stopped vehicles, and queue types of detection zones. The processor unit shall meet the following requirements:

1. Each video processor module card shall be capable of a minimum of 64 detector outputs and each processor input shall be capable of a minimum of 20 detection zones.

2. The processor unit shall meet the environmental requirements set forth by the latest NEMA (National Electrical Manufacturers Association) TS1 and TS2 standards. Operating temperature shall be from -25°F to +160°F at zero to 95 percent relative humidity, non-condensing.

3. Detection input shall be via a SDLC interface connection to the signal controller front panel.

4. The processor unit software and/or the supervisor software shall include diagnostic to allow testing of the system functions. It shall include the capability to set, clear individual detector outputs, and display the status of inputs to setup and troubleshoot in the field.

5. The processor shall provide real-time vehicle detection within 112 milliseconds (ms) of vehicle arrival. It shall be capable of simultaneously processing information from various video sources, including CCTV video image sensors and video tape players. The video sources may be, but are not required to be, synchronized or line-locked.

6. The processor shall compensate for minor camera movement up to 2 percent of the field of view at 400 ft. without falsely detecting vehicles. The camera movement shall be measured on the unprocessed video input to the processor unit. The camera shall operate while directly connected to the processor unit. Once the detector configuration has been downloaded or saved, the video detection system shall operate with the monitoring equipment (monitor and/or laptop) disconnected or on-line.

1020.02.2.3 BIU (Bus Interface Unit): The VDS system shall incorporate one BIU to accomplish controller interface connection. This BIU shall be capable of a minimum of 64 outputs with the BIU assignment being hardware selectable.

1020.02.2.4 Video Detection Camera: The video detection camera shall be compatible with the video detection processor and shall be certified by the manufacturer to ensure proper system operation.

The camera shall produce a useable video image in 0.009 to 930 foot-candles luminance.

Images shall be produced with a Charge Coupled Device (CCD) sensing element with horizontal resolution of at least 470 lines and vertical resolution

of at least 400 lines. Images shall be output as a video signal conforming to RS 170A or CCIR.

The camera shall include mechanisms to compensate for changing of lighting by using an electronic shutter and/or auto-iris lens.

The camera shall include a motorized variable focal length lens with factory preset focus that requires no field adjustment. Zooming of the camera lens is required to suit the site geometry by means of a portable interface device designed for that purpose and manufactured by the detection system supplier or via software and standard laptop.

When operating in the environmental enclosure with power and video signal cables connected, the image sensor shall meet FCC class B requirements for electromagnetic interference emissions.

The video output of the cameras shall be isolated from earth ground. All video connections for the cameras to the video interface panel shall also be isolated from earth ground. Connections for both video and power shall be made to the processor using waterproof, quick disconnect connectors.

1020.02.2.5 Camera Enclosure: The camera and lens assembly shall be housed in an environmental enclosure that meets or exceeds NEMA-4X and provides the following capabilities:

1. Be metallic and waterproof and dust-tight to the latest NEMA-4X specifications.

2. Allow the camera to operate satisfactorily over an ambient temperature range from -25°F to +160°F while exposed to precipitation as well as direct sunlight.

3. Allow the camera horizon to be rotated in the field during installation.

4. Include a provision at the rear of the enclosure for connection of power and video signal cables. The input power to the environmental enclosure shall be nominally 120 or 240 VAC 50/60 Hz and the power consumption shall be 35 watts or less under all conditions.

5. A thermostatically controlled heater shall be at the front of the enclosure to prevent the formation of ice and condensation, as well as to assure proper operation of the lens's iris mechanism. The heater shall not interfere with the operation of the camera electronics, and it shall not cause interference with the video signal.

6. The enclosure shall be light-colored and shall include a sun shield to minimize solar heating. The front edge of the sunshield shall protrude beyond the front edge of the environmental enclosure and shall include provision to divert water flow to the sides of the sunshield. The amount of overhang of the sun shield shall be adjustable to block the view of the horizon

to prevent direct sunlight from entering the lens. Any plastics used in the enclosure shall include ultra violet inhibitors.

7. The total weight of the image sensor in the environmental enclosure with sunshield shall be less than 20 lbs.

8. Camera mounting hardware shall allow for vertical or horizontal mounting to the camera enclosure.

1020.02.2.6 Maintenance and Support: Maintenance and support is required from the manufacturer for 10 years. The equipment manufacturer shall maintain an adequate inventory of parts to support maintenance and repair of the video detection system. These parts shall be available for delivery within 48 hours of placement of an order.

The equipment manufacturer shall maintain an ongoing program of technical support for the video detection system. The equipment manufacturer shall provide on-site technical support and support on any special circuitry that may be required in certain applications.

The equipment manufacturer shall be on call 24/7 and be present at any designated state signal location within 12 hours of notification. The contact information shall be provided to the State Traffic Signal Engineer at Traffic Services and continually updated.

1020.02.2.7 Warranty: All material and workmanship shall be covered by supplier(s')/manufacturer(s') guarantee and/or warranty for a period of a minimum of 2 years or longer, if offered by the manufacturer. Warranty period shall begin the day the video detection system is activated, either as new order or warranty repair.

The equipment manufacturer shall bear all expenses connected with return of any equipment which the Department deems necessary to return for adjustments during warranty period.

Equipment manufacturer(s) shall make all engineering data, diagrams, and software changes or improvements available to the Department at no additional cost.

1020.02.3 Pedestrian Pushbuttons:

1020.02.3.1 Housing: The pedestrian push button housing shall be weather-tight and tamper-proof.

Housing shall be designed to prevent an electrical shock. It shall have provisions for grounding in accordance with the National Electrical Code (NEC).

Pedestrian push button housing shall be cast from aluminum alloy, smooth, and free of blemishes. The manufacturer's name or trademark shall be located on the housing.

Both housing and cover shall have an anodized conversion coating to provide a proper base for paint adhesion. The assembly shall match the signal head's color. Apply paint or powder coat to match the color of the signal heads.

All bolts, nuts, washer, lock washers, screws, and other assembly hardware shall be galvanized steel, stainless steel, or dichromate sealed aluminum. When dissimilar metals are used, the metals shall be so selected or insulated to prevent corrosion.

The bottom provisions of the housing shall be tapped for and provided with a 1/2-inch National Pipe Tapered (NPT) threaded conduit plug. The back of the push button housing shall be provided with a hole capable of being threaded for a 1/2 - inch NPT threaded conduit plug and capped with a non-threaded 1/2- inch plastic plug. The back mounting provisions of the housing shall be designed to accommodate pole diameters from 3 inches to 14 inches.

1020.02.3.2 Push Button:

The push button switch shall be actuated by a plunger with a minimum 2-inch convex diameter. The assembly shall be designed so that the maximum plunger travel does not exceed the switch travel. A spring shall be installed between the plunger and switch. The spring shall provide an operating force of less than 5 lbs. A protective shroud shall encircle the plunger to deter vandalism. The shroud shall be cast as an integral part of the cover. There shall be a moisture barrier between the plunger and the switch. The assembly shall conform to all minimum requirements set forth with the American with Disabilities Act.

1020.02.3.3 Wiring and Electrical Requirements:

The switch shall have terminal connection points on back to allow for an electrical spade connection to the back of the switch allowing user to connect twisted pair directly to the back of the switch. Wire and wire nut connections from the back of the switch shall not be acceptable.

The switch assembly shall be capable of operating in temperature ranges of 20 ºF through 120 ºF. The switch assembly shall be electrically rated to carry 25 amps at 125 volts AC, 250 volts maximum. The switch assembly must have the following recognized certifications and/or approval: UL, CSSA, Mil Spec # MIL-S-8805.

1020.02.4 Wireless Magnetometer Vehicle Detection System:

Only Wireless Magnetometer Vehicle Detection Systems on the Traffic Operations Approved Products List will be accepted.

1020.03 TRAFFIC SIGNAL HARDWARE AND EQUIPMENT.

1020.03.1 General: This subsection defines the general requirements that apply to all hardware and equipment not specifically listed. When design tests are specified, provide documentation indicating that such tests have been satisfactorily completed.

1020.03.2 Miscellaneous Hardware: Screws, nuts, and lock washers shall be stainless steel or galvanized in accordance with Section 811. Do not use self-tapping screws unless approved.

1020.03.3 Pedestal Anchor Bolts: Furnish steel anchor bolts as shown on the plans and fit with one hex nut and one washer. Nuts, washers, and anchor bolts shall be galvanized in accordance with ASTM A153.

1020.03.4 Support Cable (Span): Support cable for interconnect and detector support cable shall be 1/4-inch outside diameter and signal support cable and guy wire shall be 3/8-inch outside diameter and shall comply with ASTM A475, 7-strand Siemens-Martin grade with Class A coating.

1020.03.5 Guy Components: Guying components and hardware shall be galvanized in accordance with ASTM A123 and ASTM A153.

Guy clamps shall be steel, 3-bolt type, 6 inches in length, and of proper strand size to fit both sizes of cable. Clamp bolts shall have an upset shoulder fitting into the clamp plate.

1020.03.6 Traffic Signal Conductors: Furnish 600 volt insulated THHN/THWN or XHHW cable. Filler material, when used, shall be non-metallic, moisture resistant, non-hydroscopic, non-wicking, and non-absorbent. The conductors that are to be marked with tracer in addition to the solid color shall have the tracer as part of the insulation. Ink marking is not acceptable. The outside jacket shall be smooth and shall not display patterns of the conductor lay on the outside of the jacket.

The traffic signal cable shall be No. 14 AWG stranded conductor. All material, color code, and testing shall comply with IMSA 20-1. The interconnecting cable between intersections for closed loop and telemetry operation shall be 6 pair No 19 AWG, IMSA 20-2.

Loop lead-in conductor shall be tinned copper No. 14 AWG stranded conductor, twisted pair with an overall shield. The cable shall comply with IMSA 50-2. Loop detector wire shall comply with IMSA 51-7 and shall be 19 strand insulated by a cross linked polyethylene compound. The insulated conductor shall be completely incased in a tube of low density polyethylene compound.

1020.03.7 Underground Electrical Junction Box: Only pull boxes on the Traffic Operations Approved Products List will be accepted.

1020.03.8 LED Blank-Out Signs:

1020.03.8.1 General: Blank-Out Signs shall have "on" or "off" functions and shall operate on 120 VAC power.

Blank-Out Signs legend shall be in compliance with the current FHWA/MUTCD specification. The symbols shall be clearly legible under all lighting conditions. Also, the sign shall be capable of continuous operation over a range in temperatures from -15ºF to +140ºF.

1020.03.8.2 Enclosure: Each enclosure shall be a minimum of NEMA 3R construction, self-supporting, aluminum. Enclosure shall come with complete mounting hardware to be suspended from a 3/8 inch span wire, or a mast arm as shown on the plans. Enclosure shall use a neoprene strip to provide a watertight seal between the door and the display lens; it also shall have one or more stainless steel link locks to tightly secure the door to the gasket.

Mount the LED assembly on the face of the Blank-Out Sign. The sign shall have a visor to protect the sign's face from direct sunlight. Blank-Out Signs' components shall be readily accessible. Provide drain holes that prevent insect entrance to the enclosure and an adequate means for condensation to drain from the enclosure. All corners or seams shall be heli-arc welded to provide a weatherproof seal around the entire case.

Maximum weight of enclosure including all components shall be 35 pounds. The finish for the enclosure body shall be powder coated satin black. The message board mask shall be finished in a flat black powder coat. The inside surface of the glare shield shall be powder coated flat black and the outside surface of the glare shield shall be powder coated the color of the enclosure body.

1020.03.8.3 LED Modules: LED assembly shall be mounted to a flat black aluminum panel. Diming shall be a standard feature on the Blank-Out Signs. Incorporate a dimmer failsafe feature whereby the light engine will continue operating at its full intensity in the event of a dimmer relay or sensor failure.

1020.03.8.4 Electrical:

Electrical requirements shall comply with ITE VTCSH, July 1, 2007 Edition, Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement, Sections 5.2 thru 5.8.

1020.03.9 Flashing Switch Assembly for Beacons:

1020.03.9.1 General: The flashing switch assembly shall include a preassembled: enclosure, required hubs and gaskets, back panel, Cinch

Jones socket, solid state flasher, and terminal block with provision for terminating all field and local wiring. , The assembly specified herein shall be designed to operate on 110-130 volt, 60 cycle, alternating current, and shall be completely wired and enclosed in a weatherproof cabinet. The flasher shall meet NEMA standards for a two-circuit flasher rated at 15 amps per circuit (Type 3).

For the purpose of these specifications, the term "solid state" is defined as: the main current to the signal load that is not switched by electro-mechanically operated contacts.

The flasher shall be certified by an independent laboratory as conforming to NEMA TS-1, Section 8, and Section 2.2.3.2. This certificate shall be included with the drawing and literature for this equipment.

1020.03.9.2 Cabinet: Furnish the switch in a weatherproof aluminum cabinet with minimum interior dimensions of 9-3/4 inches wide, 12 inches long and 5-1/2 inches deep. Provide a standard lock with one key to the door "Traffic Control" or "Traffic Signals" shall be cast or embossed into the metal with letters 3/4 inches high or larger on the door.

All cabinets shall be suitable for wood or steel pole mounting. Cabinet shall have two 2-inch wire entrance holes, one in the top and one in the bottom. The wire entrance holes shall be located on the back edge of the cabinet and centered on the width of the cabinet. The hubs to the cabinet shall align on the center of the entrance hole. Lock washers and hex nuts for the bolts shall be used to attach to the hub. The bolt pattern for the hub is 2-1/8 inch centered on a line perpendicular to the outside back of the cabinet and 3-3/4 inch parallel to the back of the cabinet. Mounting holes for the bolts shall be 3/8 inch. The centers of the bolt pattern on the hub and the wire entrance hole shall coincide. The location of the hubs shall allow minimum clearance for box end wrenches to fit onto the nuts within the cabinet. Apply paint or powder coat to match the color of the signal heads. The interior shall be furnished with gloss white enamel by the manufacturer.

1020.03.9.3 Hub, Conduit: Hubs for the cabinet shall be cast aluminum, ASTM B108. All threaded hubs shall have a threaded collar a minimum of 2 inches from the base of the hub. The manufacturer shall make all hubs with stainless steel bolts casted into the hub. The manufacturer shall design the hub with the outside smooth to shed water.

Table 1020-2
Cabinet Hub Description

TYPE	OPENING(S) SIZE, Inches	OPENING DESCRIPTION Inches
blank	- 0 -	no opening, flat plate, ¼ minimum thickness
single	3/4	one (1) opening, 3/4 conduit thread
single	1	one (1) opening, 1 conduit thread
single	1-1/2	one (1) opening, 1-1/2 conduit thread
single	2	one (1) opening, 2 conduit thread
single	2-1/2	one (1) opening, 2-1/2 conduit thread
single	3	one (1) opening, 3 conduit thread
Double	3/4	two (2) openings, each 3/4 conduit thread
Double	1	two (2) openings, each 1 conduit thread

1020.03.9.4 Back Panel Characteristics: The panel shall have mounted on it a cartridge type fuse, connector for NEMA Type 3 flasher, flasher support bracket, and permanently identified field terminals. The back panel size shall be 9 inches wide and 12 inches high. The back panel constructed of 1/4 inch electrical grade *masonite*. The panel shall have four (4) mounting holes approximately 11/32 inches in diameter. The holes shall be centered on an 8-inch x 9-inch bolt pattern. The bolt pattern shall be centered on the back panel. The back panel shall support the NEMA flasher from the panel along its longest dimension. The support shall not restrict removal or installation of the flasher unit on the back panel while the panel is in the cabinet. All wiring shall be on the front of the panel. The field terminals shall be wired to the field side of the terminal block.

1020.03.9.5 Electrical Characteristics: Flashers shall have the following electrical characteristics:

1. The rating of the output circuit shall be the minimum rating for a tungsten lamp or gas-tuning-transformer load over a voltage range of 60 to 135 volts at 60 hertz. The output circuit shall not be de-rated for the operation over the ambient range of -30 ºF to 165 °F and the humidity range as both detailed in NEMA TS 2 standards.

2. Input to the solid-state flashers shall consist solely of the 60-hertz alternating-current power source. This input shall supply the power for the output circuit and also provide power to the flasher logic. The flasher shall turn on within 5 degrees of the zero voltage point of the alternating current line sinusoid and shall turn off within 5 degrees of the zero current point of the alternating-current line sinusoid. The flasher need not turn on within 5 degrees of the zero point of the alternating-current sinusoid for the first flash

cycle (on-off cycle) after the initial application of alternating-current power to the flasher.

3. The "flashing" voltage output shall provide not less than 50, nor more than 60, flashes per minute with an on period of 50 + 5%.

4. The flasher output shall have a dv/dt rating of 100 volts per microsecond at 70 °F.

5. The flasher output shall have a peak standoff voltage of 480 volts or greater at 70 °F.

6. The output current from the flasher through the load, when the flasher is in the off state, shall not exceed a maximum of 15 milliamperes rms.

7. The flashing output shall consist of 2 outputs each rated at 15 amperes.

8. Flashers shall be so designed that circuit #1 will be essentially ON when circuit #2 is OFF, and vice-versa. The principal purpose served by this arrangement is to smooth out the loading on the power source. The maximum OFF period when both circuit #1 and circuit #2 are OFF, or the maximum ON period when both circuit #1 and circuit #2 are ON, shall not exceed 17 milliseconds during the transition from OFF to ON to OFF.

9. The line power shall be fused with NON 0-30 amp fuse. This fuse shall be sized properly for the load limit of the flasher. The wiring shall be properly sized for the design current of each circuit. Separate terminals for the line and field neutral shall be provided.

10. Lightning protection shall be provided for line input and each signal circuit. A gas filled fuse shall be across the line input on the load side of the fuse. It shall be capable of clamping input voltage at 350 volts. A Metal Oxide Varistor (MOV) shall be on each signal circuit and provide a minimum clamping voltage of 395 volts and dissipate 30 joules of energy (GE - V150LA10A or approved equal).

11. All electrical connectors shall be insulated from the back panel at a 600 VAC rating.

12. Use a Cinch-Jones socket type S-406-SB or equivalent.

13. All printed circuit boards shall be made from NEMA (FR-4) glass-epoxy, or equivalent (See NEMA Standards Publication No. LI 1-1971). Circuit boards exceeding 2 inches in any dimension shall have a nominal thickness of at least 1/32 inches.

14. All PC boards shall be coated with an epoxy or approved equal type material to prevent erratic performance due to high humidity, condensation, and growth of fungus and mildew. This coating will not cover the components on the board, but once the components are in place, the soldered joints shall be covered with a moisture and fungus proof, clear type of acrylic lacquer. This coating shall not be injurious to the board or components and

shall not interfere with the repair of the circuitry or replacement of components. The walls of all plated through holes shall have a minimum copper plating thickness of 0.001 inches. All circuit tracks shall have conductivity equivalent to at least 2 ounces per square foot of copper (2 oz/ft² Cu).

15. All electrical mating surfaces shall be made of non-corrosive material. The unit shall be designed so that each component is identified by a circuit reference symbol. This identification may be affixed to the printed circuit boards, the cover of the unit, or in an assembly drawing provided with the unit.

1020.04 POLES FOR TRAFFIC SIGNAL SYSTEMS.

1020.04.1 Pedestal Signal Poles: The pole shall be in accordance with the plans. The base of the pedestal pole shall be cast iron or aluminum and shall be at least 16 inches wide at the bottom, at least 16 inches high and shall be octagonal.

The upper end of the base shall be threaded to receive a 4-inch diameter pipe shaft.

The base shall be designed so that it may be fastened to the foundation using 5/8-inch-by-16-inch anchor bolts located 90 degrees apart on the circumference of a circle 12-3/4 inches in diameter.

The base shall contain a removable door to allow access to anchor bolts and to permit cable splicing. This door shall be fastened to the base using a hex head stainless steel screw into a threaded hole in the base.

The shaft shall be 4 inches in inside diameter welded steel tubing with a minimum 1/8-inch wall thickness. The lower end of the shaft shall be welded to a 6-inch nipple to screw into the base. This shaft shall be a single piece of tubing.

Apply paint or powder coat to match the color of the signal heads.

1020.04.2 Steel Signal Strain Pole:

1020.04.2.1 General: Poles and fittings shall be in accordance with the plans and shall be galvanized in accordance with Section 811. Poles shall be suitable for a minimum horizontal load of 4,000 pounds applied 1 foot below the top of pole.

1020.04.2.2 Pole Shaft:

The pole shaft shall have a minimum base diameter of 11 inches and a maximum base diameter of 11 3/4 inches. The pole shaft shall be tapered to 7 1/2 inch minimum to 8 1/2 inch maximum diameter at the top. The pole shaft may have a round or octagonal cross section. A removable cap shall be used to cover the top of the pole shaft.

The pole shall be designed so that its maximum deflection is as shown in Table 1020-3.

Table 1020-3
Steel Pole Deflection

Pole Length, ft	Maximum Deflection, in/100 lb
26	0.25
28	0.30
30	0.38

The pole base shall be designed to fit a 16 inches diameter bolt pattern utilizing four 1-3/4 inches 5NC threaded anchor bolts. The base shall have the manufacturer's name and pole height stenciled on it and shall be readable from the outside of the pole. The stencil shall be legible after galvanizing.

1020.04.2.3 Hand Holes and Bosses: A hand hole shall be provided approximately 18 inches above the base with approximate dimensions of 4 inches by 6 1/2 inches and cover shall be provided. The cover shall be restrained to the pole with a 15 inch No. 35 stainless steel chain fastened to the cover and to the inside of the hand hole so that the chain will be inside the pole after the cover is installed on the pole. There shall be no sharp edges on the cover, in the hand hole, or in the pole. The cover shall have the manufacturer's name and the pole height stenciled on it, readable from the outside of the pole. The stencil shall be legible after galvanizing. The hand hole strain bar shall be formed to provide a mechanical lock against the hand hole to prevent turning. No obstructions shall be in the hand hole with the cover removed. A Underwriters Laboratories (U.L.) approved grounding lug shall be provided with each pole. Ground lug shall accept a #6 AWG solid bare copper ground wire.

All poles shall have one 1-inch and one 3-inch boss centered on a horizontal line 18 inches from the base and one 1-inch and two 3-inch bosses 18 inches from the top. When facing the bosses, the 1-inch boss shall be 35 degrees ±3 degrees to the right of the 3-inch boss. The 3-inch boss shall be located 180 degrees from the hand hole. The bosses at the top of the pole shall be in line with the bosses at the bottom. The poles shall be shipped with all bosses plugged using galvanized steel conduit plugs installed to full thread depth. On octagonal poles the 3-inch boss shall be centered on one face that is parallel to one edge of the base plate.

1020.04.2.4 Pole Hardware: Furnish anchor bolts in accordance with the standard details. Anchor bolts shall be 1 3/4 inch, 5 NC thread with

a yield strength of 105,000 psi and be hot dipped galvanized for the top 12 inches and comply with ASTM A193-B7. Furnish one additional anchor bolt for acceptance testing by the Department.

1020.04.3 Steel Signal Mast Arm Poles:

1020.04.3.1 50 Feet Single, 45 Feet x 40 Feet Dual and Less:

All mast arms 50 feet single, 45 feet x 40 feet dual and less shall be required to conform to AASHTO 1994. All mast arm designs will be approved by State Traffic Signal Engineer.

Mast arms and fittings shall be galvanized in accordance with Section 811. The height of poles, shaft dimensions, and wall thickness shall meet the design requirements and mounting height of traffic signals set forth in the project specifications and in the plans. The length of arms shall be as shown on the plans.

Standards shall consist of straight or uniformly tapered shafts, cylindrical or octagonal in cross section, having a base welded to the lower end with anchor bolts. Castings shall be clean and smooth with details well defined and true to pattern. Mechanical control shall prevent the arm from twisting on the shaft. Friction is not acceptable.

Mast arms shall be compatible with poles in materials, strength, shape, and size. Mast arms shall slip fit on the shaft.

1020.04.3.1.1 Hand Holes and Bosses: A hand hole shall be provided for access to the wireway at the union of the arm and the pole shaft. Bosses shall be 1 1/2 FPT in the mast arm and set at 45 degrees from horizontal (downward rotation at the center of the boss, 0 degrees toward the arm top). Bosses shall be located a horizontal distance of 10 feet apart, the first located 16 inches from the top of the arm. The number of bosses required is listed in Table 1020-4.

Table 1020-4
Steel Signal Support Standards

Shaft		Shaft Base Plate	
Arm Length, ft	Number of Bosses	Diameter, Inches, Max.	Bolt Circle, Inches, Max.
15 -20	2	10	14 1/2
25-30	3	12	15
35-50	4	13	16

1020.04.3.1.2 Hanger Plate: A hanger plate and horizontal boss shall be at the tip of the arm. The arm shall have an up-sweep design.

Design load on the arm shall be sufficient to place a signal head at each boss.

1020.04.3.1.3 Design Requirements: For establishing the loads, applied to each structure, the weights and projected areas of Table 1020-5 shall be used for traffic signal heads.

Table 1020-5
Steel Signal Support Standards Design Requirements

Type[1]	Design Weight Per Signal, pounds[1]	Projected Area Per Signal	
		Less Backplates, square feet	Backplates, square feet
1-Way, 3 Section	62	4.8	8.9
1-Way, 4 Section	76	6.6	11.2
2-Way, 3 + 3 Sections	126	8.7	12.2
3-Way, 3+3+3 Sections	179	13.35	15.6
4-Way, 3+3+3+3 Sections	235	13.2	15.6

[1]When signal heads of a type different from that shown above are used, the weights and projected area shown above shall be increased for the equipment proposed for use. Adjusted values shall be based on the use of 12-inch diameter lenses and backplates (when used) extending 5 inches beyond signal enclosure.

1020.04.3.1.4 Standard Shaft: The standard shaft base shall have a minimum diameter of 11 inches. Mast arm standards shall be provided with a transformer type base.

Each pole shall be bolted to transformer base with four hex head bolts with two washers and one nut for each bolt.

1020.04.3.1.5 Transformer Base: The transformer base shall be approximately 20 inches high. The top of the transformer base shall have four 1 1/2-inches-by-2 1/2-inches slots for bolting the pole to the transformer base. The 2 1/2-inches dimension of the slot shall be centered on and perpendicular to a 13 1/2-inches bolt circle.

A removal panel on the side of the transformer base shall be provided for access to the base. A 1/2-inch -13NC grounding nut shall be provided 90 degrees left of this panel. A U.L. approved grounding lug shall be provided with each pole. Ground lug shall accept a #6 AWG solid bare copper ground wire. The bottom of the transformer base shall fit a 16-inches bolt circle using four 1 3/4-inches bolts supplied with each pole. These bolts shall conform to these specifications and plan details with exception that the cap nuts shall be replaced with the regular hex nuts. The transformer base shall be capable of being rotated 360 degrees.

1020.04.3.1.6 Wireways: The pole shaft and mast arm shall be suitable for wire ways throughout their length.

1020.04.3.1.7 Identification: The pole shaft, mast arm and arms, and transformer base shall have a matching serial number.

1020.04.3.2 55 Feet Single, 50 Feet x 35 Feet Dual and Greater: Only Bolt-On Mast Arms & Dual Mast Arm Poles on the Traffic Operations Approved Products List will be accepted. The design shall meet the requirements of the 2009 edition *AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.* All mast arm designs will be approved by the State Traffic Signal Engineer.

Mast arm assemblies, anchor bolts and hardware shall be hot dipped galvanized in accordance with Section 811 and all materials shall conform to the applicable provisions of Section 1013.

1020.04.4 Anchor Bolts for Steel Signal Support Poles and Standards

For all strain poles and 55 feet or less mast arm, furnish anchor bolts in accordance with the standard details. Anchor bolts shall be 1 3/4 inches, 5 NC thread with a yield strength of 105 ksi, be hot dipped galvanized for the top 12 inches, and comply with ASTM F1554 Grade 105. Furnish one additional anchor bolt for acceptance testing by the Department.

For 55 feet single, 50 feet x 35 feet dual and greater mast arms, furnish anchor bolts in accordance with the standard details. Anchor bolts shall be 2-1/4 inch, with a yield strength of 55 ksi, shall be hot dipped galvanized for the top 12 inches, and shall comply with ASTM F1554 Grade 55. Furnish one additional anchor bolt for acceptance testing by the Department.

1020.04.5 Treated Timber Poles: Comply with Section 1014.

1020.05 Traffic Signal Cabinet

Only TS-2 Traffic Signal Cabinets on the Traffic Operations Approved Products List will be accepted.

1020.06 Solar Powered Flashing Beacons

Only Solar Powered Flashing Beacons on the Traffic Operations Approved Products List will be accepted.