

## SECTION 701

### AGGREGATES

**701.01 AGGREGATE FOR CONCRETE**

These specifications describe the quality and size of aggregate for hydraulic cement concrete pavements and bases, highway bridges, and incidental structures.

The following test methods are used to evaluate the quality of aggregates for concrete:

Coal and Light Particles .....	AASHTO T 113
Clay Lumps .....	AASHTO T 112
Fineness Modulus of Fine Aggregate .....	AASHTO M 6
Mortar-making Properties .....	AASHTO T 71
Organic Impurities .....	AASHTO T 21
Sieve Analysis for Fine and Coarse Aggregate .....	MT 202
Sulfate Soundness .....	AASHTO T 104 or ASTM C88
Wear Test .....	MT 209
Combining Aggregate Gradations .....	MT 215

When wear factors are specified in the contract, the term “aggregate surfacing” includes the coarse aggregate for concrete.

**701.01.1 Fine Aggregates for Concrete**

**A. General Requirements.** Fine aggregate is natural sand having hard, strong, durable particles meeting the gradation requirements in Table 701-2.

Other approved inert material with similar characteristics or combinations of the above materials may be used, if the materials meet these specifications.

Do not mix or store in the same pile fine aggregate from different sources or use alternately in the same class of construction or mix without the Project Manager’s written permission.

The deleterious substances and soundness specified in Subsections 701.01.1(B) and (C) below will be waived for aggregate used in structures or portions of structures not exposed to weather.

**B. Deleterious Substances.** Meet the deleterious material limits in Table 701-1.

**TABLE 701-1  
LIMITS ON DELETERIOUS MATERIAL  
IN FINE AGGREGATE**

Material	Maximum % By Wt.
Coal and lightweight pieces	1.00
Clay lumps	1.00

Ensure that the material does not contain other deleterious material.

**C. Soundness.** When fine aggregate is subjected to 5 cycles of the sodium or magnesium sulfate soundness test, the total corrected loss cannot exceed:

- 10% by weight for the sodium sulfate.
- 15% by weight for the magnesium sulfate.

**D. Organic Impurities.** Aggregate subjected to the colorimetric test for organic impurities and producing a color darker than the standard will be rejected unless the aggregates pass the mortar strength test specified in Subsection 701.01.1(E). Do not use aggregates showing a darker color than that of samples originally approved for the work until tested

to determine whether the increased color indicates a harmful quantity of deleterious material.

- E. Mortar-making Properties.** The fine aggregate, when mixed with Type I or II cement and tested using the mortar making property test, must develop at 7 days, a minimum compressive strength of 95% of the strength developed by a mortar made with the same cement in accordance with AASHTO T 71.
- F. Grading.** The gradation requirements listed in Table 701-2 are the outer acceptance limits for use from all supply sources. The gradation must be uniform from any one source and not change from the low to the high gradation limits.

The fineness modulus of samples taken from proposed sources must be a minimum 2.50 and a maximum 3.10 when tested in accordance with AASHTO M 6. Fine aggregate from a source with a fineness modulus variation greater than  $\pm 0.20$  from the design fineness modulus of the sample may require a concrete mix redesign. Applying the 0.20 variation does not permit the fineness modulus to be less than 2.50 or more than 3.10.

**TABLE 701-2  
TABLE OF GRADATIONS - FINE AGGREGATE FOR CONCRETE**

Percentage By Weight Passing Square Mesh Sieves	
Sieve Size	Percent Passing
3/8-inch (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (0.600 mm)	25-60
No. 50 (0.300 mm)	5-30
No. 100 (0.150 mm)	0-10
No. 200 (0.075 mm)	0-3

A maximum 45% of the fine aggregate can be retained between any two consecutive sieves.

#### 701.01.2 Coarse Aggregate for Concrete

- A. General Requirements.** Coarse aggregate is crushed stone, gravel, or blast-furnace slag having hard, strong, durable pieces, free from adherent coatings. Other approved inert materials with similar characteristics or combinations of the above materials may be used, provided they are in accordance with the contract.

The limits for deleterious material and soundness specified in Subsection 701.01.2(B) and (C) will be waived for aggregate used in structures or portions of structures not exposed to the weather.

- B. Deleterious Substances.** Meet the deleterious material in accordance with Table 701-3.

**TABLE 701-3  
LIMITS ON DELETERIOUS SUBSTANCES  
IN COARSE AGGREGATE**

Substance	Maximum % By Wt.
Coal and lignite	1.00
Clay lumps	0.25
Soft fragments	5.00
Thin or elongated aggregate having a length greater than five times average thickness.	15.00
Material passing the No. 200 (0.075 mm) sieve	1.00 <sup>1</sup>

Notes:1. In crushed aggregates, if the material finer than the No. 200 (0.075 mm) sieve consists of fracture dust essentially free from clay or shale, the maximum limit may be increased to 1.5%.

Ensure that the material does not contain other deleterious material.

- C. Soundness.** When the coarse aggregate is subjected to five cycles of the sodium or magnesium sulfate soundness test, the total percentage loss cannot exceed 12 and 18% by weight respectively.
- D. Percentage of Wear.** Furnish coarse aggregate having a wear factor not exceeding 40%.
- E. Reserved.**
- F. Grading.** Furnish 1½-inch (37.5 mm) aggregate in accordance with Table 701-4 for No. 4 to 1½-inch (4.75 to 37.5 mm), furnished in two separate sizes respectively meeting the gradations for No. 4 to ¾-inch (4.75 to 19 mm) and ¾ to 1½-inch (19 mm to 37.5 mm) size material.

Furnish ¾-inch (19 mm) aggregate meeting the gradations for No. 4 to ¾-inch (4.75 to 19 mm) material.

Furnish coarse aggregate uniformly graded between the limits in accordance with Table 701-4.

The aperture shape used for coarse aggregate acceptance has no relation to the size and shape of the aperture or screen type used in producing the material.

**TABLE 701-4  
TABLE OF GRADATIONS - COARSE AGGREGATE FOR CONCRETE**

Percentage By Weight Passing Square Mesh Sieves Designated Sizes				
Sieve Size	No. 1	No. 2	No. 3	No. 4
	No. 4 to 1½" (4.75 to 37.5 mm)	No. 4 to ¾" (4.75 to 19 mm)	¾" to 1½" (19 to 37.5 mm)	No. 4 to ½" (4.75 to 12.5 mm)
2-inch (50 mm)	100		100	
1½-inch (37.5 mm)	95-100		90-100	
1-inch (25 mm)		100	20-55	
¾-inch (19 mm)	35-70	90-100	0-15	100
½-inch (12.5 mm)				90-100
⅜-inch (9.5 mm)	10-30	20-55	0-5	40-70
No. 4 (4.75 mm)	0-5	0-10		0-15
No. 8 (2.36 mm)		0-5		0-5

Note: Nos. 1, 2, 3, and 4 correspond to AASHTO/ASTM designations 467, 67, 4, and 7, respectively.

**701.01.3 Optimized Gradations for Concrete**

Optimizing a gradation by combining two or more sizes of aggregate is allowed and may be required for specific classes of concrete. Meet all the specifications listed in Subsections 701.01.1 and 701.01.2 for fine and coarse aggregate respectively except for the gradation requirements. Furnish a combined gradation in accordance with MT 215. If the combined gradation in the mix design submittal is approved, adhere to the tolerances listed in Table 701-5 during concrete production. The tolerances will be placed on the combined percent passing each sieve as defined in MT 215.

**TABLE 701-5  
OPTIMIZED GRADATION REQUIREMENTS**

Sieve Size	Production Tolerance
No. 4 or greater (4.75 mm or greater)	± 5%
No. 8 to No. 30 (2.36 mm to 0.600 mm)	± 4%
No. 50 (0.300 mm)	± 3%
No. 100 (0.150 mm)	± 2%
No. 200 or lesser (0.075 mm or lesser)	± 1.5%

Perform quality control gradations as necessary to control the production of aggregate and concrete. The combined aggregate gradation tests must meet the mix design target gradation and the tolerances listed above.

Do not target a combined percent passing of more than 2.0% on the #200 sieve.

**701.02 AGGREGATE FOR SURFACING****701.02.1 General Requirements**

The following test methods are used to evaluate the surfacing aggregate quality:

Fracture .....	MT 217
Liquid Limit, Plastic Limit, Plasticity Index .....	MT 208
Micro-Deval.....	MT 233
Sand Equivalent.....	MT 213
Sieve Analysis For Fine And Coarse Aggregate .....	MT 202
Sulfate Soundness.....	AASHTO T 104 or ASTM C88
Wear Test .....	MT 209

Passing wear test results are mandatory for Department approval of sources. Micro-Deval or sulfate soundness tests may be used by the Department for source approval. If Micro-Deval is used and the test fails, the Department will conduct the sulfate soundness test. If the sulfate soundness test fails the Contractor may not use the source to produce coarse surfacing aggregate.

Meet the following Micro-Deval requirements:

- Coarse Aggregate, 18.0% loss maximum for acceptance.

Meet the following sulfate soundness requirements:

- When coarse aggregate is subjected to 5 cycles of the sodium or magnesium sulfate soundness test, the total corrected loss cannot exceed 12 and 18% by weight respectively.

If the test results indicate the aggregate does not meet the requirements, the Contractor may make a written request for an independent laboratory to retest the material in question. The Contractor and the Department must agree upon the choice of the independent laboratory before release of the sample for testing. The Department will maintain and provide the original sample

in the event of a retest. The independent laboratory results will be averaged with the results provided by the Department and the averaged results will be binding on both parties for acceptance of the material in question. The Contractor must pay the cost of duplicate testing if the average results in a failing test. The Department will pay the cost of duplicate testing if the average results in a passing test.

Furnish aggregate that does not contain wood and other plant material.

Do not use scoria (fired clay commonly found in conjunction with burned coal in the lignite fields of the State) as aggregate. Sources of scoria are common but not limited to Daniels, Sheridan, Roosevelt, McCone, Dawson, Prairie, Wibaux, Custer, Fallon, Rosebud, Treasure, Bighorn, Powder River, and Carter Counties.

That portion of the aggregate retained on the No. 4 (4.75 mm) sieve is coarse aggregate, and that passing the No. 4 (4.75 mm) sieve is fine aggregate.

When wear factors are specified in the contract, the term “aggregate surfacing” includes all aggregates specified in Subsections 701.02.4 through 701.02.9.

The Department has 30 calendar days from receipt of the test sample to furnish the test results. Contract time will be increased working day for working day, for each day the test results are delayed beyond the 30-day review period, if the Departments delay affects the Contractor’s operation as shown on the current work schedule. Contract time will not be extended if the delay occurs from November 16<sup>th</sup> through April 15<sup>th</sup>, unless the Contractor is being charged contract time under Subsection 108.07.3.

### 701.02.2 Select Surfacing

Furnish select surfacing, including added binder or blending material in accordance with Table 701-6.

**TABLE 701-6  
TABLE OF GRADATIONS - SELECTED SURFACING**

Percentage By Weight Passing Square Mesh Sieves						
Sieve Size	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
4-inch (100 mm)	100					
3-inch (75 mm)		100				
2½-inch (63 mm)			100			
2-inch (50 mm)				100		
1½-inch (37.5 mm)					100	
1-inch (25 mm)						100
No. 200 (0.075 mm)	15 max.					

For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 30, and the plasticity index must not exceed 6.

### 701.02.3 Sand Surfacing

Furnish sand surfacing in accordance with Table 701-7.

**TABLE 701-7  
TABLE OF GRADATIONS - SAND SURFACING**

Percentage By Weight Passing Square Mesh Sieves					
Sieve Size	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1½-inch (37.5 mm)	100				
1-inch (25.0 mm)		100			
¾-inch (19.0 mm)			100		
½-inch (12.5 mm)				100	
No. 4 (4.75 mm)					100
No. 10 (2.00 mm)	65 min.	65 min.	65 min.	50 min.	50 min.
No. 200 (0.075 mm)	20 max.				

For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 25, and the plasticity index must not exceed 0.

#### 701.02.4 Crushed Base Course Type “A”

Furnish crushed base course Type “A”, including added binder or blending material in accordance with Table 701-8. Glass cullet meeting Subsection 701.11 requirements may be used as blending material.

**TABLE 701-8  
TABLE OF GRADATIONS - CRUSHED BASE COURSE TYPE “A”**

Percentage By Weight Passing Square Mesh Sieves		
Sieve Size	Grade 5A	Grade 6A
2-inch (50 mm)	100	
1½-inch (37.5 mm)	94-100	100
¾-inch (19.0 mm)	70-88	74-96
⅜-inch (9.5 mm)	50-70	40-76
No. 4 (4.75 mm)	34-58	24-60
No. 40 (0.425 mm)	6-30	6-34
No. 200 (0.075 mm)	0-8	0-8

Meet the following requirements for crushed base course Type “A”:

1. For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 25, and the plasticity index must not exceed 6;
2. Dust ratio limitations do not apply;
3. A wear factor not exceeding 50% at 500 revolutions;
4. Furnish binder meeting Subsection 301.02.2 requirements; and
5. At least 35% by weight of the aggregate retained on the No. 4 (4.75 mm) sieve has at least one mechanically fractured face.

#### 701.02.5 Crushed Base Course Type “B”

Furnish crushed base course Type “B”, including added binder or blending material in accordance with Table 701-9.

**TABLE 701-9  
TABLE OF GRADATIONS - CRUSHED BASE COURSE TYPE "B"**

Percentage By Weight Passing Square Mesh Sieves			
Sieve Size	Grade 1	Grade 2	Grade 3
2-inch (50 mm)	100		
1½-inch (37.5 mm)		100	
1-inch (25 mm)	50-80		100
No. 4 (4.75 mm)	20-50	25-55	30-60
No. 10 (2.00 mm)			20-50
No. 200 (0.075 mm)	8 max.	8 max.	8 max.

Meet the following requirements for crushed base course Type "B":

1. For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 35, and the plasticity index must not exceed 10;
2. Dust Ratio: The portion passing the No. 200 (0.075 mm) sieve must not exceed two-thirds of the portion passing the No. 40 (0.425 mm) sieve;
3. A wear factor not exceeding 50% at 500 revolutions;
4. Up to 5% by weight of material one grade larger than that being produced is allowed. For example, when producing 1½-inch (37.5 mm) material, up to 5% of the total weight of material produced may be 2-inch (50 mm) material;
5. Furnish binder meeting Subsection 301.02.2 requirements; and
6. At least 20% by weight of the aggregate retained on the No. 4 (4.75 mm) sieve must have one mechanically fractured face.

#### 701.02.6 Crushed Top Surfacing Type "A"

Furnish crushed top surfacing Type "A", including added binder or blending material in accordance with Table 701-10.

**TABLE 701-10  
TABLE OF GRADATIONS - CRUSHED TOP SURFACING TYPE "A"**

Percentage By Weight Passing Square Mesh Sieves					
Sieve Size	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1-inch (25 mm)	100				
¾-inch (19.0 mm)		100			
⅝-inch (16.0 mm)			100		
½-inch (12.5 mm)				100	
⅜-inch (9.5 mm)					100
No. 4 (4.75 mm)	40-70	40-70	40-70	40-70	50-80
No. 10 (2.00 mm)	25-55	25-55	25-55	25-60	35-70
No. 200 (0.075 mm)	2-8	2-8	2-8	2-8	2-8

Meet the following requirements for crushed top surfacing Type "A", including added binder or blending material:

1. Dust Ratio: the portion passing the No. 200 (0.075 mm) sieve cannot exceed two-thirds of the portion passing the No. 40 (0.425 mm) sieve;
2. For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 25, and the plasticity index must not exceed 6;

3. The composite aggregate does not contain adherent films of clay and other matter that prevents thorough coating with bituminous material. Bituminous material must remain adhered to the material upon contact with water;
4. When the aggregate is to be bituminized, both the material source and the composite aggregate must not show cracking or disintegration;
5. Do not remove intermediate sizes from the material during production, unless authorized in writing;
6. Have a wear factor not exceeding 50% at 500 revolutions; and
7. At least 35% by weight of the aggregate retained on the No. 4 (4.75 mm) sieve must have at least one mechanically-fractured face.

#### 701.02.7 Crushed Top Surfacing Type “B”

Furnish crushed top surfacing Type “B”, including added binder or blending material in accordance with Table 701-11.

**TABLE 701-11  
TABLE OF GRADATIONS - CRUSHED TOP SURFACING TYPE “B”**

Percentage By Weight Passing Square Mesh Sieves			
Sieve Size	Grade 1	Grade 2	Grade 3
1½-inch (37.5 mm)	100		
1-inch (25 mm)		100	
¾-inch (19.0 mm)			100
½-inch (12.5 mm)			
No. 4 (4.75 mm)	40-80	40-80	40-80
No. 10 (2.00 mm)	25-60	25-60	25-60
No. 200 (0.075 mm)	8-20	8-20	8-20

Meet the following requirements for crushed top surfacing Type “B”, including added binder or blending material:

1. Dust Ratio: the portion passing the No. 200 (0.075 mm) sieve cannot exceed two-thirds of the portion passing the No. 40 (0.425 mm) sieve;
2. For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 35, and the plasticity index must not be below 6 or above 12;
3. A wear factor not exceeding 40% at 500 revolutions; and
4. At least 35% by weight of the aggregate retained on the No. 4 (4.75 mm) sieve must have one fractured face.

#### 701.02.8 Crushed Cover Aggregate - Cover Material

Furnish cover material in accordance with Table 701-12.

**TABLE 701-12  
TABLE OF GRADATIONS - COVER MATERIAL**

Percentage By Weight Passing Square Mesh Sieves		
Sieve Size	Type 1	Type 2
½-inch (12.5 mm)		100
¾-inch (9.5 mm)	100	40-100
No. 4 (4.75 mm)	0-15	0-8
No. 200 (0.075 mm)	0-2	0-1

Meet the following requirements:

1. The composite aggregate must not have adherent films of clay, vegetable matter, frozen lumps, and other extraneous matter that prevents thorough coating with bituminous material. Bituminous material must remain adhered to the material upon contact with water. No combination of shale, clay, coal, and soft particles can exceed 1.5%;
2. The aggregate must have a wear factor not exceeding 30% at 500 revolutions; and
3. A minimum of 70% by weight of the coarse aggregate must have at least one fractured face.

#### 701.02.9 Aggregate for CTB

Furnish aggregate for CTB; including added blending material in accordance with Table 701-13.

**TABLE 701-13  
TABLE OF GRADATIONS - AGGREGATE FOR CTB**

<b>Percentage By Weight Passing Square Mesh Sieves</b>	
<b>Sieve Size</b>	<b>Percent Passing</b>
¾-inch (19.0 mm)	100
No. 4 (4.75 mm)	40-70
No. 10 (2.00 mm)	25-55
No. 200 (0.075 mm)	4-12

Meet the following requirements:

1. For material passing the No. 40 (0.425 mm) sieve, the liquid limit must not exceed 30, and the plasticity index must not exceed 7; and
2. The material used to produce the aggregate must have a wear factor not exceeding 50% at 500 revolutions.

#### 701.03 AGGREGATE FOR BITUMINOUS MIXTURES

##### 701.03.1 General Requirements

The following test methods will be used to evaluate the quality of aggregate to be bituminized:

**TABLE 701-14  
AGGREGATE REQUIREMENTS**

<b>Coarse Aggregate (No. 4 (4.75 mm) And Larger)</b>	
Angularity (MT 217 or ASTM D5821)	See Table 701-15
Wear (MT 209 or AASHTO T 96)	40% max
	30% max <sup>1</sup>
Flat and elongated particles (ASTM D4791) (3:1 ratio; by mass; No. 4 (4.75 mm) and larger)	20% max.
Absorption (AASHTO T 85) <sup>2</sup>	2.5% max
<b>Fine Aggregate (All Material Passing No. 4 (4.75 mm))</b>	
Angularity (AASHTO T 304 Method A)	45% min.
Sand equivalent (MT 213 or AASHTO T 176)	45% min.

Notes:

1. For ¾-inch (9.5 mm) mixes only.
2. For warm mixes only.
3. As determined by alternate method No. 2.

All aggregate must be non-plastic when tested in accordance with MT 208 or AASHTO T 89 and T 90.

Passing wear test results are mandatory for Department approval of bituminized material aggregate sources. Micro-Deval or sulfate soundness tests may be used by the Department for source approval. If Micro-Deval is used and the test fails, the Department will conduct the sulfate soundness test. If the sulfate soundness test fails the Contractor may not use the source to produce coarse aggregate to be bituminized.

Meet the following Micro-Deval requirements:

- Coarse Aggregate, 18.0% loss maximum for acceptance.

Meet the following sulfate soundness requirements:

- When coarse aggregate is subjected to 5 cycles of the sodium or magnesium sulfate soundness test, the total corrected loss cannot exceed 12 and 18% by weight respectively.

If the test results indicate the aggregate does not meet the requirements, the Contractor may make a written request for an independent laboratory to retest the material in question. The Contractor and the Department must agree upon the choice of the independent laboratory before release of the sample for testing. The Department will maintain and provide the original sample in the event of a retest. The independent laboratory results will be averaged with the results provided by the Department and the averaged results will be binding on both parties for acceptance of the material in question. The Contractor must pay the cost of duplicate testing if the average results in a failing test. The Department will pay the cost of duplicate testing if the average results in a passing test.

Furnish aggregate that does not contain wood and other plant material.

Do not use scoria (fired clay commonly found in conjunction with burned coal in the lignite fields of the State) as aggregate to be bituminized. Sources of scoria are common but not limited to Daniels, Sheridan, Roosevelt, McCone, Dawson, Prairie, Wibaux, Custer, Fallon, Rosebud, Treasure, Bighorn, Powder River, and Carter Counties.

The portion of the aggregate retained on the No. 4 (4.75 mm) sieve is defined as coarse aggregate, and that passing the No. 4 (4.75 mm) sieve is defined as fine aggregate.

The Department has 30 calendar days from receipt of the test sample to furnish the test results. Contract time will be increased, working day for working day, for each day the test results are delayed beyond the 30-day review period, if the Departments delay affects the Contractor's operation as shown on the current work schedule. Contract time will not be extended if the delay occurs from November 16<sup>th</sup> through April 15<sup>th</sup> unless the Contractor is being charged contract time under Subsection 108.07.3.

#### **701.03.2 Aggregate for Plant Mix Surfacing**

Furnish aggregate for plant mix surfacing, including hydrated lime when required, in accordance with following.

**TABLE 701-15  
GRADE S MIXTURE DESIGN AND PRODUCTION REQUIREMENTS  
¾-inch (19 mm), ½-inch (12.5 mm) and ⅜-inch (9.5 mm) Nom. Max. Aggregate Size**

20 Year Design ESALs <sup>1</sup>		Number of Compactive Gyration			% of Rice		Coarse Agg Angularity	VMA %			VFA %	VTM % (Air Voids)	DP (Dust to effective binder ratio) <sup>2</sup>	
Total (million)	Daily	Initial (N <sub>ini</sub> )	Design (N <sub>des</sub> )	Max (N <sub>max</sub> )	Max @ N <sub>ini</sub>	Max @ N <sub>des</sub>		Max @ N <sub>max</sub>	Min @ N <sub>des</sub> (¾")	Min @ N <sub>des</sub> (½")				Min @ N <sub>des</sub> (⅜")
≤ 0.3	≤ 41	7	75	115	91.5	96 to 96.6	98	≥ 13.0	≥ 13.5	≥ 15.5	70 to 80	3.4 to 4.0	Range (P0.075/Pbe) 0.6 to 1.4	
0.3 to <10	41 to <1370				90.5						75 to 80			65 to 78
≥ 10	≥ 1370				89						95/90			

**Notes:**

1. If ESAL's are not specified in the contract, use the 0.3 to 10 million ESAL design requirements in Table 701-15 to develop the mix design, unless otherwise directed by the Project Manager.
2. In addition to meeting the DP requirement at mix design, report the D/A for the mix design target asphalt content.

**Table 701-16  
GRADE S AGGREGATE DESIGN REQUIREMENTS**

<b><math>\frac{3}{4}</math>-inch (19 mm), <math>\frac{1}{2}</math>-inch (12.5 mm) and <math>\frac{3}{8}</math>-inch (9.5 mm) Nominal Maximum Aggregate Size</b>							
<b>Percent By Weight Passing Square Mesh Sieves</b>							
<b>Sieve</b>	<b>Gradation Limits</b>						
	<b><math>\frac{3}{4}</math>-inch (19.0 mm)</b>		<b><math>\frac{1}{2}</math>-inch (12.5 mm)</b>		<b><math>\frac{3}{8}</math>-inch (9.5 mm)</b>		
	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>	<b>Min</b>	<b>Max</b>	<b>Job Mix Tolerance</b>
1-inch (25 mm)	100						
$\frac{3}{4}$ -inch (19 mm)	90	100	100				
$\frac{1}{2}$ -inch (12.5 mm)		90	90	100	100		± 7
$\frac{3}{8}$ -inch (9.5 mm)				90	90	100	± 7
No. 4 (4.75 mm)						90	± 7
No. 8 (2.36 mm)	23	49	28	58	32	67	± 6
No. 16 (1.18 mm)							± 6
No. 30 (0.600 mm)							± 4
No. 50 (0.300 mm)							± 4
No. 100 (0.150 mm)							± 2
No. 200 (0.075 mm)	2	8	2	10	2	10	± 1.5

Notes: Percentage or Quantity of hydrated lime will not be subtracted from the aggregate gradation

**TABLE 701-17  
HAMBURG WHEEL TRACK REQUIREMENTS**

<b>PG Binder Grade</b>	<b>Water Bath Temperature</b>	<b>Not To Exceed 0.5-inch (13 mm) Rut in Number of Passes</b>	
		<b>Produced Plant Mix</b>	<b>Mix Design</b>
PG 58-28	111 °F (44 °C)	10,000 Passes	15,000 Passes
PG 64-22 and PG 64-28	122 °F (50 °C)	10,000 Passes	15,000 Passes
PG 70-28	133 °F (56 °C)	10,000 Passes	15,000 Passes

**TABLE 701-18  
GRADE S SPECIFICATIONS**

<b><math>\frac{3}{4}</math>-inch (19 mm), <math>\frac{1}{2}</math>-inch (12.5 mm) and <math>\frac{3}{8}</math>-inch (9.5 mm) Nominal Maximum Aggregate Size</b>							
<b>Property</b>	<b>Job Mix Target Limits</b>			<b>Job Mix Tolerance</b>	<b>Start-Up Job Mix Range <sup>3</sup></b>		
	<b><math>\frac{3}{4}</math>-inch (19 mm)</b>	<b><math>\frac{1}{2}</math>-inch (12.5 mm)</b>	<b><math>\frac{3}{8}</math>-inch (9.5 mm)</b>		<b><math>\frac{3}{4}</math>-inch (19 mm)</b>	<b><math>\frac{1}{2}</math>-inch (12.5 mm)</b>	<b><math>\frac{3}{8}</math>-inch (9.5 mm)</b>
VMA	13.0 to 17.0	13.5 to 18.0	16.1 to 18.4	± 0.6	12.4 to 17.6	12.9 to 18.6	15.5 to 19.0
VFA	65 to 80			± 5.0	60 to 85		
VTM @ N <sub>des</sub> <sup>1</sup>	3.4 to 4.0			± 1	2.4 to 5.0		
D/A <sup>2</sup>	0.6 to 1.4			±0.2	0.6 to 1.4		
<b>Commercial Plant Mix Requirements</b>							
VMA	12.4 to 17.6	12.9 to 18.6	15.5 to 19.0	N/A	N/A		
VFA	60 to 85			N/A	N/A		
VTM <sup>1</sup>	2.4 to 5.0			N/A	N/A		
D/A	0.6 to 1.4			N/A	N/A		

Notes:

1. Choose the design and production air voids target to be the lowest value, within the range in Table 701-16 inclusive of 3.4 and 4.0, such that all other criteria are met.
2. Percentages or quantities of hydrated lime will not be subtracted from the aggregate gradation.
3. Start-up job mix range only applies to production before initial target set. Tolerances do not apply to start up job mix range.

## **701.04 FOUNDATION AND BEDDING MATERIAL FOR STRUCTURES**

### **701.04.1 Bedding Material**

Furnish bedding material for minor drainage structures and culvert foundations. Glass Cullet meeting Subsection 701.11 requirements may be used as blending material.

Furnish bedding material that is reasonably free of clay, silt, and other deleterious material in accordance with Table 701-19.

**TABLE 701-19  
TABLE OF GRADATIONS - BEDDING MATERIAL**

<b>Percentage By Weight Passing Square Mesh Sieves</b>	
<b>Sieve Size</b>	<b>Percent Passing</b>
1½-inch (37.5 mm)	100
No. 4 (4.75 mm)	24-60
No. 200 (0.075 mm)	12 maximum

**701.04.2 Foundation Material**

Foundation material is one or more aggregate material courses to provide a stable foundation for culvert and drainage structure installations in unstable areas.

Use shot rock, pit-run aggregate, crushed aggregate, or any combination of these materials. The largest rock or rock fragment allowed may be as great in dimension as the thickness of the lift being placed. In the top 1-foot (305 mm) of the foundation, the largest rock or rock fragment cannot exceed 8 inches (200 mm). Use well-graded material in the top 1-foot (305 mm) of foundation material. A maximum 40% by weight of the foundation material must pass a No. 4 (4.75 mm) sieve.

**701.04.3 Granular Bedding Material**

Furnish granular bedding material in accordance with Table 701-4 No. 2.

**701.05 FILTER MATERIAL**

Furnish filter material in accordance with Table 701-20.

**TABLE 701-20  
TABLE OF GRADATIONS - FILTER MATERIAL**

Percentage By Weight Passing Square Mesh Sieves		
Sieve Size	No. 1	No. 2
2-inch (50 mm)		100
1½-inch (37.5 mm)		95-100
¾-inch (19.0 mm)		35-70
⅜-inch (9.5 mm)	100	10-30
No. 4 (4.75 mm)	95-100	0-5
No. 8 (2.36 mm)	80-100	
No. 16 (1.18 mm)	50-85	
No. 30 (0.60 mm)	25-60	
No. 50 (0.30 mm)	5-30	
No. 100 (0.15 mm)	0-10	

**701.06 RIPRAP**

Furnish stone that is hard, durable, and angular in shape, resistant to weathering and water action, free from overburden, spoil, shale, structural defects, and organic material.

Each stone must have its greatest dimension not greater than 3 times its least dimension.

Do not use rounded stone or boulders from a streambed source as riprap. Do not use shale or stone with shale seams.

The stone will be accepted based on visual analysis, the Department's riprap evaluation form, or both. Submit samples before placing the riprap.

**701.06.1 Handlaid Riprap**

Furnish stone or rock fragment at least 3 inches (75 mm) thick, a minimum .5 cubic foot (0.014 m<sup>3</sup>) in volume, weighing at least 75 pounds (34 kg), excluding rock spalls.

Extend all stones and fragments through the revetment, except spalls used to chock larger stones and fill voids between the larger stones.

**701.06.2 Random Riprap**

Furnish the specified random riprap in accordance with Table 701-21.

**TABLE 701-21  
TABLE OF GRADATIONS - RANDOM RIPRAP**

<b>Class</b>	<b>Weight Of Stone</b>	<b>Equivalent Spherical Diameter<sup>1</sup></b>	<b>% Of Total Weight That Must Be Smaller Than Given Size</b>
I	100 pounds (45 kg)	1.05 feet (320 mm)	100
	60 pounds (27 kg)	0.88 feet (270 mm)	70-90
	25 pounds (11 kg)	0.66 feet (200 mm)	40-60
	2 pounds (0.90 kg)	0.27 feet (80 mm)	0-10
II	700 pounds (318 kg)	2.00 feet (610 mm)	100
	500 pounds (227 kg)	1.79 feet (545 mm)	70-90
	200 pounds (91 kg)	1.32 feet (400 mm)	40-60
	20 pounds (9.0 kg)	0.61 feet (190 mm)	0-10
III	2,000 pounds (909 kg)	2.82 feet (860 mm)	100
	1,400 pounds (635 kg)	2.53 feet (770 mm)	70-90
	700 pounds (318 kg)	2.00 feet (610 mm)	40-60
	40 pounds (18 kg)	0.77 feet (235 mm)	0-10

Note 1. Based on unit weight of 165 pounds per cubic foot (2,675 kg/m<sup>3</sup>).

### 701.06.3 Grouted Riprap

Furnish stone for grouted riprap in accordance with Subsection 701.06.2.

### 701.07 BANK PROTECTION

Furnish rock that is hard, dense, and durable. Use either quarried rock or natural coarse gravel. Rock may be obtained from adjacent roadway excavation. Do not use rock obtained from streambeds.

Furnish the specified bank protection in accordance with Table 701-22.

**TABLE 701-22  
SIZE REQUIREMENTS - BANK PROTECTION**

<b>Type</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Nominal thickness	24-inch (610 mm)	18-inch (455 mm)	12-inch (305 mm)	Coarse gravel
Overall thickness including bedding	30-inch (760 mm)	24-inch (610 mm)	18-inch (455 mm)	As specified in the contract
Largest rock permissible	¼ cubic yd. (0.19 m <sup>3</sup> )	⅛ cubic yd. (0.09 m <sup>3</sup> )	1 cubic ft. (0.03 m <sup>3</sup> )	⅛ cubic ft. (0.003 m <sup>3</sup> )
Smallest rock permissible	1/10 cubic ft. (0.003 m <sup>3</sup> )	1/10 cubic ft. (0.003 m <sup>3</sup> )	1½-inch (38 mm)	3/16-inch (5 mm)

### 701.08 SAND-GRAVEL CUSHION

Furnish sand-gravel cushion for concrete slope protection in accordance with Subsection 701.04.1 for bedding material except that all the material must pass a 1½-inch (38 mm) sieve.

**701.09 BACKFILL FOR METAL BIN-TYPE RETAINING WALLS**

Furnish backfill for the bins specified by the bin manufacturer. If not specified, use a gravel-type soil with 95% passing the 2-inch (50 mm) sieve and not more than 10% passing the No. 200 (0.075 mm) sieve. The material must have a plasticity index not exceeding 10.

**701.10 DRAIN AGGREGATE**

Furnish drain aggregate that is rounded to sub-rounded aggregate in accordance with Table 701-23.

**TABLE 701-23  
TABLE OF GRADATIONS - DRAIN AGGREGATE**

Percentage By Weight Passing Square Mesh Sieves	
Sieve Size	Percent Passing
6-inch (152 mm)	100
¾-inch (19 mm)	0-10
No. 4 (4.75 mm)	0-5

**701.11 GLASS CULLET FOR SOIL-AGGREGATE FILLER**

When requested and approved as an aggregate blending material, furnish and blend Glass Cullet in accordance with AASHTO M 318. Meet the following requirements for the glass cullet and the blended product:

- A. Furnish glass cullet containing no more than 5% cullet originating from non-beverage container glass. Furnish the Project Manager certification that the cullet meets this limit before it is used. If the cullet exceeds this limit, submit a laboratory test plan that meets the requirements of the appendices of AASHTO M 318. Approval of the cullet will be based on the approved testing plan and the test results;
- B. Have the glass cullet tested to ensure it meets the physical properties and deleterious substances requirements in AASHTO M 318. Furnish the Project Manager copies of the test results before using the glass cullet;
- C. Produce a glass cullet/aggregate blended product that meets all requirements for the specified aggregate; and
- D. Limit the glass cullet content to no more than 10% of the total blended product.

**701.12 DIGOUT AND SUB-EX REPLACEMENT MATERIAL**

If crusher reject material is used for digout and sub excavation replacement material, meet the gradation requirements in Table 701-24.

**TABLE 701-24  
DIGOUT AND SUB-EX REPLACEMENT MATERIAL (CRUSHER REJECT)**

Percentage By Weight Passing Square Mesh Sieve	
Sieve size	Percent Passing
4-inch (100 mm)	100
No. 4 (4.75 mm)	0-50
No. 200 (0.075 mm)	8 maximum

**701.13 BRIDGE END BACKFILL**

Furnish Bridge End Backfill in accordance with Table 701-25.

**TABLE 701-25  
TABLE OF GRADATIONS – BRIDGE END BACKFILL**

Sieve Size	Percentage By Weight Passing Square Mesh Sieves		
	Type 1 <sup>1</sup>	Type 2	Type 3
4-inch (100 mm)		100	100
2-inch (50 mm)	100	60-100	Modified AASHTO Soil Class A-1-a
1-inch (25 mm)	60 – 80		
½-inch (12.5 mm)	40 – 60		
¾-inch (9.5 mm)		25-65	
No. 4 (4.75 mm)	20 – 40		
No. 10 (2.00 mm)		10-30	
No. 40 (0.425 mm)	5 – 20		
No. 200 (0.075 mm)	0 – 8	0-8	0-8

Note 1. Provide a minimum of 35% of the material retained on the No. 4 (4.75 mm) sieve having at least 1 mechanically fractured face.

**SECTION 702  
BITUMINOUS MATERIALS**

**702.01 BITUMINOUS MATERIALS**

A. Furnish bituminous materials in accordance with following tables.

- Cationic Emulsified Asphalt ..... AASHTO M 208<sup>1</sup>, Table 1
- Emulsified Asphalt..... AASHTO M 140<sup>1</sup>, Table 1
- High Float Emulsions..... Table 702-5
- Medium Curing Liquid Asphalt (MC) ..... Table 702-4
- Performance Graded Asphalt Binder ..... Table 702-2
- Polymer-Modified Cationic Emulsified Asphalt... Table 702-3

Note 1. Cement mixing test does not apply when SS-1 or CSS-1 emulsion is used for spray or tack application.

Meet the requirements for bituminous materials in accordance with the contract.

B. Polymerize CRS-2P emulsions using at least 3% polymer by weight (mass) of the asphalt binder.

**702.02 TESTING AND ACCEPTANCE**

Bituminous materials are accepted on the test results of samples selected and tested by the Department or its authorized representative. Collect samples in accordance with Subsection 402.03.2 and tested using the applicable AASHTO method. The Project Manager may permit using bituminous materials before the test results are available, if the test results of material previously furnished by the refiner have consistently been satisfactory. The use of bituminous materials before receipt of the test results as permitted by the Project Manager does not waive the Department's right to accept or reject materials under these specifications.

Asphalt cement penetration is sampled and accepted in accordance with Subsections 402.03.2 and 402.03.5(B).

**TABLE 702-1  
BASIS FOR ACCEPTANCE OF BITUMINOUS MATERIALS**

Sample Tested	Specification Limits <sup>1</sup>		Remarks
	Test Results Within Limits	Test Results Outside Limits <sup>2</sup>	
Original sample	accept material	test retained sample	Retained samples may be tested by the Department at any time.
Retained sample	accept material	accept material at reduced price or reject	

Notes:

1. See specification for bituminous materials.
2. Pay adjustments will be applied under QA.

If test results of both the original and retained samples are not within the tolerance limits, the average of the two values will determine the basis for acceptance of the material.

Exception: If either of the two test values are outside the applicable ASTM Repeatability Range, then the test value numerically nearest the specification requirement will be used as the basis for acceptance. In the event a material fails more than one test requirement, that requirement with the greatest violation will determine the basis for acceptance. See Subsection 402.03.5(C) for the method of calculating price reductions.

**TABLE 702-2  
SPECIFICATION FOR PERFORMANCE GRADED ASPHALT BINDER<sup>1</sup>**

Property		Test Method: AASHTO	Requirements by Performance Grade			
			58-28	64-22	64-28 <sup>2</sup>	70-28 <sup>2</sup>
<b>Original</b>						
Flash point, °C		T 48	230 min.	230 min.	230 min.	230 min.
Rotational viscosity, Pa·s	135 °C	T 316	3.0 max.	3.0 max.	3.0 max.	3.0 max.
Dynamic shear, kPa (g*/sin δ, 10 rad./sec)		T 315	1.00 min.	1.00 min.	1.00 min.	1.00 min.
Test temperature			58 °C	64 °C	64 °C	70 °C
<b>RTFO residue</b>		T 240				
Mass change, %		T 240	1.00 max.	1.00 max.	1.00 max.	1.00 max.
Dynamic shear, kPa (g*/sin δ, 10 rad./sec.)		T 315	2.20 min.	2.20 min.	2.20 min.	2.20 min.
Test temperature			58 °C	64 °C	64 °C	70 °C
Ductility, cm	25 °C	T 51 <sup>2</sup>	-	-	30 min.	30 min.
<b>Pav residue</b>		R 28	100 °C, 20 hrs, 300 psi			
Dynamic shear, kPa (g* · sin δ, 10 rad./sec.)		T 315	5000 max.	5000 max.	5000 max.	5000 max.
Test temperature			19 °C	25 °C	22 °C	25 °C
Creep stiffness, mPa		T 313	300 max.	300 max.	300 max.	300 max.
Test temperature			-18 °C	-12 °C	-18 °C	-18 °C
M-value		T 313	0.300 min.	0.300 min.	0.300 min.	0.300 min.
Direct tension, % strain		T 314	-	-	-	-

## Notes:

1. For Performance Graded Asphalt Binders not shown in Table 702-2, refer to AASHTO M 320, Table 1.
2. Pull rate is established at 5 cm/minute.

Use PG 64-28 asphalt cement if not specified elsewhere in the contract.

**TABLE 702-3  
LAYTEX OR POLYMER MODIFIED CRS-2 EMULSIFIED ASPHALT**

<b>Property</b>	<b>Test Method</b>	<b>CRS-2P</b>
Viscosity at 122 °F (50 °C), sec.	AASHTO T 59	70-400
Sieve, %	AASHTO T 59	0.3 max.
Settlement, 5 days, %	AASHTO T 59	5 max.
Demulsibility, %	AASHTO T 59	40 min.
Storage stability test, 1 day, %	AASHTO T 59	1 max.
Particle charge	AASHTO T 59	Positive
Ash content, %	AASHTO T 111	0.2 max.
Tests on residue by evaporation:		
% residue <sup>1</sup>	AASHTO T 59	65 min.
penetration, 100 g, 5 sec. at 77 °F (25 °C), dmm	AASHTO T 49	90-250
ductility at 77 °F (25 °C), 5 cm per minute, cm	AASHTO T 51	75 min.
elastic recovery, %	AASHTO T 301	58 min.

Note 1: AASHTO T 59 residue by evaporation will be used to obtain samples for all residue testing requirements. AASHTO T 59 is modified by deleting Note 8.

**TABLE 702-4  
SPECIFICATION FOR MEDIUM CURING LIQUID ASPHALTS**

	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic viscosity at 140 °F (60 °C), centistokes <sup>1</sup>	30	60	70	140	250	500	800	1600	3000	6000
Flash point (tag, open-cup), °F (°C)	100 (38)	—	100 (38)	—	150 (66)	—	150 (66)	—	150 (66)	—
Water, %	—	0.2	—	0.2	—	0.2	—	0.2	—	0.2
Distillation test: distillate, percentage by volume of total distillate to 680 °F (360 °C) to 437 °F (225 °C) to 500 °F (260 °C) to 600 °F (315 °C)	— 40 75	25 70 93	0 20 65	20 60 90	0 15 60	10 55 87	— 0 45	— 35 80	— 0 15	— 15 75
Residue from distillation to 680 °F (360 °C) volume percentage of sample by difference	50	—	55	—	67	—	75	—	80	—
Tests on residue from distillation: Penetration, 100 g, 5 sec. at 77 °F (25 °C), dmm ductility <sup>2</sup> , 5 cm/min, cm solubility, %	120 100 99	250 — —	120 100 99	250 — —	120 100 99	250 — —	120 100 99	250 — —	120 100 99	250 — —
Spot test	negative for MC-3000 only									

## Notes:

- As an alternate, Saybolt-Furol viscosities may be specified as follows:  
Grade MC-70 - Furol viscosity at 122 °F (50 °C) - 60 to 120 sec.  
Grade MC-30 - Furol viscosity at 77 °F (25 °C) - 75 to 150 sec.  
Grade MC-250 - Furol viscosity at 140 °F (60 °C) - 125 to 250 sec.  
Grade MC-800 - Furol viscosity at 180 °F (82.2 °C) - 100 to 200 sec.  
Grade MC-3000 - Furol viscosity at 180 °F (82.2 °C) - 300 to 600 sec.
- If the ductility at 77 °F (25 °C) is less than 100, the material will be acceptable if its ductility at 60 °F (15.5 °C) is more than 100.

**TABLE 702-5  
SPECIFICATIONS FOR HIGH FLOAT EMULSIONS**

Grade	HF-100	
	Min.	Max.
Tests on emulsions:		
Viscosity Saybolt Furol at 122 °F (50 °C), sec.	50	400
Storage Stability 24 hr., %	—	1
Sieve Test, %	—	0.1
Demulsibility, 50 mL 5.55 g/L CaCl <sub>2</sub> , % by mass	30	—
Distillation:		
Residue, %	65	—
Oil Distillate, by volume of emulsion, %	—	2
Tests on residue from distillation test:		
Penetration at 77 °F (25 °C), 100 g, 5 sec., dmm	100	170
Ductility at 77 °F (25 °C), 5 cm per min., cm	40	—
Solubility, %	95.5	—
Float Test at 140 °F (60 °C), sec.	1200	—



## **SECTION 703**

### **LIGHTING & SIGNAL MATERIALS**

#### **703.01 GENERAL**

Furnish all electrical equipment that meets the contract and the following requirements:

1. NEMA;
2. The NEC;
3. The standards of the ASTM;
4. ANSI; and
5. All state and local laws or ordinances that may apply.

References to the above codes or standards are the current editions of the code, order, or standard at the time the contract is let and governs throughout the life of the contract.

Furnish galvanized parts in accordance with ASTM A153, B695 (Class 50), or other applicable ASTM galvanizing specifications. Galvanize the top 12 inches (305 mm) of anchor bolts. Galvanized bolts and nuts must thread together without damaging the coating.

#### **703.02 CONDUIT**

##### **703.02.1 Plastic Conduit**

Furnish rigid polyvinyl chloride (PVC) in accordance with UL 651, or continuous length high density polyethylene (HDPE) in accordance with UL 651B, schedule 80, 150 °F (66 °C) wire rated, direct bury type.

##### **703.02.2 Steel Conduit**

Furnish galvanized rigid steel conduit and fittings of mild steel in accordance with UL 6 and ANSI C 80.1.

#### **703.03 PULL BOXES**

##### **703.03.1 Concrete Pull Boxes**

Furnish concrete pull boxes, extensions, and covers made of reinforced concrete. Use Class General concrete in accordance with Section 551. Use reinforcing steel in accordance with Section 555.

Meet the pull box size and details specified in the contract.

Inscribe reinforced concrete covers for signal systems and/or lighting systems with the words "ELECTRIC". Furnish a steel cover designed to withstand AASHTO HS-20 loads for pull boxes subject to vehicular traffic loads.

Furnish metal frames and covers for boxes or vaults formed in the concrete. Inscribe covers with the wording specified in the contract. Ensure gasket surfaces form a true plane. Install a 1/8-inch (3 mm) one-piece neoprene gasket on the frame or cover for the seal.

##### **703.03.2 Composite Pull Boxes**

Furnish pull boxes and covers made of polymer concrete with fiberglass reinforcement. Furnish pull boxes having continuous fiberglass cloth reinforcement on the inside and outside perimeters. Furnish covers having a minimum of 2 layers of fiberglass cloth reinforcement.

Ensure the pull boxes and covers comply with all test provisions of the most current ANSI/SCTE 77 for tier 15 applications. Furnish pull boxes and covers that have been tested and certified by a nationally recognized third party independent testing firm such as UL or Intertek Testing Services verifying that the boxes and covers meet all test provisions of the ANSI/SCTE 77.

Furnish pull boxes that have markings showing the tier 15 rating labeled or stenciled on the inside and outside of the box. Furnish covers that have markings showing the tier 15 rating

embossed in the top surface of the cover. Furnish covers having pull slots rated for a minimum pull out of 3,000 pounds (1,360 kg).

Furnish  $\frac{3}{8}$  x 7-inch (M10 x 178 mm) lag thread hex head bolts to secure the cover to the pull box.

#### **703.04 STANDARDS AND POSTS**

##### **703.04.1 General**

Furnish standards fabricated and inspected in accordance with Section 556 and designed to the 1994 AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals*.

Use a minimum luminaire dead load of 77 lb (35 kg), and a minimum luminaire projected area of 3.3 square feet (0.3 m<sup>2</sup>) for design purposes. Use a design wind velocity for all standards of 90 miles per hour. Include on the shop drawings the following reaction data at the base of the pole, reported as reactions normal to the standard global coordinate system:

- Moment X (MX) Ft.-Lb.
- Moment Y (MY) Ft.-Lb.
- Torsion Z (MZ) Ft.-Lb.
- Shear force X (VX) Lb.
- Shear force Y (VY) Lb.
- Axial load (P) Lb.

Fabricate all standards from steel. Meet the standard manufacturer's requirements for the anchor bolt placement in the foundation.

##### **703.04.2 Type 1 Signal Standards**

Furnish standards in accordance with the contract.

Furnish a cast aluminum base with an internal ground lug and handhole with removable cover. Plumb bases with factory-made shims.

Furnish 4 high strength steel anchor bolts with each base. Furnish "L" shaped anchor bolts with a minimum 6 inches (150 mm) of the bolt threaded at the top. Furnish a nut and washer with each anchor bolt for the base.

Follow the manufacturer's recommendations for anchor bolt size.

All accessories welded to the shaft must be factory-welded to the shaft before galvanizing

##### **703.04.3 Type 2 and 3 Signal Standards**

Furnish a single steel section shaft formed into a round, continuous taper with a single, automatic electrically welded seam, or an approved equal.

Show the type of steel used for the shafts on the shop drawings.

Furnish 4 high-strength steel anchor bolts with each shaft. Furnish each anchor bolt with 2 nuts and 2 washers over and under the shaft base to adjust rake and plumb.

All accessories welded to the shaft must be factory-welded before galvanizing.

Furnish rain tight metal covers for the top of Type 2A and 3A signal standards.

##### **703.04.4 Type 10 Luminaire Standards**

Shafts must be a single section formed into a round, continuous taper with a single, automatic electrically welded seam, or approved equal. Steel shafts must be a minimum No. 11 Manufacturers Standard Gauge.

Show the type of steel on the manufacturer's shop drawings.

Furnish rain-tight metal covers for the top of each shaft.

Shafts not mounted on transformer bases must have a handhole with removable cover and an internal grounding lug, as shown in the contract. Locate the handhole in the same quadrant as the mast arm.

Shafts mounted on transformer bases do not require a handhole or grounding lug.

The shaft base (anchor or breakaway) to be used is specified in the contract.

The shaft base plate must be a one-piece plate circumferentially welded to the shaft for anchor and breakaway base types.

For anchor bases, the base plate must attach directly to the anchor bolts. Furnish each anchor bolt with 2 nuts and 2 washers for plumbing and raking the shaft.

For breakaway bases, the plate must be attached to a breakaway device that attaches to the anchor bolts.

Use breakaway bolt couplings unless they do not function with the approved luminaire standard. The bolt coupling must meet the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* requirements.

Use frangible transformer bases where bolt couplings cannot be used. Transformer bases must have an access door, grounding lug, and factory-made shims for plumbing. Provide each anchor bolt with one nut and one washer.

Furnish 4 high strength steel anchor bolts with each shaft. Furnish “L” shaped anchor bolts with a minimum 6 inches (150 mm) of the bolt threaded at the top. Size the anchor bolt in accordance with the shaft manufacturer’s recommendations.

Anchor bolts used with breakaway bolt couplings must project out of the foundation the length recommended by the coupling manufacturer. Furnish the breakaway bolt coupling, washer, nut and bolt covering that enclose the area between the base plate and foundation.

Anchor bolts used with transformer bases must project at least 3 inches (75 mm) from the foundation.

Provide a mounting base where the mast arm connects to the shaft. Provide an opening in the base for running wire from the shaft to the mast arm.

All accessories welded to the shaft must be factory-welded before galvanizing.

#### **703.04.5 Mast Arms - Signal and Luminaire**

Traffic signal mast arms up to 50 feet (15.2 m) in length must be single tapered members. Traffic signal mast arms over 50 feet (15.2 m) long may be two piece tapered members.

Luminaire mast arm ends must have a 2-inch (50 mm) slip-fitter tenon at least 6 inches (150 mm) long.

All accessories welded to the mast arm must be factory-welded before galvanizing.

Mast arm lengths and mounting heights are shown in the contract.

#### **703.04.6 Welding Steel**

Meet the requirements of Section 624 and the following:

Ensure that all Nondestructive Testing is performed by personnel qualified in conformance with the American Society for Nondestructive Testing Recommended Practice *No. SNT-TC-1A* to minimum Testing Level II for the individual methods. Provide ASNT certifications and procedures before testing. Meet all the applicable AASHTO and AWS welding inspection requirements including those modified as follows:

- 1. Circumferential Weld Splices.** Perform radiographic testing or ultrasonic testing as approved by the Project Manager meeting AWS D1.1, Structural Welding Code, Section 6.
- 2. Longitudinal Seams.** Inspect 100% of all full penetration groove welds using radiography or testing may be by ultrasonic test methods AWS D1.1, Structural Welding

Code Ultrasonic, Section 6, both of the above test methods to be approved by the Project Manager before use.

Randomly test 25% of all partial penetration welds and fillet welds per component using magnetic particle test methods.

- 3. Base Connection Welds.** Randomly inspect 25% of all base connection welds and all fillet welds using magnetic-particle testing specified in AWS D 1.1, Structural Welding Code, Section 6.

#### **703.04.7 Reserved**

#### **703.04.8 Finish**

Furnish standards galvanized inside and out. A primer finish is not acceptable. Use stainless steel or zinc, cadmium, or galvanized coated fasteners. Provide galvanized nuts, washers, and shims for anchor bolts.

#### **703.04.9 Wire Protection**

Use insulated bushings or grommets to prevent wire abrasion at all wire openings and inlets.

#### **703.04.10 Inspection**

All standards will be inspected at the project before they are erected and may be inspected where fabricated.

### **703.05 CONDUCTORS AND CABLE**

#### **703.05.1 Conductors**

Furnish conductors of solid or stranded copper of the gauge shown in the contract. Insulation for conductors must be Type THW, XHHW, USE, RHH, RHW, THWN, or THHN. All insulation must be designed for 600 volts and meet NEC requirements.

#### **703.05.2 Signal Cable**

Furnish cable in accordance with the IMSA specification No. 19-1 or 20-1. Individual conductors must be stranded copper.

#### **703.05.3 Detector Loop Shielded Cable**

Use detector loop shielded cable as a lead-in between the loop pull box and the loop detector as specified.

Furnish with an aluminum-polyester shield with two AWG No. 14 stranded, tinned, polyethylene-insulated copper conductors, a stranded and tinned copper AWG No. 18 or 16 drain wire, all encased in a black polyethylene jacket meeting IMSA specification No. 50-2.

#### **703.05.4 Emergency Preemption Detector Cable**

Use cable recommended by the manufacturer for the emergency preemption system.

#### **703.05.5 Communication Cable**

Furnish BJFC 6 pair AWG No. 19 copper cable in accordance with REA specification PE 39.

#### **703.05.6 50-Ohm Coaxial Cable**

Furnish  $\frac{3}{8}$  or  $\frac{1}{2}$ -inch (10 or 13 mm), super flexible, low loss, foam filled, watertight, coaxial cable. Furnish coaxial cable with the following characteristics:

1. Impedance of 50 ohms,  $\pm 1$  ohm.
2. Maximum attenuation of 13.0 dB/100 m at 900 MHz.
3. Outer conductor of bonded aluminum tape and an overall braid of tinned copper with an inner conductor of copper-clad aluminum.
4. Foam polyethylene dielectric.
5. UV protected black polyethylene jacket.

6. Minimum bending radius of 1-inch (25 mm) for installation, 4 inches (100 mm) for repeated bending, for  $\frac{3}{8}$ -inch (10 mm). Minimum bending radius of 2 inches (50 mm) for  $\frac{1}{2}$ -inch (13 mm) cable.

Furnish coaxial cable that is compatible with type “N” connector.

### **703.06 SERVICE AND CONTROL ASSEMBLY**

Furnish cabinets meeting NEMA Type 3, 3R, or 12, made of aluminum or NEC-grade steel having a hinged, lockable door.

Include a terminal strip having the number of attaching points for the required conductors with the service and control assembly. Ensure the terminal strip has the capacity equal to an AWG No. 6 conductor.

### **703.07 CONTROL EQUIPMENT**

#### **703.07.1 Flasher**

Furnish a solid-state dual circuit, plug-in type electronic flasher producing between 50 and 60 flashes per minute with equal on-and-off time intervals meeting all NEMA Type 3 requirements and conforming to part 4B-18 of the MUTCD.

#### **703.07.2 Loop Detectors**

Furnish two channel loop detectors of the rack mount type.

The loop detectors must be solid-state digital using external power. The front panel must contain sensitivity controls, mode selector switch, and an actuation indicator LED.

The loop detectors cannot use more than 150 MA of current at 24 volts DC. The output must be by relay and plug mounted. The relay must be normally energized providing fail-safe functioning should the power fail. Furnish loop detectors in accordance with all NEMA temperature requirements. Use a 44 pin edge card connector to make all electrical connections.

### **703.08 TRAFFIC AND PEDESTRIAN SIGNALS**

- A. Optical Units.** Furnish vehicular signal indications which utilize LEDs in accordance with the latest issue of the I.T.E. Vehicle Traffic Control Signal Heads specification. Furnish 12-inch (305 mm) circular and arrow signal indications that have clear polycarbonate lenses. The lens must be diffused or the module must have some other method of achieving the appearance of an incandescent lamp (smooth and non-pixelated). Furnish bi-modal “green/yellow” arrow indications that utilize LEDs.

Furnish pedestrian signal indications which utilize LEDs in accordance with the latest issue of the I.T.E Pedestrian Traffic Control Signal Indication specification and the MUTCD. Furnish 16 x 18-inch (405 x 455 mm) pedestrian indications that utilize LEDs for the “UPRAISED HAND” symbol, the “WALKING PERSON” symbol and the countdown display. Furnish indications that have the countdown display and pedestrian displays in the same housing. Furnish indications with a countdown display that is at least 9 inches (225 mm) in height. Furnish indications that have filled in symbols to give the appearance of an incandescent indication. Furnish indications that are compatible with the pedestrian signal housing.

Supply LED indications that have a guarantee to be replaced or repaired if a signal indication fails to function as intended due to workmanship or material defects within the first 60 months of operation. Furnish LED indications that work with a conflict monitor utilizing NEMA-plus functions, specifically dual indication.

- B. Signal Housing.** Assemble the signal head housing sections together in a watertight assembly. Each section must house an individual optical unit complete with a one-piece hinged door, a mounting for the lens and other optical system parts, watertight gaskets, and a non-corrodible door-lock.

Construct the optical system so the individual components swing open for access or removal. Ensure sections are interchangeable and constructed so sections can be added or removed. Each section must have a round opening in the bottom and top to receive a 1½-inch (38 mm) supporting pipe frame. The housing, including the doors and end plates must be die-cast aluminum, clean and smooth, free from flaws, cracks, blow holes, or other imperfections. Hinges, pins, lens clips, and locking devices must be non-corroding metal.

Mount a terminal block inside at the back of the housing. Wire all sockets with a white wire connected to the socket shell and a black wire to the bottom or end terminal of the socket. Connect these wires to the terminal block mounted in the housing.

The terminal block must have studs to terminate all field wires and lamp wires independently. Permanently identify the terminals.

Use paint in accordance with Section 710. Factory-enamel signal heads and fittings black or dark olive-green as to not require painting in the field. Apply one coat of primer and two coats of enamel to signal heads and other components, including the outside of visors and backplate backs.

Use the same color for like components in the same intersection.

Furnish with each section of each vehicle signal head, a removable tunnel visor (open bottom) of the appropriate size made from at least 0.050-inch (1.3 mm) thick aluminum. Factory apply two coats of flat black enamel to visor interiors, in accordance with this subsection.

**C. Backplates.** Furnish and install back plates on all traffic signal heads to form a 5-inch (130 mm) border around the signals. Make backplates from at least 0.058-inch (1.5 mm) sheet aluminum. Factory apply 2 coats of flat black enamel to front faces of backplates, in accordance with Subsection 703.08(B). Furnish backplates with a 2-inch (50 mm) wide yellow strip of Type IX retro-reflective sheeting. Apply the sheeting around the outer edge of the backplate.

**D. Mounting Brackets.** Mount signal heads using brackets made from 1½-inch (38 mm) standard steel pipe and malleable iron or brass pipe fittings. The slip fitter must fit over a 4-inch (103 mm) standard pipe. Provide each slip-fitter with two rows of three set screws in each row to plumb the assembly. Provide cadmium plated set screws.

Provide each compartment with a terminal block with twelve terminals, each with 2 pressure type connectors. Size each connector to accommodate at least 5 No. 14 conductors.

Provide the terminal compartment with an access opening to the terminal block with a rain-tight cover. All slip-fitters and terminal compartments must be made of non-frangible metal.

**E. Optically-programmed Traffic Signals.** The traffic signals must be optically-programmed and visible only to a specific area of the intersection. Meet all other contract requirements for construction or signal heads.

Use LED programmable visibility modules for optically-programmed signals that are compatible with the signal heads.

### 703.09 LOOPS

Furnish preformed and prefilled detector loops constructed from conduit. Use one continuous length of stranded No. 12 XHHW or stranded No. 14 THHN or TFFN conductor from the pull box, through the loops and returning back to the pull box. Construct loops using continuous ⅜-inch (9.5 mm) conduit for No. 14 conductor or ¼-inch (19 mm) conduit for No. 12 conductor.

Completely fill the conduit with hot rubberized asphalt or an approved flexible sealant to prevent incursion of moisture, and to set the turns of wire firmly in place.

Encase lead-in wires in a non-conductive 2,250 psi (15,500 kPa) flex hose constructed with a seamless extruded polyester fiber braid reinforcement and a non-conductive, seamless extruded urethane non-perforated jacket. Fill the lead-in hose completely with hot rubberized asphalt or flexible sealant. Twist wires in all lead-ins a minimum of 2 turns per foot (305 mm) for the entire length of the lead-in. Attach lead-ins to loop heads with a schedule 80 CPVC tee and a CPVC adapter bushing. Supply loops with sufficient lead-in to reach adjacent pull boxes. Use a continuous conductor without splices throughout the entire loop and lead-in hose.

### **703.10 PEDESTRIAN PUSH BUTTONS**

Furnish tamper-proof pedestrian push buttons using a piezo type switch meeting ADA requirements. The push button must be flush with the housing and be at least 2 inches (50 mm) in the smallest dimension. The push button housing must be weatherproof, and electrically insulated to prevent shock under all weather conditions. Furnish a dark olive green housing back plate to fit the pole curvature and, when required, provide saddles to make a near fit. Furnish push button signs shown in the contract.

#### **703.10.1 Accessible Pedestrian Signals (APS) (Tactile Push Buttons)**

Furnish APS that include the pedestrian pushbutton and housing combination. The pushbutton must be in accordance with Subsection 703.10. The housing must have a locator tone to indicate the location of the button. The volume of the locator tone must be adjustable by digital means and must automatically adjust to ambient noise level. The volume over ambient noise level must be adjustable in increments of 5 decibels (dB). The button must have a raised arrow, which can be adjusted to point toward the appropriate crosswalk. The button and housing combination must also provide feedback that a call for service has been placed. The feedback must be in the form of a lit LED and an audible indication. The accessible signal must also provide vibro-tactile information, in the form of the button vibrating during the appropriate Walk signal. The pedestrian signals must operate without any additional equipment in the signal cabinet, or additional signal conductors from the cabinet.

When voice messaging is required, provide accessible pedestrian signal stations with custom voice messages that provide location information on a button push, and street crossing message when the appropriate walk signal activates. The voice messages will be in the following format:

- Voice on location (VOL): Wait to cross (Street to be crossed) at (Intersecting Street).
- Walk Message: (Street name being crossed). Walk sign is on to cross (Street name to be crossed).

### **703.11 LUMINAIRES**

Furnish and install luminaires and lamps meeting these specifications and the contract requirements.

Wire all luminaires for 240-volt operation.

Furnish and install clear high pressure sodium vapor lamps having a 24,000 hour rated life.

Meet the following wattage and initial lumens requirements:

1. 200 Watt: 22,000 initial lumens.
2. 250 Watt: 27,500 initial lumens.
3. 400 Watt: 50,000 initial lumens.

Ballasts and luminaire must be integral, with the ballast providing  $-20^{\circ}\text{F}$  ( $-29^{\circ}\text{C}$ ) starting capacity. Multiple ballasts must be 240 volt regulated lag type, 0.90 power factor, with an operating range of  $\pm 10\%$ . Starting and open circuit volt-amperes must not exceed operating values.

Furnish the unit with an independent, replaceable starting board.

The luminaire assemblies must be slip-fitter type, end mounted on a 2-inch (50 mm) pipe tenon.

Furnish ANSI/IES full-cutoff (flat lens), medium, type III distribution luminaires.

### **703.12 PHOTOELECTRIC CONTROLS**

Furnish photoelectric control units of the twist-lock type.

Furnish units that turn on at  $1.3 \pm 0.5$  foot candles, have a turn-on/off ratio in the range of 1:2 to 1:5, and are rated for a minimum of 1,000 watts at 120 volts.

Incorporate a time delay mechanism into the control preventing operation during brief light condition changes.

Provide a fail-safe that leaves the load on or becomes energized if the control fails.

### **703.13 RADIO ANTENNAS**

#### **703.13.1 Master Antenna**

Furnish an omnidirectional antenna with the following specifications:

1. Frequency range of 890 MHz to 960 MHz;
2. Gain of 6 dBd;
3. Impedance of 50 ohms;
4. Termination with a type "N" connector, and;
5. Wind survival rating of 125 mph (200 kph).

#### **703.13.2 Yagi Antenna**

Furnish a yagi antenna for mounting on traffic signal poles as shown in the detailed drawings that meets the following specifications:

1. Frequency range of 896 MHz to 960 MHz;
2. Front to back ratio of 20 dB;
3. Nominal gain of 10 dBd; and
4. Bandwidth of 90 MHz.

Furnish an antenna that withstands wind speeds of 100 mph (160 kph), plus a 1.3 gust factor. Construct the antenna of rust resistant, corrosive free materials. Provide an antenna that has  $\frac{3}{8}$ -inch (10 mm) coaxial cable meeting Subsection 703.05.6 integrally attached by the manufacturer.

### **703.14 CLASS 4 TREATED TIMBER POLES**

Furnish the pole length and place as specified in the contract.

Furnish ANSI Class 4 poles as specified in the contract. Full length pressure-treat poles with a 5% solution of pentachlorophenol or copper naphthenate (CuN) in accordance with AWPA Standards and Commodity specification D and use category 4A.

### **703.15 OVERHEIGHT DETECTOR**

An overheight detector consists of a transmitter and receiver each mounted on an adjustable metal pole. Furnish detectors meeting the following requirements:

- Operating voltage: 115 AC  $\pm$  10%
- Operating temperature range:  $-40$  °F ( $-40$  °C) to 130 °F (54 °C)
- Detector beam: infrared or visible-red LEDs
- Alarm output adjustment: 5 to 30 second duration

Ensure the detector can discern the vehicles direction of travel and is able to detect vehicles traveling between 2 mph (3.2 km/h) and 90 mph (145 km/h).

The transmitter and receiver must mount on metal poles that permit adjusting the detector height from 10 to 16 feet (3.1 to 4.9 m).

**SECTION 704  
SIGNING MATERIALS**

**704.01 MATERIAL FOR SIGNS**

**704.01.1 Sheet Aluminum**

Use aluminum alloy in accordance with the Aluminum Association alloy AA5052-H38 or AA6061-T6 requirements. Meet the sheet thickness requirements listed in Table 704-1.

**TABLE 704-1  
SINGLE POST MOUNTING**

Sign Size Inches (mm)	Thickness Inches (mm)
<b>Regulatory Series Without Back Bracing</b>	
0 to 33 (0 to 838) wide, inclusive	0.080 (2)
34 to 41 (864 to 1,041) wide, inclusive	0.100 (2.54)
42 to 51 (1,067 to 1,295) wide, inclusive	0.125 (3.17)
<b>Warning Series Without Back Bracing</b>	
30 x 30 (762 x 762) or smaller	0.080 (2)
36 x 36 (914 x 914)	0.080 (2)
48 x 48 (1,219 x 1,219)	0.100 (2.54)
60 x 60 (1,524 x 1,524)	0.125 (3.17)
<b>Delineator Reflectors</b>	
All sizes	0.063 (1.6)
<b>All Signs With Back Bracing</b>	
Maximum Back Brace Spacing Thickness	Thickness Inches (mm)
≤ 32 (813)	0.080 (2)
≤ 40 (1,016)	0.100 (2.54)
≤ 50 (1,270)	0.125 (3.17)

Use the sheet thickness shown in the regulatory series for the route marker series, using the widest point on the cut-out shield for the width dimension. Make all signs not listed above from 0.080-inch (2 mm) thick sheeting.

**704.01.2 Aluminum Sheet Increment**

Construct aluminum sheet increment signs using AA5052-H38 or AA 6061-T6 sheet aluminum (thickness in Subsection 704.01.1) fastened to an extruded T-section (AA6063-T6) back brace with  $\frac{3}{16}$ -inch (5 mm) blind rivets. Use the back brace and rivet spacing shown in the Detailed Drawings. Use extruded T-sections weighing a minimum 0.88 pounds per linear foot (1.3 kg/m) with a minimum moment of inertia about the neutral axis of 0.40 inches<sup>4</sup> (166.5 mm<sup>4</sup>).

**704.01.3 Plywood**

Use douglas fir meeting the *Commercial Standard 45 for Douglas Fir plywood*, B-B high density overlay, 60/60 with plastic overlay, both sides,  $\frac{3}{4}$ -inch (19 mm) thick. Do not use plywood on multiple post installations.

**704.01.4 Aluminum and Steel Posts**

**A. General.** Furnish posts meeting the contract requirements. Treat steel post field cuts and holes with one coat of metal primer and two coats of aluminum paint. Coat galvanized posts meeting AASHTO M 111 specifications.

**B. Steel Posts.**

1. **Structural Steel.** Furnish structural steel posts having a nominal weight exceeding 3 pounds per foot (4.5 kg/m) meeting ASTM A36 requirements. Bid these posts as “steel structural sign posts”. Paint the posts meeting the Detailed Drawing requirements.
2. **Steel U Sign Posts.** Furnish steel posts formed into a “flying U” shape having a nominal weight exceeding 3 pounds per foot (4.5 kg/m) meeting AASHTO M 281. Bid these posts as “steel U sign posts”.
3. **Tubular Steel Posts.** Furnish round tubular steel posts meeting ASTM A53 Type E or S, Grade B requirements. Furnish square or rectangular tube posts meeting ASTM A500 or A501 requirements. Painted or galvanized posts are acceptable. Meet ASTM A123 requirements for galvanizing. Paint the posts in accordance with the Detailed Drawing.
4. **Square Tubular Steel Posts.** Ensure that all square tubular perforated and non-perforated steel post telescoping devices meet the velocity change criteria of the current AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. Furnish square tubular steel sign posts, anchor posts, anchor sleeves, and splice sleeves meeting one of the following requirements:
  - a. ASTM A653 Grade A steel in 10 or 12 gauge having a 33,000-psi (22.7 MPa) minimum yield strength and a 45,000-psi (31 MPa) minimum tensile strength.
  - b. ASTM A570, steel in 12 or 14 gauge having a 60,000-psi (41.4 MPa) minimum yield strength and a 75,000 (51.7 MPa) minimum tensile strength. Use ASTM A307 Grade 2 bolts and nuts. Ensure the sign posts, sleeves, anchor posts, auxiliary fittings and anchor sleeves have  $\frac{7}{16}$ -inch (11 mm) diameter holes or knockouts on 1-inch (25 mm) centers on all four sides. The permissible pole straightness variation is  $\frac{1}{16}$ -inch in 3 feet (1 mm/m) with the corner radius being  $\frac{5}{32}$ -inch (4 mm)  $\pm$   $\frac{1}{64}$ -inch (0.4 mm).

Coat the post with Type 2 aluminum paint at a minimum 0.75 ounces per square foot (228 kg/m<sup>2</sup>) of surface area, measured by triple spot testing under AASHTO T 213. Follow with a chromate conversion coating, and a thin acrylic or polymer resin film; or a triple coating of hot dipped zinc weighing 0.60  $\pm$  0.15 ounces per square foot (183 kg  $\pm$  4.3 kg/m<sup>2</sup>) in accordance with AASHTO M 120, followed by a chromate conversion coating 15  $\pm$  5 micrograms per square inch (645 mm<sup>2</sup>), and a clear organic coating 0.2  $\pm$  0.1 mils (0.005 mm  $\pm$  0.0025 mm) thick on the outside surface. Provide double in-line application of a full zinc-based organic coating 1.2  $\pm$  0.6 mils (0.003 mm  $\pm$  0.0015 mm) thick tested in accordance with ASTM B117 on the inside surface.

**C. Aluminum U Posts.** Furnish aluminum posts made of AA6061-T6 alloy extruded to a U-channel in accordance with ASTM B209.

**D. Breakaways.**

1. **Structural and Tubular Steel.** Furnish frangible bolt devices and reduced section (or perforated) fuse plates. Use devices commercially manufactured and designed in accordance with AASHTO’s current edition of *Standard Specifications for Structural Steel Support for Highway Signs, Luminaires and Traffic Signals*, crash tested and approved for use by FHWA.

- 2. Square Tubular Steel Posts.** Furnish slip base breakaway devices in accordance with the Detailed Drawings. Ensure the breakaway device meets the velocity change criteria in accordance with AASHTO's current edition of *Standard Specifications for Structural Steel Support for Highway Signs, Luminaires and Traffic Signals*, for both single tube and telescoping installations.

#### 704.01.5 Reserved

#### 704.01.6 Treated Wood Posts and Poles

Timber poles are specified by the top diameter. Meet Table 704-2 top diameter limits:

**TABLE 704-2  
TIMBER POLE - TOP DIAMETER LIMITS**

Specified Top Diameter inch (mm)	Diameter Limits inch (mm)	
	Min.	Max.
3 (75)	3 (75)	4 (100)
4 (100)	4 (100)	5 (130)
5 (130)	5 (130)	6 (150)
6 (150)	6 (150)	7 (180)

Furnish posts and poles 10 feet (3 m) in length or less free of crooks and sweeps greater than  $\frac{3}{4}$ -inch (19 mm) from the post centerline. The maximum offset from centerline for posts and poles longer than 10 feet (3 m) is  $\frac{3}{4}$ -inch (19 mm) plus  $\frac{1}{16}$ -inch (2 mm) per additional foot of length. The centerline is defined as a straight line from the center of the tip to the center of the butt. Gain and chamfer posts and poles in accordance with the Detailed Drawings. Perform all machining before treatment. Full length pressure-treat all timber posts and poles in accordance with Subsection 706.04.1, regardless of length.

Treat round posts and poles in accordance with AWPA *Standards for Commodity* specification B and use Category 4A, regardless of length. Supply round posts and poles meeting the AWPA minimum penetration requirements specified for natural posts and poles, with a penetration of at least  $\frac{3}{8}$ -inch (9 mm). Posts and poles must have sufficient sapwood to provide the  $\frac{3}{8}$ -inch (9 mm) minimum penetration.

Gain each post and pole on the sign face at least 2 inches (50 mm) in width in accordance with the Detailed Drawings.

Use construction grade 2 x 4-inch (38 x 89 mm actual thickness), pressure treated in accordance with Subsection 706.04, in S4S for back bracing.

#### 704.01.7 Reserved

#### 704.01.8 Overhead Structures

Furnish overhead sign structures in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, including fatigue requirements in Section 11.

Include fatigue design requirements for all sign structures as follows:

- Design life: 50 years
- Fatigue Category: 1
- Galloping: cantilevered structures only
- Truck-Induced gusts: posted speed limit
- Natural wind gusts

**704.01.9 Concrete**

Use Class General concrete in accordance with Section 551 for steel sign post foundations. Hand mixing is not allowed. Add an air entraining agent to all foundation concrete.

**704.01.10 Retro-reflective Sheeting**

**A. General.** Furnish the type of retro-reflective sheeting and color specified in the contract.

Use traffic control sheeting in accordance with ASTM retro-reflective sheeting on the traffic control devices specified in Table 704-3.

The following traffic control devices in the traffic control rate schedule require ASTM designated retro-reflective sheeting as specified. Provide orange sheeting that is fluorescent. All other sign colors need not be fluorescent:

**TABLE 704-3  
ASTM RETRO\_REFLECTIVE SHEETING REQUIREMENTS**

Traffic Control Rate Schedule Group No.	Specification	Type
1-15, 18 (sign panel), 19, 25 (panel) and all other work zone sign faces (e.g. flag person paddles, pilot car signs, etc.)	ASTM D4956	XI, X, IX VIII, VII or VI
17, 23, 27, 28 and all cones and tubular markers	ASTM D4956	III or V

Reflective sheeting may only be overlaid on reflective sheeting of the same color. Remove any existing legend prior to overlaying.

**B. Letters - Direct Applied.** Furnish letters, numerals, symbols, and borders from Type III sheeting, permanently adhered to the sign face reflective sheeting.

Apply the letters, numerals, symbols, and borders following the sheeting manufacturer's recommendations. Follow the size, series, and spacing in the FHWA's *Standard Alphabets* proportion and spacing requirements.

Use finished pieces that are clean cut, free of ragged borders.

**C. Acceptance.** Submit manufacturer's certification that the retro-reflective sheeting used meets the designated ASTM type retro-reflective requirement specified.

The Department may take sheeting samples for analysis and testing. The Project Manager may visually compare the sheeting's diffuse day color in the field using standard color charts and test the signs retro-reflectivity using a retro-reflectometer.

Replace rejected material at Contractor expense.

**704.01.11 Reserved****704.01.12 Paint**

Use paints in accordance with Section 710.

**704.01.13 Hardware**

**A. Miscellaneous.** Use bolts, washers, nuts, lock washers, incidental hardware, and angles for erecting aluminum sheet and plywood signs that are:

1. Galvanized in accordance with ASTM A153 or ASTM B633; or
2. Aluminum alloy in accordance with ASTM B211 for alloy 2024-T4.

**B. Hinges.** Use only non-rusting hardware of like material. When mounting on Aluminum sheeting for folding signs, use hinges that are:

1. Aluminum alloy in accordance with ASTM B211 for alloy 2024-T4; or
2. Stainless steel in accordance with ASTM A276.

## 704.02 FABRICATION OF SIGNS

### 704.02.1 Aluminum Signs

Provide a reflectorized sheet background. Clean rust, white rust, oil, and dirt from the aluminum sheeting. De-grease the sheeting using vapor or alkaline de-greasing agent following the de-greasing agent manufacturer's recommendations. De-grease, acid or alkaline etch, rinse, and dry the sheeting as recommended by the etching solution manufacturer.

Treat the etched sheeting with a light, tight adherent chromate conversion coating before applying the reflective sheeting. This coating must not leave a powdery residue and may leave a silvery iridescence to pale yellow appearance. Coat in accordance with ASTM B449, Class 2, 10 to 35 milligrams thick per square foot (0.093 m<sup>2</sup>). Hot air dry the sheeting once coated. Apply and seal the reflectorized sheeting on the prepared aluminum sheeting following the reflective sheeting manufacturer's recommendations. Apply legends and borders in accordance with Subsection 704.01.10(B).

Color the blind rivet heads to match the sign face. Apply background material to the sheet aluminum before fabricating the sign. Butt the sheet increments together to produce a joint that meets the specified tolerances limits.

Do not use water to float the reflective sheeting or legends into place during fabrication.

### 704.02.2 Plywood Signs

Provide a reflective background. Seal all wood edges, including interior joints, before fabrication using one coat of exterior aluminum paint followed by one coat of enamel, colored to match the reflective background sheeting. Apply the reflective sheeting and seal the edges following the sheeting manufacturer's recommendations.

**A. Screen-processed Legend and Borders.** Screen process or reverse-screen process the legend and borders on reflectorized backgrounds meeting the contract requirements. Use the process and paints recommended by the sheet manufacturer.

**B. Reflective Sheeting Legend and Borders.** Cut the legend and borders from Type III sheeting.

Do not splice legend characters. Apply legends following the sheeting manufacturer's recommendations. Do not use water to float the reflective sheeting or legend into place during fabrication.

**C. Demountable Reflective Legend and Borders.** Fabricate demountable legend in accordance with Subsection 704.01.10(B). Furnish the letter type specified in the contract. Letters cannot be spliced. Make borders and median sections in the longest pieces possible. Butt all joints with no overlap.

### 704.02.3 Inspection and Acceptance

Completed signs will be inspected where fabricated for acceptance. Signs will be rejected for defects including, but not limited to cracks, tears, splits, crazing, gouges and curled edges of background sheeting or legends.

## 704.03 FLEXIBLE DELINEATORS

Furnish delineator material that is impact resistant within a temperature range of -30 to +130 °F (-34.4 to +54.4 °C). Ensure the material from which the vertical tube post is fabricated flexes upon impact and results in little or no damage to impacting vehicles. Use a delineator that is ultra violet stabilized and resistant to ozone and hydrocarbons. Ensure the delineator design allows for quick and easy removal and replacement of delineator tube with only the use of common hand tools. Use delineators that are listed on the QPL and in accordance with NCHRP 350 or MASH requirements.

Ensure the delineator is flexible, self-erecting to original position and capable of withstanding numerous impacts from a direction without splitting, breaking or detachment from the base or the surface to which the base is attached.

Use delineators with a minimum height of 36 inches (915 mm) and width configuration that allows a minimum of 46.5 square inches (300 cm<sup>2</sup>) of retro-reflective sheeting to be affixed at the top of the post. Place retro-reflective sheeting completely within the top 9 inches (230 mm) of the delineator. Ensure color, area and configuration of retro-reflective sheeting equals that required by the standard drawings for the type of delineator specified. Use a post color that matches the attached sheeting.

Provide the mounting as specified in the contract.

- A. Surface Mount Flexible Delineators.** Ensure base material is flexible, high impact composite material with a maximum of 72 square inches (464 cm<sup>2</sup>) surface area and capable of being mechanically attached to the mounting surface.
- B. Driveable Flexible Delineators.** Ensure anchor is made of rigid materials and cannot collapse or buckle when driven into dense soil. Metallic materials must be galvanized. Ensure anchor is driveable with manual or common installation tools.

## **SECTION 705 GUARDRAIL**

### **705.01 GUARDRAIL**

Furnish metal beam and cable guardrail materials in accordance with the contract.

#### **705.01.1 Steel Beams and Fittings**

Furnish steel beam guardrail in accordance with AASHTO M 180, Class A, Type 1 requirements. Supply rail in lengths that place the splices on posts. Shape rail to be erected on curve radii less than 150 feet (45.75 m) before erecting.

Use ASTM A307 bolts with ASTM A563, Grade A or better nuts. Use ANSI B27.2, Type A plain steel washers.

Galvanize all bolts, nuts, washers, and fittings in accordance with ASTM A153 or B695 (Class 50).

Furnish rounded end sections, buffer sections, and terminal connectors in accordance with AASHTO M 180, Class B, Type 1.

#### **705.01.2 Wood Posts and Blockouts**

Furnish wood posts and blockouts made from Douglas fir, Hemlock, Ponderosa Pine, Spruce, Larch, Southern Yellow Pine, or Lodgepole pine. Furnish posts that are straight, sound, free from defects, and meet the dimensions specified in the contract.

Meet the Western Wood Products Association requirements or equivalent grading rules for No. 2 grading or better in accordance with ASTM D245.

Ensure the posts surfaces do not vary more than 1-inch (25 mm) from a straight line connecting the ends. Saw the wood posts before treating. Ensure the wood posts and blockouts are seasoned to accept the specified treatment in accordance with Subsection 705.03.1.

Other acceptable blockouts may be manufactured from recycled plastic or recycled plastic with wood fibers provided they meet the requirements of Subsection 606.03.1.

Use only one type of blockout in each run of guardrail.

#### **705.01.3 Concrete Posts**

Furnish precast concrete posts in accordance with the contract. Use Class General concrete or concrete of equal strength in accordance with Section 551. Manufacture, transport, and handle guardrail posts in accordance with Section 554. Use reinforcing steel in accordance with Section 711.

#### **705.01.4 Lightweight Concrete Guardrail Posts**

Lightweight aggregates may be used in manufacturing guardrail posts.

Produce both fine and course aggregates for lightweight concrete by expanding, calcining, or sintering blast furnace slag, clay, diatomite, shale, or slate.

Meet AASHTO M 195 aggregate requirements. Use separate fine and course aggregate. Use fine aggregate in the No. 4 (4.75 mm) to 0 size. Use course aggregate of either ¾-inch (19.0 mm) to No. 4 (4.75 mm) or ½-inch (12.5 mm) to No. 4 (4.75 mm).

Meet a minimum compressive strength of 3,000 psi (20.7 MPa) (equal to Class General concrete) with a maximum absorption of 15% by volume and a maximum unit weight of 115 pounds per cubic foot (1,864 kg/m<sup>3</sup>). Aggregate pre-wetting may be required.

Use reinforcing steel in accordance with Section 711. Steel size and shape is specified in the contract.

The AASHTO M 195 Freeze-Thaw test is not required.

**705.01.5 Steel Posts**

Furnish steel posts for cable guardrail in accordance with the contract. Spot paint all bruised, broken, scaled, or damaged coating on steel posts with two coats of cold galvanizing compound following the paint manufacturer's recommendations.

Furnish minimum 6-foot (1830 mm) long steel guardrail posts for steel beam guardrail.

Ensure that steel guardrail posts and associated hardware meets the AASHTO *Guide to Standardized Highway Barrier Hardware* (Task Force 13 Report).

**705.02 WIRE ROPE AND CONNECTING HARDWARE**

Furnish wire rope and hardware for cable guardrail in accordance with the contract.

**705.03 WOOD TREATMENT AND PAINTING****705.03.1 Wood Treatment**

Furnish wood posts and blocks pressure treated in accordance with Subsection 706.04.1 using commodity specification A with retention specifications from commodity specification B, use category 4B. Chamfer and perform other required framing and boring of bolt holes before post treating. Plug drill holes used for determining preservative penetration depth with tight fitting treated wood plugs.

**705.03.2 Painting**

Use paint and perform painting in accordance with the contract.

## **SECTION 706**

### **TREATED AND UNTREATED TIMBER**

#### **706.01 STRUCTURAL TIMBER AND LUMBER**

Furnish timbers and lumber being:

- A.** Standard sawn Douglas fir or Larch.
- B.** Graded under the current West Coast Lumber Standard Grading Rules or the Western Lumber Grading Rules.
- C.** Grade stamped by an American Lumber Standards certified inspection agency.

The recommended design values under the rules for grading timbers and lumber grades cannot be less than those shown in the contract for the required minimum timber stress.

Note the grade, the grading rule, and the recommended design stress value for that rule on the shop drawings for each size.

Use only pieces of sound wood free from all decay.

When untreated timber is specified, it must show at least 85% heartwood on the girth, measured where the least amount of heartwood occurs on any girth. When treated timber is specified, there are no heartwood requirements and the sapwood amount is not limited.

#### **706.02 RESERVED**

#### **706.03 POLES AND POSTS**

Furnish the poles and posts in accordance with the contract.

#### **706.04 TREATED TIMBER AND LUMBER**

Furnish structural timber and lumber treated with a wood preservative specified as follows.

##### **706.04.1 Treating**

Furnish timber and lumber that is pressure treated meeting the preservative retention and penetration requirements found in AWPA Standards U1 and T1, Commodity Specification A, B or D, use category 4A, appropriate for the application of material.

Use one of the following preservatives:

- 5% by weight solution of pentachlorophenol meeting AWPA Standards P35 using solvent meeting AWPA P9 Type A
- CCA, Type C meeting AWPA Standard P23.
- CuN solution meeting AWPA Standard P36 using solvent meeting AWPA P9 Type A.

Treated timber or lumber to receive paint must permit the paint to adhere to the treated surface without discoloration.

Meet AASHTO M 133 requirements for all preservatives and their sampling and testing methods.

Treat injuries, cuts, and holes in wood after treatment with three applications of copper naphthenate solution containing a minimum of 2% copper metal or with CCA meeting AWPA M4 requirements.

##### **706.04.2 Incising**

Mechanically incise timber and lumber as specified in Section 8 of Commodity Specification A, part 12 of AWPA Standard T1 having a nominal thickness of 2 inches (actual 38 mm thickness) or greater before treating.

Incise timber and lumber 3 inches (63 mm actual thickness) thick or greater on all four sides. Incise timber and lumber less than 3 inches (63 mm actual thickness) thick on the wide faces only, unless otherwise specified. Ensure incision depth and pattern for all material are dense enough to achieve uniform depth of penetration as specified in Section 8 of Commodity Specification A, part 12 of AWPA standard T1. Incise Intermountain Douglas Fir then treat to

refusal with preservative and retention requirements meeting AWPA standards listed in 706.04.1. Refusal being specified as the pressure and temperature shall be maintained constant or be increased within a range with good practice for the material being treated until the quantity of preservative absorbed in each of any two consecutive half hours is not more than 2% of the amount already injected. 1½-inch (38 mm actual dimension) center-matched material used for flumes, boxes, etc., does not need to be incised.

Ensure incised wood meets the penetration and retention requirements appropriate for identified Use Category Commodity Specification.

### **706.04.3 Inspection**

Wood products will be inspected in accordance with MT 404. Only wood products with worm holes and any staining due to fungus will be inspected in the white along with the moisture content of Intermountain Douglas Fir. For inspecting wood in the white a minimum of 72 hours advanced notice must be given and must be traceable from inspection in the white to inspection of the treated product. If stain is present in the wood use only material with blue stain. The correct moisture content for Intermountain Douglas Fir is 22% ± 2% and the method to obtain this moisture content is outlined in the AWPA standards.

The acceptance of any material or finished members by the Inspector does not prevent their rejection if found defective. Replace rejected material and work at Contractor expense.

## SECTION 707 JOINT MATERIALS

### 707.01 CONCRETE JOINT FILLERS

#### 707.01.1 Concrete Pavement

- A. **Expansion Joint Filler.** Furnish expansion joint filler Type II cork in accordance with AASHTO M 153.
- B. **Joint Sealing Material.** Furnish sealing material for all types of pavement joints that is a hot-poured thermoplastic rubber or rubber asphalt compound in accordance with AASHTO M 324, furnished in one grade only. Use ready-mixed, cold applied joint fillers for sealing concrete pavement joints only with the Project Manager's prior written approval.

#### 707.01.2 Concrete Structures Other than Pavement

- A. **Expansion Joint Filler.** Furnish Type II cork pre-formed expansion joint filler in accordance with AASHTO M 153.
- B. **Expansion Joint System.** Furnish expansion joint system in accordance with the contract.
- C. **Silicone Joint Seal.** Furnish silicone joint seal in accordance with the contract.
- D. **Fabric Reinforced Neoprene Joint Seal.** Furnish fabric reinforced neoprene joint seal in accordance with the contract.
- E. **Expansion Joint Asphalt Plug.** Furnish expansion joint asphalt plug in accordance with the contract.

#### 707.01.3 Concrete Curbs, Gutters, and Sidewalks

Use preformed expansion joint filler for concrete curbs, gutters, and sidewalks in accordance with AASHTO M 213.

### 707.02 CULVERT SEALERS

#### 707.02.1 Rubber Gaskets

Furnish ring gaskets in accordance with ASTM C1619.

#### 707.02.2 Flexible Joint Sealers

Furnish flexible joint sealants in accordance with ASTM C990.

### 707.03 SHEET COPPER, RUBBER, AND PLASTIC WATERSTOPS

#### 707.03.1 Sheet Copper

Furnish sheet copper for waterstops in accordance with ASTM B152 for copper sheet, strip, plate, and rolled bar, Type ETP with a nominal weight of 16 ounces per square foot ( $5 \text{ kg/m}^2$ )  $\pm$  8%.

#### 707.03.2 Rubber

Furnish molded or extruded rubber waterstops having a uniform cross section, free from porosity or other defects, and meeting the nominal dimensions specified in the contract. An equivalent standard shape may be furnished if approved. The waterstop may be compounded from natural rubber, synthetic rubber, or a blend of the two, together with other materials that produce a finished waterstop in accordance with the contract. Reclaimed material cannot be used. Furnish a manufacturer's certificate showing the material composition and the values for the designated properties in Table 707-1. Furnish samples when requested.

**TABLE 707-1  
PROPERTIES AND TEST METHODS - FINISHED RUBBER WATERSTOP**

<b>Property</b>	<b>Federal Test Method Standard No. 601</b>	<b>Requirement</b>
Hardness (shoredurometer)	3021	60 to 70
Compression set	3311	30% max.
Tensile strength	4111	2,500 psi (17 Mpa) min.
Elongation at breaking	4121	450% min.
Tensile stress at 300% elongation	4131	900 psi (6 Mpa) min.
Water absorption by weight	6631	5% max.
Tensile strength	7111	80% min. after aging original

### 707.03.3 Plastic

Furnish plastic waterstops manufactured from virgin PVC plastic or other material in accordance with Table 707-2.

**TABLE 707-2  
PROPERTIES AND TEST METHODS - FINISHED PLASTIC WATERSTOP**

<b>ASTM Standard</b>	<b>Property</b>	<b>Requirement</b>
D2240	Hardness	78 ± 3
D638	Tensile strength, min.	2000 psi (14 MPa)
D638	Ultimate elongation, min.	300%
D746 procedure B	Low temperature brittleness at -37 °C	no failure

Furnish for approval, a drawing or catalog cut of the waterstop intended for use, and a written certificate from the manufacturer that the waterstop meets the specifications.

**SECTION 708**  
**CONCRETE, PLASTIC, AND FIBER PIPE**

**708.01 REINFORCED CONCRETE PIPE**

**708.01.1 General**

Use cement in reinforced concrete pipe in accordance with AASHTO M 85 for portland cement.

Furnish reinforced concrete pipe produced by a manufacturing plant that has been approved by the Department before the contract award date.

The bid tabulations specify only the span dimension to the nearest inch (mm), of pipe arch culverts as shown in the Detailed Drawings for the culverts. The contract show both span and rise dimensions.

The Department will inspect and approve the equipment and methods for manufacturing, protecting, curing and storing pipe before fabrication.

Meet AASHTO M 55 requirements for reinforcement in circular or elliptical pipe.

Use Type V cement unless otherwise specified in the contract.

**708.01.2 Circular Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe**

Furnish pipe in accordance with AASHTO M 170, except that part 12.4 does not apply. Use a minimum wall B pipe.

**708.01.3 Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe**

Furnish pipe in accordance with AASHTO M 206 with Class A-III pipe strength requirements.

**708.01.4 Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe**

Furnish pipe in accordance with AASHTO M 207.

**708.01.5 Flared End Terminal Sections and Tee Risers**

Furnish flared end terminal sections and the riser of tee sections in accordance with AASHTO M 170 Class III pipe.

**708.02 CONCRETE PRESSURE PIPE**

Furnish reinforced concrete low head pressure pipe in accordance with ASTM C361.

**708.03 PERFORATED CONCRETE PIPE**

Furnish perforated concrete pipe in accordance with AASHTO M 175.

**708.04 POROUS CONCRETE PIPE**

Furnish porous concrete pipe in accordance with AASHTO M 176.

**708.05 PVC GRAVITY SEWER AND DRAIN PIPE**

**708.05.1 Pipe**

Furnish gravity pipe 4-inch through 12-inch (100 - 300 mm) nominal diameter produced by continuous extrusion and having self-extinguishing characteristics. The PVC plastic must have a cell classification of 12454-B, 12454-C, or 13364-B [minimum tensile modulus of 500,000 psi (34.5 MPa) as specified in ASTM D1784]. Meet ASTM D3034 requirements for pipe and fittings. Meet a minimum Standard Dimension Ratio (SDR) of 35.

Furnish perforated pipe in accordance with ASTM D2729.

Furnish pipe with nominal laying lengths of 12.5 feet (3.8 m), except for connections to manholes, inlets, and other appurtenances.

Ensure each pipe length is marked with nominal size, PVC cell classification, SDR, and ASTM designation.

**708.05.2 Pipe Joints**

Each pipe length must have a bell end. The bell must have an elastomeric rubber gasket in a retaining groove to provide a watertight joint when the pipe is joined. The rubber gasket must maintain a watertight joint under all service conditions including expansion, contraction, settlement, and pipe deformation movements. Make the joint connections following the pipe manufacturer's recommendations.

**708.05.3 Appurtenance Joints**

Make all connections to manholes, inlets, or other appurtenances watertight using rubber gaskets, waterstops, or non-shrink portland cement grout for grouted joints.

**708.06 PVC PRESSURE WATER PIPE****708.06.1 Pipe**

Furnish pressure PVC water pipe 4-inch through 12-inch (100 mm - 300 mm) nominal diameter in either Class 150 with a dimension ratio (DR) of 18 or Class 200 with a DR of 14 in accordance with AWWA Specification C-900. Pipe sections must be marked with diameter, code designation, DR, pressure class, and AWWA specification.

**708.06.2 Pipe Joints**

Each manufactured length of pipe must have an integral bell with an elastomeric gasket in a retaining groove that provides a watertight joint when joined.

**708.07 CORRUGATED POLYETHYLENE DRAINAGE PIPE**

Furnish heavy duty corrugated polyethylene drainage pipe or tubing and fittings in accordance with AASHTO M 252 (Type S – non-perforated or Type SP – perforated) requirements for nominal diameters 3 through 10 inches (80 - 250 mm) and AASHTO M 294 for nominal diameters 12 through 48 inches (300 - 1200 mm).

**708.08 HIGH DENSITY POLYETHYLENE PIPE**

Furnish and install polyethylene pipe and fittings manufactured from a PE 3408, PE 3608, or PE 4710 resin in accordance with ASTM D3350. Molded and fabricated butt fusion fittings must meet ASTM D3261 and have at least the same pressure rating as the pipe.

**708.08.1 Pressurized Polyethylene Pipe**

Furnish pressure rated polyethylene pipe less than or equal to 2-inch (50 mm) diameter in accordance with ASTM D2737. Use a class 200 with a DR of 7 for polyethylene pipe.

**708.08.2 Solid Wall Polyethylene Pipe**

Furnish solid wall polyethylene pipe greater than 2-inch (50 mm) in diameter in accordance with ASTM F714.

## **SECTION 709**

### **METAL PIPE**

#### **709.01 DUCTILE IRON AND STEEL WATER PIPE**

##### **709.01.1 Ductile Iron Pipe**

Furnish ductile iron pipe in accordance with AWWA C 151 for the pipe class specified in the contract.

Use mechanical or slip-on joints in accordance with AWWA C 111 (ANSI A 21.11). Construct the joints to provide electrical conductivity using bronze shims, or gaskets with metallic shims molded into the gasket.

##### **709.01.2 Steel Water Pipe**

Furnish steel pipe in accordance with AWWA C 200 Standard for Water Pipe, 6 inches (150 mm) and larger.

Field weld joints and bends in accordance with AWWA C 206. Meet AWWA C 203 requirements for shop and field coatings.

#### **709.02 CORRUGATED STEEL PIPE AND PIPE ARCHES**

Furnish corrugated steel pipe that is lock seam helically corrugated pipe or continuously welded seam corrugated pipe.

Furnish corrugated steel pipe and pipe arches and coupling bands in accordance with AASHTO M 36 (excluding projection bands under 9.1.3) and the following:

- A.** When pipe is cut and to be rejoined, matchmark cut pipe ends and rejoin the matching ends during installation.
- B.** When using corrugated locking bands, re-roll the pipe ends forming at least two annular corrugations. Unraveling of lock seams due to re-rolling pipe ends is a defect and the pipe will be rejected.

Repair zinc or aluminized pipe coating damaged by re-rolling using a zinc rich paint. Apply the paint to provide a minimum 0.005 inch (0.13 mm) thickness.

If flanges are provided on the pipe ends, the coupling may be made by interlocking the flanges with a preformed channel band or other band incorporating a locking channel in accordance with AASHTO M 36. These bands may be used only on pipes with diameters up to and including 36 inches (900 mm).

The coupling bands or devices other than those specified in AASHTO M 36 require the Project Manager's approval before use.

Meet the following additional requirements for syphon and irrigation pipe installations:

- 1.** Use lock seam helically corrugated pipe, or welded seam helically corrugated pipe;
- 2.** Continuously weld lock seams from end to end of each lock seam helically corrugated pipe section for syphon installations. Perform the welding after re-rolling the ends;
- 3.** For irrigation installations using lock seam helically corrugated pipe, weld the lock seams as specified above or fabricate by inserting a  $\frac{3}{16}$ -inch (5 mm) diameter continuous rubber chord meeting pipe industry standards into the lock seam during fabrication, in accordance with AASHTO M 36; and
- 4.** Construct watertight field joints. Make the connection using a 10½-inch (267 mm) wide "hugger" type band. Hugger bands must have O-ring gaskets. Lubricate and install gaskets and coupling bands following the manufacturer's recommendations.

The Project Manager may direct the fabricator to conduct a water-tightness test, witnessed by an Inspector, on the type or types of pipe and coupling devices to be furnished. Submit the test method to the Project Manager for approval before testing. Alternate test methods may be required.

**709.03 STEEL STRUCTURAL PLATE PIPE AND PIPE ARCHES**

Use galvanized corrugated steel structural plates and fasteners for constructing pipe in accordance with AASHTO M 167.

Bevel the end plates of structural steel pipe plate arches as specified in the contract.

Meet AASHTO M 167 requirements for allowable tolerance in span and rise for pipe arches.

Submit a supplier's itemized statement of the plate sizes for each shipment for field inspection of the plates. Department inspection will include examining pipe for deficiencies in the lengths of sheets used and evidence of poor workmanship. Samples may be taken for chemical analysis and weight of spelter coating.

**709.04 BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCHES, AND STEEL STRUCTURAL PLATE PIPE AND PIPE ARCHES**

Meet AASHTO M 243 pipe coating requirements except as modified below:

- Clean and dry the surface to be coated before applying the bituminous coating. Apply coating with the ambient air temperature at least 50 °F (10 °C) and rising. Coat the full circumference of the pipes outside and the bottom up to one third of the vertical height of the pipes inside circumference. Provide a coat thickness of at least 0.05 inch (1.3 mm).

**709.05 PRE-COATED, GALVANIZED STEEL CULVERTS AND UNDERDRAINS**

Meet AASHTO M 245, M 246 and Subsection 709.02 for irrigation and syphon pipe installations.

Provide a minimum 0.010-inch (0.25 mm) coating for both inside and outside surfaces in accordance with AASHTO M 246, Section 7.

**709.06 CORRUGATED STEEL PIPE FOR UNDERDRAINS**

Furnish pipe and coupling bands in accordance with AASHTO M 36. The class of underdrain in AASHTO M 36 is the Contractor's option.

Furnish semi-circular underdrain and coupling bands in accordance with AASHTO M 36 and the Detailed Drawings. Furnish nuts, caps, screws and other parts galvanized in accordance with ASTM A153 or B695 (Class 50). Furnish screens and caps for semicircular underdrains in accordance with the Detailed Drawings.

Furnish bituminous coated underdrains in accordance with AASHTO M 190. Nuts, bolts and screens must not be coated.

**709.07 CORRUGATED ALUMINUM PIPE AND PIPE ARCH CULVERTS**

Furnish corrugated aluminum pipe and pipe arch culverts in accordance with AASHTO M 196, and the modifications to AASHTO M 36 specified in Subsection 709.02.

**709.08 CORRUGATED ALUMINUM PIPE FOR UNDERDRAINS**

Furnish corrugated aluminum pipe for underdrains in accordance with AASHTO M 196.

**709.09 SEAMLESS STEEL PIPE**

Furnish seamless steel pipe in accordance with ASTM A53.

**709.10 COPPER PIPE**

Furnish copper pipe and tube in accordance with ASTM B88, Type K.

**709.11 SLOTTED CORRUGATED STEEL PIPE**

Furnish slotted corrugated steel pipe that is commercially fabricated with the grate and steel pipe an integral unit. Pressure or fusion weld the grate spacer bars to the bearing bar. Meet ASTM A36 requirements for grating materials galvanized after fabrication.

**709.12 TYPE II ALUMINIZED CORRUGATED STEEL PIPE**

Furnish pipe and coupling bands fabricated from material in accordance with AASHTO M 274. Ensure the prefabricated pipe and coupling bands are in accordance with Subsection 709.02.



## SECTION 710

### PAINTS

#### 710.01 PIGMENTS, VEHICLES, AND THINNERS

Ensure all materials from which paints are made and formulated are in accordance with the following specifications:

Aluminum Pigments .....	ASTM D962
Black Synthetic Iron Oxide Pigment .....	ASTM D769
Bone Black Pigment.....	ASTM D210
Calcium Carbonate Pigments.....	ASTM D1199
Carbon Black Pigment.....	ASTM D561
Chrome Oxide Green Pigment .....	ASTM D263
Chrome Yellow and Chrome Orange Pigments.....	ASTM D211
Lampblack Pigments.....	ASTM D209
Liquid Paint Driers.....	ASTM D600
Magnesium Silicate Pigments .....	ASTM D605
Mica Pigment .....	ASTM D607
Ochre (Ferrous Earthy Pigments).....	ASTM D85
Petroleum Spirits (Mineral Spirits) .....	ASTM D235
Raw and Burnt Sienna Pigments.....	ASTM D765
Raw and Burnt Umber Pigments .....	ASTM D763
Red and Brown Iron Oxide Pigments .....	ASTM D3722
Titanium Dioxide Pigments.....	ASTM D476
Yellow Iron Oxide Pigment-hydrated .....	ASTM D768
Zinc Dust (Pigment) .....	ASTM D520
Zinc Oxide Pigments .....	ASTM D79

#### 710.02 PAINTS AND ENAMELS

- A. General.** Follow the paint manufacturer's recommendations including but not limited to storage, application, thinning, safety precautions, and film thickness unless otherwise specified.

Furnish all paints under this section free of lead, or zinc chromate unless specified.

Provide the manufacturer's MSDS. Supply the paint in the original container labeled with the manufacturer's name, address, paint type, formula identification, date of manufacture, and lot or batch number.

Paints for structural steel where multiple coats are applied must be produced by the same manufacturer. Provide the Project Manager certified test results from an independent testing facility showing the following paints supplied meet the applicable requirements.

- B. Paints for Miscellaneous Metals.** Use the following paints on metal unless otherwise specified.

**1. Reserved.**

- 2. Aluminum Epoxy Paint.** Furnish aluminum epoxy paint that is a self-priming, two-component, high build, aluminum filled epoxy mastic. The paint must adhere to metal surfaces and existing painted surfaces when the surface is prepared following the paint manufacturer's recommendations.

Apply the coating following all the manufacturer's recommendations to produce a minimum 5 mil (0.125 mm) dry film thickness.

Meet Table 710-1 minimum paint composition requirements.

**TABLE 710-1  
ALUMINUM EPOXY PAINT COMPOSITION**

	<b>Composition</b>
Solids	90% ± 2% by volume (ASTM D2697)
Pigment	19% by volume
Vehicle	66% by volume
Percent non-volatile vehicle	74%
Nominal VOC	0.74 pounds per gallon (89.1 g/L)

The mixed paint must weigh between 11 to 12 pounds per gallon (1.3 to 1.4 kg/L) when measured in accordance with ASTM D1475 at 75 ± 2 °F (24 ± 1 °C).

The mix ratio of the two components must be 1:1 by volume and have a minimum pot life of 4 hours at 75 °F (24 °C) when thinned following the manufacturer's recommendations.

- 3. Epoxy Paint for Pipe Pile.** Furnish epoxy paint that is a two-component, self-priming epoxy coating in accordance with Table 710-2.

**TABLE 710-2  
EPOXY PAINT FOR PIPE PILE REQUIREMENTS**

	<b>Requirement</b>
Drying Time at 75 °F (24 °C) To Touch To Cure	2 hours max. 10 days max.
Pot Life at 70 °F (21 °C)	12 hours min.
Abrasion resistance (ASTM D4060; CS-17 wheel, 1,000 Gram load, 1,000 cycles)	170 mg loss, max.
Direct impact resistance (ASTM D2794)	60 inch-pounds (6.8 N-m) minimum

Additional requirements:

- a. **Salt Fog.** No blistering, cracking, or film delamination when tested in accordance with ASTM B117 for 1,500 hours; and
  - b. **Moisture Condensation Resistance.** No blistering, cracking, or film delamination when tested in accordance with ASTM D2247 for 1,000 hours at 100 °F (37 °C).
- 4. Equipment Enamel.** Furnish equipment enamel that is formulated using Federal Specification TT-E-489b, Class A, spray or brush consistency in accordance with the contract. Match the appropriate color chip, available from the Materials Bureau. Meet the thinner requirements of Federal Specification TT-T306. Use at a maximum rate of 1 pint per gallon (0.12 L/L) when required.
- 5. White, Yellow, and Black Enamel.** Furnish water resistant enamels made from synthetic gums capable of brush application to vertical metal surfaces without running, streaking, or sagging.  
Meet Table 710-3 requirements.

**TABLE 710-3  
ENAMEL PAINT REQUIREMENTS**

	<b>White</b>	<b>Yellow</b>	<b>Black</b>
Coarse particles and skins retained on No. 325 sieve (0.045 mm), max.	0.50%	0.50%	0.50%
Nonvolatile matter, min.	85%	85%	85%
Dry to touch at 70 °F (21 °C) time in hours, max.	5	5	5
Dry hard at 70 °F (21 °C) time in hours, max.	24	24	24
Toughness, Kauri reduction test at 75 °F (24 °C), min.	150%	150%	150%
Hiding power, square feet per gallon (m <sup>2</sup> /L) by Pfund cryptometer model E,	300	450	
Black plates, min.	(7.3)	(11)	

Meet federal test method standard No. 141C for whitening, dulling, or change in color, brushing, flowing, covering, and leveling properties.

The white enamel must be equal in brightness to rutile (Type IV) titanium dioxide pigment.

Yellow enamel must match standard color sample for D-2 yellow guardrail paint. Black enamel must be jet black and cover completely in one coat.

- 6. Zinc Phosphate Paint.** Zinc phosphate paint may be used as a primer or finish coat unless otherwise specified. Provide the finish paint color specified in the contract and match the appropriate color chip, available upon request. The paint must:
- a. Be well ground;
  - b. Show no skinning in a freshly opened, full can;
  - c. Not cake or settle in the container;
  - d. Readily break up with a paddle to a smooth, uniform consistency;
  - e. Brush easily, possess good leveling qualities; and
  - f. Dry to a hard uniform finish.

Meet Table 710-4 requirements.

**TABLE 710-4  
ZINC PHOSPHATE PAINT REQUIREMENTS**

	Requirement	
	Min.	Max.
<b>Pigment<sup>4</sup></b>	56.5%	58.5%
<b>Vehicle<sup>5</sup></b>	41.5%	43.5%
<b>Pigment Composition:</b>		
Zinc phosphate	60.0%	—
Titanium dioxide (Rutile) <sup>6</sup>	13.0%	—
Calcium carbonate	21.4%	—
<b>Vehicle Composition:</b>		
Alkyd phthalic resin (50% Solids)	52.4%	—
Raw linseed oil	26.2%	—
Mineral spirits	17.2%	—
Driers and additives	4.2%	—
<b>Finished Paint:</b>		
Consistency (Krebs-Stormer) <sup>1</sup>	70 KU	83 KU
Weight <sup>2</sup> , pounds per gallon (g/mL)	12.6 (1.51)	—
Dry to touch <sup>3</sup>		8 hours
Dry to handle <sup>3</sup>		16 hours
Dry film thickness, mil (mm)	1.0 (0.025)	—

## Notes:

1. By ASTM D562
2. By ASTM D1475
3. Federal Test Method Standards 141C Method 4061.2
4. Federal Test Method No. 141-Method 4021
5. Federal Test Method No. 141-Method 4051
6. ASTM D1394

**710.02.1 Paint Coating Systems for Structures**

- A. Epoxy Zinc Rich Primer.** Meet AASHTO M 300 Type I or II requirements, excluding those in Section 4.7.
- B. Intermediate Coat.** Use a two-component polyamide epoxy in accordance with Table 710-5.

**TABLE 710-5  
STRUCTURES - INTERMEDIATE COAT REQUIREMENTS**

	Requirement
Drying time @ 50 °F (10 °C) to touch tack free cure	4 hours max. 24 hours max. 14 days max.
Pot Life @ 50 °F (10 °C)	10 hours min.
Abrasion resistance (ASTM D4060, CS-17 wheel, 1,000 cycles)	224 mg max. loss
direct impact resistance	120 inch-pounds (13.6 N-m) minimum

Additional requirements:

1. **Salt Fog.** No blistering, softening, cracking or film delamination when tested in accordance with ASTM B117 for 1,000 hours; and
  2. **Moisture Condensation Resistance.** No blistering, rusting or delamination when tested in accordance with ASTM D2247 for 1,000 hrs. at 100 °F (37 °C).
- C. Finish Coat.** Provide urethane paint in accordance with Table 710-6.

**TABLE 710-6  
STRUCTURES - FINISH COAT REQUIREMENTS**

	Requirement
Drying time @ 50 °F (10 °C) to touch tack free cure	10 hours max. 24 hours max. 14 days max.
Pot life @ 50 °F (10 °C)	10 hours min.
Abrasion resistance (ASTM D4060, CS-17 wheel, 1,000 cycles)	224 mg. max. loss
Impact resistance	120 inch-pounds (13.6 N-m) minimum

Additional requirements:

1. **Salt Fog.** No blistering, softening, cracking or film delamination when tested in accordance with ASTM B117 for 1,000 hours; and
2. **Moisture Condensation Resistance.** No blistering, rusting or delamination when tested in accordance with ASTM D2247 for 1,000 hours at 100 °F (37 °C).

### 710.03 POWDER COATING PREQUALIFICATION AND CERTIFICATION

Provide certified test results of the tests shown in Table 710-7 for powder coated material. Submit certified test results and samples for approval. Only coatings approved are permitted to be used.

**TABLE 710-7  
CERTIFIED TEST RESULTS**

Test Name	ASTM Designation	Specification Limits
Salt spray test	D1654 (B117)	rating number minimum 6 (from Table 1) after 1000 hours
Impact test	D2794	80 inch-pounds (9.0 N-m) minimum
Cross hatch adhesion test	D3359	5A or 5B minimum
Hardness test	D3363	2H
Bend test	D522	180° bend ½-inch (12.5 mm) diameter mandrel with no breaks flaking or cracks
UV exposure	G154	1,000 hours no film failure
Thickness	G12	3 mil (0.075 mm) minimum
Abrasion taber abraser	D4060	1,000 gram 1,000 cycles 100 mg maximum weight loss

Submit two 4 x 4-inch (100 x 100 mm) by 24 gauge (0.51 mm) coupons along with the test results of the coating material used to the Project Manager. The coating must be representative of expected quality and color of coatings from a production line.

**710.04 ANTI-GRAFFITI COATING-PERMANENT**

Furnish a permanent, non-sacrificial siloxane-based anti-graffiti coating capable of withstanding multiple cleanings which is listed on the QPL. Coating must allow graffiti to be removed through the use of a water pressure washer and without detergents or chemicals. Product must be approved by the manufacturer for use on the intended material or surface and have a finished dry film thickness of not less than 6 mils (0.150 mm). Remove any graffiti prior to application of an anti-graffiti coating. Prepare the substrate surface, apply, cure, and maintain coating in accordance with the manufacturer's recommendations.

**SECTION 711**  
**REINFORCING STEEL, STRUCTURAL**  
**STEEL HARDWARE, AND**  
**MISCELLANEOUS STRUCTURE ITEMS**

**711.01 REINFORCING STEEL**

**711.01.1 Bar Reinforcing**

Furnish the specified reinforcing steel in accordance with AASHTO M 31.

The Project Manager may accept small lots of reinforcing steel subject to it passing the bending test specified in AASHTO M 31.

**711.01.2 Epoxy-coated Reinforcing Bars**

Furnish epoxy-coated reinforcing bars in accordance with ASTM A615 and the contract requirements. Epoxy-coating on reinforcing bars must be in accordance with ASTM A775 or ASTM A934.

Ensure the bars are coated by an applicator plant listed on the QPL and certified under the CRSI epoxy coating plant certification program for fusion-bonded epoxy applicator plants.

**711.01.3 Wire and Wire Mesh**

Furnish concrete reinforcing wire in accordance with AASHTO M 32.

Furnish wire mesh reinforcing for concrete in accordance with AASHTO M 55 and the contract.

Furnish bar mats AASHTO M 54.

**711.02 STRUCTURAL STEEL**

Furnish structural steel for:

**A. Bridge superstructure applications in accordance with AASHTO M 270.**

Use material in accordance with Charpy V-notch impact test requirements for zone 3 to fabricate webs, flanges in tension or stress reversal zones, splice plates, w-shaped rolled beams.

This requirement applies to diaphragms and diaphragm connection plates for horizontally curved girders.

**B. Other applications in accordance with AASHTO M 270.**

**711.03 STRUCTURAL STEEL TUBING**

Furnish structural steel tubing in accordance with ASTM A500, Grade B, for cold-formed welded seamless carbon steel structural tubing in rounds and shapes.

**711.04 PINS AND ROLLERS**

Furnish pins and rollers of annealed carbon steel forgings in accordance with AASHTO M 102, Class C requirements, or cold-finished carbon steel shaft in accordance with AASHTO M 169, Grades 1018 to 1030 inclusive. Fabricate pins and recessed pin nuts as detailed in the *AISC Manual of Steel Construction*.

**711.05 WELDING ELECTRODES**

Use welding electrodes in accordance with AWS, AASHTO, and the contract.

**711.06 HIGH TENSILE STRENGTH BOLTS**

Furnish high strength bolts for structural steel joints in accordance with ASTM A325 Type 1 or 3, ASTM A490 Type 1 or 3 as specified in the contract.

- A. Tension Control Bolts.** Meet the requirements of ASTM F1852 when substituting tension control bolt assemblies for ASTM A325 bolts. Meet the requirements of ASTM F2280 when substituting tension control bolt assemblies for ASTM A490 bolts.
- B. Nuts.** Furnish heavy hex nuts for high strength bolts in accordance with Table 711-1.

**TABLE 711-1  
HEAVY HEX NUTS**

Bolt Type		Heavy Hex Nut ASTM A563
ASTM A325	Type 1-plain	Grade C, C3, D, DH, DH3
	Type 1-galvanized	DH
	Type 2	Grade C3, DH3
ASTM A490	Type 1	Grade DH, DH3
	Type 2	Grade DH3

Notes:

1. Plain heavy hex nuts Grades C, C3 and D must have a minimum hardness of 89 HRB.
2. A194 Grade 2H may be substituted for A563 Grade DH
3. When galvanized fasteners are specified, furnish assemblies manufactured and lubricated with a visible dye, so a visual check verifies the lubricant's presence at installation.

- C. Hardened Washers.** Furnish washers for ASTM A325 or A490 bolts in accordance with ASTM F436. Washers are to be circular, beveled or extra thick as required in the contract. Washers must have the same surface condition and weathering characteristics as the bolts specified in the contract.
- D. Direct Tension Indicators.** Furnish direct tension indicators in accordance with ASTM F959. Galvanize DTI's by mechanical deposition in accordance with ASTM B695 Class 55. Hot dip galvanizing is not allowed.
- E. Galvanized High Strength Bolts.** Hot dip galvanize ASTM A325 bolts and hardware in accordance with ASTM F2329. Hot dip galvanizing ASTM A490 bolts is not allowed. Testing for failure and additional rotation will be done in accordance with MT 601.

### 711.07 BOLTS AND NUTS

Furnish bolts, threaded rod, and nuts in accordance with ASTM A307 Grade A requirements.

### 711.08 GALVANIZED METAL

Furnish galvanized ferrous metal products in accordance with AASHTO M 111, or when applicable, meeting ASTM B695 (Class 50) requirements.

### 711.09 WELDED STUD SHEAR CONNECTORS

Furnish shear connector studs in accordance with AWS D1.5 Section 7 specification for *Stud Welding* and the contract.

### 711.10 STEEL PILING

#### 711.10.1 Structural Steel Piles

Furnish new steel "H" piles, melted and manufactured in the USA, in accordance with AASHTO M 270 Grade 345 MPa (50 ksi) and contract.

**711.10.2 Steel Pipe Piles**

Furnish new steel pipe piles, melted and manufactured in the USA, in accordance with ASTM A252, Grade 2 with a minimum yield strength of 45 ksi (310 MPa). Steel pipe diameter and wall thickness is specified in the contract.

**711.11 PRESTRESSING STEEL**

Furnish prestressing steel in accordance with ASTM A416.

**711.12 CASTINGS****711.12.1 Steel Castings for Highway Bridges**

Furnish castings in accordance with ASTM A148.

**711.12.2 Chromium Alloy Steel Castings**

Furnish castings made from Grade CA-15 in accordance with AASHTO M 163.

**711.12.3 Drainage Structure Castings**

Furnish structural drainage castings in accordance with the Detailed Drawings and AASHTO M 306 - HS-25.

**711.13 BEARING ASSEMBLY ANCHOR BOLTS FOR BRIDGES**

Furnish anchor bolts sized in accordance with AASHTO M 314.

**711.14 ELASTOMERIC BEARING DEVICES**

Furnish elastomeric bearings in accordance with AASHTO M 251 and the contract. For reinforced elastomeric devices, furnish steel laminates in accordance with AASHTO M 270 Grade 36 or ASTM A1011.

**711.15 COMPRESSION JOINT SEALS**

Furnish preformed elastic joint seals in accordance with the open cell compression seal requirements of ASTM D3542 and the contract.

Furnish joint seals that accommodate the design movement specified in the contract and follow the manufacturers recommended installation width.

Use the seal manufacturer's recommended adhesive lubricant for seal installation. Use Lubricant in accordance with ASTM D4070.

Furnish a minimum 3-foot (915 mm) long seal sample taken from each size and type furnished on the project. Order the seals 3 feet (915 mm) longer than required for the installation. Submit a copy of the manufacturer's certificate of compliance in accordance with Subsection 106.03, attesting that the material meets specifications.

Obtain the Project Manager's approval of all joint seals before installation.

Install the seals following the manufacturer's recommendations. Do not field splice seals.

Furnish and install the seals, including these costs in the bid price for structural steel.

**711.16 FIBER REINFORCED PADS**

Furnish vulcanized rubber-fiber pads made from new un-vulcanized rubber and synthetic fibers. Each component must make up 50% of the pads weight.

The pad surface must have:

1. A standard rubber hardness of  $80 \pm 5$  Shore A durometer;
2. An ultimate compressive breakdown strength of at least 7,000 psi (48.3 MPa); and
3. A minimum and maximum pad thickness of  $\frac{1}{16}$ -inch (2 mm) and  $\frac{1}{8}$ -inch (3 mm), respectively.

Submit the manufacturer's certification that the pads meet these specifications. A copy of the certification must accompany the shipment to the project. Pads not meeting these requirements will be rejected.

Fiber reinforced pads are incidental to and included in payment for other structural steel work.

#### **711.17 METAL BIN-TYPE RETAINING WALLS**

Furnish metal bin-type retaining walls in accordance with the contract.

Furnish the necessary bolts and appurtenances for complete assembly of the members into a continuous closed-face wall of connected bins.

Ensure the base metal and spelter coating are in accordance with AASHTO M 218. Use galvanized bolts, nuts, washers, and other hardware in accordance with ASTM A153 or B695 (Class 50, Type I).

Ensure all members are fabricated so units of the same nominal size are fully interchangeable. Do not drill, punch, or drift holes to correct defects in manufacture. Replace members having improperly punched holes at Contractor expense.

Remove and replace damaged members or members with damaged or broken spelter at Contractor expense.

Meet the applicable treatment and handling requirements for bituminous-coated steel structural plate pipe and pipe arches under Section 709 when handling bituminous-treated walls. Repair broken or damaged bituminous coating at Contractor expense.

#### **711.18 MECHANICAL REBAR CONNECTORS**

Furnish any type mechanical connector meeting a yield strength minimum of 125% of the reinforcement and be of a type commonly used and readily available. Splice epoxy coated reinforcement with epoxy coated mechanical connectors.

Submit 4 copies of the product data sheet for the proposed type of connector with the specified performance criteria to the Project Manager prior to installation.

#### **711.19 METRIC PLATE SUBSTITUTION**

Define the requirements for substituting standard inch-sized steel plate for metric steel plate. This applies to AASHTO M 270 Grade 250 steel plate used in the following applications:

- Bridge rail
- Pre-stressed concrete beams
- Bridge guard angles
- Bridge pier protection anchors and plates
- Fixed shoe bearing devices

This does not apply to AASHTO M 270 Grades 345 through 690.

Show the metric plate thickness and add a table to the shop drawings similar to Table 711-2.

**TABLE 711-2  
STEEL PLATE SUBSTITUTIONS**

Plate Thickness (inch)	Allowable Substitute Plate Thickness (mm)
$\frac{1}{8}$ *	3
$\frac{3}{16}$	5
$\frac{1}{4}$	5 or 6
$\frac{5}{16}$	8
$\frac{3}{8}$	10
$\frac{1}{2}$	12 or 13
$\frac{5}{8}$	16
$\frac{3}{4}$	19 or 20
$\frac{7}{8}$	22
1	25
$1\frac{1}{4}$	30
$1\frac{1}{2}$	38 or 40

\*10 gauge ASTM A1011 sheet may also be substituted for  $\frac{1}{8}$ -inch (3 mm) shim plates

**711.20 POLYTETRAFLUOROETHYLENE (PTFE)**

Furnish PTFE resin in accordance with ASTM D4894 and ASTM D4895 requirements. Use PTFE sheets consisting of pure PTFE resin, molded by pressure and heat and skived into sheets of  $\frac{1}{16}$ -inch (1.5 mm) thick. Finished sheets must conform to the properties listed in Table 711-3.

**TABLE 711-3  
PTFE SHEET PROPERTIES**

ASTM Test	Physical Property	Requirement
D 4894	Tensile Strength	2800 psi (19.3 MPa)
D 4895	Tensile Elongation	200%

Furnish stainless steel sheets, if applicable, in accordance with ASTM A167 or ASTM A240 Type 304.



## **SECTION 712 FENCING MATERIALS**

### **712.01 CHAIN LINK FENCE**

#### **712.01.1 General**

Meet AASHTO M 181 requirements, as modified herein. Use one of the following fence fabrics, as specified in the contract:

- Type 1 Class C zinc-coated steel
- Type 2 aluminum-coated steel
- Type 3 aluminum alloy

Zinc-5% aluminum-mischmetal alloy in accordance with ASTM B750 may be substituted for zinc coating (hot-dipped) at a Class 2, or 1.0 oz/ft<sup>2</sup> (305 g/m<sup>2</sup>), coating thickness as specified by ASTM F1345.

Use zinc-coated steel for all Type 1 and Type 2 fabric fence parts; including posts, rails, gate frames, expansion sleeves, wire ties, fabric ties, hog rings, tension wire, miscellaneous fittings, and hardware. Use aluminum alloy for these same Type 3 fabric fence parts. Use either zinc-coated steel or aluminum alloy for these Type 4 fabric fence parts.

#### **712.01.2 Fence Fabric**

Furnish fence fabric having 2-inch (50 mm) openings and in accordance with AASHTO M 181. Use 11-gauge wire for fabric 48 inches (1,220 mm) high and under. Use 9-gauge wire for fabric 60 inches (1,525 mm) high and over. The fabric height is specified in the contract.

#### **712.01.3 Posts, Rails, and Braces**

Meet ASTM F1043 and the contract length requirements. Furnish all posts with a watertight cap that fits securely over the outside post top and supports the top rail.

#### **712.01.4 Truss Rods**

Furnish 3/8-inch (9.5 mm) truss rods as follows:

- Steel - galvanized with dropforged turnbuckles or other approved type of adjustment.
- Aluminum - with cast aluminum turnbuckles or other approved type of adjustment.

#### **712.01.5 Fabric Bands and Stretcher Bars**

Furnish bands as follows:

- Steel - a minimum 1/8-inch (3 mm) thick x 1-inch (25 mm) wide.
- Aluminum - a minimum 1/8-inch (3 mm) thick x 3/8-inch (22 mm) wide.

Furnish aluminum or steel stretcher bars as follows:

- A minimum 1/4-inch (3 mm) thick x 3/4-inch (19 mm) wide.
- At least 2 inches (50 mm) shorter than the fabric width used.

#### **712.01.6 Tie Wire**

Furnish 9-gauge galvanized steel tie wire in accordance with AASHTO M 279. Furnish 11-gauge; Class 1 galvanized steel hog ring fasteners in accordance with AASHTO M 279.

Furnish 9-gauge aluminum tie wire in accordance with ASTM B211 Alloy 1100, Temper H14. Furnish minimum 11-gauge aluminum hog ring fasteners in accordance with ASTM B211, Alloy 6061.

#### **712.01.7 Tension Wire**

Furnish 7-gauge galvanized coiled spring steel tension wire. Meet AASHTO M 279, Class 1 galvanizing requirements.

Furnish 6-gauge aluminum tension wire in accordance with ASTM B211, Alloy 6061, Temper T 94.

### 712.01.8 Gates

Furnish gates complete with all necessary hinges, latch, and drop-bar locking device for the type of gate and gateposts specified. Weld in accordance with Section 624.

**A. Steel Gates.** Construct gate frames from steel sections in accordance with ASTM F900. The gate frame corners may be welded or fastened and reinforced with galvanized malleable-iron fittings designed for this use.

Use chain link fabric for gate frames in accordance with Subsection 712.01.2 and match the fabric used in the fence.

**B. Aluminum Gates.** Construct gate frames from aluminum sections in accordance with ASTM F900. Assemble the gates frames by welding.

Use aluminum alloy cast hinges in accordance with ASTM B108 or B26 or made of malleable iron or steel and hot-dip galvanized or mechanically galvanized in accordance with ASTM B695 (Class 50). Make all latches, stops, and keepers of the aluminum alloy specified for hinges or use galvanized malleable iron or pressed steel.

Use chain link fabric for the gate frame in accordance with Subsection 712.01.2 and matching the fabric used in the fence.

## 712.02 WIRE FENCE

### 712.02.1 Woven Wire

Furnish woven wire in accordance with AASHTO M 279 and either of Table 712-1 designations.

**TABLE 712-1  
WOVEN WIRE REQUIREMENTS**

Specification	Grade	Design Number	Metallic Coating
AASHTO M 279	No. 12½ Grade 60	832-6-12 ½*	Type Z, Class 1 or Type ZA, Class 20
AASHTO M 279	No. 14 Grade 125	832-6-14*	Type Z, Class 3 or Type ZA, Class 40

\*For use with Type C fence.

Provide a 6-inch (150 mm) stay spacing. Match the fence height and mesh dimensions of the fence being replaced if not specified.

### 712.02.2 Barbed Wire

Use 2-point 12½ or 13½-gauge barbed wire in accordance with AASHTO M 280. Space barbs at a 4-inch nominal (100 mm) or a 5-inch nominal (130 mm) spacing. Provide the Project Manager certification that the wire is in accordance with AASHTO M 280.

### 712.02.3 Brace Wire

Use 9 or 12½-gauge soft, smooth wire.

### 712.02.4 Staples and Nails

Use minimum 9-gauge U-shaped, 1¾-inch (45 mm) long staples unless otherwise specified in the contract.

### 712.02.5 Tie Wires

Use minimum 12½-gauge galvanized tie wire. Commercial galvanized fasteners supplied with the wire may be used if approved by the Project Manager.

**712.02.6 Metal Fence Stays**

Use commercially made and fabricated metal fence stays from 9½-gauge wire twisted to form a two-wire unit.

**712.02.7 Metal Posts and Assemblies**

Provide metal fence posts and assemblies in accordance with AASHTO M 281, modified as follows:

- Section 7 and Tables 3 and 4 of AASHTO M 281 apply to finished posts and assemblies after fabrication, punching, drilling, and finish coating.

Galvanize or paint posts, braces, and anchor plates. Meet AASHTO M 111 galvanizing requirements. Furnish nuts, bolts, fittings, and other hardware in accordance with ASTM A153 or B695 (Class 50) galvanizing. Paint following the paint manufacturer's recommendations.

Furnish fence posts and braces of the lengths shown in Table 712-2.

**TABLE 712-2  
POST LENGTHS**

Post Type	Braces, Brace Rails And Panel Posts	Line Posts
Metal	--	6 feet - 6 inch (2.0 m)
Wood	8 feet (2.4 m)	7 feet (2.1 m)

Use Tee, Channel, U, or Y bar section line posts with corrugations, knobs, notches, holes, or studs placed to engage the fence line wires.

Attach a steel anchor plate to each line post so that the anchor top is 2 to 3 inches (50 to 75 mm) below ground line when the post is set to the specified depth.

**712.02.8 Wood Fence Posts and Brace Rails**

- A. General.** Make fence posts and brace rails from well-seasoned, sound, and straight-grained western larch, lodgepole pine, ponderosa pine, southern yellow pine, or douglas fir. Remove all bark from the posts.

Taper round posts, to be driven, from 6 to 12 inches (150 to 305 mm) up from the bottom to a  $1 \pm \frac{1}{2}$ -inch ( $25 \pm 12$  mm) point. Bevel the edges of post tops to produce a flat surface with a diameter  $1 \pm \frac{1}{2}$ -inch ( $25 \pm 12$  mm) less than post diameter. These taper lengths are included in the specified post lengths. Perform all machining before treatment.

Furnish posts and rails 10 feet (3 m) in length or less free of crooks and sweeps greater than  $\frac{3}{4}$ -inch (19 mm) from the post centerline. The maximum offset from centerline for posts and rails longer than 10 feet (3 m) is  $\frac{3}{4}$  plus  $\frac{1}{16}$ -inch (19 plus 2 mm) per additional foot (305 mm) of length. The centerline is defined as a straight line from the center of the tip to the center of the butt.

Treat round posts and rails meeting AWPAs Standards for Commodity Specification B and Use Category 4A. Supply round posts and rails meeting the AWPAs minimum penetration requirements specified for natural posts, with a penetration of at least  $\frac{3}{8}$ -inch (9 mm). Posts and rails must have sufficient sapwood to provide the  $\frac{3}{8}$ -inch (9 mm) minimum penetration. Treat the S4S post in accordance with Subsection 706.04.

Treat injuries, cuts, and holes in timber pile after treatment in accordance with Subsection 706.04.

- B. Line Posts.** Furnish line posts and brace rails from a minimum 4-inch (100 mm) diameter round, or a minimum 4 x 4-inch (100 x 100 mm) square sawn. Furnish corner, end, gate,

and pull posts from a minimum 5-inch (130 mm) diameter round post or a 5 x 5-inch (130 x 130 mm) square sawn post.

#### 712.02.9 Metal Gates

Furnish each gate complete with hinges, latch, and all other hardware used with the type of gate and gate post specified.

#### 712.02.10 Gates for Interstate Fence

Use plain-top single-drive metal gates of tubular steel frame with wire fabric filler. Fit the gate to the opening between the gate posts of the approximate widths shown in the Detailed Drawings. Provide a centered steel upright brace for gates for openings of less than 14 feet (4.3 m), two upright steel braces at third points for gates for openings of 14 feet (4.3 m) or greater.

Fill the metal gates with galvanized wire fabric securely fastened to the top, bottom, ends of the gate frame.

Use fabric in accordance with Subsection 712.02.1, Class 1 or better.

The approximate weight of the gate frames (less fabric) must meet Table 712-3 requirements.

**TABLE 712-3  
APPROXIMATE GATE FRAME WEIGHTS**

<b>Width of Opening</b>	<b>Approximate Wt<sup>1</sup></b>
8 feet (2.4 m)	48 pounds (22 kg)
10 feet (3.0 m)	55 pounds (25 kg)
12 feet (3.7 m)	62 pounds (28 kg)
14 feet (4.3 m)	72 pounds (33 kg)
16 feet (4.9 m)	80 pounds (36 kg)

Notes:

1. Heavier gates will be permitted if they meet all other requirements.

#### 712.02.11 Gates for Farm Fence

Furnish farm fence gates in accordance with the Detailed Drawings and contract.

#### 712.02.12 Deadman or Anchor

Furnish deadman and anchor(s) in accordance with the Detailed Drawing.

#### 712.02.13 Miscellaneous

Bolts, nuts, fittings, hinges, and all other metal parts for constructing fences and gates must be galvanized in accordance with ASTM specifications.

**SECTION 713**  
**MISCELLANEOUS MATERIALS**

**713.01 WATER**

Furnish water for mixing and curing concrete in accordance with AASHTO M 157, 4.1.4. Water will be tested in accordance with AASHTO T 26. Known potable water may be used without testing.

Use irrigation quality water for irrigating trees, plants, and seeded areas, free of elements harmful to plant growth.

**713.02 HYDRATED LIME**

Furnish hydrated lime in accordance with AASHTO M 303.

**713.03 CHLORIDES**

- A. Magnesium Chloride.** Furnish liquid magnesium chloride in accordance with Table 713-1. Products will be tested as received in accordance with MT 532.

**TABLE 713-1**  
**LIQUID MAGNESIUM CHLORIDE REQUIREMENTS**

	Requirement
Alkali chlorides	≤5.0% by mass NaCl
Arsenic	≤5.0 mg/Kg
Assay	≥28.5% MgCl <sub>2</sub> by mass
Barium	≤100.0 mg/Kg
Cadmium	≤0.2 mg/Kg
Chromium	≤1.0mg/Kg
Copper	≤1.0 mg/Kg
Cyanide	≤0.20 mg/Kg
Lead	≤1.0 mg/Kg
Magnesium hydroxide	≤0.2% by mass Mg(OH) <sub>2</sub>
Mercury	≤0.05 mg/Kg
Phosphorous	≤2500.0 mg/Kg
Selenium	≤5.0 mg/Kg
Settleable solids	≤1.0%
Sulfate	≤3.0% by mass SO <sub>4</sub>
Zinc	≤10.00 mg/Kg

**B. Calcium Chloride.**

1. Furnish liquid calcium chloride in accordance with Table 713-2. Products will be tested as received in accordance with MT 531.
2. Furnish dry calcium chloride in accordance with Table 713-2 and ASTM D98 Type S.

**TABLE 713-2  
LIQUID CALCIUM CHLORIDE REQUIREMENTS**

	<b>Requirement</b>
Alkali chlorides	≤6.0% by mass NaCl
Arsenic	≤5.0 mg/Kg
Assay	≥30.0% CaCl <sub>2</sub> by Mass
Barium	≤100.0 mg/Kg
Cadmium	≤0.2 mg/Kg
Calcium hydroxide	≤0.2% by mass Mg(OH) <sub>2</sub>
Chromium	≤1.0mg/Kg
Copper	≤1.0 mg/Kg
Cyanide	≤0.20 mg/Kg
Lead	≤1.0 mg/Kg
Magnesium	≤0.5% by mass MgCl <sub>2</sub>
Mercury	≤0.05 mg/Kg
Phosphorous	≤2500.0 mg/Kg
Selenium	≤5.0 mg/Kg
Settleable solids	≤1.0%
Zinc	≤10.00 mg/Kg

**713.04 CEMENT GROUT**

Produce grout consisting of 1 part cement to 3 parts of sand thoroughly mixed with water to produce a uniform thick mortar. Use mortar within 30 minutes of adding water. Mortar cannot be re-tempered.

Use sand for mortar in accordance with Subsection 701.01.1 and Table 713-3 gradation.

**TABLE 713-3  
MORTAR SAND GRADATION REQUIREMENTS**

<b>Percentage By Weight Passing Square Mesh Sieves</b>	
<b>Sieve Size</b>	<b>% Passing</b>
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	90-100
No. 16 (1.18 mm)	60-90
No. 50 (0.300 mm)	15-40
No. 100 (0.150 mm)	0-10

**713.05 TOPSOIL**

Furnish topsoil meeting Table 713-4 gradation requirements.

**TABLE 713-4  
TOPSOIL GRADATION REQUIREMENTS**

<b>Fraction</b>	<b>Particle Size (mm)</b>	<b>Max. % Of Soil (-10 Mesh) (2mm) Fraction</b>
Sand	0.05-2.0	85
Silt	0.005-0.05	80
Clay	less than 0.005	50
Gravel	larger than 2.0	max. % of total sample <sup>1</sup>

Notes:

1. A maximum of 20% is allowable. Any quantity exceeding 10% is not included in the basis for payment. Gradation is tested in accordance with AASHTO T 88.

Meet the following:

1. Soil pH between 5.5 and 8.0 or up to 8.5 if the exchangeable sodium is less than 10%;
2. Soil conductivity factor less than 4; and
3. Organic content between 1% and 20%.

Topsoil is sampled and tested in accordance with MT 412.

**713.06 RESERVED****713.07 RESERVED****713.08 RECLAMATION SEED**

Furnish all seed that meets and is labeled under Montana Seed Law and meeting the contract requirements.

Furnish seed originating from the North American Continent above 41 degrees latitude. Make written request for waivers of the above requirements to the Project Manager who will work with the Department Agronomist. Do not furnish seed, grown or originating, from production fields outside of North America.

Furnish seed free of prohibited noxious weed seed with restricted weed seed not exceeding Montana Seed Law.

Wet, moldy, or otherwise damaged seed will be rejected.

Calculations of "pure live seed" may be made based on either a germination test or a tetrazolium test, in addition to the purity analysis.

Submit a purity analysis and germination test of the seed proposed for use. A germination test must have been performed within 12 months of the seeding date.

Apply seed on a "pure live seed" basis. The quantity of "pure live seed" per 100 pounds (45.4 kg) of seed is determined as follows:

$$\% \text{ Pure Live Seed} = \text{Germination \%} \times \text{Purity} \times 100$$

$$\text{Bulk Seed Needed} = \text{Total Lbs. Pure Live Seed Required} / \% \text{ Pure Live Seed} \times 100$$

Submit a written notification of the seed source and the approximate date the seeding is planned to begin. Do not begin seeding until the germination and purity test results are known and a Department seed blend report is furnished to the Project Manager.

Store all seed under weather-proof cover until time of seeding. Seed bags exposed to rain or snow will be rejected.

**713.09 FERTILIZER**

Furnish fertilizer in accordance with all applicable laws, rules, and regulations. Furnish the

product data sheet to the Project Manager upon delivery. Contaminated or damaged fertilizer will be rejected.

### 713.10 MULCH

Furnish mulch listed on the QPL, and in accordance with the contract.

#### 713.10.1 Vegetative Mulch

Vegetative mulch is dried cereal grain or oilseed crop straw, cornfield residue, or grass hay with the majority of stems and leaves at least 4 inches (100 mm) in length.

Mulch will be rejected for any of the following reasons:

1. Chopped or ground mulch;
2. Mulch that is musty, moldy, rotted, or contains noxious weed or grass seed-bearing stalks;
3. Mulch containing stones, dirt, roots, stumps, and other foreign material; or
4. Harvested or stored for over 2 years.

#### 713.10.2 Hydraulic Mulch

**A. Wood Fiber.** Wood fiber hydraulic mulch is specially prepared wood fibers free of growth or germination inhibiting materials that forms a homogeneous slurry when combined with water, tackifiers, fertilizer, and other specified additives and remains uniformly suspended under agitation. The mulch may be colored with a water-soluble, nontoxic dye to aide visual metering during application. Apply the mulch to produce a uniform mat-like cover on the seeded ground.

At least 30% of the mulch fibers must average 0.15 inches (4 mm) or longer with 50% or more retained on a Clark Fiber Classifier 24-mesh screen.

**B. Straw Fiber.** Straw fiber hydraulic mulch is specially manufactured and prepared straw stems that are packaged and commercially sold specifically as hydraulic mulch. Straw hydraulic mulch can be formulated as 100% straw or combined with other types of mulch and tackifer products during the manufacturing process. The contract will specify the rate, type and formulation of straw fiber hydraulic mulch to be used.

**C. Multi-Fiber.** Multi-fiber hydraulic mulches are composed of various types and percentages of natural fibers and tackifiers. The contract will specify the type of multi-fiber mulches allowed.

### 713.11 SOD

Furnish commercially manufactured sod that is a living, vigorous growth of grass of the type and thickness specified.

Sod that shows signs of stress from mishandling or lack of water will be rejected.

Provide sod adapted to the general locality of the project, having a dense root system, is free of noxious weeds, and other foreign substances harmful to the development and maintenance of the sod.

Furnish a product data sheet to the Project Manager prior to delivery specifying the origin of the sod.

Cut the sod when the grass length is approximately 2 inches (50 mm) high but not exceeding 3 inches (75 mm). Ensure the sod is free of debris before cutting.

Wet the sod to permit cutting, rolling, and hauling without crumbling or breaking.

Water the sod using water and equipment free of contaminants, from a municipal, domestic, or other source suitable for irrigation. Trucks previously used for application of salt solutions are prohibited for use as watering vessels, unless approved by the Project Manager.

### 713.12 ROLLED EROSION CONTROL PRODUCTS

Furnish erosion blankets listed on the QPL, and in accordance with the contract. Furnish natural fiber netting consisting of woven 100% biodegradable natural fibers such as coir, jute or sisal. Furnish blankets designed to stabilize and hold previously applied mulch or compost on slopes as well as newly constructed stream banks and slopes.

Natural fiber netting is available in various fiber types, strengths, weights and mesh-opening sizes.

**A. Short Term Blankets.** An erosion control blanket composed of processed natural fibers mechanically bound together with 100% biodegradable threading and natural fiber nettings to form a continuous matrix. The fiber matrix can be composed of straw, coir, cotton, wool, curled wood or other approved product. Thread and netting material must be non-synthetic, generally of plied coir, jute or cotton. Meet the requirements for Type II blankets in accordance with Table 713-5.

**B. Long Term Blankets.** An erosion control blanket composed of one of the following materials:

1. Processed slow degrading natural or polymer fibers mechanically-bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.
2. An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

Meet the requirements for Type III-B blanket in accordance with Table 713-5.

**TABLE 713-5  
TEMPORARY ROLLED EROSION CONTROL**

Property	Type II				Type III		Type IV	Test Method
	A <sup>1</sup>	B	C	D	A <sup>1</sup>	B		
Typical functional longevity <sup>2</sup> (months)	12				24		36	N/A
Minimum tensile strength <sup>3</sup> lbs/ft <sup>2</sup> (kg/m <sup>2</sup> )	5 (24.4)	50 (244.1)	75 (366.2)	75 (366.2)	25 (122.1)	100 (488.2)	125 (610.3)	ASTM D4595
Maximum "C" factor <sup>4</sup>	0.10 at 1V:5H	0.10 at 1V:4H	0.10 at 1V:3H	0.10 at 1V:2H	0.10 at 1V:5H	0.25 at 1V:1.5H	0.25 at 1V:1H	ASTM D6459
Minimum permissible shear stress <sup>5,6</sup> psf (Pa)	.25 (12)	.50 (23.9)	1.50 (71.8)	1.75 (83.8)	.25 (12)	2.00 (95.8)	2.25 (107.7)	ASTM D6460

Notes:

1. Obtain max "C" factor and allowable shear stress for mulch control nettings with the netting used in conjunction with pre-applied mulch material.
2. Functional longevities are for guidance only. Actual functional longevities may vary based on site and climatic conditions.
3. Minimum average roll values, machine direction.
4. "C" factor calculated as ratio of soil loss from rolled erosion control product protected slope (tested at specified or greater gradient, v:h) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #2.
5. Minimum shear stress the rolled erosion control product (un-vegetated) can sustain without physical damage or excess erosion (>1/2-inch (13 mm) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ECTC test method #3.
6. The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 to 0.05.

**C. Permanent Turf Reinforcement Mat (TRM).**

- 1. Synthetic Fiber Matrix.** Furnish a web of mechanically bonded synthetic fibers that are entangled to form a strong and dimensionally stable mat. Place fibers between 2 or 3 high-strength, biaxially oriented nets mechanically bound together by stitching with polyolefin thread. The netting material must be resistant to biological, chemical, and ultra-violet degradation.

**TABLE 713-6  
SYNTHETIC FIBER TRM**

Property	Value	Test Method
Matrix material -100% synthetic fibers	minimum 10 oz/yd <sup>2</sup> (339 g/m <sup>2</sup> )	N/A
Top, bottom and center netting	polypropylene, polyethylene or nylon minimum 5 lbs/1,000 ft <sup>2</sup> (2.44 kg/100 m <sup>2</sup> )	N/A
Minimum tensile strength – TD	400 lbs/ft (5.84 kN/m)	ASTM D6818
Minimum tensile strength – MD	300 lbs/ft (4.38 kN/m)	ASTM D6818
UV stability (minimum % tensile retention)	80%	ASTM D4355 (1,000-hour exposure)
Minimum thickness (inches)	¼-inch (6 mm)	ASTM D6525
Minimum shear stress	minimum 10 lbs/ft (.15 kN/m)	ASTM D6525

- 2. Natural Fiber Matrix.** Furnish a natural fiber matrix constructed of two or three nets of heavy-duty polypropylene, polyethylene or nylon. The internal matrix fiber is composed of a natural fiber such as curled wood, straw or coconut.

**TABLE 713-7  
NATURAL FIBER TRM**

Property	Value	Test Method
Matrix material – 100% biodegradable	70% straw/30% coconut, or 100% coconut fiber, or 100% Curled wood fiber. minimum 0.5 lbs/yd <sup>2</sup> (.27 kg/m <sup>2</sup> )	N/A
Top and bottom netting	Synthetic fiber – minimum 5.0 lbs/1,000 ft <sup>2</sup> (2.44 kg/100m <sup>2</sup> )	N/A
Center net	Synthetic fiber – minimum 24.0 lbs/1,000 ft <sup>2</sup> (11.72 kg/100 m <sup>2</sup> )	N/A
Minimum tensile strength – TD	737 lbs/linear ft (10.76 kN/m)	ASTM D6818
Minimum tensile strength – MD	620 lbs/linear ft (9.05 kN/m)	ASTM D6818
UV stability (minimum % tensile retention)	100%	ASTM D4355 (1000-hour exposure)
Minimum thickness	0.7 inches (17.5 mm)	ASTM D6525

**713.13 COMPOST**

Compost is the soil amendment product resulting from the controlled decomposition of organic materials also known as feedstock material. Acceptable compost feedstock material consist of agricultural vegetative residuals, leaf/yard trimmings, manure, domestic livestock

carcasses, wood residue, municipal biosolids (sewage sludge), or food waste. If biosolids are used as a feedstock, compliance with USEPA 40 CFR Part 503 is required.

Furnish compost in accordance with Table 713-8.

**TABLE 713-8  
COMPOST PHYSICAL AND CHEMICAL PROPERTIES**

<b>Property</b>	<b>Requirement</b>	<b>Method<sup>1</sup></b>
Particle size	90% (by volume) passing 1-inch (25 mm) screen	TMECC 05.08-B
% Moisture	30% to 55%	TMECC 03.09-A
% Organic matter	30% minimum	TMECC 05.07-A
pH	5.0 to 8.5	TMECC 04.11-A
C/N ratio	10:1 to 30:1	TMECC 05.02-A
Inert material	<1%	TMECC 03.02-A
Maturity	Stable, $\geq 5$ using Solvita test	Solvita test kit
Soluble salt concentration (electrical conductivity)	11.0 mmhos/cm maximum	TMECC 04.10-A

Notes:

1. TMECC – test methods for evaluating compost and composting

Provide a manufacturer's certification in accordance with Subsection 106.03, attesting that the material meets these specifications.



**SECTION 714**  
**PAVEMENT MARKING MATERIALS**

**714.01 TEMPORARY STRIPING TAPE**

Furnish temporary striping tape that is 4-inch (100 mm) wide, retro-reflective, pressure-sensitive tape specifically manufactured for use as pavement striping. The tape must be available in white and yellow.

**714.02 TEMPORARY STRIPING TABS**

Furnish temporary striping tabs in accordance with the following:

1. Types I and II: "L" shaped, extruded polyurethane, at least 4 inches (100 mm) wide by 2 inches (50 mm) high with a reflectorized strip meeting requirement No. 2 below; attached horizontally across the top of the vertical portion of the tab; an adhesive strip meeting requirement No. 3 below:
  - a. Type I tabs: white reflectorized tape on both sides with white bodies;
  - b. Type II tabs: yellow reflectorized tape on both sides with yellow bodies;
2. Reflective flexible sheeting meeting ASTM D4956 Type V or better;
3. An adhesive strip at least 3/4-inch (19 mm) wide x 1/8-inch (3 mm) thick on the tabs underside; and
4. A cover protecting the reflective strip that does not come off under traffic but is manually removable.

**714.03 TEMPORARY WATERBORNE TRAFFIC PAINT**

Furnish temporary waterborne traffic paint in accordance with Table 714-1.

**TABLE 714-1**  
**TEMPORARY WATERBORNE TRAFFIC PAINT COMPOSITION**

Test	Specification	Test Method
Color (x, y, Y)	ASTM D6628	ASTM D6628 and ASTM D7585
Antimony	≤20.0 mg/Kg	MT 544
Arsenic	≤20.0 mg/Kg	
Cadmium	≤4.0 mg/Kg	
Chromium	≤5.0 mg/Kg	
Cobalt	≤20.0 mg/Kg	
Lead	≤20.0 mg/Kg	
Mercury	≤1.00 mg/Kg	
Tin	≤20.0 mg/Kg	

**714.04 WATERBORNE TRAFFIC PAINT**

Furnish waterborne traffic paint in accordance with Table 714-2. Where the NTPEP method is specified, recorded NTPEP results must be within the specifications shown.

**TABLE 714-2  
WATERBORNE TRAFFIC PAINT COMPOSITION**

<b>Test</b>	<b>Specification</b>	<b>Method</b>
Color (x, y, Y)	ASTM D6628	ASTM D6628 and ASTM D7585
Durability (Wheel)	minimum of 6 at 12 months	NTPEP
Luminance	white: $\geq 30$ at 12 months yellow: $\geq 20$ at 12 months	NTPEP
Viscosity (Krebs Stormer), K.U. at 77 °F (25 °C)	80-95	ASTM D562
Density deviation	maximum of $\pm 0.30$ lbs/gallon ( $\pm 35.9$ g/L) from density target	ASTM D1475
Contrast ratio	0.92	MT 545
Dry no track	90 seconds	NTPEP
Freeze-thaw stability	$\Delta 10$ KU	ASTM D2243
Static heat stability	$\Delta 10$ KU	MT 548
Bleeding ratio	0.95 minimum	ASTM D868
Skinning and lumps	Pass	MT 549
Settling	Pass	MT 549
Skinning	Pass	MT 549
NTPEP lab test verification	must match NTPEP	NTPEP and MT 543
Antimony	$\leq 20.0$ mg/Kg	MT 544
Arsenic	$\leq 20.0$ mg/Kg	
Cadmium	$\leq 4.0$ mg/Kg	
Chromium	$\leq 5.0$ mg/Kg	
Cobalt	$\leq 20.0$ mg/Kg	
Lead	$\leq 20.0$ mg/Kg	
Mercury	$\leq 1.00$ mg/Kg	
Tin	$\leq 20.0$ mg/Kg	

#### 714.05 HIGH DURABILITY WATERBORNE TRAFFIC PAINT

Furnish high durability waterborne traffic paint in accordance with Table 714-3. Where the NTPEP method is specified, recorded NTPEP results must be within the specifications shown.

**TABLE 714-3  
HIGH DURABILITY WATERBORNE TRAFFIC PAINT COMPOSITION**

Test	Specification	Method
Color (x, y, Y)	ASTM D6628	ASTM D6628 and ASTM D7585
Durability (wheel)	minimum of 8 at 24 months	NTPEP
Luminance	white: $\geq 30$ at 12 months yellow: $\geq 20$ at 12 months	NTPEP
Viscosity (Krebs Stormer), K.U. at 77 °F (25 °C)	80-95	ASTM D562
Density deviation	maximum of $\pm 0.30$ lbs/gallon ( $\pm 35.9$ g/L) from density target	ASTM D1475
Contrast ratio	0.92	MT 545
Dry no track	10 minutes maximum	NTPEP
Freeze-thaw stability	$\Delta 10$ KU	ASTM D2243
Static heat stability	$\Delta 10$ KU	MT 548
Bleeding ratio	0.95 minimum	ASTM D868
Skinning and lumps	Pass	MT 549
Settling	Pass	MT 549
Skinning	Pass	MT 549
NTPEP lab test verification	must match NTPEP	NTPEP and MT 543
Antimony	$\leq 20.0$ mg/Kg	MT 544
Arsenic	$\leq 20.0$ mg/Kg	
Cadmium	$\leq 4.0$ mg/Kg	
Chromium	$\leq 5.0$ mg/Kg	
Cobalt	$\leq 20.0$ mg/Kg	
Lead	$\leq 20.0$ mg/Kg	
Mercury	$\leq 1.00$ mg/Kg	
Tin	$\leq 20.0$ mg/Kg	

#### 714.06 EPOXY OR OTHER POLYMERIC TRAFFIC PAINT

Furnish epoxy or other polymeric traffic paint in accordance with Table 714-4. Where the NTPEP method is specified, recorded NTPEP results must be within the specifications shown.

**TABLE 714-4  
EPOXY OR OTHER POLYMERIC TRAFFIC PAINT COMPOSITION**

Test	Specification	Method
Color (x, y, Y)	ASTM D6628	ASTM D6628 and ASTM D7585
Durability (wheel)	minimum of 7 at 36 months	NTPEP
Luminance	White: $\geq 30$ at 36 months Yellow: $\geq 15$ at 36 months	NTPEP
Dry no track	45 minutes maximum	NTPEP
NTPEP lab test verification	must match NTPEP	NTPEP and MT 543
Antimony	$\leq 20.0$ mg/Kg	MT 544
Arsenic	$\leq 20.0$ mg/Kg	
Cadmium	$\leq 4.0$ mg/Kg	
Chromium	$\leq 5.0$ mg/Kg	
Cobalt	$\leq 20.0$ mg/Kg	
Lead	$\leq 20.0$ mg/Kg	
Mercury	$\leq 1.00$ mg/Kg	
Tin	$\leq 20.0$ mg/Kg	

## 714.07 PREFORMED PLASTIC PAVEMENT MARKING MATERIAL

### 714.07.1 Composition Requirements

Furnish preformed plastic pavement marking material consisting of plastics and plasticizers, pigments, and reflective glass beads combined and proportioned to meet the following:

1. Available in both yellow and white color;
2. The total pigment in white marking material a minimum 20% by weight titanium dioxide;
3. The total pigment in yellow marking material a minimum 18% by weight medium chrome yellow;
4. Marking material colors that match the Federal Standard Highway color # 595 A, 33538 for yellow, 37925 for white;
5. Non-yellowing white material;
6. Non-fading yellow material during the expected life of the materials; and
7. Having reflective glass beads in accordance with Subsection 714.08 uniformly distributed throughout the entire material.

### 714.07.2 Adhesive Requirements

Furnish material having a pre-coated pressure-sensitive adhesive on the base to adhere to plant mix and PCCP. The adhesive must:

1. Be sufficiently free of tack so the material can be handled or repositioned on the pavement before being permanently fixed in position;
2. Mold to the pavement contours, breaks, faults under traffic at normal pavement temperatures;
3. Reseal itself so that, under normal use, it fuses with itself and previously applied markings of similar composition;
4. Capable of being inlaid in pavement at temperatures up to 275 °F (135 °C); and
5. Not lose its adhesive and reflective properties when exposed to water used in rolling operations.

**714.07.3 Dimensional Requirements**

Furnish the pavement marking material in standard manufactured widths of 4-inch, 6-inch, 8-inch, 12-inch, and 24-inch (105, 155, 205, 305, and 610 mm).

Furnish the material for words and symbols in pre-cut configurations matching the shapes and dimensions in accordance with the Detailed Drawings.

Furnish the pavement marking material in the thickness specified in the contract.

**714.07.4 Physical Requirements**

- A. Tensile Strength.** Furnish plastic material having a minimum tensile strength of 40 psi (276 kPa) when tested in accordance with ASTM D638. The break resistance is based on an average of at least 3 samples tested at a temperature of 70 to 80 °F (21 to 27 °C) using a jaw speed of 0.25-inch (6 mm) per minute.
- B. Plastic Pull Test.** A 1 x 6-inch (25 x 150 mm) sample of the plastic material must support a dead weight of 0.66 pounds per 0.01 inch (1.2 kg/mm) of material thickness for at least 5 minutes at a temperature of 70 to 80 °F (21 to 27 °C).
- C. Bend Test.** At 80 °F (27 °C) bend a 3 x 6-inch (75 x 150 mm) sample over a 1-inch (25 mm) diameter mandrel until the end faces are parallel and 1-inch (25 mm) apart. The sample must not show any fracture lines in the uppermost surface under unassisted visual inspection.
- D. Skid Resistance.** The plastics surface friction properties must be at least 35 BPN when tested under ASTM E303.
- E. Reseal Test.** The plastic must re-seal itself without adhesives when tested as follows: Overlap two 1 x 3-inch (25 x 75 mm) pieces face-to-face forming a single 1 x 5-inch (25 x 130 mm) piece with a 1 square inch (645 mm<sup>2</sup>) overlap in the center. Place the 1 x 5-inch (25 x 130 mm) piece on a hard surface with a 1,000-gram weight resting uniformly on the entire overlap area and maintain at 140 to 190 °F (60 to 88 °C) for 2 hours. Maintain the temperature within the specified range. Cool to room temperature. The pieces must not separate without tearing.
- F. Reflectivity.** Meet the reflective values listed in Table 714-5. Reflective values are measured on a 2 x 2½-foot (610 x 762 mm) panel in accordance with the instrumental photometric measurements of retro-reflective materials and retroreflective devices, Federal test method Standard 370.

**TABLE 714-5**  
**MINIMUM SIA<sup>1</sup> (CANDELAS PER FOOTCANDLE PER SQUARE FOOT (m<sup>2</sup>))**  
**PLASTIC PAVEMENT MARKING MATERIAL**

Observation Angle	Entrance Angle	White	Yellow
0.2°	86°	0.20 (2.1)	0.15 (1.6)
0.5°	86°	0.15 (1.6)	0.10 (1.0)

Notes:

1. SIA - specific intensity per unit area

**714.07.5 Samples**

Submit a 4-inch x 1-foot (100 x 305 mm) sample from each lot of material proposed for use on the project to the Materials Bureau for approval. Obtain approval before using in the work.

**714.07.6 Certification**

Submit the manufacturer's certification in accordance with Subsection 106.03. Include evidence from the manufacturer that the material proposed for use in the work has performed

successfully under similar climatic conditions and traffic usage. This evidence of successful use is required for the product to be approved for use.

#### 714.08 REFLECTIVE GLASS BEADS

- A. General.** Provide glass beads for reflectorizing traffic pavement markings that are spherical, transparent, have a smooth, lustrous surface, and in accordance with AASHTO M 247 except as modified below and the pavement marking manufacturer's recommendations. Ensure the delivered beads are free from extraneous material and bead clumps easily break up while handling and distributing onto the stripe.
- B. Imperfections.** Ensure the glass beads do not contain more than 25% irregularly shaped particles when tested in accordance with ASTM D1155.
- C. Color.** Ensure the glass beads do not impart a noticeable daytime hue to white pavement markings.
- D. Chemical Stability.** Ensure the beads can withstand refluxing in distilled water in a Soxhlet extractor for 90 hours without noticeable dulling of the surface luster and not more than 2.5% loss in weight.
- E. Gradation.** Meet Table 714-6 gradations, tested in accordance with ASTM D1214.

**TABLE 714-6  
REFLECTIVE GLASS BEAD GRADATION**

<b>Percentage By Weight Passing Square Mesh Sieves</b>		
<b>Sieve Size</b>	<b>Montana Type 1</b>	<b>Montana Type 2</b>
No. 20 (0.850 mm)	100	90 – 97
No. 30 (0.600 mm)	75 - 95	50 - 75
No. 40 (0.425 mm)	--	15 - 45
No. 50 (0.300 mm)	15 - 35	0 - 15
No. 80 (0.180 mm)	--	0 - 5
No. 100 (0.150 mm)	0 - 5	--

- F. Packaging and Marking.** Package glass beads in moisture-proof containers marked to identify the contents, manufacturer, lot number, batch number and net weight.
- G. Samples.** Furnish a sample of the beads upon request. The Department will furnish the containers.
- H. Heavy Metals.** Ensure the glass beads contain no more than 200 ppm of lead or arsenic when tested under EPA method 6010C. The beads will be prepared by EPA method 3052.

## **SECTION 715**

### **TRAFFIC CONTROL DEVICES**

#### **715.01 SIGNS AND CHANNELIZING DEVICES**

Meet the Detailed Drawings and MUTCD requirements. Use rigid materials for sign backing. Flexible signs are not permitted. Adjust signs within specified distances to prevent obstruction from or to existing signs.

Mount signs so they are vertical and stable. Posts must not extend more than 2 feet (610 mm) above the top of signs.

Construction signs may be horizontally hinged at the midpoint of the sign face provided the hinge gap does not exceed ½-inch (13 mm) and the sign legend is legible.

#### **715.02 CONSTRUCTION SIGN SUPPORT ASSEMBLIES**

Construct sign support assemblies from lightweight yielding material. Meet the following requirements:

- A.** Use wood members with a maximum 16 square inch (10,325 mm<sup>2</sup>) cross section for base construction and 8 square inch (5,160 mm<sup>2</sup>) cross section for uprights and braces. Provide wood members that are free of bark.
- B.** Use tubular metal members with a maximum 9 square inch (5,805 mm<sup>2</sup>) cross section.
- C.** Use solid metal members with a maximum 1 square inch (645 mm<sup>2</sup>) cross section.

Signs may be portable trailer mounted if:

- 1.** The weight of the trailer assembly does not exceed 250 pounds (113.5 kg);
- 2.** The axle, frame, support assembly, and other structural members cannot exceed the dimensions of the portable sign support assembly; and
- 3.** The trailer tire outside diameter does not exceed 28 inches (715 mm). Automotive and equipment axle assemblies cannot be used for trailer-mounted sign supports.

#### **715.03 ADVANCE WARNING ARROW PANELS**

Furnish advance warning arrow panels (arrow boards) in accordance with Part 6 of the MUTCD, equipped with at least 25 lamps.

Use 36 x 72-inch (915 x 1,830 mm) Type "B" arrow boards on striping units and shadow vehicles. Use Type "C", 48 x 96-inch (1,220 x 2,440 mm) for all other applications.

Equip the arrow board with a dimming device to automatically reduce the intensity of the flasher at night.

#### **715.04 WARNING LIGHTS**

Equip all vehicles, hauling units, and mobile construction equipment operating within the project limits and operating on roadways used by the traveling public with an amber flashing or strobe light visible from all directions for at least 0.4 mile (0.6 km) during daylight and clear weather conditions.

#### **715.05 ADVANCE WARNING SIGNS**

Illuminate the W20-7a (advance flagger ahead sign) and the W3-3 (advance traffic signal ahead sign) to meet the following:

- Signs may be illuminated either internally or externally.
- Use 8 high-power amber LEDs.
- Mount LEDs to illuminate each corner of the sign with an additional LED spaced equally between the corners.
- All LEDs activate simultaneously with a flash rate of 50 to 60 times per minute.
- LEDs must be visible a minimum of 1,000 feet upstream from the W20-7a, W3-3 during both daylight and nighttime use.

- Power the LEDs using a generator, solar panel, or battery power, or a combination of the three.

Meet Subsection 715.02 requirements for mounting portable sign support assemblies and the illumination power source.

## SECTION 716 GEOTEXTILES

### 716.01 GENERAL PHYSICAL REQUIREMENTS

Use geotextiles and thread used in joining geotextiles manufactured from fibers consisting of long-chain polymers, composed of at least 95% by weight of polyolefin or polyesters. Use geotextiles with fibers formed into a stable network such that the fibers or yarns retain their dimensional stability relative to each other, including selvages (edges) during shipping, handling, placement, and in service. Use geotextile free from defects or tears.

**A. Minimum Average Roll Values.** All property values, with the exception of Apparent Opening Size (AOS), represent MARV in the weakest principal direction. Provide geotextiles whose average test results from any roll sampled in a lot for conformance or quality assurance testing meets or exceeds minimum values provided in this Section.

**B. Apparent Opening Size.** Values for AOS represent maximum average roll values. Acceptance will be based on ASTM D4759.

Furnish geotextiles in accordance with the strength property requirements of Table 716-1 and the AOS, permittivity, and ultraviolet stability requirements of Table 716-2 for separation geotextile, Table 716-3 for stabilization geotextile, Table 716-4 for subsurface drainage geotextile filter, and Table 716-5 for erosion control geotextile. Furnish temporary silt fence geotextile in accordance with Table 716-6. The geotextile properties required for each class of survivability are dependent upon geotextile type (i.e. woven or nonwoven). When sewn seams are used, the strength of the sewn seams must be equal to or greater than 90% of the specified grab tensile strength.

**TABLE 716-1 E  
GEOTEXTILE STRENGTH PROPERTY REQUIREMENTS**

			Geotextile Survivability <sup>1</sup>			
			Moderate Survivability		High Survivability	
Property	Test Methods	Units	Woven	Nonwoven	Woven	Nonwoven
Grab elongation	ASTM D4632	%	< 50	≥ 50	< 50	≥ 50
Grab strength	ASTM D4632	lbs.	250	160	315	200
Sewn seam strength <sup>2</sup>	ASTM D4632	lbs.	225	145	285	180
Tear strength	ASTM D4533	lbs.	90	55	110	80
Puncture strength	ASTM D6241	lbs.	495	310	619	433
Apparent opening size	ASTM D4751	sieve size	Required property values for AOS, permittivity, and UV stability are based on the geotextile applications. Refer to Table 716-2 for separation geotextile, Table 716-3 for stabilization geotextile, Table 716-4 for subsurface drainage geotextile filter, and Table 716-5 for erosion control geotextile.			
Permittivity	ASTM D4491	sec. <sup>-1</sup>				
Ultraviolet stability (retained strength)	ASTM D4355	%				

Notes:

1. All numeric values represent MARV in the weaker principal direction.
2. When sewn seams are required. Refer to Subsection 622.03 for overlap requirements.

**TABLE 716-1 M  
GEOTEXTILE STRENGTH PROPERTY REQUIREMENTS**

			Geotextile Survivability <sup>1</sup>			
			Moderate Survivability		High Survivability	
Property	Test Methods	Units	Woven	Nonwoven	Woven	Nonwoven
Grab elongation	ASTM D4632	%	< 50	≥ 50	< 50	≥ 50
Grab strength	ASTM D4632	N	1100	700	1400	900
Sewn seam strength <sup>2</sup>	ASTM D4632	N	990	630	1260	810
Tear strength	ASTM D4533	N	400	250	500	350
Puncture strength	ASTM D6241	N	2200	1375	2750	1925
Apparent opening size	ASTM D4751	mm	Required property values for AOS, permittivity, and UV stability are based on the geotextile applications. Refer to Table 716-2 for separation geotextile, Table 716-3 for stabilization geotextile, Table 716-4 for subsurface drainage geotextile filter, and Table 716-5 for erosion control geotextile.			
Permittivity	ASTM D4491	sec. <sup>-1</sup>				
Ultraviolet stability (retained strength)	ASTM D4355	%				

Notes:

1. All numeric values represent MARV in the weaker principal direction.
2. When sewn seams are required. Refer to Subsection 622.03 for overlap requirements.

### 716.02 SEPARATION GEOTEXTILE

Provide geotextile in accordance with the strength requirements from Table 716-1 for the level of survivability specified in the contract or special provisions. Provide geotextile in accordance with the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-2.

**TABLE 716-2  
SEPARATION GEOTEXTILE PROPERTY REQUIREMENTS**

	Test Methods	Units	Requirements
Geotextile survivability	As specified from Table 716-1		
Permittivity <sup>1</sup>	ASTM D4491	sec. <sup>-1</sup>	≥ 0.02
Apparent opening size	ASTM D4751	sieve size (mm)	No. 30 (≤ 0.60)
Ultraviolet stability (retained strength)	ASTM D4355	%	≥ 50 after 500 hrs. of exposure

Notes:

1. Minimum value. Permittivity of the geotextile must be greater than that required for the soil. Use greater value as specified in the contract or special provisions.

### 716.03 STABILIZATION GEOTEXTILE

Do not use woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character). Provide geotextile in accordance with the strength requirements for high survivability from Table 716-1. Provide geotextile in accordance with the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-3.

**TABLE 716-3  
STABILIZATION GEOTEXTILE PROPERTY REQUIREMENTS<sup>1</sup>**

	<b>Test Methods</b>	<b>Units</b>	<b>Requirements</b>
Geotextile survivability	High survivability from Table 716-1		
Permittivity <sup>2</sup>	ASTM D4491	sec. <sup>-1</sup>	≥ 0.10
Apparent opening size	ASTM D4751	sieve size (mm)	No. 40 (≤ 0.43)
Ultraviolet stability (retained strength)	ASTM D4355	%	≥ 50 after 500 hrs. of exposure

## Notes:

1. Do not use woven slit film geotextiles.
2. Minimum value. Permittivity of the geotextile must be greater than that required for the soil. Use greater value as specified in the contract or special provisions.

**716.04 SUBSURFACE DRAINAGE GEOTEXTILE FILTER**

Do not use woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character). Provide geotextile in accordance with the strength requirements from Table 716-1 for the level of survivability specified in the contract or special provisions. Provide geotextile in accordance with the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-4.

**TABLE 716-4  
SUBSURFACE DRAINAGE GEOTEXTILE FILTER PROPERTY REQUIREMENTS<sup>1</sup>**

			<b>Requirements<sup>2</sup></b>		
	<b>Test Methods</b>	<b>Units</b>	<b>Class A</b>	<b>Class B</b>	<b>Class C</b>
Geotextile survivability			As specified from Table 716-1		
Permittivity <sup>3</sup>	ASTM D4491	sec. <sup>-1</sup>	≥ 0.5	≥ 0.4	≥ 0.3
Apparent opening size	ASTM D4751	sieve size (mm)	No. 40 (≤ 0.43)	No. 60 (≤ 0.25)	No. 80 (≤ 0.18)
Ultraviolet stability (retained strength)	ASTM D4355	%	≥ 50 after 500 hrs. of exposure		

## Notes:

1. Do not use woven slit film geotextiles.
2. Use Class "A" subsurface drainage geotextile when the in situ soil has less than 15% fines (gravel or sand). Use Class "B" subsurface drainage geotextile when the in situ soil has 15 to 50% fines (silty or clayey sand or gravel). Use Class "C" subsurface drainage geotextile when the in situ soil has more than 50% fines (silt or clay).
3. Minimum values. Permittivity of the geotextile must be greater than that required for the soil. Use greater values as specified in the contract or special provisions.

**716.05 PERMANENT EROSION CONTROL GEOTEXTILE**

Do not use woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character). Provide geotextile in accordance with the strength requirements from Table 716-1 for the level of survivability specified in the contract or special provisions. Provide geotextile in accordance with the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-5.

**TABLE 716-5  
PERMANENT EROSION CONTROL GEOTEXTILE PROPERTY REQUIREMENTS<sup>1</sup>**

	Test Methods	Units	Requirements <sup>2</sup>		
			Class A	Class B	Class C
Geotextile survivability			As specified from Table 716-1		
Permittivity <sup>3</sup>	ASTM D4491	sec. <sup>-1</sup>	≥ 0.7	≥ 0.4	≥ 0.2
Apparent opening size	ASTM D4751	sieve size (mm)	No. 40 (≤ 0.43)	No. 60 (≤ 0.25)	No. 70 (≤ 0.22)
Ultraviolet stability (retained strength)	ASTM D4355	%	≥ 70 after 500 hrs. of exposure		

## Notes:

1. Do not use woven slit film geotextiles.
2. Use Class "A" permanent erosion control geotextile when the in situ soil has less than 15% fines (gravel or sand). Use Class "B" permanent erosion control geotextile when the in situ soil has 15 to 50% fines (silty or clayey sand or gravel). Use Class "C" permanent erosion control geotextile when the in situ soil has more than 50% fines (silt or clay).
3. Minimum values. Permittivity of the geotextile must be greater than that required for the soil. Use greater values as specified in the contract or special provisions.

**716.06 TEMPORARY SILT FENCE GEOTEXTILE**

Provide geotextile in accordance with Table 716-6.

**TABLE 716-6  
TEMPORARY SILT FENCE PROPERTY REQUIREMENTS**

	Test Methods	Units	Stabilized Silt Fence <sup>1</sup>	Unstabilized Silt Fence <sup>2</sup>
Grab strength, machine direction	ASTM D4632	lb. (N)	≥ 90 (≥ 400)	≥ 125 (≥ 550)
Grab strength, X-machine direction	ASTM D4632	lb. (N)	≥ 90 (≥ 400)	≥ 100 (≥ 450)
Permittivity <sup>3</sup>	ASTM D4491	sec. <sup>-1</sup>	≥ 0.05	≥ 0.05
Apparent opening size	ASTM D4751	sieve size (mm)	No. 30 (≤ 0.60)	No. 30 (≤ 0.60)
Ultraviolet stability (retained strength)	ASTM D4355	%	≥ 70 after 500 hrs. of exposure	

## Notes:

1. Unstabilized silt fence is supported with either wood or metal fence posts.
2. Stabilized silt fence is supported with metal fence posts and with woven wire backing.
3. Minimum values. Use greater values as specified in the contract or special provisions.

**SECTION 717  
CONCRETE SEALANTS**

**717.01 CONCRETE CURING MATERIALS**

**717.01.1 Curing and Protective Coverings**

Furnish protective cover materials for curing concrete in accordance with ASTM C 171, Sheet Materials for Curing Concrete, excluding curing paper.

**717.01.2 Burlap Cloth**

Furnish burlap cloth in accordance with AASHTO M 182, Class 3. In lieu of the minimum weight (mass) specified, ensure that a sample dried in an oven at a temperature of 215 to 225 °F (102 to 107 °C) has a weight not less than 8.0 ounces per square yard (270 g/m<sup>2</sup>).

**717.01.3 Liquid Membrane-Forming Concrete Curing Compounds**

Furnish liquid membrane-forming compounds for curing concrete in accordance with ASTM C 309 Type 1-D, clear or translucent and containing a fugitive dye, or Type 2, white pigmented.

**717.02 BRIDGE DECK SEALANTS**

**717.02.1 Silane Sealer**

Furnish a Silane Sealant listed on the QPL.

**717.02.2 Bridge Deck Crack Sealant**

**A. High Molecular Weight Methacrylate (HMWM) Bridge Deck Crack Sealant.**

Furnish a low viscosity, non-fuming, HMWM resin conforming to Table 717-1 and listed on the QPL.

**TABLE 717-1  
PROPERTIES OF HMWM**

<b>Physical Property Requirements for HMWM Resin</b>	
Viscosity:	1.4 x 10 <sup>-3</sup> lb/in-s (25 centipoises) maximum (Brookfield Model RVT Viscometer, No. 1 Spindle at 60 RPM)
Specific Gravity:	0.90 minimum at 77 °F (25 °C)
Tensile Elongation:	30% minimum (ASTM D638)
Odor:	Low
Vapor Pressure:	0.02 psi at 77 °F (140 Pa at 25 °C) maximum
Flash Point:	175 °F (80 °C) minimum (ASTM D3278)
Solids Content:	100%
<b>Performance Properties of HMWM Resin</b>	
Cure Speed	-
Bulk Cure	less than 3 hours at 73 °F (25 °C)
Surface Cure	less than 8 hours at 73 °F (25 °C) less than 24 hours at application temperature
Gel Time	25-75 min. at application temperature, 1.7 fl. oz. (50 ml) sample

**B. Epoxy Bridge Deck Crack Sealant.**

Furnish epoxy bridge deck crack sealant listed on the QPL.

**C. Deck Sealant Sand.**

Furnish silica or garnet sand containing less than 0.5% moisture and in accordance with Table 717-2.

**TABLE 717-2  
DECK SEALANT SAND GRADATIONS**

<b>Percentage By Weight Passing Square Mesh Sieves</b>	
<b>Sieve Size</b>	<b>Percent Passing</b>
No. 8 (2.36 mm)	100
No. 16 (1.18 mm)	80-100
No. 50 (0.30 mm)	0-7