SECTION 701
AGGREGATES

701.01 AGGREGATE FOR CONCRETE

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

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

Fineness Modulus of Fine Aggregate .....AASHTO M 6
Sieve Analysis for Fine and Coarse Aggregate MT-202
Wear Test MT-209
Sulfate Soundness.....AASHTO T 104 or ASTM C-88
Mortar-making Properties .....AASHTO T 71
Organic Impurities.....AASHTO T 21
Coal and Light Particles.....AASHTO T 113
Clay Lumps.....AASHTO T 112

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 (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

The material must not contain other deleterious material, such as shale, alkali, mica, coated grains, and soft, flaky particles.

C. Soundness. When fine aggregate is subjected to five cycles of the sodium or magnesium sulfate soundness test, the total corrected loss cannot exceed 10 and 15 percent by weight respectively.

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 (E) below. 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 seven days, a minimum compressive strength of 95 percent of the strength developed by a mortar made with the same cement under AASHTO T 71.

F. Grading. The gradation requirements 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 under AASHTO M 6. Fine aggregate from a source with a fineness modulus variation greater than plus or minus 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 percent 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 meet these specifications.

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

B. Deleterious Substances. Meet the deleterious material limits in 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 pieces having a length greater than five times average thickness	15.00
Material passing the No. 200 sieve	1.00[1]

Notes:

1. In crushed aggregates, if the material finer than the No. 200 sieve consists of fracture dust essentially free from clay or shale, the maximum limit may be increased to 1.5 percent.

The material must not contain other deleterious material, such as shale, alkali, mica, coated grains, and soft, flaky particles.

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 percent by weight respectively.

D. Percentage of Wear. Furnish coarse aggregate having a wear factor not exceeding 40 percent.

E. Reserved.

F. Grading. Furnish 1 1/2-inch (37.5 mm) aggregate meeting the gradations in Table 701-4 for No. 4 (4.75 mm) to 1 1/2-inch (37.5 mm), furnished in two separate sizes respectively meeting the gradations for No.4 (4.75 mm) to 3/4-inch (19 mm) and 3/4-inch to 1 1/2-inch (19 mm to 37.5 mm) size material.

Furnish 3/4-inch (19 mm) aggregate meeting the gradations for No 4 (4.75 mm) to 3/4-inch (19 mm) material.

Furnish coarse aggregate uniformly graded between the limits specified in 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 1 1/2" (4.75 to 37.5 mm)	No. 4 to 3/4" (4.75 to 19mm)	No. 4 to 1 1/2" (4.75 to 37.5 mm)	No. 4 to 1/2" (4.75 to 12.5 mm)
2" (50 mm)	100		100	
1 1/2" (37.5 mm)	95-100		90-100	
1" (25 mm)		100	20-55	
3/4" (19 mm)	35-70	90-100	0-15	100
1/2" (12.5 mm)				90-100
3/8" (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

Notes:

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

701.02 AGGREGATE FOR SURFACING

701.02.1 General Requirements

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

Sieve Analysis For Fine And Coarse Aggregate MT-202
Wear Test MT-209
Liquid Limit, Plastic Limit, Plasticity Index MT-208
Fracture MT-217
Volume Swell of Bituminous Mixtures.....MT-305
Sulfate Soundness.....AASHTO T-104 or ASTM C-88

Sulfate soundness will be tested by the Department for source approval. If the test fails the Contractor may not use the source to produce coarse surfacing aggregate.

Meet the following sulfate soundness requirements:

- Sodium or Magnesium sulfate soundness test, five cycles.
- Coarse aggregate, 12 percent and 18 percent maximum respectively.

A. Acceptance. 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 submission of the sulfate soundness 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 through April 15, 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, meeting Table 701-6 gradation requirements.

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				
2 1/2 inch (63 mm)			100			
2 inch (50 mm)				100		
1 1/2 inch (37.5mm)					100	
1 inch (25 mm)						100
No.200 (0.075)	15 max.	15 max.	15 max.	15 max.	15 max.	15 max.

The maximum liquid limit and plasticity index for the material passing the No. 40 sieve is 30 and 6 respectively.

701.02.3 Sand Surfacing

Furnish sand surfacing meeting Table 701-7 gradation requirements.

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**
1 1/2 inch (37.5 mm)	100				
1 inch (25.0 mm)		100			
3/4 inch (19.0 mm)			100		
1/2 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)	20 max.	20 max.	20 max.	20 max.	20 max.

The liquid limit for the material passing the No. 40 sieve is 25 maximum, and the plasticity index cannot exceed 0.

701.02.4 Crushed Base Course Type "A"

Furnish crushed base course Type "A," including added binder or blending material, meeting Table 701-8 gradation requirements. 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				
	Grade 5A		**Grade 6A**	
Sieve Size	**Job Mix Target Limits**	**Job Mix Tolerance**	**Job Mix Target Limits**	**Job Mix Tolerance**
2 inch (50 mm)	100			
1 1/2 inch (37.5 mm)	97	± 3	100	
3/4 inch (19.0 mm)	78-80	± 8	82-88	± 8
3/8 inch (9.5 mm)	58-62	± 8	52-64	± 12
No. 4 (4.75 mm)	42-50	± 8	36-48	± 12
No. 40 (0.425)	14-22	± 8	16-24	± 10
No. 200 (0.075)	3-5	± 3	3-5	± 3

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

1. The maximum liquid limit and plasticity index for the material passing the No. 40 sieve is 25 and 6 respectively;
2. Dust ratio limitations do not apply;
3. A wear factor not exceeding 50 percent at 500 revolutions;
4. Furnish binder meeting Subsection 301.02.2 requirements; and
5. At least 35 percent by weight of the aggregate retained on the No. 4 sieve has at least one mechanically fractured face for Grade 5 and 25 percent for Grade 6.

701.02.5 Crushed Base Course Type "B"

Furnish crushed base course Type "B", including added binder or blending material, meeting Table 701-9 gradation requirements.

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		
1 1/2 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. The liquid limit for the fine aggregate passing the No. 40 must not exceed 35, while the plasticity index cannot exceed 10;
2. Dust Ratio: The portion passing the No. 200 sieve must not exceed two-thirds of the portion passing the No. 40 sieve;
3. A wear factor not exceeding 50 percent at 500 revolutions;
4. Up to five percent by weight of material one grade larger than that being produced is allowed. For example, when producing 1 1/2-inch (37.5 mm) material, up to five percent 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 percent by weight of the aggregate retained on the No. 4 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, meeting Table 701-10 gradation requirements.

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				
3/4 inch (19.0 mm)		100			
5/8 inch (16.0 mm)			100		
1/2 inch (12.5 mm)				100	
3/8 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 sieve cannot exceed two-thirds of the portion passing the No. 40 sieve;
2. The maximum liquid limit and plasticity index for the material passing the No. 40 sieve is 25 and 6 respectively;
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 have a volume swell not exceeding 10 percent, and 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 percent at 500 revolutions; and
7. At least 35 percent by weight of the aggregate retained on the No. 4 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, meeting Table 701-11 gradation requirements.

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**
1 1/2 inch (37.5 mm)	100		
1 inch (25 mm)		100	
3/4 inch (19.0 mm)			100
1/2 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)	5-20	5-20	5-20

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 sieve cannot exceed two-thirds of the portion passing the No. 40 sieve;
2. The maximum liquid limit and plasticity index for the material passing the No. 40 sieve must not exceed 35, while the plasticity index may vary from 3 to 10;
3. A wear factor not exceeding 40 percent at 500 revolutions; and
4. At least 20 percent by weight of the aggregate retained on the No.4 sieve must have one fractured face.

701.02.8 Crushed Cover Aggregate - Cover Material

Furnish cover material meeting the gradation requirements of Table 701-12.

TABLE 701-12

TABLE OF GRADATIONS - COVER MATERIAL

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES					
Sieve Size	**Grade 1A**	**Grade 2A**	**Grade 3A**	**Grade 4A**	**Grade 5A**
5/8 inch (16.0 mm)	100				
1/2 inch (12.5 mm)		100	100		
3/8 inch (9.5 mm)	33-55	40-100	95-100	100	100
No. 4 (4.75 mm)	0-15	0-8	0-30	0-15	9-50
No. 8 (2.36 mm)	0-5	—	0-15	—	2-20
No. 200 (0.075 mm)	0-2	0-1	0-2	0-2	2-5

Meet the following requirements:

1. The material for Grades 1A through 4A must be non-plastic. For Grade 5A the liquid limit and plasticity index for the material passing the No. 40 (0.425 mm) sieve cannot exceed 25 and 6 respectively;
2. 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 percent;
3. The aggregate must have a wear factor not exceeding 30 percent at 500 revolutions; and
4. A minimum of 70 percent by weight of the coarse aggregate for Grades 1A through 4A must have at least one fractured face. A minimum of 50 percent by weight of the coarse aggregate for Grade 5A must have at least one fractured face.

701.02.9 Aggregate for Portland Cement Treated Base

Furnish aggregate for portland cement treated base; including added blending material, meeting Table 701-13 gradation requirements.

TABLE 701-13

TABLE OF GRADATIONS - AGGREGATE FOR CEMENT TREATED BASE

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES	
Sieve Size	**Job Mix Target Limits**
3/4 inch (19.0 mm)	100
No. 4 (4.75 mm)	40-70
No. 10 (2.00 mm)	25-55
No. 200 (0.075)	4-12

Meet the following requirements:

1. The maximum liquid limit and plasticity index for the material passing the No. 40 sieve must be 30 and 7 respectively; and
2. The material used to produce the aggregate must have a wear factor not exceeding 50 percent 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:

Sieve Analysis For Fine And Coarse Aggregate	MT-202
Wear Test	MT-209
Liquid Limit, Plastic Limit, Plasticity Index	MT-208
Fracture	MT-217
Volume Swell Of Bituminous Mixtures	MT-305
Plastic Fines In Graded Aggregates	MT-213
Sulfate Soundness	AASHTO T-104 or ASTM C-88

Sulfate soundness will be tested by the Department for source approval. If the test fails the Contractor may not use the source to produce coarse aggregate to be bituminized.

Meet the following sulfate soundness requirements:

- Sodium or Magnesium sulfate soundness test, five cycles.
- Coarse aggregate, 12 percent and 18 percent maximum respectively.

A. Acceptance. 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 submission of the sulfate soundness 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 through April 15 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 mineral filler when required, meeting Table 701-15 gradation requirements.

TABLE 701-15

TABLE OF GRADATIONS - AGGREGATE FOR PLANT MIX SURFACING

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES				
	Grade A		Grade B	
Sieve Size	Job Mix Target Limits	Job Mix Tolerance	Job Mix Target Limits	Job Mix Tolerance
3/4 inch (19.0)	100		100	
1/2 inch (12.5)	87-93	± 8	86-90	± 7
3/8 inch (9.5)	77-83	± 8	75-79	± 7
No. 4 (4.75)	52-58	± 7	51-57	± 7
No. 10 (2.00)	36-41	± 6	32-40	± 6
No. 40 (0.425)	19-21	± 5	14-16	± 4
No. 200 (0.075)	6-8	± 2	4.5-6.5	± 1.5

Meet the following requirements:

1. A wear factor not exceeding 40 percent at 500 revolutions using Montana Test MT-209;
2. For Grade A aggregate at least 50 percent by weight of the coarse aggregate particles must have at least one mechanically fractured face. For Grade B aggregate at least 60 percent by weight of the coarse aggregate particles must have at least two mechanically fractured faces;
3. The maximum liquid limit for the aggregate passing the No. 40 sieve is 25. The maximum plasticity index for Grade A aggregate is 6. Grade B aggregate must be non-plastic;
4. The final produced aggregate, including treated aggregate, must have a volume swell not exceeding 10 percent and cannot show cracking or disintegration; and
5. The aggregate must not contain adherent films of clay and other matter that prevents thorough coating with bituminous material.

The target Marshall field density is established from test results using MT-311 on specimens molded with 50 blows per side.

A. Plant Mix Bituminous Surfacing - Grade D. Furnish plant mix bituminous surfacing Grade D meeting all the specifications for Grade B except as modified below.

TABLE 701-15 A

TABLE OF GRADATIONS - AGGREGATE FOR PLANT MIX SURFACING

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES		
	Grade D	
Sieve Size	Job Mix Target Limits	Job Mix Tolerance
3/4 inch (19.0)	100	
1/2 inch (12.5)	79-83	± 7
3/8 inch (9.5)	68-72	± 7
No. 4 (4.75)	44-50	± 7
No. 10 (2.00)	27-33	± 6
No. 40 (0.425)	12-15	± 4
No. 200 (0.075)	4.5-6.5	± 1.5

At least 60 percent of coarse aggregate particles by weight must have at least two mechanically fractured faces as determined by MT-217.

Aggregate used in the mix consists of crushed particles. Separate natural fines before crushing. Do not exceed five percent of minus No. 4 sieve material in the crusher feed.

The target Marshall field density is established from results of tests made using MT-311 from specimens molded with 75 blows per side.

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 and meets Table 701-17 gradation requirements.

TABLE 701-17

TABLE OF GRADATIONS - BEDDING MATERIAL

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES	
Sieve Size	Percent Passing
4 inch (100 mm)	100
No. 4 (4.75 mm)	25-60
No. 200 (0.075 mm)	12 max.

Notes:

- Use minus 1 1/2-inch (37.5 mm) aggregate in the top 3 inches (75 mm) of bedding material.

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 percent by weight of the foundation material must pass a No. 4 sieve.

701.05 FILTER MATERIAL

Furnish filter material meeting Table 701-18 gradation requirements.

TABLE 701-18

TABLE OF GRADATIONS - FILTER MATERIAL

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES		
Sieve Size	**No. 1**	**No. 2**
2 inch (50 mm)		100
1 1/2 inch (37.5 mm)		95-100
3/4 inch (19.0 mm)		35-70
3/8 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 three 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 1/2 cubic foot (0.014 cubic meters) 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 meeting Table 701-19 requirements.

TABLE 701-19

TABLE OF GRADATIONS - RANDOM RIPRAP

CLASS	WEIGHT OF STONE	EQUIVALENT SPHERICAL DIAMETER[1]	% OF TOTAL WT THAT MUST BE SMALLER THAN GIVEN SIZE
I	100 pounds (45 kg) 60 pounds (27 kg) 25 pounds (11 kg) 2 pounds (0.90 kg)	1.05 feet (320 mm) 0.88 feet (270 mm) 0.66 feet (200 mm) 0.27 feet (80 mm)	100 70-90 40-60 0-10
II	700 pounds (318 kg) 500 pounds (227 kg) 200 pounds (91 kg) 20 pounds (9.0 kg)	2.00 feet (610 mm) 1.79 feet (545 mm) 1.32 feet (400 mm) 0.61 feet (190 mm)	100 70-90 40-60 0-10
III	2000 pounds (09 kg) 1400 pounds (35 kg) 700 pounds (318 kg) 40 pounds (18 kg)	2.82 feet (860 mm) 2.53 feet (770 mm) 2.00 feet (610 mm) 0.77 feet (235 mm)	100 70-90 40-60 0-10

Notes:

1. Based on unit weight of 165 pounds per cubic foot (2,675 kg/cubic meter).

701.06.3 Grouted Riprap

Furnish stone for grouted riprap meeting Subsection 701.06.2 requirements.

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 meeting Table 701-20 requirements.

TABLE 701-20

SIZE REQUIREMENTS - BANK PROTECTION

TYPE	1	2	3	4
Nominal Thickness	24 inch (610mm)	18 inch (460 mm)	12 inch (305 mm)	Coarse gravel
Overall Thickness Including Bedding	30 inch (760mm)	24 inch (610 mm)	18 inch (460 mm)	As specified in the contract
Largest Rock Permissible	1/4 cubic yd. (0.19 m^3)	1/8 cubic yd. (0.09 m^3)	1 cubic ft. (0.03 m^3)	1/8 cubic ft. (0.003 m^3)
Smallest Rock Permissible	1/10 cubic ft. (0.003 m^3)	1/10 cubic ft. (0.003 m^3)	1-1/2” (40 mm)	3/16" (5 mm)

701.08 SAND-GRAVEL CUSHION

Furnish sand-gravel cushion for concrete slope protection meeting Subsection 701.04.1 requirements for bedding material except that all the material must pass a 1 1/2 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 percent passing the 2-inch (50 mm) sieve and not more than 10 percent passing the No. 200 sieve. The material volume swell cannot exceed 10 percent and must have a plasticity index not exceeding 10.

701.10 DRAIN AGGREGATE

Furnish drain aggregate that is rounded to sub-rounded aggregate meeting Table 701-21 gradation requirements.

TABLE 701-21

TABLE OF GRADATIONS - DRAIN AGGREGATE

PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES	
Sieve Size	**Percent Passing**
6 inch (152 mm)	100
3/4 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 meeting AASHTO M-318. Meet the following requirements for the glass cullet and the blended product:

- **A.** Furnish glass cullet containing no more than five percent 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 then 20 percent of the total blended product.

SECTION 702
BITUMINOUS MATERIALS

702.01 BITUMINOUS MATERIALS

Furnish bituminous materials meeting the requirements of the following tables. The MDT tables are located at the end of this Section.

Meet the requirements for bituminous materials specified in the contract.

702.02 TESTING AND ACCEPTANCE

A. All Properties Except Asphalt Cement Penetration. Bituminous materials are accepted on the test results of samples selected and tested by the Department or its authorized representative. Collect samples as specified in 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. Bituminous materials used before receipt of the test results and permitted by the Project Manager does not waive the Department's right to accept or reject materials under these specifications.

B. Asphalt Cement Penetration. Asphalt cement penetration is sampled and accepted under Subsections 402.03.2 and 402.03.5(B).

TABLE 702-1

BASIS FOR ACCEPTANCE OF BITUMINOUS MATERIALS

SAMPLE TESTED	SPECIFICATION LIMITS[1]		TOLERANCE LIMITS		REMARKS
	Test Results Within Limits	Test Results Outside Limits	Test Results Within Limits	Test Results Outside Limits[3]	
Original Sample	Accept Material	Apply Tolerance Limits[2]	Accept Material	Test Retained Sample	Retained sample may be tested only if test results of original sample are outside tolerance limits.
Retained Sample	Accept Material	Apply Tolerance Limits[2]	Accept Material	Accept Material at Reduced Price or Reject	

Notes:

1. See specification for bituminous materials.
2. Tolerance limits are applied to the minimum and maximum specification values of specification tables. See Table 702-2 for Schedule of Tolerances.
3. 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

SCHEDULE OF TOLERANCES

TEST	ALLOWABLE VARIATION		REMARKS
	From Min. Specification Requirement	From Max. Specification Requirement	
Flash Test Asphalt Cement Cutback Asphalt	 -5% -10%		
Penetration Liquid Asphalt Distillation Residues	-10%	+10%	
% Residue from Distillation	5%		% of Total Distillate: 2 ml may be added or subtracted at any distillation temp. before calculating the % recovered
Ductility	-10%		
Solubility	-0.5%		
Viscosity Cutback Asphalts Emulsified Asphalts	 -10% 0%	 +10% +25%	Emulsified asphalt in violation of the minimum specification requirement subject to rejection and removal from the work or 50% price reduction at the Engineer's discretion.
% Residue of 100 pen.	-5%	—	
Thin Film Oven Test % loss in wt. % retained pen.	 — -2%	 +10% —	
Demulsibility and Sieve Tests	-10%	+10%	
Spot Test	NO TOLERANCE - Materials in violation of spec. subject to standard price reduction.		
Water	NO TOLERANCE - Materials in violation of spec. subject to rejection or 50% price reduction at the Engineer's discretion.		
Particle Charge	NO TOLERANCE - Materials in violation of spec. and any aggregate used in conjunction with its use will, at the Engineer's discretion, be either rejected or paid for at a unit rate not to exceed 50% of the cost of the materials.		

TABLE 702-3

SPECIFICATION FOR ASPHALT CEMENT

	PENETRATION GRADE									
	40-50		60-70		85-100		120-150		200-300	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Penetration, 100 g, 5 sec. at 77 °F (25 °C), dmm	40	50	60	70	85	100	120	150	200	300
Flash Point, (Cleveland open-cup), °F (°C)	450 (232)	—	450 (232)	—	450 (232)	—	425 (218)	—	350 (176)	—
Ductility at 77 °F (25 °C), 5 cm per min., cm	100	—	100	—	100	—	100	—	—	—
Solubility, percent	99	—	99	—	99	—	99	—	99	—
Thin-film Oven Test, 1/8 in. (3.2 mm), 325 °F (163 °C), 5 hour loss on heating, percent	—	0.8	—	0.8	—	1.0	—	1.3	—	1.5
Penetration of residue, percent of original	58	—	54	—	50	—	46	—	40	—
Ductility of residue at 77 °F (25 °C), 5 cm per min., cm	—	—	50	—	75	—	100	—	100	—
Spot Test	Negative for all grades									

TABLE 702-4

SPECIFICATIONS FOR RAPID CURING LIQUID ASPHALTS

	RC-70		RC-250		RC-800		RC-3000	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Kinematic Viscosity at 140 °F (60 °C), centistokes[1]	70	140	250	500	800	1600	3000	6000
Flash Point (tag, open-cup), °F (°C)	—	—	80 (27)	—	80 (27)	—	80 (27)	—
Water, percent	—	0.2	—	0.2	—	0.2	—	0.2
Distillation Test: Distillate, percentage by volume of total distillate to 680 °F (360 °C)								
to 374 °F (190 °C)	10	—	—	—	—	—	—	—
to 437 °F (225 °C)	50	—	35	—	15	—	—	—
to 500 °F (260 °C)	70	—	60	—	45	—	25	—
to 600 °F (315 °C)	85	—	80	—	75	—	70	—
Residue from distillation to 680 °F (360 °C) volume percentage of sample by difference	55	—	65	—	75	—	80	—
Tests on residue from distillation:								
Penetration, 100 g, 5 sec. at 77 °F (25 °C), dmm	80	120	80	120	80	120	80	120
Ductility, 5 cm/min. at 77 °F (25 °C), cm	100	—	100	—	100	—	100	—
Solubility, percent	99	—	99	—	99	—	99	—

Notes:

1. As an alternate, Saybolt-Furol viscosities may be specified as follows:
   Grade RC-70 - Furol viscosity at 122 °F (50 °C) - 60 to 120 sec.
   Grade RC-250 - Furol viscosity at 140 °F (60 °C) - 125 to 250 sec.
   Grade RC-800 - Furol viscosity at 180 °F (82.2 °C) - 100 to 200 sec.
   Grade RC-3000 - Furol viscosity at 180 °F (82.2 °C) - 300 to 600 sec.

TABLE 702-5

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[1]	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, percent	—	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)	—	25	0	20	0	10	—	—	—	—
to 500 °F (260 °C)	40	70	20	60	15	55	0	35	0	15
to 600 °F (315 °C)	75	93	65	90	60	87	45	80	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	120	250	120	250	120	250	120	250	120	250
Ductility, 5 cm/cm, cm [2]	100	—	100	—	00	—	100	—	100	—
Solubility, percent	99	—	99	—	99	—	99	—	99	—
Spot Test	Negative for MC-3000 only									

Notes:

1. 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.
2. 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 702-6

SPECIFICATIONS FOR SLOW CURING LIQUID ASPHALTS

	SC-70		SC-250		SC-800		SC-3000	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Kinematic Viscosity at 140 °F (60 °C), centistokes[1]	70	140	250	500	800	1600	3000	6000
Flash Point (Cleveland, open-cup), °F (°C)	150 (66)	— —	175 (79)	— —	200 (93)	— —	225 (107)	— —
Water, percent	—	0.5	—	0.5	—	0.5	—	0.5
Asphalt residue of 100 pen., percent by wt.	50	—	60	—	70	—	80	—
Distillation Test: Total distillate to 680 °F (360 °C), percent by volume	10	30	4	20	2	12	—	5
Tests on residue from distillation:								
Kinematic Viscosity at 140 °F (60 °C), centistokes	4	70	8	100	20	160	40	350
Ductility of 100 pen., residue at 77 °F (25 °C), 5 cm per min., cm	100	—	100	—	100	—	100	—
Solubility, percent	99	—	99	—	99	—	99	—

Notes:

1. As an alternate, Saybolt-Furol viscosities may be specified as follows:
   Grade SC-70 - Furol viscosity at 122 °F (50 °C) - 60 to 120 sec.
   Grade SC-250 - Furol viscosity at 140 °F (60 °C) - 125 to 250 sec.
   Grade SC-800 - Furol viscosity at 180 °F (82.2 °C) - 100 to 200 sec.
   Grade SC-3000 - Furol viscosity at 180 °C (82.2 °F) - 300 to 600 sec.

TABLE 702-7

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 CaCl2, % 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, percent	95.5	
Float Test at 140 °F (60 °C), sec.	1200	—

TABLE 702-8

LATEX OR POLYMER MODIFIED CRS-2 EMULSIFIED ASPHALT

PROPERTY	TEST METHOD	LMCRS-2	CRS-2P
Viscosity at 122 °F (50 °C), sec.	AASHTO T-59	75-400	50-400
Sieve, percent	AASHTO T-59	0.3 max.	0.3 max.
Settlement, 5 days, percent	AASHTO T-59	5 max.	5 max.
Demulsibility, percent	AASHTO T-59	40 min.	40 min.
Storage Stability Test, 1 day, percent	AASHTO T-59	1 max.	1 max.
Particle Charge	AASHTO T-59	Positive	Positive
Ash Content, percent	AASHTO T-111	0.2 max.	0.2 max.
Tests on Residue by Evaporation: Percent Residue	AASHTO T-59	65 min.	65 min.
Penetration, 100 g, 5 sec. at 77 °F (25 °C), dmm	AASHTO T-49	100-200	100-250
Ductility at 77 °F (25 °C), 5 cm per minute, cm	AASHTO T-51	40 min.	75 min.
Elastic Recovery, percent	AASHTO T-301		58 min.
Torsional Recovery, percent	MT-333	18 min.	

TABLE 702–9

PERFORMANCE GRADED ASPHALT BINDER (PGAB)

PERFORMANCE GRADE	PG 52				PG 58				PG 64				PG 70			
	–22	–28	–34	–40	–22	–28	–34	–40	–22	–28	–34	–40	–22	–28	–34	–40
Average 7–day Maximum Pavement Design Temperature, °C	<52				<58				<64				<70			
Minimum Pavement Design Temperature, °C	–22	–28	–34	–40	–22	–28	–34	–40	–22	–28	–34	–40	–22	–28	–34	–40
Original Binder																
Flash Point Temp, AASHTO T48: Minimum °C Cleveland Open Cup (COC)	230															
Viscosity, AASHTO T316 Maximum, 3 Pa•s (3000 cP), Test Temp, °C M	135															
Dynamic Shear (DSR), AASHTO T315 G*/sin Δ, Minimum, 1.00 kPa Test Temperature @ 10 rad/s, °C	52				58				64				70			
Rolling Thin Film Oven Residue AASHTO T240																
Mass Loss, Maximum, %	1.0															
Dynamic Shear (DSR), AASHTO T315 G*/sin Δ, Minimum, 2.20 kPa Test Temperature @ 10 rad/s, °C	52				58				64				70			
Pressure Aging Vessel Residue AASHTO R28																
Pressure Aging Vessel (PAV) Aging Temperature, °C	90				100				100				100			
Dynamic Shear (DSR), AASHTO T315 G*sin Δ, Maximum 5000 kPa Test Temperature @ 10 rad/s, °C	19	16	13	10	22	19	16	13	25	22	19	16	28	25	22	19
Bending Beam Rheometer (BBR) Creep Stiffness, AASHTO T313 S, Maximum, 300 Mpa m-value, Minimum, 0.300 Test Temp, @ 60 sec, °C	–12	–18	–24	–30	–12	–18	–24	–30	–12	–18	–24	–30	–12	–18	–24	–30
Direct Tension (DT), AASHTO T314 Failure Strain, Minimum, 1.0% Test Temp @ 1.0 mm/minute C	–12	–18	–24	–30	–12	–18	–24	–30	–12	–18	–24	–30	–12	–18	–24	–30

SECTION 703
LIGHTING & SIGNAL MATERIALS

703.01 GENERAL

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

- National Electrical Manufacturers Association (NEMA);
- The National Electrical Code (referred to as the Code);
- The standards of the American Society for Testing Materials (ASTM);
- The American National Standards Institute (ANSI); and
- 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 and meeting ASTM A 153, B 454 (Class 50), or other applicable ASTM galvanizing specifications. Anchor bolts may be galvanized, or cadmium plated with Type NS coating meeting ASTM A 165. Galvanized bolts and nuts must thread together without damaging the coating.

703.02 CONDUIT

703.02.1 Plastic Conduit

Furnish rigid polyvinyl chloride meeting UL 651, schedule 80, 150 °F (66 °C) wire rated, direct bury type. Install conduit meeting the applicable requirements of Section 616.

703.02.2 Steel Conduit

Furnish galvanized rigid steel conduit and fittings of mild steel meeting UL 6 and ANSI C 80.1 requirements. Cut a 3-foot (915 mm) test sample of conduit, witnessed by an Inspector, from the end of each size of conduit to be used on the project. Conduit is tested under ASTM A 239.

Install conduit meeting the applicable requirements of Section 616.

703.03 PULL BOXES

703.03.1 Concrete Pull Boxes

Furnish concrete pull boxes, extensions, and covers made of reinforced concrete. Use Class "DD" concrete meeting Section 551 requirements. Use reinforcing steel meeting Section 555 requirements.

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

Inscribe reinforced concrete covers for signal systems, or combined signal and low-voltage lighting systems with the words "TRAFFIC SIGNALS". Furnish reinforced concrete covers for lighting systems inscribed with the words "STREET LIGHTING" ("HIGH VOLTAGE" where specified). Provide two 3/8-inch (9.5 mm) brass or stainless steel hold-down bolts, washers and nuts with the cover. Recess the nuts below the surface of the cover. Furnish a steel cover designed to withstand AASHTO H-20 loads for pull boxes subject to traffic loads.

Assure pull boxes are watertight. Seal the covers with a 1/4-inch (6 mm) bead of asphaltic mastic in the cover recess. Make conduit enter from the bottom of the box.

Furnish metal frames and covers for boxes or vaults formed in the concrete. Inscribe covers with the wording specified in the contract. Assure 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 Metal Pull Boxes

Furnish metal pull boxes made from cast iron with a checkered steel cover, both hot dip galvanized. Attach the cover to the box with brass or stainless steel screws. Provide the cover with a gasket that, with the cover in place, forms a NEMA Type 4 watertight fit. Boss, drill, tap and treat conduit entrances to the box for corrosion protection. Meet the pull box size and details shown in the contract.

703.03.3 Reserved

703.04 STANDARDS AND POSTS

703.04.1 General

Furnish standards fabricated under Section 556 and designed meeting the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals".

Use a minimum luminaire dead load of 75 pounds (34 kg), and a minimum luminaire projected area of 3.3 square feet (0.31 square meter) for design purposes. Use a design wind velocity for all standards of 90 miles per hour (145 km/h).

All standards must be steel. Once the standards, posts, or pedestals are erected and the installation complete, grout any gap between the base and foundation using grout meeting Subsection 713.04 requirements. Form a 3/4-inch (19 mm) drain hole in the grout at the lowest point.

Meet the standard manufacturer’s recommendations for the anchor bolt placement in the foundation.

Install standards or posts as specified in the contract.

Repair all damage to galvanized surfaces on poles and standards by applying one coat of cold galvanizing compound to the damaged area.

703.04.2 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.

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

Field-drill other holes for wire entry, mounting pedestrian and vehicle signals, or pedestrian pushbuttons. Treat the holes or threads with a cold galvanizing compound following the manufacturer's directions.

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.

703.04.3 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 Manufacturer's Standard Gauge.

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

Provide a rain-tight cover 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 on the plans. 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 two nuts and two 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 publication, “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.

Provide four high strength steel anchor bolts with each shaft. Furnish "L" shaped anchor bolts with a minimum 6-inches (155 mm) of the bolt threaded at the top. Size the anchor bolt following the shaft manufacturers 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.

Field drill other holes for wire entry, mounting pedestrian and vehicle signals, or pedestrian pushbuttons. Treat the holes or threads with a cold galvanizing compound following the manufacturers recommendations.

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

703.04.4 Mast Arms - Signal and Luminaire

Mast arms must be single tapered members.

The mast arm end must have a 2-inch (50 mm) slip-fitter tenon at least 6 inches (155 mm) long.

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

Mast arm lengths and mounting heights are shown on the plans.

703.04.5 Type 1-80, 1-100, 1-120, 1-140, and 1-160 Signal Standards

Furnish standards as specified in the contract.

Furnish a cast aluminum base with an internal ground lug and handhole with removable cover. Plumb bases with factory-made shims. Provide a nut and washer with each anchor bolt for the base.

Anchor bases may be used when a single conduit enters the shaft base. The anchor base must be a one-piece steel plate circumferentially welded to the shaft before galvanizing. Furnish two nuts and two washers with each anchor bolt for plumbing and raking the standard.

Provide four high strength steel anchor bolts with each shaft. Furnish "L" shaped anchor bolts with a minimum 6 inches (155 mm) of the bolt threaded at the top.

Leave anchor bolts projecting at least 3 inches (75 mm) from the foundation.

Follow the manufacturer's recommendations for anchor bolt size and bolt circle.

Field drill holes for wire entry, mounting pedestrian and vehicle signals, or pedestrian push buttons. Treat the holes or threads with a cold galvanizing compound following the manufacturer's recommendations.

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

703.04.6 Welding Steel

Meet the American Welding Society Specifications for Welded Highway and Railway Bridges, AWS D-1.1-75 and AWS D1.1 or current revisions, and as amended by AASHTO and the Montana Supplemental Specifications for Welding.

Furnish weld procedures with the shop drawings showing complete welded joint details including material, process, procedure, filler metal, welding technique, workmanship, dimensional tolerances for each type joint used in fabrication, pre-heat, interpass, and heat treatment temperature schedules.

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 CONCRETE FOUNDATIONS

Use Class "D" concrete for all foundations for standards.

Concrete quantity increases for foundations to accommodate the standard furnished by the manufacturer are at Contractor expense.

Construct foundations to accommodate the steel conduit and anchor bolts as specified.

Pancake grounds cannot be used.

Reinforce foundations with No.4 (#13) hoops at 1-foot (610 mm) centers and with eight No.6 (#19) bars equally spaced around the hoops. Form the top 6 inches (155 mm) of the foundation, beveling the exposed concrete edge 2 inches (50 mm). Electrically bond all conduit in each foundation to an anchor bolt using an AWG No.6 copper grounding strap. Connect a bare copper AWG No.6 solid wire between the grounding lug on the standard and the grounding strap.

703.06 CONDUCTORS AND CABLE

703.06.1 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 the code requirements.

Supply connectors and fuses shown in the contract and required to complete the work. Furnish watertight connectors with midget ferrule type fuses.

703.06.2 Signal Cable

Furnish cable meeting the International Municipal Signal Association (IMSA) Specification No.19-1 or 20-1.

Individual conductors must be stranded copper.

Use spade-type connectors.

703.06.3 Detector Loop Shielded Cable

Use 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.

Ground the drain wire at the controller cabinet and dead end where the cable connects to the loop wires.

Make cable to loop wire connections within the pull boxes or signal standards with soldered, waterproof splices.

No other splices are allowed.

703.06.4 Emergency Preemption Detector Cable

Run the cable from the detector head to the discriminator.

Follow the preemption manufacturers recommendations for detector cable connections at the discriminator and detector head.

No splices are allowed in the cable.

703.06.5 Communication Cable

Furnish BJFC 6 pair AWG No. 19 copper cable meeting REA specification PE 39. Do not splice this cable.

703.07 SERVICE AND CONTROL ASSEMBLY

Equip and locate service and control assemblies as shown on the plans. Meet the Code and local utility company requirements.

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

Furnish the Project Manager three keys to the lock.

Include a terminal strip having the number of attaching points for the required conductors with the service and control assembly. Assure the terminal strip has the capacity equal to an AWG No. 6 conductor. Run a bare AWG No.6 solid copper ground wire from the cabinet to a 5/8-inch (16 mm) by 8 foot (2.4 m) copperweld ground rod and clamp, as shown in the plans.

Provide all steel conduit, ground wire, insulated clevis, service wire, all mounting hardware and fittings to complete the work.

Construct photoelectric controls and their associated wires meeting Subsection 703.14 requirements.

703.08 SIGNAL CONTROLLERS

703.08.1 General

Furnish traffic signal equipment meeting the National Electrical Manufacturer's Association (NEMA) Standards Publication No. TS 1-1976 through TS 1-1989 for traffic control systems.

The equipment must also comply with the National Electric Code, ASTM, ANSI, MUTCD and state plus local requirements.

Warrant the entire cabinet and electronics to be free from defects in workmanship and material for six months from the date of installation. Replace any defective parts at Contractor expense.

Assure a signal controller and cabinet manufacturer's representative is present at the signal turn-on to provide technical assistance in setting up, checking out, and demonstrating that the signal meets functional requirements.

703.08.2 Traffic Actuated Controller

Furnish a controller that is a micro-processor based solid state traffic responsive machine that provides 4 pedestrian phases and 4 vehicle phases for the Type 4-A-SS, and 4 pedestrian phases and 8 vehicle phases for the Type 8-A-SS. The 4-A-SS must have two programmable phase overlaps and the 8-A-SS must have four programmable phase overlaps.

The basic elements for the controller must be on modules that are plug connected to the main frame assembly and interchangeable between Traconex controllers. The controller must have an RS232 port capable of upload, download, modem connection, using a DB25 system connector.

The controller must have an internal time clock to enable outputs such as coordination, flash, dial, split, and offset choices. Timing must be accomplished by digital methods and utilize the power line frequency as a base. All automatic time corrections or synchronization except from power outages must be made at 12:00 midnight.

The controller must have an internal coordinator capable of being a master or slave with the appropriate inputs/outputs for 6 dials, 3 splits, and 3 offsets. Coordination must not interfere with non-coordinated signal operation when any other NEMA controller with the same number of phases is substituted.

Assure each phase has identical control capabilities, features, and options. The options and features for each phase must be able to be exercised independently of the options and features exercised on other phases. All controller unit timing intervals and phase options must be programmable from the front panel via a keyboard pad without the use of tools or special auxiliary units. The controller must be menu driven with an LCD display having at least 4 lines, 40 characters long.

The front panel must display the following information:

1. Presence of Vehicle Calls and Actuations on each phase;
2. Presence of Pedestrian Calls on each phase;
3. Termination of phase because of Gap-out;
4. Termination of phase because of maximum Time-out or Force-off;
5. Maximum 2 in effect;
6. Phase Timing;
7. Phase Next;
8. Interval Timing;
9. Time remaining in interval;
10. Hold in effect;
11. Controller at rest; and
12. Preemption.

The front panel must permit programming the following functions and display their status:

1. Phases that are to be enabled for the specific intersection configuration;
2. Concurrent pedestrian phases that are to be enabled for the specific intersection configuration;
3. Flashing or steady walk outputs per phase;
4. Phase that is to rest in walk if there are no conflicting calls;
5. Phases that guarantee timing of the pedestrian clearance intervals when under manual control;
6. Phases assigned to non-actuated #1 and #2 inputs;
7. Start up phase and phase indication;
8. Start up flashing time; and
9. Phase Overlaps.

Overlaps must be programmable from a NEMA overlap card or from the front panel. The programming must consist of assigning the overlapped phases to the respective overlap.

It must be able to display previously programmed data stored in the controller from the front panel. The parameter called for and its current programmed value must be displayed without interruption of the controllers cyclic operation. It must be possible to change any programmed values while the controller is operating.

All display indicators must have a minimum design life of 20,000 hours at the rated voltage.

A. Cabinet. The controller and auxiliary equipment making up the rest of the controller unit with the exception of the preemption detectors and their lead-in cable must be housed in a weatherproof cabinet. Furnish a NEMA Type 3R rated and UL listed cabinet.

Fabricate the cabinets from sheet aluminum at least 0.125-inches (3.2 mm) thick, adequately reinforced, and weatherproof. The cabinet exterior must have a factory-applied prime coat and grey powder coated finish. The cabinet interior must have a white finish.

Provide the main cabinet door with a handle and a tumbler lock keyed for a Corbin #2 key. Equip the auxiliary door with a lock for a standard police key. Furnish two keys for each lock. The door must lock automatically when the door is closed and latched, with the key removed.

Furnish the cabinet with a doorstop assembly to hold the door open at approximately 90 degrees and 150 degrees.

Cabinet sizes are as follows:

1. **"H" Cabinet, Pole Mounted.** The minimum dimensions are 42 inches (1066 mm) high x 26 inches (660 mm) wide x 17 inches (430 mm) deep.
2. **"M" Cabinet, Pedestal Mounted.** The minimum dimensions are 51 inches (1295 mm) high x 30 inches (765 mm) wide x 17 inches (432 mm) deep.
3. **"P" Cabinet, Pedestal Mounted.** The minimum dimensions are 56 inches (1422 mm) high x 44 inches (1118 mm) wide x 26 inches (660 mm) deep.

Furnish two anchor bolts with "M" cabinets. Furnish four anchor bolts with "P" cabinets. Furnish two washers and one nut with each bolt. Furnish bolts meeting the manufacturer's recommendations. Furnish hardware to pole mount the "H" cabinets.

Equip cabinets with an electric fan rated at 100 cubic feet per meter (2.8 cubic meters per min.) minimum. Mount the fan in the top of the cabinet in a manner that prevents rain from entering. The fan must be thermostatically controlled and manually adjustable to turn on between 70 °F (20 °C) and 150 °F (65 °C). Fuse the cabinet fan circuit 125 percent of the capacity of the fan motor.

Furnish the cabinet with louvered filtered vents in the front door. Mount a removable air filter with a metal retainer spring inside the cabinet door behind the louvered vents.

Mount an incandescent lamp on the inside top of the cabinet, near the door. The lamp must provide illumination whenever the cabinet door is open. Florescent lamps are not acceptable.

Equip cabinets with a 150-watt strip heater with a variable adjustable thermostat on a separate circuit breaker and switch.

Supply a copy of the cabinet wiring diagram, a copy of the operating manual for each device, and a copy of the manual for controller P.C. software. Place the wiring diagram in a heavy-duty clear plastic pouch, attached to the inside of the main cabinet door. This pouch must be of a material and design that it provides storage and access to the wiring diagram.

Submit a schematic wiring diagram of the controller and auxiliary equipment before purchasing. This diagram must detail all circuits and parts. Identify the parts shown by name or number. Furnish parts that are readily available and non-proprietary.

B. Cabinet Wiring. The cabinet wiring must provide the following services:

Cabinets must have interface panels capable of terminating a 12-conductor wire 120-volt interconnect and 4-conductor telemetry. A master cabinet must have a relay driven 120-volt panel. A slave cabinet must have a solid-state 120-volt panel. This interface panel must provide the following functions:

1. Offset 1;
2. Offset 2;
3. Offset 3;
4. Dial 2;
5. Dial 3;
6. Dial 4;
7. Flash;
8. Split 2;
9. Coordination/Free;
10. Split 3;
11. AC common from Master; and
12. Spare.

Wire cabinets with a plug-in mounted (solid-state) flasher, and jack mounted relays to permit any combination of flashing red or yellow lights. Operation must cut in flasher and isolate controller from signal light circuits. The NEMA flash circuit must not be controlled by the controller.

Furnish a readily accessible mounting panel in each controller cabinet with provisions for terminating all field circuits.

Wire "H" cabinets for 6 load switches, (4 vehicle and 2 pedestrian). Wire "M" cabinets for 9 load switches, (4 vehicle, 4 pedestrian and 1 overlap). Wire "P" cabinets for 14 load switches, (8 vehicle, 4 pedestrian and 2 overlap).

Terminate the spare output circuits of pedestrian load switches on field terminals for future use.

The cabinet must include a police panel with the following switches:

Switch	**Function**
Auto-flash	The Flash position places the intersection in Flash and turns the conflict monitor and Opticom off and stop-times the controller. Assure the controller begins its mode of operation in the startup routine upon return from the Flash position to the Auto position.
Main Switch	The On position provides normal operation. The Off position removes power from the cabinet, with the exception of the convenience outlet.

Include an auxiliary test panel with the following switches for the cabinet:

Switch	Function
Auto-flash	The Flash position places the intersection in Flash and allows the controller and auxiliary equipment to operate.
Stop-time	The On position applies stop-timing (On - Off - Auto) to the controller. The Auto position allows the conflict monitor or other external source to apply stop-timing to the controller. The Off position removes any external stop-timing applied to the controller.

Each phase has vehicle and pedestrian push buttons to place calls on the phase; six for "H" cabinets, 8 for "M" cabinets, and 12 for "P" cabinets.

Include a 15 amp fused convenience ground fault outlet with the auxiliary test panel. Wire the outlet so it remains functional even with the main switch or main circuit breaker in the off position.

The cabinet must contain an input power panel with the following:

1. Main Circuit Breaker: 40 Amp for 4-A-SS, 50 Amp for 8-A-SS;
2. 20 Amp Auxiliary Equipment Circuit Breaker;
3. 50 Amp RIS;
4. Transient Voltage Protector;
5. Neutral Bus Bar;
6. Base-mounted MOV rated at 70 joules or greater;
7. Ground Bus Bar;
8. 50 Amp Mercury Contactor; and
9. Gas Tube Lightning Arrester.

Wire a transient voltage protector into the cabinet.

The power input for the controller, conflict monitor and other control equipment, exclusive of the flasher circuitry, must come from the transient voltage protection device that protects against abnormalities of less than one-half cycle duration. The protector must be a solid-state high energy circuit containing no spark gap, gas tube or bar component.

The devices current rating must equal or exceed 15 amps.

The protection must be a transient suppression of 200 volts peak, a transient response of less than five nanoseconds, a power dissipation of 10,000 watts, and an overvoltage response of five seconds. The protector must function with a 10 x 1000 microsecond wave form clamping no greater than 200 volt peak.

Wire cabinets to provide for a conflict monitor. Provide cabinet interlock circuitry which automatically places the intersection signals on flashing operation if the conflict monitor is disconnected while the controller is operating the signals and the cabinet door is closed.

Wire cabinets for rack mount vehicle detectors. "H" and "M" cabinets must have a 6-position rack. "P" cabinets must have a 10-position rack. Assign rack slots with slot 1 being for phase 1 detector, slot 2 for phase 2 detector with other slots following this example. Reserve slots 5 and 6 for Opticom in "H" and "M" cabinets. Reserve slots 9 and 10 for Opticom in "P" cabinets. Equip all racks with an external wall mount fused +24 volt DC regulated power supply rated at 2.4 amps.

Install a panel mounted on the lower left side of the cabinet having terminals to terminate loop lead-in cables and up to 4 pedestrian push button lead-in cables for the Type 4-A-SS and 8-A-SS controllers.

Pin assignments for the 4th connector are shown in Table 703-1:

TABLE 703-1

PIN ASSIGNMENTS FOR THE 4TH CONNECTOR

PIN	FUNCTION	I/O	ADDRESS BIT
1	Emergency Preempt 4 Out	O	$62-3
2	Offset 3 Out	O	$61-2
3	Offset 4 In (Add Bit 3)	I	$61-3
4	ON LINE	I	$61-5
5	Spare	O	$62-7
6	Dial 4 In	I	$60-3
7	Dial 6 In	I	$60-5
8	Special Function 2 Out	O	$61-6
9	Split 3 In	I	$60-7
10	Offset 2 In (Add Bit 1)	I	$61-1
11	Flash Out	O	$62-6
12	Offset 1 In (Add Bit 0)	I	$61-0
13	System Detector 8	I	$63-7
14	Dial 5 In	I	$60-4
15	Special Function 3 Out	O	$61-7
16	Split 2 In	I	$60-6
17	System Detector 1 (Seq. #1)	I	$63-0
18	System Detector 4 (Seq. #4)	I	$63-3
19	System Enable	I	$61-6
20	Dimming On	I	$61-7
21	Split 2 Out	O	$60-6
22	Emergency Preempt 2 Out	O	$62-1
23	Railroad Preempt Out	O	$62-4
24	Spare	O	$62-5
25	Dial 2 In (Special Function 2)	I	$60-1
26	Coordination On (Special Function 1)	I	$60-0
27	Coordination Out	O	$60-0
28	Special Function 1 Out	O	$61-5
29	Dial 4 Out	O	$60-3
30	System Detector 5 In	I	$63-4
31	System Detector 3 (Seq. #3)	I	$63-2
32	Emergency Preempt 1 Out	O	$62-0
33	Offset 1 Out	O	$61-0
34	Emergency Preempt 3 Out	O	$62-2
35	Dial 3 In (Special Function 3)	I	$60-2
36	Offset 3 In (Add Bit 2)	I	$61-2
37	Flash Status In	I	$62-7
38	Offset 5 In (Add Bit 4)	I	$61-4
39	System Detector 6 In	I	$63-5
40	System Detector 7 In	I	$63-6
41	Offset 4 Out	O	$61-3
42	Offset 2 Out	O	$61-1

PIN	FUNCTION	I/O	ADDRESS BIT
43	Dial 2 Out	O	$60-1
44	Dial 3 Out	O	$60-2
45	Offset 5 Out	O	$61-4
46	Split 3 Out	O	$60-7
47	System Detector 2 (Seq. #2)	I	$63-1
48	Logic Ground		
49	Emergency Preempt 1 In	I	$62-0
50	Emergency Preempt 2 In	I	$62-1
51	Dial 5 Out	O	$60-4
52	Dial 6 Out	O	$60-5
53	Logic Ground		
54	Logic Ground		
55	Emergency Preempt 3 In	I	$62-2
56	Emergency Preempt 4 In	I	$62-3
57	Railroad Preempt In	I	$62-4
58	Conflict Status In	I	$62-5
59	Reserved		
60	Flash Command In	I	$62-6
61	Reserved		
62	Reserved		
63	Chassis Ground		

Wire cabinets for Opticom emergency preemption equipment. Provide interface terminals for two Model 562 discriminators wired as follows:

4-A-SS

Discriminator #1 Channel A = Ø1
Discriminator #1 Channel B = Ø3
Discriminator #2 Channel A = Ø2
Discriminator #2 Channel B = Ø4

8-A-SS

Discriminator #1 Channel A = Ø1 & Ø6
Discriminator #1 Channel B = Ø3 & Ø8
Discriminator #2 Channel A = Ø2 & Ø5
Discriminator #2 Channel B = Ø4 & Ø7

Provide the necessary logic and wiring to allow the following operation:

1. Immediate advance of the controller to the clearance intervals of the phase timing;
2. All clearance intervals to be timed as set on the controller;
3. After proper clearances, the controller goes directly to the preempted phase bypassing any intervening phases in the normal sequences;
4. During preemption, all pedestrian indications to hold in DON'T WALK; and
5. Following preemption, places a minimum vehicle recall on all phases.

The Opticom interface panel must provide terminations for up to 4 Model 521 Opticom detectors for the Type 4-A-SS and 8-A-SS controllers. One detector must be assigned to correspond to each of the channels available on the discriminator.

Mark all wiring for easy identification. Use permanent labels.

703.08.3 Conflict Monitor

Furnish a self-contained solid-state conflict monitor able to detect the presence of conflicting signal indications and the absence of proper voltage at the field connection terminals of the red signals. It must be able to monitor for the presence of proper operating voltages in the controller and also within itself.

The conflict monitor must monitor switch fail conditions, inadequate yellow timing and have serial communications for a printer or computer.

Furnish a Type 6 or 12 conflict monitor with respect to the corresponding Type 4-A-SS or 8-A-SS controller. It must monitor the Green, Yellow, Red and Walk of each phase.

The front of the monitor unit must contain the MS connector, AC+ power fuse, power indicator, reset switch, signal conflict and Red failure indicators, +24 Volts DC #1 and #2 indicators, controller voltage failure indicator, signal status indicators for each channel, universal removable programming card, initial flash time adjustment control, a RS232 serial communications port, and an LCD display indicating which input on each channel is the conflicting display. All indicators must be LED type.

If a conflict monitor channel is used, bring out all unused inputs to a terminal for future use.

703.08.4 Flasher

Furnish a solid-state 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.

703.08.5 Solid-state Load Switches

Accomplish switching of signal lights (external to the controller mechanism) by using solid-state switching assemblies. Furnish a load switch meeting all NEMA requirements as to the type. Supply 8 load switches with each Type 4-A-SS controller. Supply 12 load switches with each 8-A-SS controller.

703.08.6 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 not 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 meeting all NEMA temperature requirements. Use a 44 pin edge card connector to make all electrical connections.

Supply 4 loop detectors with each Type 4-A-SS controller.

Supply 8 loop detectors with each Type 8-A-SS controller.

703.08.7 Railroad Interconnect

Where railroad interconnects to railroad circuits are specified, the railroad company must furnish a set of normally closed contacts in the railroad cabinet. Perform the traffic signal cabinet to railroad signal cabinet interconnect. Run the circuit conductors in underground, rigid electrical conduit as specified in the contract. Terminate the conduit in the railroad cabinet as directed by the railroad company engineer. Leave the wire ends projecting at least 3 feet (0.9 m) beyond the end fitting inside the railroad cabinet. The railroad must perform all work inside the railroad cabinet. Do not begin work within the railroad right of way without the Engineer's approval. The Engineer will obtain the railroad's approval and notify the Contractor. The railroad may provide any inspection necessary to oversee the Contractor's work on railroad right of way. Railroad inspection costs are at Contractor expense.

Observe the railroad special clearances found elsewhere in the contract.

Furnish solid-state railroad preemption devices meeting the following requirements:

A. Signal Operation Preempted by Train. Any vehicle signal displaying a green immediately receives a yellow clearance. The yellow clearance time may be controller-timed or by other timing device with a range of between 0 to 60 seconds.

Any vehicle signal displaying a yellow continues to time out the controller-set time or switch to an adjustable timer separate from the controller.

All pedestrian signals immediately receive a "DON'T WALK" call.

If vehicle signals are in emergency flashing, they remain flashing with the preemptor disconnected from the circuit.

Upon train preemption, a red signal must always be presented to approaching traffic in advance of the tracks.

The signal phasing during railroad preemption is specified in the contract.

B. Signal Operation After Train Passage. A signal call for "Green" and/or "Walk" must be placed on each phase for normal operation once the train has passed.

Any signal having the "Green" indication must receive a yellow clearance indication. The indication must be timed on the controller phase or other adjustable timer with limits of 0 to 30 seconds.

Once the yellow clearance interval is timed out, the controller reverts to normal operation unless a special sequence is specified.

703.09 TYPE "D" CABINET PEDESTAL

Locate the pedestal as specified or directed. Construct the pedestal, including the concrete work, as specified.

703.10 TRAFFIC AND PEDESTRIAN SIGNALS

703.10.1 Traffic Signal Heads

Furnish traffic signals meeting or exceeding the Traffic Engineers Technical Report No. 1, USAS D010.1-1966, UDC 656.057, or latest revision thereof. Use AWG No. 14 signal cable meeting Subsection 703.06.2 between the mast-arm mounted signals and the pole shaft mounted terminal block.

A. Optical Units. Furnish optical units consisting of a lens, reflector, lamp holder, and 120 volt, clear, 8,000-hour life, traffic signal lamp. Furnish 90, 91 or 116 watt traffic signal lamps rated at 1050 initial lumens for 8-inch (200 mm) signals and 135 watt traffic signal lamps rated at 1570 initial lumens for 12-inch lenses (300 mm).

Furnish the lens color and size specified in the contract. Use a polycarbonate traffic signal lens true to color.

Furnish an "Alzak" Type reflector.

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.

Mount the optical system so the individual components swing open for access or removal. Assure 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 1 1/2-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.

Where terminal compartments are used, terminal blocks in the heads may be omitted.

Supply with each lens a removable tunnel visor (open bottom) of the appropriate size made from at least 0.050-inch (1.3 mm) thick aluminum.

The inside surface of all visors are to be flat black.

C. Back Plates. 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. Paint back plates under Subsection 617.03.12.

D. Mounting Brackets. Mount signal heads using brackets made from 1 1/2-inch (38 mm) standard steel pipe and malleable iron or brass pipe fittings. Plumb or level all elements, symmetrically arrange, and securely assemble. Conceal all conductors in the poles and assembly. At each signal location, construct a terminal compartment in the bracket system as shown on the plans. Bracket mounted signals that are post top mounted must have a terminal compartment cast with an integral slip-fitter. For post-top mounted one-way signal head, a slip-fitter without a terminal compartment may be used. Fit the slip fitter over a 4-inch (105 mm) standard pipe. Provide each slip-fitter with two rows of three set screws in each row to plumb the assembly. Use cadmium plated set screws. Signal heads mounted on luminaire standards or other tall poles must have a terminal compartment to bolt or clamp securely to the pole.

Provide each compartment with a terminal block with twelve terminals, each with two pressure type connectors. Size each connector to accommodate at least five 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. Signal Head Mounting. Mount signal heads as shown on the plans. Use the standard mounting for all three-section mast arm mounted signals, unless 17.5 feet (5.3 m) of roadway clearance cannot be obtained. Use an elevator plumbizer, when necessary, to obtain the 17.5 foot (5.3 m) clearance.

Elevator plumbizer mount all four and five section signals.

Use internally wired plumbing devices for mounting signal heads to mast arms.

Provide positive lock rings and fittings for all signal heads. Use rings and fittings with serrated contacts.

F. Installing Signal Heads. Install signal heads after all other signal equipment is placed and ready for operation, or cover the signal faces with an opaque covering.

G. Directional Traffic Signals. The traffic signals must be optically-programmed and visible only to a specific area of the intersection.

Use 150-watt PAR lamps for optically-programmed signal lamps.

Furnish back plates, mounting brackets, installation, and mounting meeting Subsections 703.10.1(C), (D), (E), (F) and (G).

H. Dual Color Arrows. Furnish traffic signals equipped with a dual row of fiber-optic elements that produce a uniform display for yellow and green arrow indication. Ensure the fiber-optic elements have at least 74 light points and a 0.125-inch (3 mm) thick polycarbonate lens.

703.10.2 Pedestrian Signals

Furnish pedestrian signals rectangular in shape containing the letter messages "WALK" and "DON'T WALK" or the international symbols as specified. Letters must be at least 4 1/2 inches (115 mm) high. Furnish international symbols a minimum of 9 inch (230 mm) high. If, due to electrical or mechanical failure, the word "DON'T fails to illuminate in the "DON'T WALK" lens the signal must not illuminate the word "WALK".

Furnish one piece, watertight, cast aluminum housings with a polycarbonate lenses.

Furnish mounting hardware for pedestrian signals and mount as shown in the contract and meeting Subsection 703.10.1(D) requirements.

Furnish a terminal compartment with the frame-work for each signal mounting.

Provide AWG No.14 conductors meeting Subsection 703.06.1 from the signals to the terminal compartment as a part of this work.

Use pedestrian signals of the same type within each intersection.

Furnish lunar white "WALK" lens. Furnish portland orange "DON'T WALK" lens with both colors meeting the current requirements of the Institute for Traffic Engineers standards.

Furnish clear 90, 91 or 116-watt traffic signal lamps rated at 1050 initial lumens, and 8,000 hours of life at 120 volts.

703.11 LOOPS, LOOP DETECTORS, AND CABLE

703.11.1 Loops

Size and install loops as specified in the contract and to meet the following.

Use one continuous length of No. 12 XHHW wire from the pull box, through the loops and returning back to the pull box. The number of loops is shown on the plans. Twist the loop wires together at three turns per foot (305 mm) between the loop and pull box.

Place the loop wire in the saw-cut slot, pour sealant into the slot encapsulating the wire, and fill the slot level to the pavement surface. Sealant must not require a primer.

Sealant must have a non-critical mix ratio allowing application and cure at ambient temperatures of 40 °F (4.4 °C) or higher.

Cured sealant must withstand heavy vehicle traffic and freeze-thaw cycles, be unaffected by water, gasoline, oils, roadway salts, and most corrosive chemicals.

Repair saw cuts through existing pavement markings as directed.

Clean the saw cut slot by high pressure air before placing the loop and sealant.

Make loop wire connections in pull boxes or signal standards using soldered, waterproof splices. Excess make-up wire or lead-in or loop wire coils is not permitted. Use rosin core solder.

Tag loop wire in the pull box, or signal standard if spliced there, with a permanent wire marker indicating the approach, loop number, and "input" or "output".

703.11.2 Loop Detector

Furnish loop detectors meeting NEMA requirements and Subsection 703.08.6.

703.11.3 Detector Loop Shielded Cable

Furnish cable meeting Subsection 703.06.3.

703.12 PEDESTRIAN PUSH BUTTONS

Furnish and install tamper-proof pedestrian push buttons having a direct push button with a single momentary contact switch in a cast-metal housing. The push button must be raised or flush with the housing and be at least 2 inches (50 mm) in the smallest dimension. The push button must activate with less than 5 pounds (22 N) of push force. The push button housing must be weatherproof, and electrically insulated to prevent shock under all weather conditions. Furnish a housing back plate to fit the pole curvature and, when required, provide saddles to

make a near fit. Furnish and install push button signs shown on the plans. Install the push button and sign on the crosswalk side of the pole with the arrow pointing in the direction of the crosswalk.

Field drill and tap signal standards treating the holes with a rust preventative following the manufacturers directions.

703.13 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:

- 200 Watt: 22,000 initial lumens
- 250 Watt: 27,500 initial lumens
- 400 Watt: 50,000 initial lumens

Ballasts and luminaire must be integral, with the ballast providing -20 °F (-29 °C) starting capacity. Multiple ballasts must be 240 volt regulated lag type, 0.90 power factor, with an operating range of ± 10 percent. 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.

Check luminaires on the ground to insure they provide the specified ANSI/IES light distribution pattern before mounting. Adjust the luminaires at night, as directed, to provide the best roadway light distribution.

703.14 PHOTOELECTRIC CONTROLS

Wire photoelectric controls to meet the contract requirements.

Furnish photoelectric control units of the twist-lock type.

Furnish units that turn on at 1.3 ± 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.

Mount the control at the top of the standard with the photocell oriented toward the north sky or as directed.

Use AWG No. 14 conductor meeting Subsection 703.06.1 between the photoelectric controller and the electrical service. Supply the conductor as part of this work.

703.15 EMERGENCY PREEMPTION SYSTEM

Emergency preemption equipment must be directly interchangeable and compatible with Opticom emergency preemption equipment. Furnish Opticom model 562 discriminators.

Furnish a system using a high-intensity light source to beam a coded message from the emergency vehicles to the detectors at the intersection.

The system must hold the green light in favor of the emergency vehicle or accelerate the normal cycle of the signal change, within NEMA Standards Publication No. TS 1-1976, to provide a standard yellow light clearance, and then a red light stopping traffic across the emergency vehicle path.

When emergency preemption detector cable is included in the system use the cable recommended by the manufacturer or cable meeting Subsection 703.06.4 requirements.

Assure a preemption equipment factory representative provides technical assistance in setting up, checking out, and demonstrating that the system meets functional requirements.

703.16 CLASS 4 TREATED TIMBER POLES

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

Furnish Class 4, machine peeled poles with 8 feet (2.4 m) of the butt treated with a five percent solution of pentachlorophenol. Seat, backfill, and compact around the poles. Compact backfill in 9-inch (230 mm) lifts. Plumb and rake the pole as directed.

703.17 OVERHEAD CONDUCTOR LIGHTING INSTALLATION

703.17.1 Luminaire

Furnish luminaires meeting Subsection 703.13 requirements.

703.17.2 Lighting Brackets

Furnish brackets as shown in the contract that meet or exceed NEMA and IES standards for vertical and horizontal deflection. Use AWG No. 10 copper wiring insulated for 600 volts between luminaire and ballast secondary.

703.17.3 Wood Poles for Overhead Conductor Highway Lighting

Furnish wood poles meeting ANSI specifications. The poles must be straight so that a line drawn from the butt center to the top center passes through the pole body. The poles must be machined-peeled and set to the ANSI recommended depth. Set poles plumb and true to line. Compact backfill in 9-inch (230 mm) lifts.

Pressure treat the bottom 8 feet (2.4 m) of the poles with a five percent by weight pentachlorophenol solution or Chromated Copper Arsenate (CCA), Type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWPA standards and Section 706 requirements.

Repair pole finish damage as directed.

703.17.4 Steel Poles for Overhead Conductor Highway Lighting

Furnish steel poles meeting Subsection 703.04.3 and 703.04.4 requirements.

703.17.5 Line Material

Furnish all line material that meets the contract requirements and the following.

Furnish insulators for brackets, clevises and upset bolts of the wet process type, 3-inch (75 mm) diameter x 3/16-inch (5 mm), 5/8-inch (16 mm) bolt hole having a 7/16 inch (11 mm) radius wire slot, and vertical mounting. It must be rated for wet flashover of 14KV, horizontal mounting wet flashover 17KV, dry flashover 26KV, and ultimate mechanical strength of 5,000 pounds (2,270 kg).

Furnish double upset bolts of 9/16-inch (14 mm) steel with 5/8-inch (16 mm) rolled threads, 1 1/2-inch (38 mm) upset to upset, and 4 1/2-inch (115 mm) threaded insulator end with cotter key.

Use insulated brackets that are spool clevises of the cross arm mounting type constructed of 1 3/4 inch x 1/8-inch (45 x 3 mm) steel providing a 3/4-inch (19 mm) mounting hole and a 5/8-inch (16 mm) cotter pin for mounting the insulator. The clevis must provide a 5-inch (130 mm) distance from the center of the insulator to the mounting face.

Furnish insulated swinging clevises of 1 1/2 x 3/16-inch steel (38 x 5 mm), 5 inches (130 mm) from 5/8-inch (16 mm) cotter pin to eye attachment for 3-inch (75 mm) insulator and 5/8-inch (16 mm) eyebolt or eye-nut.

Furnish copper to copper connectors of high strength silicon bronze threaded with spacer and nut. Use aluminum to copper connectors of an aluminum-alloy bolt and nut with a plated

copper spacer and plated copper contact. Remove the plating from the contact surfaces to identify the copper conductor location.

Insulated tension splices must have a 4-inch (100 mm) insulated length. Size the tap wire attaching clips for the appropriate wire size being installed. Obtain the Project Manager's approval before installation. Use insulated tension splices where required, in series installations, as follows:

1. Do not locate splices closer than 18 inches (460 mm) from a support point.

2. Do not locate splices in spans crossing a highway, street, or railroad.

Do not use conductor with cuts, kinks, or other injuries.

On angle assemblies, place the conductors on the insulator side away from the strain and tie it in place as shown on the plans. Sag all wire with the Project Manager present. The Project Manager will provide the sag tables. Provide an approved thermometer for the temperature reading. Gradually pull the wire to the required sag, keeping the wire free to move at intermediate support points. Do not pull wire beyond the required sag.

703.17.6 Guys and Anchors

Install guys and anchors as specified. Use two strain insulators in all guy spans. Use eye-bolts, eye-nuts, and anchor rods with thimble eyes when used on guys. Furnish eye-bolts and eye-nuts used on down guys of the 45° angle type.

Use 3/8-inch (9.5 mm) Siemens-Martin seven strand, galvanized guy wire meeting ASTM A 363.

Use three medium duty bolt clamps where necessary. Draw all three bolts up tight. Clamps using a stainless steel bail for straight through dead ending of the guy wire are an acceptable alternate to guy clamps.

Furnish 8-feet (2.4 m) long, full round gauge 14 galvanized steel guy protectors.

Use strain insulators meeting the following:

- Rated Voltage, KV: 4.4
- Flashover Voltage, 60 CY, Dry KV: 30
  60 CY, Wet KV: 15
- Mechanical Strength, Pounds (kN): 12,000 (53.3)
- Max. Cable Size, Inches (mm): 1/2 (13)
- Length, Inches (mm): 4-1/8 (105)
- Width, Inches (mm): 2-7/8 (73)

Provide anchors and rods as specified. Install in line with the strain and installed with approximately 6 inches (155 mm) of the rod projecting out of the ground. Backfill the hole with course crushed rock 2 feet (610 mm) above the anchor, compacting in 6-inch (155 mm) lifts for the full depth.

703.17.7 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 ± 10%
- Operating Temperature Range: -40 °F (-40 °C) to 130 °F (54 °C)
- Detector Beam: infrared or visible-red light-emitting-diodes (LED)
- 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).

Mount the transmitter and receiver on metal poles that permit adjusting the detector height from 10 to 16 feet (3.1 m to 4.9 m). Install and adjust the detectors on the poles following the manufacturer's recommendations.

Furnish the transmitter, receiver, two poles, anchor bolts, nuts, washers, all necessary wiring and connectors for this item. The concrete foundations are a separate item.

This work is measured under Subsection 617.04.2(4) and paid for under Subsection 617.05.2.

SECTION 704
SIGNING MATERIALS

704.01 MATERIAL FOR SIGNS

704.01.1 Sheet Aluminum

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

TABLE 704-1

SINGLE POST CENTERLINE MOUNTING

SIGN SIZE inches (mm)	THICKNESS inches (mm)
REGULATORY SERIES WITHOUT BACK BRACING	
0 to 33 (0 to 838) inclusive	0.080 (2)
34 to 41 (864 to 1,041) inclusive	0.100 (2.54)
42 to 51 (1,067 to 1,295) inclusive	0.125 (3.17)
WARNING SERIES WITHOUT BACK BRACING	
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)
ALL SIGNS WITH BACK BRACING	
< or = 32 (813)	0.080 (2)
< or = 40 (1,016)	0.100 (2.54)
< or = 50 (1,270)	0.125 (3.17)
DELINEATOR REFLECTORS	
All sizes	0.063 (1.6)

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.

704.01.2 Aluminum Sheet Increment

Construct Aluminum sheet increment signs using AA5052-H38 or AA 6061-T6 sheet aluminum (thickness in Table 704-1) fastened to an extruded T-section (AA6063-T6) back brace with 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^4 (166.5 mm^4).

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, 3/4-inch (20 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 A 36 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 A 53 Type E or S, Grade B requirements. Furnish square or rectangular tube posts meeting ASTM A 500 or 501 requirements. Painted or galvanized posts are acceptable. Meet ASTM A 123 requirements for galvanizing. Paint the posts meeting the Detailed Drawing requirements.
4. **Square Tubular Steel Posts.** Furnish square tubular steel sign posts, anchor posts, anchor sleeves, and splice sleeves meeting one of the following requirements as specified in the contract:
   - **a.** ASTM A-446 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 A-570, 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 A-307 Grade 2 bolts and nuts. Ensure the sign posts, sleeves, anchor posts, auxiliary fittings and anchor sleeves have 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 1/16-inch in 3 feet (1 mm per m) with the corner radius being 5/32-inch (4 mm) plus or minus 1/64-inch (0.4 mm).
   - **c.** Coat the post with Type 2 aluminum paint at a minimum 0.75 ounces per square foot (228 kg per square meter) 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 ± 0.15 ounces per square foot (183 kg ± 4.3 kg per square meter) meeting AASHTO M-120, followed by a chromate conversion coating 15 ± 5 micrograms per square inch (645 square mm), and a clear organic coating 0.2 ± 0.1 mils (0.005 mm ± 0.0025 mm) thick on the outside surface. Provide double in-line application of a full zinc-based organic coating 1.2 ± 0.6 mils (0.003 mm ± 0.0015 mm) thick tested under ASTM B-117 on the inside surface.

C. Aluminum U Posts. Furnish aluminum posts made of AA6061-T6 alloy extruded to a U channel meeting ASTM B 209.

704.01.5 Treated Timber Posts

Furnish treated timber posts of construction grade, S4S, full length pressure treated with a five percent by weight pentachlorophenol solution or Chromate Copper Arsenate (CCA), Type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWPA standards and Subsection 706.04.1. Perform all cutting, trimming and boring, excluding the breakaway hole, before treatment. Assure individual posts are uniform in color for each project. The posts will be inspected where treated.

Treat injuries, cuts, and holes in posts after treatment with three applications of copper napthenate solution containing a minimum two percent copper metal or with Chromate Copper Arsenate (CCA) meeting AWPA M4 requirements.

704.01.6 Treated Timber Poles

Furnish treated timber poles meeting ANSI Specification 05.1 and of the species listed in Table 4, 5, or 6. All poles on each project must be the same species and uniform in color after treatment. Machine-peel and full-length pressure treat all posts with a five percent by weight pentachlorophenol solution or CCA (Type B or C), or ACA as specified in Subsection 706.04.1. Gain each pole on the sign face as specified. Poles may be gained full-length, or half gained from the top.

Use pressure treated, construction grade 2-inch x 4-inch (50 mm x 105 mm) in S4S for back bracing.

Treat poles, damaged, cut, or bored after treatment meeting Subsection 704.01.5 requirements.

704.01.7 Barn Poles

Barn poles are specified by the top diameter. Meet the following table 704-2 top diameter limits:

TABLE 704-2

BARN 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 poles that are straight so that a line from center of tip to center of butt passes through the pole body from tip to butt. The poles must be free of crooks and sweeps. Full length pressure treat all barn poles with a 5 percent by weight pentachlorophenol solution or Chromate Copper Arsenate (CCA), Type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWPA standards and Subsection 706.04.1 requirements.

Treat damaged, cut, or bored holes in treated posts meeting Subsection 704.01.5 requirements. Gain each pole on the sign face at least 2 inches (50 mm) in width as specified. The post may be gained full length or half-gained from the top.

Use pressure treated, construction grade 2-inch x 4-inch (50 x 105 mm) in S4S for back bracing.

704.01.8 Overhead Structures

Furnish overhead sign structures meeting the current AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, and the contract requirements.

704.01.9 Concrete

Use Class "A" or "D" concrete meeting Section 551 requirements 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. Meet AASHTO M 268 requirements for the type specified.

B. Acceptance. Submit a notarized manufacturer's certification that the retro-reflective sheeting used for each project meets or exceeds contract requirements.

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 reflectivity using a reflectometer.

Replace rejected material at Contractor expense.

704.01.11 Letters, Symbols, and Accessories

A. General. Furnish the material type(s) specified in the contract. Use Type A, Type B, or Type C, described as follows.

B. Type A Letters Using Acrylic Plastic Reflectors.

1. **Description.** Furnish Cutout letters, numerals, alphabet accessories, and border strips of embossed aluminum frames with prismatic reflectors installed or affixed as an integral part of the character. Do not use tape or adhesives to affix the reflectors.
2. **Design and Fabrication.** Use the Federal Standard Alphabet Series "D" or " E modified " for character sizes, series, and spacing. Fabricate characters, borders, and accessory frames from minimum 0.040-inch (1.01 mm) thick sheet aluminum. Drill mounting holes in the frames for attaching to the sign panel. Size and space reflectors to provide maximum night legibility and visibility to the finished figure. The Project Manager will conduct a night inspection for legibility and visibility.
3. **Frame Finishing.** Once metal fabrication is complete, de-grease, etch, neutralize, and treat the frame for painting following the paint manufactures recommendation. Paint the frames the specified color with a quality metal enamel following the paint manufacturer's recommendations. White reflective sheeting meeting Subsection 704.01.10 may be used in place of painting.
4. **Acrylic Plastic Reflector.** Use acrylic plastic reflectors meeting AASHTO M 290 requirements.

C. Type B Letters - Removable.

1. **General.** Provide letters, numerals, symbols, and borders that are adhesive-coated reflective sheeting permanently adhered to die cut aluminum backing. De-grease, etch, and treat the aluminum with a light, tight amorphorous chromate type coating. Use Type III white reflective sheeting. Letter and number design is Federal Standard Alphabet Series "E modified".
2. **Fabrication.** Fabricate letters, numerals, and symbols from minimum 0.040-inch (1.01 mm) thick 3003 H 14 alloy aluminum sheeting. Fabricate borders from 0.032-inch (0.81 mm) thick AA6062 T 6 alloy aluminum sheeting. Prepare the aluminum sheeting and apply the reflective sheeting following the reflective sheeting manufacturer's recommendations. All pieces must have an embossed height of approximately 1/8-inch (3 mm).

   Space mounting holes for screws, bolts, or rivets no more than 8 inches (205 mm) on center; determined by the character size and shape. Edge-seal completed pieces following the reflective sheeting manufacturer's recommendations.

D. Type C Letters - Direct Applied.

1. **Sheeting.** Furnish letters, numerals, symbols, and borders from Type III sheeting, permanently adhered to the sign face reflective sheeting.
2. **Fabrication.** Apply the letters, numerals, symbols, and borders following the sheeting manufacturer's recommendations. Follow the size, series, and spacing in the Federal Highway Administration's Standard Alphabets proportion and spacing requirements.

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

704.01.12 Paint

Use paints meeting Section 710 requirements.

704.01.13 Hardware

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

A. Galvanized meeting ASTM A 153 or ASTM A 164 specifications; or

B. Cadmium-plated steel meeting ASTM A 165; or

C. Aluminum alloy meeting ASTM B 211 for alloy 2024-T4.

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 meeting ASTM B-499, Class 2, 10 to 35 milligrams thick per square foot (0.093 square meter). Hot air dry the sheeting once coated. Apply and seal the reflectorized sheeting on the prepared aluminum sheeting following the reflective sheeting manufacturers recommendations. Meet the applicable requirements of Subsection 704.01.11 for legend and borders.

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 meeting Subsection 704.01.11 requirements. 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.

SECTION 705
GUARDRAIL AND GUIDE POSTS

705.01 GUARDRAIL

Furnish metal beam and cable guardrail materials meeting the contract requirements.

705.01.1 Steel Beams and Fittings

Furnish steel beam guardrail meeting 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 A 307 bolts with ASTM A 563, Grade A or better nuts. Use ANSI B27.2, Type A plain steel washers.

Galvanize all bolts, nuts, washers, and fittings meeting ASTM A 153 or B 695 (Class 50) requirements.

Furnish rounded end sections, buffer sections, and terminal connectors meeting AASHTO M 180, Class B, Type 1 requirements.

705.01.2 Wood Posts and Blockouts

Furnish wood posts and blockouts made from Douglas fir, Hemlock, Ponderosa Pine, Spruce, Larch, 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, all of which must meet ASTM D 245.

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 are seasoned to accept the specified treatment. Furnish wood posts and blocks treated with a minimum 5 percent by weight pentachlorophenol solution or Chromated Copper Arsenate (CCA), Type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWPA standards. The minimum penetration depth is 1/2-inch (13 mm). Do not paint posts unless specified.

Other acceptable blockouts may be manufactured from steel, recycled plastic, and recycled plastic with wood fibers provided information is furnished that they meet NCHRP 350 requirements for the application, i.e., for use with wood, concrete or steel guard rail posts.

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

705.01.3 Concrete Posts

Furnish precast concrete posts meeting the contract requirements. Use Class "DD" concrete or concrete of equal strength meeting Section 551 requirements. Manufacture, transport, and handle guardrail posts meeting Section 554 requirements. Use reinforcing steel meeting Section 711 requirements.

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 3/4-inch (19.0 mm) to No.4 (4.75 mm) or 1/2-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 "DD" concrete) with a maximum absorption of 15 percent by volume and a maximum unit weight of 115 pounds per cubic foot (1,864 kg per cubic meter). Aggregate pre-wetting may be required.

Use reinforcing steel meeting Section 711 requirements. 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 meeting the contract requirements.

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) and the National Cooperative Highway Research Council (NCHRP) 350 crashworthy requirements.

705.02 WIRE ROPE AND CONNECTING HARDWARE

Furnish wire rope and hardware for cable guardrail meeting the contract requirements.

705.03 WOOD TREATMENT AND PAINTING

705.03.1 Wood Treatment

Furnish wood posts and blocks pressure treated meeting Subsection 706.04.1, with a five percent by weight pentachlorophenol solution Chromated Copper Arsenate (CCA), Type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWPA standards. 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. The requirements of Subsection 706.04.2 for incising, do not apply to Ponderosa pine sawn wood posts.

705.03.2 Painting

Use paint and perform painting meeting Subsection 612.03.5(C)(2) requirements when specified.

705.04 GUIDE POSTS

705.04.1 Wood Posts

Furnish wood posts meeting Subsection 705.01.2 and 705.03 requirements. Size and shape are specified in the contract.

705.04.2 Flexible Guideposts

Furnish flexible guideposts meeting the contract requirements and the following:

- The posts must be a white seamless polyethylene extrusion with a minimum 5/32-inch (4 mm) wall thickness having a minimum weight of one pound per foot (1.49 kg/m). The post cross section may be round, triangular, or other shape providing at least 4 inches (100 mm) viewable width.

Erect permanent installations meeting the contract requirements.

Epoxy-cement or nail temporary installations to the pavement surface.

705.04.3 Hardware

Furnish backplates or faceplates for posts meeting the contract requirements.

Furnish bolts, nuts, or studs for fastening the backplate to the post, galvanized meeting ASTM A 153 or B 454 (Class 50) requirements or use cadmium plated. Furnish nuts and studs that are "vandal-resistant".

Furnish other miscellaneous hardware galvanized meeting ASTM A 153 or B 454 (Class 50) requirements.

SECTION 706
TREATED AND UNTREATED TIMBER AND TIMBER PILES

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 on the plans 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 percent 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 as specified.

706.04 TREATED TIMBER AND LUMBER

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

706.04.1 Treating

Furnish timber and lumber that is pressure treated retaining at least the minimum preservative treatment quantity per cubic foot (cubic meter) specified in AWPA C-14.

Use one of the following preservatives:

- Creosote oil, creosote coal tar solution, five percent by weight pentachlorophenol solution; or
- Chromated Copper Arsenate (CCA), Type B or C; or
- Ammoniacal Copper Arsenate (ACA).

Use preservative meeting AWPA standards.

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.

706.04.2 Incising

Mechanically incise timber and lumber of the following listed species having a nominal thickness of 2 inches (actual 38 mm thickness) or greater before treating:

Intermountain Douglas Fir	Northern White Pine	Jack Pine
Pacific Coast Douglas Fir	Red Pine	Red Wood
Western Hemlock	Sugar Pine	Lodgepole Pine
Western Larch	Western White Pine	

Incise timber and lumber 3 inches (63 mm actual thickness) thick or greater on all four sides. Incise timber and lumber 3 inches (63 mm actual thickness) thick and less on the wide faces only, unless otherwise specified. The spacing and shape of the cutting teeth and the incising method must produce a uniform penetration. 1 1/2-inch (38 mm actual dimension) center-matched material used for flumes, boxes, etc., does not need to be incised.

Follow the requirements for minimum incision depths in Table 706-1:

TABLE 706-1

MINIMUM INCISION DEPTHS

SIZE IN INCHES (mm)	MINIMUM DEPTH OF INCISION inch (mm)
1 1/2 x 12 (38 x 286)	3/8 (9)
3 x 12 (63 x 290)	7/16 (11)
4 x 12 (89 x 290)	1/2 (13)
8 x 10 (190 x 240)	9/16 (14)
10 x 12 (240 x 290)	5/8 (16)
12 x 12 (290 x 290)	3/4 (19)

Notes:

- Proportion intermediate sizes.

706.04.3 Inspection

Each shipment of treated timber or lumber must be inspected before and after treating at the plant by a Department Inspector. The Inspector must stamp the ends of each accepted piece with the Inspector's copyrighted stamp. File a true impression of the copy-righted stamp with the Department before transporting timber or lumber to the project. Provide the Project Manager the Inspector's itemized report of all timber and lumber inspected, giving temperatures, quantity of preservative, time of treatment, length and sizes of timbers, total footage, and other pertinent information. Treated timber and lumber not bearing the Inspector's stamp in legible form cannot be transported to the project.

Each shipment of untreated timber and lumber must be inspected at its source by a Department Inspector. If inspection at the source is, in the Project Manger's opinion impractical the material may be accepted by a "Certificate of Inspection" from a recognized competent grading or inspection bureau or agency.

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.

706.05 TIMBER PILES

Meet the following straightness requirements for both treated and untreated timber piles:

- A straight line from the center of the butt to the center of the tip must lie entirely within the body of the pile. Piles must be free from short crooks that deviate more than 2 1/2 inches (64 mm) from straightness in any 5-foot (1525 mm) length.

A. Treated Timber Piles. Furnish treated timber piling of Douglas Fir, Southern Pine, or Western Larch meeting ASTM D 25 requirements, excluding Tables 1 and 2.

Season, condition, and treat piles meeting ASTM D 1760 and AWPA Standard Specifications for preservative treatment by pressure process. Use creosote oil, creosote coal tar solution, or a 5 percent by weight pentachlorophenol solution for the preservative.

B. Untreated Timber Piles. Furnish untreated timber piles meeting ASTM D 25 requirements, except for Tables 1 and 2.

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 meeting AASHTO M 153 requirements.

B. **Joint Sealing Material.** Furnish sealing material for all types of pavement joints that is a hot-poured thermoplastic rubber or rubber asphalt compound meeting 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

Furnish Type II cork pre-formed expansion joint filler meeting AASHTO M 153 requirements.

707.01.3 Concrete Curbs, Gutters, and Sidewalks

Use joint material for concrete curbs, gutters, and sidewalks meeting AASHTO M 213 requirements.

707.02 CULVERT SEALERS

707.02.1 Rubber Gaskets

Furnish ring gaskets meeting AASHTO M 198 requirements.

707.02.2 Flexible Plastic Gaskets

Furnish flexible plastic joint compounds produced from refined hydrocarbon resins and plasticizing materials reinforced with inert mineral filler and not containing solvents. Cohesive and adhesive strength must not be developed by oxidation, evaporation, or chemical action. Supply the gasket in extruded rope form, sized to fill spaces between the pipe sections. Furnish with a two-piece removable wrapper that permits removing one half without disturbing the other half.

Meet Table 707-1 requirements.

TABLE 707-1

COMPOSITION AND PROPERTIES - FLEXIBLE PLASTIC GASKETS

PROPERTY	TEST METHOD	REQUIREMENT	
		Min.	Max.
Bitumen (petroleum plastic content), percent	ASTM D 4	50	70
Mineral Matter (Ash Inert), percent	AASHTO T 111	30	50
Penetration, dmm 0 °C, 300 g, 60 sec. 25 °C, 150g, 5 sec. 46.1 °C, 150 g, 5 sec.	ASTM D 217 Cone	 75 50	 120 150
Softening Point at 25 °C, °C	ASTM D 36	160	
Specific Gravity at 25 °C	ASTM D 71	1.20	1.35
Weight, pounds per gallon		10.4	11.25
Ductility at 77 °F (25 °C), cm	ASTM D 113	5.0	
Flash Point (Cleveland, open-cup), °C	ASTM D 92	315.5	
Fire Point (Cleveland, open-cup), °C	ASTM D 92	329	
Volatile Matter, percent	ASTM D 6		2.0

707.03 SHEET COPPER, RUBBER, AND PLASTIC WATERSTOPS

707.03.1 Sheet Copper

Furnish sheet copper for waterstops meeting ASTM B 152 requirements for copper sheet, strip, plate, and rolled bar, Type ETP with a nominal weight of 16 ounces per square foot (5 kg per square meter) plus or minus eight percent.

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 meeting contract requirements. Reclaimed material cannot be used. Furnish a manufacturer's certificate showing the material composition and the values for the designated properties in Table 707-2. Furnish samples when requested.

TABLE 707-2

PROPERTIES AND TEST METHODS - FINISHED RUBBER WATERSTOP

PROPERTY	FEDERAL TEST METHOD STANDARD NO. 601	REQUIREMENT
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 polyvinyl chloride plastic or other material meeting Table 707-3 requirements.

TABLE 707-3

PROPERTIES AND TEST METHODS - FINISHED PLASTIC WATERSTOP

ASTM STANDARD	PROPERTY	REQUIREMENT
D 2240	Hardness	75 ± 5
D 412	Tensile Strength, min.	2000 psi (14 MPa)
D 412	Ultimate Elongation, min.	350%
D 746	Low Temperature	
Procedure B	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 meeting AASHTO M 85 requirements for Portland cement.

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

The bid tabulations specify only the span dimension to the nearest inch (25 mm), of pipe arch culverts as shown in the Detailed Drawings for the culverts. The plans 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.

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

Furnish pipe meeting AASHTO M 170 requirements, except that par. 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 meeting AASHTO M 206 requirements with Class A-III pipe strength requirements.

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

Furnish pipe meeting AASHTO M 207 requirements.

708.01.5 Flared End Terminal Sections and Tee Risers

Furnish flared end terminal sections and the riser of tee sections meeting AASHTO M 170 Class III pipe requirements.

708.02 CONCRETE PRESSURE PIPE

Furnish reinforced concrete low head pressure pipe meeting ASTM C 361 requirements.

708.03 PERFORATED CONCRETE PIPE

Furnish perforated concrete pipe meeting AASHTO M 175 requirements.

708.04 POROUS CONCRETE PIPE

Furnish porous concrete pipe meeting AASHTO M 176 requirements.

708.05 PVC GRAVITY SEWER AND DRAIN PIPE

708.05.1 Pipe

Furnish gravity pipe 4-inch through 12-inch (105 through 305 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 D 1784. Meet ASTM D 3034 requirements for pipe and fittings. Meet a minimum Standard Dimension Ratio (SDR) of 35.

Furnish perforated pipe meeting ASTM D 2729 requirements.

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

Assure 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 (105 mm through 305 mm) nominal diameter in either Class 150 with a dimension ratio (DR) of 18 or Class 200 with a dimension ratio (DR) of 14 meeting 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 POLYETHYLENE CORRUGATED DRAINAGE PIPE OR TUBING

Furnish heavy duty corrugated polyethylene drainage pipe or tubing and fittings meeting AASHTO M 252 requirements for nominal diameters 3 through 10 inches (76 through 254 mm) and AASHTO M 294 for nominal diameters 12 through 36 inches (305 through 915 mm).

SECTION 709
METAL PIPE

709.01 DUCTILE IRON AND STEEL WATER PIPE

709.01.1 Ductile Iron Water Pipe

Furnish ductile iron pipe meeting AWWA C 151 requirements for the pipe class specified in the contract.

Use mechanical or slip-on joints meeting AWWA C 111 (ANSI A 21.11) requirements. 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 meeting AWWA C 200 Standard for Water Pipe, 6 inches (155 mm) and larger.

Field weld joints and bends meeting AWWA C 206 requirements. 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 meeting AASHTO M 36 requirements (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 that meets AASHTO M 36 requirements. These bands may be used only on pipes with diameters up to and including 36 inches (915 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 3/16-inch (5 mm) diameter continuous rubber chord meeting pipe industry standards into the lock seam during fabrication, all meeting AASHTO M 36; and

4. Construct watertight field joints. Make the connection using a 10 1/2-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 meeting AASHTO M 167 requirements.

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

Meet AASHTO M 245 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 and 246 requirements and the requirements of Subsection 709.02 for irrigation and syphon pipe installations.

Provide a minimum 0.010 in (0.25 mm) coating for both inside and outside surfaces meeting AASHTO M 246, Section 7 requirements.

709.06 CORRUGATED STEEL PIPE FOR UNDERDRAINS

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

Furnish semi-circular underdrain and coupling bands meeting AASHTO M 36 requirements and the Detailed Drawings. Furnish nuts, caps, screws and other parts galvanized meeting ASTM A 153 or B 695 (Class 50). Furnish screens and caps for semicircular underdrains meeting the Detailed Drawings.

Furnish bituminous coated underdrains meeting AASHTO M 190 requirements. 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 meeting AASHTO M 196 requirements, 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 meeting AASHTO M 196 requirements.

709.09 SEAMLESS STEEL PIPE

Furnish seamless steel pipe meeting ASTM A 53 requirements.

709.10 COPPER PIPE

Furnish copper pipe and tube meeting ASTM B 88, Type K requirements.

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 A 36 requirements for grating materials galvanized after fabrication.

709.12 TYPE II ALUMINIZED CORRUGATED STEEL PIPE

Furnish pipe and coupling bands fabricated from material meeting AASHTO M274 requirements. Assure the prefabricated pipe and coupling bands meet the applicable Subsection 709.02 requirements.

SECTION 710
PAINTS

710.01 PIGMENTS, VEHICLES, AND THINNERS

Assure all materials from which paints are made and formulated meet the following specifications:

Zinc Oxide Pigments	ASTM D 79
Pure Chrome Green Pigments	ASTM D 212
Iron Blue Pigments	ASTM D 261
Calcium Carbonate Pigments	ASTM D 1199
Titanium Dioxide Pigments	ASTM D 476
Bone Black Pigment	ASTM D 210
Carbon Black Pigment	ASTM D 561
Black Synthetic Iron Oxide Pigment	ASTM D 769
Red and Brown Iron Oxide Pigments	ASTM D 3722
Ochre (Ferrous Earthy Pigments)	ASTM D 85
Raw and Burnt Umber Pigments	ASTM D 763
Raw and Burnt Sienna Pigments	ASTM D 765
Copper Phtalocyanine Blue Pigment	ASTM D 963
Iron Blue Pigment	ASTM D 261
Ultramarine Blue Pigments	ASTM D 262
Chrome Oxide Green Pigment	ASTM D 263
Chrome Yellow and Chrome Orange Pigments	ASTM D 211
Yellow Iron Oxide Pigment-hydrated	ASTM D 768
Aluminum Pigments	ASTM D 962
Zinc Dust (Pigment)	ASTM D 520
Magnesium Silicate Pigments	ASTM D 605
Diatomaceous Silica Pigments	ASTM D 604
Mica Pigment	ASTM D 607
Raw Linseed Oil	ASTM D 234
Boiled Linseed Oil	ASTM D 260
Spirits of Turpentine	ASTM D 13
Petroleum Spirits (Mineral Spirits)	ASTM D 235
Lampblack Pigments	ASTM D 209
Liquid Paint Driers	ASTM D 600
Raw Tung Oil	ASTM D 12

710.02 PAINTS AND ENAMELS

A. General. Follow the paint manufacturers 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 Product Safety Data Sheets. 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. Aluminum Paint, Ready-mixed. Furnish aluminum paint meeting AASHTO M 260 (Type II, Leafing Finish).

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 (125 µm) dry film thickness.

Meet Table 710-1 minimum paint composition requirements.

TABLE 710-1

ALUMINUM EPOXY PAINT COMPOSITION

	COMPOSITION
Solids	90% ± 2% by volume (ASTM D 2697)
Pigment	19% by volume
Vehicle	66% by volume
Percent non-volatile vehicle	74%
Nominal VOC	0.74 pounds/gal. (89.1 grams/liter)

The mixed paint must weigh between 11 to12 pounds per gallon (1.3 to 1.4 kg per liter) when measured under ASTM D 1475 at 75 plus or minus 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 meeting Table 710-2 requirements.

TABLE 710-2

EPOXY PAINT FOR PIPE PILE REQUIREMENTS

	REQUIREMENT
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 D 4060; CS-17 wheel, 1,000 Gram load, 1,000 cycles)	170 mg loss, max.
Direct Impact Resistance (ASTM D 2794)	60 in. pounds min. (6.8 N×m/min)

Additional requirements:

a. Salt Fog. No blistering, cracking, or film delamination when tested under ASTM B 117 for 1,500 hours; and

b. Moisture Condensation Resistance. No blistering, cracking, or film delamination when tested under ASTM D 2247 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 as specified in 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 per 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

	WHITE	YELLOW	BLACK
Coarse particles and skins retained on No. 325 sieve, max. (45 µm)	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^2 per 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.**
Pigment[4]	56.5%	58.5%
Vehicle[5]	41.5%	43.5%
Pigment Composition:		
Zinc Phosphate	60.0%	—
Titanium Dioxide (Rutile)[6]	13.0%	—
Calcium Carbonate	21.4%	—
Vehicle Composition:		
Alkyd Phthalic Resin (50% Solids)	52.4%	—
Raw Linseed Oil	26.2%	—
Mineral Spirits	17.2%	—
Driers and Additives	4.2%	—
Finished Paint:		
Consistency (Krebs-Stormer)[1]	70 KU	83 KU
Weight Per Gallon, pounds[2]	12.6 (5.7 kg)	—
Dry To Touch[3]		8 hours
Dry To Handle[3]		16 hours
Dry Film Thickness mil	1.0	—

Notes:

1. By ASTM D-562
2. By ASTM D-1475
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 D 1394

710.02.1 Reserved

710.02.2 Reserved

710.02.3 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 meeting Table 710-5 requirements.

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 D 4060, CS-17 wheel, 1,000 cycles)	 224 mg max. loss
Direct Impact Resistance	120 in. pounds. (13.6 N×m min.)

Additional requirements:

1. **Salt Fog.** No blistering, softening, cracking or film delamination when tested under ASTM B 117 for 1,000 hours; and
2. **Moisture Condensation Resistance.** No blistering, rusting or delamination when tested under ASTM D 2247 for 1,000 hrs. at 100 °F (37 °C).

C. Finish Coat. Provide a two-component finish epoxy meeting Table 710-6 requirements.

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 D 4060, CS-17 wheel, 1,000 cycles)	 224 mg. max. loss
Impact Resistance	120 in. pounds. (6714 mm kg min.)

Additional requirements:

1. **Salt Fog.** No blistering, softening, cracking or film delamination when tested under ASTM B 117 for 1,000 hours; and
2. **Moisture Condensation Resistance.** No blistering, rusting or delamination when tested under ASTM D 2247 for 1,000 hours at 100 °F (37 °C).

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 meeting AASHTO M 31 requirements.

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 meeting AASHTO M 284 and the contract requirements.

Assure the bars are coated by an applicator plant certified under the Concrete Steel Institute's certification program for Fusion-bonded Epoxy Applicator Plants, or equivalent certification program.

711.01.3 Wire and Wire Mesh

Furnish concrete reinforcing wire meeting AASHTO M 32 requirements.

Furnish wire mesh reinforcing for concrete meeting AASHTO M 55 requirements and the contract.

Furnish bar mats meeting AASHTO M 54 requirements.

711.02 STRUCTURAL STEEL

Furnish structural steel for:

A. Bridge superstructure applications meeting AASHTO M 270/M 270M.

Use material meeting 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 meeting AASHTO M 183/ M 183M.

711.03 STRUCTURAL STEEL TUBING

Furnish structural steel tubing for bridges meeting ASTM A 500, Grade B, requirements 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 forging's meeting AASHTO M 102, Class C requirements, or cold-finished carbon steel shaft meeting AASHTO M 169 requirements, Grades 1018 to 1030 inclusive. Fabricate pins and recessed pin nuts as detailed in the AISC Manual of Steel Construction, current edition.

711.05 WELDING ELECTRODES

Use welding electrodes meeting AWS, AASHTO, and the contract requirements.

711.06 HIGH TENSILE STRENGTH BOLTS

Furnish heat-treated carbon steel bolt, nut, and washer material meeting AASHTO M 164 requirements.

Specify in the purchase order for galvanized high tensile strength bolts that copies of the manufacturer's inspection test reports for the materials are to be forwarded with the order. Make the reports available to the Project Manager upon request.

Rockwell C hardness cannot exceed 32 before galvanizing.

711.07 BOLTS AND NUTS

Furnish bolts, threaded rod, and nuts meeting ASTM A 307 Grade A requirements. Use hexagonal headed nuts for steel machine bolts and tap bolts.

711.08 GALVANIZED METAL

Furnish galvanized ferrous metal products meeting AASHTO M 111 requirements, or when applicable, meeting ASTM B 695 (Class 50) requirements.

711.09 WELDED STUD SHEAR CONNECTORS

Furnish shear connector studs meeting the AWS specification for "Stud Welding" and the contract requirements.

711.10 STEEL PILING

711.10.1 Structural Steel Piles

Furnish new steel H piles, smelted and manufactured in the USA, meeting AASHTO M270 Grade 345 MPa (50 ksi) and contract requirements.

711.10.2 Steel Pipe Piles

Furnish new steel pipe piles, smelted and manufactured in the USA, meeting ASTM A 252, Grade 2 requirements with a minimum yield strength of 310 Mpa (45 ksi). Steel pipe diameter and wall thickness is specified in the contract.

711.11 PRESTRESSING STEEL

Furnish prestressing steel meeting ASTM A 416 requirements.

711.12 CASTINGS

711.12.1 Steel Castings for Highway Bridges

Furnish castings meeting AASHTO M 192, Class 485 requirements.

711.12.2 Chromium Alloy Steel Castings

Furnish castings made from Grade CA-15 meeting AASHTO M 163 requirements.

711.12.3 Drainage Structure Castings

Furnish structural drainage castings meeting the Detailed Drawing requirements and AASHTO M 306 requirements modified as follows:

1. References to Federal Specification RR-F-621C are changed to read RR-F-621 and current amendments thereto;
2. The Grey iron casting requirements of Subsection 3.1 are changed to AASHTO M 105 (ASTM A 48) Class 207;
3. The weight requirement of Subsection 4.2.4 is (plus or minus 5 percent Drawing/Specification Weight);
4. The proof load testing of Subsections 7.1 and 9.1.1 is 25,000 pounds. (110 kN);
5. Delete Subsections 11.1.2 and 11.1.3; and
6. Subsection 11.1.4 is changed to read Heat number or date.

711.13 BEARING ASSEMBLY ANCHOR BOLTS FOR BRIDGES

Furnish anchor bolts sized as specified and meeting ASTM A 36 requirements.

711.14 ELASTOMERIC BEARING DEVICES

Furnish elastomeric bearings meeting AASHTO M 251 and the contract requirements.

711.15 COMPRESSION JOINT SEALS

Furnish preformed elastic joint seals meeting the open cell compression seal requirements of ASTM D 3542 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 meeting ASTM D 4070 requirements.

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 manufacturers certificate of compliance meeting 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 unvulcanized rubber and synthetic fibers. Each component must make up 50 percent of the pads weight.

The pad surface must have:

1. A standard rubber hardness of 80 plus or minus 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 1/16-inch (2 mm) and 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 meeting the contract requirements.

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

Assure the base metal and spelter coating meet AASHTO M 218 requirements. Use galvanized bolts, nuts, washers, and other hardware meeting ASTM A 153 or B 695 (Class 50, Type I) requirements.

Assure 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.

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
- Type 4 Vinyl-coated Fabric

Use zinc-coated steel for all Type 1 or Type 2 fabric, fence 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 meeting AASHTO M 181 requirements. 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 Table 712-1 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 by 3/4-inch (19 mm) wide.
- Aluminum - a minimum 1/8-inch (3 mm) thick by 7/8-inch (22 mm) wide.

Furnish aluminum or steel stretcher bars as follows:

- A minimum 1/4-inch (6 mm) thick by 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 meeting ASTM A 116 requirements. Furnish 11-gauge, Class 1 galvanized steel hog ring fasteners meeting ASTM A 116 requirements.

Furnish 9-gauge aluminum tie wire meeting ASTM B 211 Alloy 1100, Temper H14 requirements. Furnish minimum 11-gauge aluminum hog ring fasteners meeting ASTM B 211, Alloy 6061 requirements.

712.01.7 Tension Wire

Furnish 7-gauge galvanized coiled spring steel tension wire. Meet ASTM A 116, Class 1 galvanizing requirements.

Furnish 6-gauge aluminum tension wire meeting ASTM B 211, Alloy 6061, Temper T 94 requirements.

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. Meet AASHTO, AWS specifications, and the contract requirements for all welding.

A. Steel Gates. Construct gate frames from steel sections meeting Table 712-1 requirements. 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 meeting Subsection 712.01.2 and match the fabric used in the fence.

B. Aluminum Gates. Construct gate frames from aluminum sections meeting Table 712-1 requirements. Assemble the gates frames by welding.

Use aluminum alloy cast hinges meeting ASTM B 108 or B 26 requirements or made of malleable iron or steel and hot-dip galvanized or mechanically galvanized meeting ASTM B 695 (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 meeting Subsection 712.01.2 requirements and matching the fabric used in the fence.

TABLE 712-1

TABLE OF FENCE SUPPORTS AND FRAMING FOR CHAIN LINK FENCE

USE	GRADE	STEEL SHAPE, SIZE, WT	ALUMINUM SHAPE, SIZE, WT
Line Posts	1	1.90" O.D. pipe at 2.70 lb/ft (48 mm O.D. pipe at 4 kg/meter), 1.875' x 1.625' x 0.113' H-section at 2.70 lb/ft (571 mm x 495 mm x 35 mm at 4 kg/meter)	2.375" O.D. pipe at 1.25 lb/ft (61 mm O.D. pipe at 1.85 kg/meter), 2.25" x 1.95" H-section at 1.25 lb/ft (58 mm x 50 mm H-section at 1.90 kg/meter)
	2	1.90" O.D. pipe at 2.28 lb/ft (48 mm O.D. pipe at 3.40 kg/meter)	
End, Corner and Pull Posts	1	2.375" O.D. pipe at 3.65 lb/ft (61 mm O.D. pipe at 5.40 kg/meter), 2.0" x 2.0" sq. tubing at 3.61 lb/ft (51 mm x 51 mm sq. tubing at 5.40 kg/meter)	2.875" O.D. pipe at 2.0 lb/ft (75 mm O.D. pipe at 3 kg/meter), 3.0" x 3.0" sq. tubing at 2.0 lb/ft (76 x 76 mm sq. tubing at 3 kg/m)
	2	2.375" O.D. pipe at 3.12 lb/ft (61 mm O.D. pipe at 4.6 kg/meter)	
Gate Posts Leaf Width: 6 ft (1.8 m) and less	1	2.875" O.D. pipe at 5.79 lb/ft (73 mm O.D. pipe at 8.60 kg/meter), 2.5" x 2.5" sq. tubing at 5.7 lb/ft (64 mm x 64 mm tubing at 8.50 kg/meter)	2.875" O.D. pipe at 2.0 lb/ft (73 mm O.D. pipe at 3 kg/meter)
	2	2.875" O.D. pipe at 4.64 lb/ft (73 mm O.D. pipe at 6.9 kg/meter)	3.0" x 3.0" sq. tubing at 2.0 lb/ft (76 x 76 mm sq. tubing at 3 kg/meter)
Over 6 ft thru 13 ft (1.8 thru 4 m)	1	4.0" O.D. pipe at 9.10 lb/ft (105 mm O.D. pipe at 13.5 kg/meter), 3.0" x 3.0" sq. tubing at 9.10 lb/ft (76 mm x 76 mm tubing 13.5 kg/meter)	4.0" O.D. pipe at 3.0 lb/ft (102 mm O.D Pipe at 4.50 kg/meter)
Over 13 ft thru 18 ft (4 thru 5.5m)	1	6.625" O.D. pipe at 18.97 lb/ft (168 mm O.D. pipe at 28.20 kg/meter)	6.625" O.D. pipe at 7.0 lb/ft (168 mm O.D. pipe at 10.50 kg/meter)
Rails and Braces	1	1.660" O.D. pipe at 2.27 lb/ft (42 mm O.D. pipe at 3.40 kg/meter)	1.660" O.D. pipe at 0.786 lb/ft (42 mm O.D. pipe at 1.2 kg/meter)
	2	1.660" O.D. pipe at 1.84 lb/ft (42 mm O.D. pipe at 2.70 kg/meter)	
Gate Frames Leaf Width: 8 ft. (2.4 m) and less	1	1.660" O.D. pipe at 2.27 lb/ft (42 mm O.D. pipe at 3.40 kg/meter), 1.5" x 1.5" sq. tubing at 1.90 lb/ft (38 mm x 38 mm tubing at 2.90 kg/meter)	1.900" O.D. pipe at 0.94 lb/ft (48 mm O.D. pipe at 1.40 kg/meter), 2.0" x 2.0" sq. tubing at 0.94 lb/ft (51 x 51 mm sq. tubing at 1.40 kg/meter)
	2	1.660" O.D. pipe at 1.84 lb/ft (42 mm O.D. pipe at 2.70 kg/meter)	
Over 8 ft (2.4 m)	1	1.90" O.D. pipe at 2.72 lb/ft (48 mm O.D. pipe at 4 kg/meter), 2.0" x 2.0" sq. tubing at 2.10 lb/ft (51 mm x 51 mm sq. tubing at 3.10 kg/meter)	1.90" O.D. pipe at 0.94 lb/ft (48 mm O.D. pipe at 1.40 kg/meter), 2.0" x 2.0" sq. tubing at 0.94 lb/ft (51 x 51 mm sq. tubing at 1.40 kg/meter)
	2	1.90" O.D. pipe at 2.28 lb/ft (48 mm O.D. pipe at 3.40 kg/meter)	

712.02.1 Woven Wire

Furnish woven wire meeting ASTM A 116 requirements and either of the Table 712-2 designations.

TABLE 712-2

WOVEN WIRE REQUIREMENTS

INTERSTATE FENCE			
Specification	**Grade**	**Design Number**	**Metallic Coating**
ASTM A 116	No. 12 1/2 Grade 60	832-6-12 1/2	Type Z, Class 1
ASTM A 116	No. 14 Grade125	832-6-14	Type Z, Class 3

FARM FENCE			
Specification	**Grade**	**Design Number**	**Metallic Coating**
ASTM A 116	No. 12 1/2 Grade 60		Type Z, Class 1
ASTM A 116	No. 14 Grade125		Type Z, Class 3

Provide a 6-inch (155 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 12 1/2 or 13 1/2-gauge barbed wire meeting ASTM A 121 requirements. Space barbs a nominal 4-inches (105 mm) or a nominal 5-inches (130 mm). Zinc coating must be Class 1 for 12 1/2 and 13 1/2 gauge wire. Provide the Project Manager Certification that the wire meets ASTM A 121 requirements.

712.02.3 Brace Wire

Use 9 or 12 1/2 gauge soft, smooth wire.

712.02.4 Staples and Nails

Use minimum 9-gauge U-shaped, 1 3/4-inch (45 mm) long staples unless otherwise specified.

712.02.5 Tie Wires

Use minimum 12 1/2 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 9 1/2-gauge wire twisted to form a two-wire unit.

712.02.7 Metal Posts and Assemblies

Provide metal fence posts and assemblies meeting ASTM A 702 requirements, modified as follows:

- Tables 3, 4, and 6.1 through 6.2.2 of ASTM A 702 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 meeting ASTM A 153 or B 695 (Class 50) galvanizing requirements. Paint following the paint manufacturer's recommendations.

Furnish fence posts and braces of the lengths in Table 712-3.

TABLE 712-3

POST LENGTHS

FENCE	POST TYPE	CORNER, END, GATE, PULL & PANEL POSTS	LINE POSTS	BRACES AND BRACE RAILS
Interstate	Metal	7 feet 8 inch (2.3 m)	6 1/2 feet (2.0 m)	7 feet 8 inch (2.3 m)
Interstate	Wood	8 feet (2.4 m)	7 feet (2.1 m)	8 feet (2.4 m)
Farm	Metal	7 feet (2.1 m)	6 feet (2.0 m)	7 feet (2.3 m)
Farm	Wood	8 feet (2.4 m)	7 feet (2.1 m)	8 feet (2.4 m)

Use 2 1/2 inch x 2 1/2 inch x 1/4 inch (64 mm x 64 mm x 6 mm) or heavier metal fence posts for Interstate and Farm fence for corner, end, gate and pull posts. Use 2 inch x 2 inch x 1/4 inch (51 mm x 51 mm x 6 mm) or heavier metal pipe brace posts. Line posts must have a nominal weight of 1.33 pounds per foot (2 kg per meter) exclusive of anchor plates.

The metal must be good commercial-quality steel having a maximum 0.82 percent carbon content.

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

Weld a steel anchor plate to each line post so that the anchor top is 2 inches to 3 inches (50 mm to 75 mm) below groundline 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, or Douglas Fir. Remove all bark from the posts.

Taper round posts to be driven from 8 inches to 12 inches (205 to 305 mm) up from the bottom to a 1-inch (25 mm) point. Taper the post tops to a round top with a minimum 3-inch (75 mm) diameter for line posts and 4-inch (105 mm) diameter for corner, brace, pull, end, and gate posts. These taper lengths are included in the specified post lengths. Perform all tapering before treatment. Treat the posts and rails meeting Subsection 706.04.1.

Use minimum 4-inch (105 mm) diameter brace rails.

Ensure the posts and rails are straight so that a line running from the center of both ends is within the body of the post or rail.

B. Posts for Farm Fence. Furnish posts meeting the dimensional requirements in Subsection 712.02.8(C).

Treat the posts with a minimum 5 percent by weight pentachlorophenol solution or Chromated Copper Arsenate (CCA), Type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWPA Standards. Assure the treatment penetrates the wood at least 1/2-inch (13 mm) or full sap, with a minimum retention of 0.4 pounds per cubic foot (6.50 kg per cubic meter).

Extend the treatment for at least 36 inches (915 mm) for line posts and 48 inches (1,220 mm) for all other posts. Post treatment must be at a Department approved plant.

C. Posts for Interstate Fence. Furnish line posts and brace rails from a minimum 4-inch (105 mm) diameter, naturally round, or a minimum 4-inch x 4-inch (105 mm x 105 mm) square sawn. Furnish corner, end, gate, pull, and brace posts from a minimum 5-inch (130 mm) diameter naturally round post or a 5 x 5-inch (130 mm x 130 mm) square sawn post.

Treat all wood fence material meeting Subsection 706.04.1 requirements.

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 meeting Subsection 712.02.1, Class 1 or better.

The approximate weight of the gate frames (less fabric) must meet Table 712-4 requirements.

TABLE 712-4

APPROXIMATE GATE FRAME WEIGHTS

WIDTH OF OPENING	APPROXIMATE WT[1]
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 meeting the Detailed Drawings and contract requirements.

712.02.12 Deadman or Anchor

Furnish deadman and anchor(s) meeting the Detailed Drawing requirements.

712.02.13 Miscellaneous

Bolts, nuts, fittings, hinges, and all other metal parts for constructing fences and gates must be galvanized meeting the specified ASTM specification.

SECTION 713
MISCELLANEOUS MATERIALS

713.01 WATER

Furnish water for mixing and curing concrete that meets AASHTO M 157, 4.1.4 requirements. Water will be tested under 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 meeting AASHTO M 303 requirements.

713.03 CALCIUM CHLORIDE

Furnish calcium chloride meeting AASHTO M 144 requirements.

713.04 CEMENT GROUT

Produce grout consisting of 1 part portland 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 meeting Subsection 701.01.1 and Table 713-1 gradation requirements.

TABLE 713-1

MORTAR SAND GRADATION REQUIREMENTS

SIEVE SIZE	% PASSING
No.4 Sieve (4.75 mm)	100
No.8 Sieve (2.36 mm)	90-100
No.16 Sieve (1.18 mm)	60-90
No.50 Sieve (0.300 mm)	15-40
No.100 Sieve (0.150 mm)	0-10

713.05 TOPSOIL

Furnish topsoil meeting Table 713-2 gradation requirements.

TABLE 713-2

TOPSOIL GRADATION REQUIREMENTS

FRACTION	PARTICLE SIZE (mm)	MAX. % OF SOIL (-10 MESH) (2mm) FRACTION
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[1]

Notes:

1. A maximum of 20 percent is allowable. Any quantity exceeding 10 percent is not included in the basis for payment. Gradation is tested under 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 percent;

2. Soil conductivity factor less than 4; and
3. Organic content between 1 percent and 20 percent.

Topsoil is sampled and tested under Montana Test Method MT-412.

713.06 MINERAL FILLER

Mineral filler is portland cement, ground limestone dust, fly ash, or graded fines free of silt or clay produced from crushing stone, gravel, slag, or other non-plastic mineral matter. Mineral filler and their sources are subject to the Project Manager's approval.

Furnish mineral filler meeting Table 713-3 gradation requirements when tested under MT-301.

TABLE 713-3
MINERAL FILLER GRADATIONS

SIEVES	TOTAL PERCENT PASSING
No. 30 (0.600 mm)	98-100
No. 80 (0.180 mm)	95-100
No. 200 (0.075 mm)	65-100

Meet the following:

1. Dry and free from fine particle lumps;
2. Free carbon less than or equal to five percent by weight as measured by the loss on ignition test; and
3. Silica content less than or equal to ten percent for un-calcined materials.

AASHTO T 165, T 167, and Montana Test Method MT-306 or other tests may be used to determine the need for mineral fillers.

713.07 CONCRETE CURING AND PROTECTIVE COATINGS

713.07.1 Water-soluble or Emulsified Liquid Membrane-forming Linseed Oil Compounds

Furnish water-soluble or emulsified liquid membrane-forming linseed oil compounds meeting AASHTO M 148 requirements. Linseed oil compounds, when used as a protective coat must contain a minimum 2.7 pounds (0.32 kg) of linseed oil per gallon (liter).

Furnish a manufacturer’s written certification showing the formulated weight of linseed oil per gallon (liter) meets or exceeds this limit.

713.07.2 Miscellaneous Combination Curing and Protective Coating Compounds

Obtain the Project Manager's written approval before using a commercial product.

Meet AASHTO M 148 requirements for a liquid membrane-forming compound for curing concrete.

713.07.3 Membrane Curing Compounds

Use membrane curing compounds meeting AASHTO M 148 requirements.

713.08 SEED

713.08.1 Grass 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 Department Agronomist.

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:

% Pure Live Seed = Germination % x Purity x 100
Bulk Seed Needed = Total Lbs. Pure Live Seed Required / % Pure Live Seed x 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.

Make each species of seed available in separate bags for sampling and inspection.

713.08.2 Legume Seed

Meet Subsection 713.08.1 requirements for source, grade, purity, germination, and "live seed" definition. Use the inoculant's specified in the contract when seeding legumes.

713.09 FERTILIZER

Use commercially manufactured fertilizer meeting the contract requirements.

The fertilizer must be labeled with the manufacturer's guaranteed analysis, meeting Montana fertilizer laws.

Contaminated or damaged fertilizer will be rejected.

Apply fertilizer at the rate specified in the contract.

713.10 MULCH

713.10.1 Vegetative Mulch

Vegetative mulch is pliable cereal grain straw or grass hay at least 8 inches (205 mm) in length.

Mulch will be rejected for the following reasons:

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

713.10.2 Reserved

713.10.3 Fabricated Netting

Fabricated netting is composed of burlap, kraft paper string, or similar products and may be fabricated on the project.

Submit samples for testing and approval before use.

713.10.4 Wood Cellulose Fiber Mulch

Wood cellulose fiber mulch is specially prepared wood cellulose fibers free of growth or germination inhibiting materials that forms a homogeneous slurry when combined with water, fertilizer, and other approved additives and remains uniformly suspended under agitation. Color the mulch with a water-soluble, nontoxic dye to aide visual metering during application. Apply the mulch to produce a mat-like cover on the seeded ground.

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

Furnish wood cellulose fiber mulch meeting Table 713-4 requirements.

TABLE 713-4

WOOD CELLULOSE FIBER MULCH
PHYSICAL AND CHEMICAL PROPERTIES

PROPERTY	LIMIT	TOLERANCE
Moisture Content (total wt. basis)	12%	± 3%
Organic Matter (oven-dried wt. basis)	99.2%	± 0.2%
Inorganic Content (Ash)	0.8%	± 0.2%
Min. Water-holding Capacity (oven-dried wt. basis)	1080 g/minute	100 g/minute

Supply the mulch in 50 pound (22.7 kg) bags net weight. Each bag must be marked by the manufacturer showing the air-dry weight content.

Supply a minimum one-pound (0 454 kg) bag of the mulch proposed for use for testing when requested.

Provide a manufacturer's certificate of compliance under Subsection 106.03, attesting that the material meets these specifications.

713.10.5 Recycled Paper Fiber Mulch

Recycled paper fiber mulch is waste paper of at least 85 percent by weight, cellulose fiber. The mulch must:

1. Not contain any germination or growth inhibiting material nor non-biodegradable material;
2. Contain at least 90 percent organic matter (oven dry) when tested under ASTM D 586;
3. Have a pH of between 5.5 and 8.0;
4. Supplied in the manufacturers packages, clearly marked showing the package weight and contents; and
5. Packaged mulch moisture content cannot exceed 15 percent by weight.

The mulch, when mixed with water and fertilizer and agitated, must be a uniform, homogenous mixture. The mulch or slurry must contain a green non-toxic dye making the mulch clearly visible once applied.

Apply the mulch hydraulically to form a moisture-retaining surface that holds the seed in contact with the ground without smothering the seed.

713.11 SOD

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

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

Cut the sod when the grass length is approximately 2 inches (50 mm) high but not exceeding 3 inches (75 mm). Assure 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 from a municipal, domestic, or other source suitable for irrigation.

713.12 SOIL RETENTION/EROSION CONTROL BLANKETS AND MATS

713.12.1 Wood Excelsior Fiber Blankets

A. Type EX 1. Type EX 1 wood excelsior fiber blanket is a machine produced mat uniform in thickness and weighing at least 1 pound per square yard (545 g per square meter). The top side of the blanket must be covered with a photo-degradable extruded plastic mesh netting.

B. Type EX 2. Furnish Type EX 2 wood excelsior fiber blankets meeting the requirements of Type EX 1. Sandwich blankets between a high strength extruded plastic mesh netting.

C. Type EX 3. Type EX 3 wood excelsior fiber blanket is a machine-produced mat of cured wood excelsior meeting the following requirements:

1. Minimum weight of 1.6 pounds per square yard (86 g per square meter);
2. Minimum width of 36 inches (915 mm);
3. Minimum roll length of 80 feet (24.4 m);
4. Eighty percent of the wood fibers must be at least 6 inches (155 mm) long, evenly distributed throughout the mat; and
5. Encased top and bottom with a high strength plastic mesh netting that resists ultraviolet breakdown.

713.12.2 Straw Blankets

A. Type ST 1. Type ST 1 straw blanket is a machine produced mat:

1. Made from 100 percent clean agricultural straw weighing a minimum 0.50 pounds per square yard (270 g per square meter) with a uniform thickness throughout the blanket; and
2. The top side is covered with a lightweight photo-degradable polypropylene net weighing approximately 1 pound per 1,000 square feet (488 g per 100 square meter).

B. Type ST 2. Type ST 2 straw blanket meets Type ST 1 requirements and the following:

1. Sandwiched between a top cover of heavyweight UV resistant polypropylene netting weighing approximately 3 pounds per 1,000 square feet (1,460 g per 100 square meter) and on the bottom cover of a lightweight photo-degradable polypropylene netting weighing approximately 1 pound per 1,000 square feet (485 g per 100 square meters).

C. Type STC. Furnish Type STC blanket that is a machine-produced mat:

1. Of 70 percent agricultural straw weighing 0.35 pounds per square yard (190 g per square meter) and 30 percent coconut fiber weighing 0.15 pounds per square yard (82 g per 100 square meter);
2. Having a uniform thickness with the straw and coconut evenly distributed within the mat;
3. That is sandwiched between a top heavy weight, UV resistant polypropylene netting weighing approximately 3 pounds per 1,000 square feet (1,460 g per 100 square meter) and the bottom being a lightweight photo-degradable polypropylene netting weighing approximately 1 pound per 1,000 square feet (485 g per 100 square meter);
4. Sewn together with durable thread; and
5. Treated to sterilize all weed seed.

Provide the Project Manager a manufacturer's certification stating the blankets supplied for the project have been sterilized and a statement detailing the method of sterilization used, before the blanket is installed on the project.

713.12.3 Jute Mat

Type JUTE mat must be:

1. New unbleached jute yarn, uniformly open weaved;
2. Loose twisted yarn not varying in thickness by more than one half its nominal diameter;
3. Having a minimum yarn warp count of 78 per width and a minimum weft of 41 per linear yard (0.9 m); and
4. Weighing 0.92 pounds per square yard (500 g per square meter), untreated and 0.97 pounds per square yard (528 g per square meter), treated to be smolder resistant.

713.12.4 Coconut Mat and Blankets

A. **Type C Coconut Mat.** Type C mat:
   1. Is coconut mat made of 100 percent coconut fiber woven into a high strength matrix; and
   2. Has a minimum weight of 0.8 pounds per square yard (0.43 kg per square meter).

B. **Coconut Blanket.** Coconut Blanket:
   1. Is a 100 percent coconut fiber matrix sewn between two heavy weight UV stabilized nets; and
   2. Weighs a minimum 0.5 pounds per square yard (0.27 kg per square meter).

713.12.5 Synthetic Polypropylene Mesh

Furnish a mesh made from polypropylene fibers spun in one direction and meeting the following:

1. Beige or Natural in color;
2. Minimum weight measured under ASTM D 3776 of 2.25 ounces per square yard (76 g per square meter);
3. Tensile strength measured under ASTM D 4632 of 225 x 120 LbF (3,280 x 1,750 N/m);
4. Elongation at break measured under ASTM D 1682 of 32 percent by 40 percent; and
5. Mullen burst strength measured under ASTM D 3786 of 120 psi (827 kPa).

713.12.6 Polypropylene Roving

Furnish polypropylene roving from continuous strands of fibrillated polypropylene yarn. Wind the roving into a cylindrical package so the roving can be continuously fed from outside of the package through a compressed air injector and expanded into a mat of polypropylene strands. The material must not contain agents toxic to plant or animal life and must meet the following requirements:

1. Contain 20 to 28 strands per rove measured by end count;
2. Have a fiber diameter, denier of 360, by calculation;
3. Rove of 170 to 515 yards per pound (340 to 1,050 km per kg) (ASTM D 1907);
4. Strand of 12,400 to 14,000 yards per pound (25 to 28.2 km/kg) (ASTM D 1907);
5. A maximum one percent organic content (ASTM D 1907); and
6. A package weight of 18 pounds to 25 pounds (8 to 11 kg).

713.12.7 Synthetic Erosion Control and Revegetation Mat

Furnish a flexible mat of polyolefin monofilament fibers positioned between 2 biaxially oriented nets and mechanically bound together by parallel stitching with polyolefin thread to form a 3 dimensional web-like weave, highly resistant to environmental and chemical deterioration, and meeting the following:

1. Green in color;
2. Minimum mat thickness of 0.125-inch (3 mm), measured under ASTM D 1777;

3. A minimum tensile strength of 108 x 36 LbF (1,580 x 525 N/m), measured under ASTM D 1682;
4. Maximum elongation[1] of 150 percent by 100 percent, measured under ASTM D 1682;
5. Calculated[2] minimum porosity of 85 percent;
6. Resiliency[3] of 80 percent, measured under ASTM D 1777; and
7. Ultraviolet stability[4] of 80 percent, measured under ASTM D 4355.

Notes:

1. Values for both machine and cross machine directions under dry or saturated conditions. Machine direction specimen for 2-inch (50 mm) strip test includes one machine direction polyolefin stitch line centered within its width and extending the full length of the specimen.
2. Calculation based upon weight, thickness, and specific gravity.
3. The percent of original thickness retained after 3 cycles of a 100-psi (690 kPa) load for 60 seconds followed by 60 seconds without load. Thickness measured 30 minutes after load removed.
4. Tensile strength retained after 1,000 hours in a Xenon ARC weatherometer.

713.12.8 Turf Reinforcement Mat

Furnish a web of mechanically or melt bonded polymer netting, monofilaments, or fibers that are entangled to form a strong and dimensionally stable mat. Bonding methods include polymer welding, thermal or polymer fusion, or the placement of fibers between 2 high-strength, biaxially oriented nets mechanically bound together by parallel stitching with polyolefin thread. The mat must be resistant to biological, chemical, and ultra-violet degradation and must meet the following:

1. Black in color;
2. Minimum mat thickness of 0.50-inch (13 mm), measured under ASTM D 1777;
3. Minimum tensile strength[1] of 94 x 54 LbF (1,370 x 790 N/m), measured under ASTM D 1682;
4. Maximum elongation[1] of 75 percent by 75 percent, measured under ASTM D 1682;
5. Minimum calculated[2] porosity of 90 percent;
6. Resiliency[3] of 80 percent, measured under ASTM D 1777; and
7. Ultraviolet stability[4] of 80 percent, measured under ASTM D 4355.

Notes:

1. Values for both machine and cross machine directions under dry or saturated conditions using 2-inch (50 mm) strip method.
2. Calculation based upon weight, thickness, and specific gravity.
3. The percent of original thickness retained after 3 cycles of a 100-psi (690 kPa) load for 60 seconds followed by 60 second without load. Thickness measured 30 minutes after load removed.
4. Tensile strength retained after 1,000 hours in a Xenon ARC weatherometer.

SECTION 714
PAVEMENT MARKING MATERIALS

714.01 TEMPORARY PAVEMENT MARKING TAPE

Furnish temporary pavement marking tape that is 4-inch (105 mm) wide, retro-reflective, pressure-sensitive tape specifically manufactured for use as pavement stripping. The tape must be available in white and yellow.

714.02 TEMPORARY PAVEMENT MARKING TABS

Furnish temporary pavement marking tabs meeting the following:

1. Types I and II: “L” shaped, extruded polyurethane, at least 4 inches (105 mm) wide by 2 inches (50 mm) high with a reflectorized strip meeting requirement No. 4 below; attached horizontally across the top of the vertical portion of the tab; an adhesive strip meeting requirement No. 5 below:
   - **a.** Type I tabs: white reflectorized tape on one side with white bodies;
   - **b.** Type II tabs: yellow reflectorized tape on both sides with yellow bodies;
2. A minimum tape reflectance of 1,200 candlepower per square foot (138,892 lux per square meter) at 0.1 degrees observation and 0.0 degrees entrance angles;
3. An adhesive strip at least 3/4 inch wide x 1/8-inch thick (19 mm x 3 mm) 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 PREFORMED PLASTIC PAVEMENT MARKING MATERIAL

714.03.1 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 percent by weight titanium dioxide;
3. The total pigment in yellow marking material a minimum 18 percent 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 meeting Subsection 714.05 requirements uniformly distributed throughout the entire material.

714.03.2 Adhesive Requirements

Furnish material having a pre-coated pressure-sensitive adhesive on the base to adhere to bituminous and portland cement concrete pavements. 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.

714.03.3 Dimensional Requirements

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

Furnish the material for words and symbols in pre-cut configurations matching the shapes and dimensions specified in the publication *Standard Alphabets for Highway Signs and Pavement Markings*.

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

Cut the edges of plastic pavement marking material clean and true.

714.03.4 Physical Requirements

A. Tensile Strength. Furnish plastic material having a minimum tensile strength of 40 psi (276 kPa) when tested under ASTM D 638. The break resistance is based on an average of at least 3 samples tested at a temperature of 70 °F to 80 °F (21 °C to 27 °C) using a jaw speed of 0.25-inch (6 mm) per minute.

B. Plastic Pull Test. A 1-inch by 6-inch (25 mm x 155 mm) sample of the plastic material must support a dead weight of 0.66 pounds per 0.01 inch (1.2 kg per mm) of material thickness for at least five minutes at a temperature of 70 °F to 80 °F (21 °C to 27 °C).

C. Bend Test. At 80 °F (27 °C) bend a 3-inch by 6-inch (75 mm x 155 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 E 303.

E. Reseal Test. The plastic must re-seal itself without adhesives when tested as follows: Overlap two 1-inch x 3-inch (25 mm x 75 mm) pieces face-to-face forming a single 1-inch x 5-inch (25 mm x 130 mm) piece with a 1 square inch (645 square mm) overlap in the center. Place the 1-inch x 5-inch (25 mm x 130 mm) piece on a hard surface with a 1000-gram weight resting uniformly on the entire overlap area and maintain at 140 °F to 190 °F (60 °C 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 714-1. Reflective values are measured on a 2-foot x 2 1/2-foot (610 mm x 762 mm) panel under the Instrumental Photometric Measurements of Retro-reflective Materials and Retroflective Devices, Federal Test Method Standard 370.

TABLE 714-1

MINIMUM SIA[1] (CANDELAS PER FOOTCANDLE PER SQUARE FOOT (m^2)) 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

714.03.5 Samples

Submit a 4-inch by 1-foot (105 mm 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.

714.03.6 Certification

Submit the manufacturer's certification meeting 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.

714.04 TEMPORARY AND INTERIM PAINT MARKINGS

The Contractor may furnish either liquid pavement markings or solid pavement marking tape for temporary and interim pavement markings. Submit a manufacturer's formulation sheet or data sheet for the product to be used.

A. Temporary Pavement Markings. Furnish marking materials that meet the following:

1. Color.

a. White. Color to match Federal color chip # 37875. Colorimeter readings may be taken on the white portion of a Leneta form 5c.1 Color Coordinates are Y=79.80, x=0.3136, y=0.3244. A ± 6 percent tolerance applies to the coordinates.

b. Yellow. Color to match Federal color chip # 595B-33538. Colorimeter readings may be taken on the white portion of a Leneta form 5c. Color coordinates are Y=48.32, x=0.4851, y=0.4455. A ± 6 percent tolerance applies to the coordinates.

B. Interim Pavement Markings. Furnish marking materials that meet the following:

2. Color.

a. White. Color to match Federal color chip # 37875. Colorimeter readings may be taken on the white portion of a Leneta form 5c1 if requested by the Project Manager. Color Coordinates are Y=79.80, x=0.3136, y=0.3244. A ± 6 percent tolerance applies to the coordinates.

b. Yellow. Color to match Federal color chip # 595B-33538. Colorimeter readings may be taken on the white portion of a Leneta form 5c if requested by the Project Manager. Color coordinates are Y=48.32, x=0.4851, y=0.4455. A ± 6 percent tolerance applies to the coordinates.

714.05 REFLECTIVE GLASS BEADS

A. General. Provide glass beads for reflectorizing traffic pavement markings that are spherical, transparent, have a smooth, lustrous surface and meet 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 20 percent irregularly shaped particles when tested under ASTM D 1155.

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 percent loss in weight.

E. Gradation. Meet Table 714-2 gradations, tested using ASTM D-1214.

TABLE 714-2

REFLECTIVE GLASS BEAD GRADATION

SIEVE NUMBER	PERCENT PASSING
20 (0.850 mm)	100
30 (0.600 mm)	75-95
50 (0.300 mm)	15-35
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.

714.06 REFLECTIVE THERMOPLASTIC PAVEMENT MARKINGS

714.06.1 General

Furnish white and yellow thermoplastic marking material that is hydrocarbon-based. Meet AASHTO M 249 except as modified and supplemented herein.

714.06.2 Color

Furnish yellow marking material matching color chip 33538 of Federal Standard No. 595a, Table 5.

Furnish white marking material matching color chip 37875 of Federal Standard No. 595a, Table 9.

White material must have no tint or coloration after weathering.

714.06.3 Glass Beads

Furnish glass beads meeting Subsection 714.05 requirements.

Submit a manufacturer's certification under Subsection 106.03 that the glass beads supplied meet specifications.

714.06.4 Spraying Consistency

Applying hot thermoplastic marking material by spraying must not adversely affect the specified reflectivity, durability, color, line and edge quality, tolerances, thicknesses, and bonding requirements.

714.06.5 Requirements for Hydrocarbon-based Materials

Meet AASHTO M 249 requirements for hydrocarbon-based thermoplastic marking material, modified and supplemented as follows:

A. Specific Gravity. Cannot vary from the manufacturer's product specification by more than 0.05.

B. Composition. Table 1, Composition, of AASHTO M 249 is replaced with Table 714-3.

TABLE 714-3

HYDROCARBON BASED MATERIAL COMPOSITION

COMPONENT	WHITE	YELLOW
Binder, Hydrocarbon Base	16.0% min.	16.0% min.
Glass Beads	25% min.	25% min.
Titanium Dioxide, Type I or II	10% min.	—
Calcium Carbonate and Inert Fillers	42% max.	—
Yellow Pigments	—	See note 1

Notes:

1. The quantity of yellow pigments, calcium carbonate, and inert fillers is the manufacturer's option providing all other requirements of this specification are met.

Furnish a manufacturer's certification under Subsection 106.03 that the titanium dioxide contains a minimum of 5.0 percent each of anatase and rutile for all batches of material supplied on the project.

C. Modifications. The following modifications are made to AASHTO M 249:

1. **Subsection 4.3:** Subsections 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.3.6, 4.3.7, 4.3.9: add "or the manufacturer's recommended application temperature range" wherever the temperatures "211 °C ± 7 °C (412.5 °F ± 12.5°F)" and "218 °C ± 2 °C (425 °F ± 3 °F)" appear.
2. **Subsection 4.3.4:** Change "-9.4 °C ± 1.7°C (15 °F ± 3 °F)" to "-20 °C (-4 °F)". Add "after being exposed to ambient room temperature of 20 °C to 23 °C (68 °F to 74 °F) after cooling." to the last sentence.
3. **Subsection 4.3.5:** Change “218 °C ± 2°C (425 °F ± 3 °F)” to “the manufacturer's recommended application temperature.”
4. **Subsection 5.1:** Add "or as recommended by the manufacturer." after "211 °C ± 7 °C (412.5 °F ± 12.5 °F)".
5. **Subsection 6.1:** Rescind the last sentence and replace with the following: "The label shall show the manufacturer's recommended application temperature range."

714.06.6 Reserved

714.07 WATERBORNE PAVEMENT MARKING PAINT

714.07.1 Water-borne Pavement Marking Paint

Furnish acrylic latex white and lead-free yellow water-borne pavement marking paint meeting the following requirements.

A. Composition. The exact composition is at the manufacturer's discretion except that the vehicle is to be 100 percent acrylic polymer and the paint is not to contain any ingredient listed below.

- Lead or chromate compounds; Mercury; Lead; Chromate compounds; Chlorinated Solvents; Hydrolyzable chlorine derivatives; Ethylene based glycol ethers and their acetates.

Meet Table 714-4 requirements.

TABLE 714-4

WATERBORNE PAVEMENT MARKING PAINT COMPOSITION

		WHITE	YELLOW
Pigment, % solids	ASTM D-3723	68 max.	68 max.
Total Solids, % by weight	ASTM D-2369	75 min.	75 min.
Titanium Dioxide, pounds per gal.	ASTM D-4563 & D-1394	1 lb. min.	0.15 lbs. min.
% Non-volatile vehicle of total vehicle weight	ASTM D-2697	41 min.	41 min.
VOC content, maximum	EPA Method 24	150 g/L	150 g/L
pH, min.	ASTM E-70	9.6	9.6
Viscosity (Krebs Stormer), K.U. at 77 °F (25 °C)	ASTM D-562	80-95	80-95
Grind, Hegman, min.	ASTM D-1210	2	2
Deviation in weight per gallon, max. pounds (from manufacturer specified wt.)		± 0.30 lbs.	± 0.30 lbs.
Daylight Reflectance, min.[1]	ASTM D- 2805	85	59.1[2]
Contrast Ratio, 15 mils wet min.	ASTM D-2805	0.92	0.88

Notes:

1. The Y-Tristimulus value (luminance) is obtained using a standardized Tristimulus colorimeter using a C illuminant at a two-degree observation angle. The paint sample is drawn to a 15 mil wet film thickness over a white substrate. The Department uses a Hunter Lab Miniscan XE Colorimeter and Leneta Corporation Form 5C opacity charts to determine this value.
2. Color to match the V+ color on the Hale color chart ± 6 percent

	ASTM Test	White and Yellow
D 711 mod.[1]	Dry Time, 15 mil wet film, 65% RH, minutes, max.	10
D 1640 mod.[2]	Dry Through at 90% RH, 15 mil wet film, minutes, max.	130
D 2243[3]	Freeze-thaw, White and Yellow	Pass
D 2486	Scrub Resistance, cycles, min.	1000
D-969	Bleeding Ratio, min.	0.95

Notes:

1. Use a wet film thickness of 15 ± 1 mil. Immediately place in a humidity chamber controlled at 65 ± 3% relative humidity and 72.5 °F ± 2.5 °F (22.5 °C ± 1.4 °C) with minimal air flow.
2. Apply a 15 ± 1 mil thick film to a non-absorbent substrate and place in a humidity chamber controlled at 85 ± 5% R.H. and 72.5 °F ± 2.5 °F (22.5 °C ± 1.4 °C). Determine dry through time under ASTM D 1640 exerting the minimum pressure needed to maintain contact with the thumb and film.
3. See B (7), Freeze-thaw Stability.

1. Titanium. Use Titanium Dioxide meeting ASTM D-476, Type I or II.

B. Characteristics.

1. Flexibility and Adhesion. Apply 15 mil wet film thickness to a 3-inch by 5-inch (75 mm by 130 mm) tin panel. Dry at 77 °F (2 °C) for 24 hours followed by two hours at 122 °F (50 °C). Bend sample over a 1/2-inch (13 mm) mandrel. Paint to adhere firmly without showing cracking or flaking.

2. **Water Resistance.** Apply 15 mil wet film thickness to a 4 inch by 8-inch (102 mm by 203 mm) glass plate. Dry at 77 °F (25 °C) for 72 hours. Immerse in distilled water at 77 °F (25 °C) for 24 hours. Air dry for two hours on a flat surface. Paint to not show blistering or adhesion loss.
3. **Skinning and Lumps.** Fill a pint (0.473 L) container 3/4 full of paint and seal tightly. After 72 hours, strain paint through a 100 mesh screen. No lumps or skin retained on the screen is permissible.
4. **Settling.** Fill a centrifuge tube with paint and revolve for two hours at 250 LbF (1112 N). Separation from top of vehicle to top of pigment is not to exceed 1/2-inch (13 mm).
5. **Skinning.** Fill 1/2-pint (0.236 L) container half full of paint and seal. Let stand for 24 hours. No skinning is to be visible.
6. **Bleeding.** When tested under ASTM D-969, paint must not show perceptible bleeding when painted on a bituminous surface.
7. **Freeze-thaw Stability.** When tested under ASTM D-2243, paint must not show coagulation or viscosity change exceeding 10 Krebs units.
8. **Static Heat Stability.** Pour paint into a pint (473 mL) within 1/4 inch (6.4 mm) of the top, put the lid on and seal with tape, and place the container in an oven heated to 140 °F ± 2 °F (60 °C ± 1 °C) for seven days. Equilibrate the paint at standard conditions and thoroughly mix by stirring for at least five minutes. Ensure the paint does not show signs of livering, hard settling, coagulation, lumps, or course particles. Perform a consistency test meeting ASTM D-562 at 77 °F (25 °C). Paint viscosity to not vary 10 K.U. from the original viscosity measured at 77 °F (25 °C).

C. Packaging and Marking. Meet Subsection 714.04.9 requirements.

D. Sampling and Acceptance. Draw three samples meeting Subsection 714.04.8 requirements.

E. Retro-reflective Glass Beads. Use silene-coated moisture resistant glass beads meeting Subsection 714.05 requirements.

F. Application. Follow the manufacturer's requirements for pavement cleaning and traffic paint application or as follows, whichever is more restrictive. Apply to a dry surface.

Clean the pavement of all loose rock, dirt, and debris immediately before applying the traffic paint.

Do not heat the traffic paint to exceed 110 °F (43.3 °C) before and during application.

Apply the traffic paint when the ambient temperature is 50 °F (10 °C) and rising. Stop application when the temperature is 50 °F (10 °C) and dropping and when rain or other weather adverse to the traffic paint during its drying time is imminent.

Apply traffic paint at 15 mils ± 1 mil (0.38 mm ± 0.025 mm), wet thickness in a single application meeting Subsection 620.03.3(A).

Re-paint using materials meeting specifications, at Contractor expense, all striping represented by paint samples where any specified property is outside 20 percent of the specified value. Subsection 620.05 tolerances do not apply.

714.08 Epoxy Pavement Marking Material - 100 Percent Solid

A. Description. This work is the furnishing of epoxy pavement markings.

B. Materials.

1. **General.** Furnish a two-component 100 percent solids epoxy material not containing fillers or pigment extenders. Follow the manufacturer’s mixing ratio when mixing the two components. Mix the components within ± 2.5 percent of the manufacturer’s

recommended mix ratio. Ensure the components, when combined, do not contain or produce volatile solvents.

Use resin/pigment component meeting Table 714-5 requirements.

TABLE 714-5

RESIN / PIGMENT COMPONENT (% BY WEIGHT)

PIGMENT	WHITE	YELLOW
TiO2, meeting ASTM D-476, Type II	18-25	12-17
Organic Yellow		7-9
Epoxy Resin	75-82	74-82

Test the epoxy content of the epoxy resin following ASTM D 1652 and calculate as the weight per epoxy equivalent (WPE) for both white and yellow. Determine the epoxy content on a pigment free basis. The accepted epoxy content range (WPE) is ± 50 of the manufacturer's target value.

Ensure the activator/curing agent meets the following requirements:

- Test the amine value under ASTM D 2074.
- Ensure the total amine value meets the manufacturer's target value with the acceptance range being ± 50 of the target value.

2. Combined Materials Requirements

a. Hardness. Ensure the epoxy has a Shore D hardness of between 75 and 100 when tested under ASTM D 2240. Apply the epoxy to a metal substrate.

b. Tensile Strength. Test the tensile strength under ASTM D 8638. Meet a minimum 6,000-psi (42 MPa) tensile strength. Cast the Type IV specimens in a mold not exceeding 1/4-inch (6.38 mm) thick. Ensure the pull rate is 1/4-inch (6.38 mm) per minute.

c. Compressive Strength. Test the epoxy under ASTM D 695, as modified below. Meet a minimum compressive strength of 12,000 psi (83 MPa), using a maximum compression rate of 1/4-inch (6.38 mm) per minute with the sample measuring 1/2-inch (12.7 mm) high by 1/2-inch (12.7 mm) in diameter.

d. Weather Resistance. Apply the mixed epoxy, both white and yellow, at 15 mils ± 1 mil thick to 3-inch x 6-inch (75 mm x 150 mm) aluminum panels. Do not apply beads to the epoxy sample. Expose the cured sample in an Environmental Test Chamber meeting ASTM G 53. Conduct the test for 80 hours at 122 °F (50 °C), alternating four-hour cycles of condensation and ultraviolet light.

e. Color.

1) White. Color is to match Federal color chip # 37875. Colorimeter readings may be taken on the white portion of a Leneta form 5c[1] if requested by the Project Manager. Color Coordinates are Y = 79.80, x = 0.3136, y = 0.3244. A ± 6 percent tolerance applies to the coordinates.

2) Yellow. Color is to match Federal color chip # 595B-33538. Colorimeter readings may be taken on the white portion of a Leneta form 5c if requested by the Project Manager. Color coordinates are Y = 48.32, x = 0.4851, y = 0.4455. A ± 6 percent tolerance applies to the coordinates.

Notes:

1. The Y-Tristimulus value (luminance) is obtained using a standardized Tristimulus colorimeter using a C illuminant at a two-degree

observation angle. The sample is drawn to a 15 mil wet film thickness over a white substrate. The Department uses a Hunter lab Miniscan XE Colorimeter and a Leneta Corporation Form 5C opacity chart to determine this value.

f. Laboratory No-track Time. Mix the epoxy marking material at the manufacturer's specified ratio and apply at 15 mils ± 1 1/2 mils (0.381 mm ± 0.0381 mm) thick wet film at 75 °F ± 2 °F (24 °C ± 1 °C) with the specified glass bead application. Ensure it has a maximum no tracking time of 30 minutes when tested using ASTM D 711.

g. Viscosity. Ensure the individual components viscosity is within ten percent of each other at the recommended spray temperature and that the activator/curing agent has a constant viscosity at the manufacturer's recommended spray temperature.

h. Mixing and Application. Mix and apply the components following all of the manufacturer's recommendations.

i. Packaging and Storage. Transport and store the epoxy marking material at the project in the manufacturer's original container. Follow the manufacturer's instructions for material storage and handling. Ensure each container is marked identifying the color, batch or lot number, manufacturer's name, address, and date of manufacture.

j. Material Acceptance. Furnish a manufacturer's certification that has a certified copy of a laboratory report listing the results of the specified tests and certifying that the materials furnished meet the specifications. Refer to the applicable specification in the certification. Perform the tests in the manufacturer's laboratory or another qualified independent laboratory. Conduct the tests on samples obtained from the lot or lots of material supplied for the work.

k. Glass beads. Use glass beads meeting Subsection 714.05 requirements and treated with coatings recommended by the pavement marking manufacturer.

SECTION 715
TRAFFIC CONTROL DEVICES

715.01 SIGNS AND CHANNELIZING DEVICES

Meet the Detailed Drawings and MUTCD requirements.

Construction signs may be horizontally hinged at the midpoint of the sign face provided the hinge gap does not exceed 1/2-inch (13 mm) and the sign legend is legible.

715.02 PORTABLE SIGN SUPPORT ASSEMBLIES

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

- **A.** Use wood members with a maximum 16 square inch (10.3 square meter) cross section for base construction and 8 square inch (5.2 square meter) cross section for uprights and braces.
- **B.** Use tubular metal members with a maximum 9 square inch (5.8 square meter) cross section.
- **C.** Use solid metal members with a maximum 1 square inch (645 square mm) cross section.

Portable signs may be 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) meeting Part 6 of the MUTCD, equipped with at least 25 lamps.

Use 36-inch x 72-inch (915 x 1,830 mm) Type "B" Arrow boards on striping units and shadow vehicles. Use Type "C", 48-inch x 96-inch (1,220 mm 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 FLAGGER AHEAD WARNING SIGNS

Equip the W20-7a (advance flagger ahead) sign with two 12-inch (305 mm) amber signals, each mounted 36 inches (915 mm) from the center of the sign panel on a line 45 degrees above horizontal. Provide each lens with a 22-inch x 22-inch (560 x 560 mm) square backplate with a dull black finish and a 12-inch (305 mm) cut-away tunnel visor. Use 116-watt traffic signal light bulbs. Furnish 115/120 V.A.C. electrical current to the flasher unit. Assure the signals flash alternately and continuously at a rate of not less than 50 nor more than 60 times per minute. The illuminated period of each flash must be not less than one-half nor more than two-thirds of the total flash cycle.

Meet Subsection 715.02 requirements for mounting portable sign support assemblies.

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 percent by weight of polyolefins 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 Minimum Average Roll Values (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 Apparent Opening Size (AOS) represent maximum average roll values. Acceptance will be based on ASTM D 4759.

Furnish geotextiles meeting 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 meeting the requirements of 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 percent of the specified grab tensile strength.

TABLE 716-1

GEOTEXTILE STRENGTH PROPERTY REQUIREMENTS

			GEOTEXTILE SURVIVABILITY[1]			
			Moderate Survivability		High Survivability	
PROPERTY	TEST METHODS	UNITS	Woven	Nonwoven	Woven	Nonwoven
Grab Elongation	ASTM D 4632	%	< 50	≥ 50	< 50	≥ 50
Grab Strength	ASTM D 4632	lbs.	250	160	315	200
Sewn Seam Strength[2]	ASTM D 4632	lbs.	225	145	285	180
Tear Strength	ASTM D 4533	lbs.	90	55	110	80
Puncture Strength	ASTM D 4833	lbs.	90	55	110	80
Apparent Opening Size	ASTM D 4751	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 D 4491	$sec.^{-1}$				
Ultraviolet Stability (retained strength)	ASTM D 4355	%				

Notes:

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

TABLE 716-1 (METRIC)

GEOTEXTILE STRENGTH PROPERTY REQUIREMENTS

			GEOTEXTILE SURVIVABILITY[1]			
			Moderate Survivability		High Survivability	
PROPERTY	TEST METHODS	UNITS	Woven	Nonwoven	Woven	Nonwoven
Grab Elongation	ASTM D 4632	%	< 50	≥ 50	< 50	≥ 50
Grab Strength	ASTM D 4632	N	1100	700	1400	900
Sewn Seam Strength[2]	ASTM D 4632	N	990	630	1260	810
Tear Strength	ASTM D 4533	N	400	250	500	350
Puncture Strength	ASTM D 4833	N	400	250	500	350
Apparent Opening Size	ASTM D 4751	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 D 4491	$Sec.^{-1}$				
Ultraviolet Stability (retained strength)	ASTM D 4355	%				

Notes:
1. All numeric values represent Minimum Average Roll Value (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 meeting the strength requirements from Table 716-1 for the level of survivability specified on the plans or in the special provisions. Provide geotextile meeting 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[1]	ASTM D 4491	$sec.^{-1}$	≥ 0.02
Apparent Opening Size	ASTM D 4751	Sieve Size (mm)	#30 (≤ 0.60)
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	≥ 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 on the plans or in the 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 meeting the strength requirements for high survivability from Table 716-1. Provide geotextile meeting the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-3.

TABLE 716-3

STABILIZATION GEOTEXTILE PROPERTY REQUIREMENTS[1]

	TEST METHODS	UNITS	REQUIREMENTS
Geotextile Survivability	High Survivability from Table 716-1		
Permittivity[2]	ASTM D 4491	$sec.^{-1}$	≥ 0.10
Apparent Opening Size	ASTM D 4751	Sieve Size (mm)	#40 (≤ 0.43)
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	≥ 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 on the plans or in the 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 meeting the strength requirements from Table 716-1 for the level of survivability specified on the plans or in the special provisions. Provide geotextile meeting the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-4.

TABLE 716-4

SUBSURFACE DRAINAGE GEOTEXTILE FILTER PROPERTY REQUIREMENTS[1]

			REQUIREMENTS[2]		
	TEST METHODS	UNITS	Class A	Class B	Class C
Geotextile Survivability			As specified from Table 716-1		
Permittivity[3]	ASTM D 4491	$sec.^{-1}$	≥ 0.5	≥ 0.4	≥ 0.3
Apparent Opening Size	ASTM D 4751	Sieve Size (mm)	#40 (≤ 0.43)	#60 (≤ 0.25)	#80 (≤ 0.18)
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	≥ 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 percent fines (gravel or sand). Use Class B subsurface drainage geotextile when the in situ soil has 15 to 50 percent fines (silty or clayey sand or gravel). Use Class C subsurface drainage geotextile when the in situ soil has more than 50 percent 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 on the plans or in the 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 meeting the strength requirements from Table 716-1 for the level of survivability specified on the plans or in the special provisions. Provide geotextile meeting the permittivity, apparent opening size, and ultraviolet stability requirements of Table 716-5.

TABLE 716-5

PERMANENT EROSION CONTROL GEOTEXTILE PROPERTY REQUIREMENTS[1]

			REQUIREMENTS[2]		
	TEST METHODS	**Units**	**Class A**	**Class B**	**Class C**
Geotextile Survivability			As specified from Table 716-1		
Permittivity[3]	ASTM D 4491	sec.$^{-1}$	≥ 0.7	≥ 0.4	≥ 0.2
Apparent Opening Size	ASTM D 4751	Sieve Size (mm)	#40 (≤ 0.43)	#60 (≤ 0.25)	#70 (≤ 0.22)
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	≥ 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 percent fines (gravel or sand). Use Class B permanent erosion control geotextile when the in situ soil has 15 to 50 percent fines (silty or clayey sand or gravel). Use Class C permanent erosion control geotextile when the in situ soil has more than 50 percent 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 on the plans or in the special provisions.

716.06 TEMPORARY SILT FENCE GEOTEXTILE

Provide geotextile meeting the requirements of Table 716-6.

TABLE 716-6

TEMPORARY SILT FENCE PROPERTY REQUIREMENTS

	TEST METHODS	**UNITS**	**STABILIZED SILT FENCE[1]**	**UNSTABILIZED SILT FENCE[2]**
Grab Strength, Machine Direction	ASTM D 4632	lb. (N)	≥ 90 (≥ 400)	≥ 125 (≥ 550)
Grab Strength, X-Machine Direction	ASTM D 4632	lb. (N)	≥ 90 (≥ 400)	≥ 100 (≥ 450)
Permittivity[3]	ASTM D 4491	sec.$^{-1}$	≥ 0.05	≥ 0.05
Apparent Opening Size	ASTM D 4751	Sieve Size (mm)	#30 (≤ 0.60)	#30 (≤ 0.60)
Ultraviolet Stability (retained strength)	ASTM D 4355	%	≥ 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 on the plans or in the special provisions.