

DIVISION 800

MATERIALS DETAILS

SECTION 801 — CEMENT

801.01 REQUIREMENTS. Provide Portland cement or blended hydraulic cement from approved mills listed in the Department's List of Approved Materials. Mills obtain approval by furnishing the Department samples and certified mill test data developed over the previous 6 months. Approved cement mill laboratories are AASHTO accredited in ASTM C150 test methods. Foreign cements are added to the approved list based upon testing by the sponsoring approved cement mill laboratory along with submittal and approval of verification samples. When supplying cement with a SO₃ content above the value in table I of ASTM C 150, include supportive ASTM C 1038 14-day expansion test data for the supplied SO₃ content on the certification.

The Department will require a signed certification from the supplier for each shipment of cement stating that the cement complies with the applicable ASTM standard and all additional requirements of this subsection.

Conform to the following requirements for cement:

- 1) Type I, II, III, IV, and V Portland cement conforms to ASTM C 150. State, on the mill certification, the nature, amount, and identity of any processing addition and its compliance with ASTM C 465.
- 2) Type E-1(K) conforms to ASTM C 845.
- 3) Type IP (≤ 20), Portland-pozzolan cement, conforms to ASTM C595, and the following additional requirements to Type IP (≤ 20).
 - a) The pozzolan constituent shall be fly ash. Ensure that the loss on ignition of the fly ash does not exceed 3.0 percent.
 - b) The cement manufacturer shall furnish to the Engineer reports showing the results of tests performed on the fly ash used in the manufacture of the Type IP(≤ 20) cement shipped to the project.
 - c) The cement manufacturer shall have a qualified technical representative readily available for consultations on the project at any time the Engineer deems necessary, at no expense to the Department.
 - d) Use only one brand of Type IP(≤ 20) cement throughout the project, unless the Engineer approves otherwise.
- 4) Type IS(≤ 30), Portland blast furnace slag cement, conforms to ASTM C 595 and the following requirements:
 - a) Use Grade 100 or 120 blast furnace slag cement conforming to the requirements of ASTM C 989.
 - b) The cement manufacturer shall furnish to the Engineer reports showing the results of the tests performed on the blast furnace slag cement used in the manufacturing of the Type IS(≤ 30) shipped to the project.
 - c) The cement manufacturer shall have a qualified technical representative readily available for consultation on the project at anytime the Engineer deems necessary, at no expense to the Department.
 - d) Use only one brand of Type IS(≤ 30) cement throughout the project, unless the Engineer approves otherwise.
- 5) Type IL(5-15), Portland-limestone cement, conforms to ASTM C 595 and the following additional requirements:
 - a) The cement manufacturer shall furnish to the Engineer reports showing the results of test performed on the limestone used in the manufacture of the Type IL cement

- shipped to the project.
- b) Use only one brand of Type II cement throughout the project, unless the Engineer approves otherwise.
 - c) The Type II blended cement shall be an intimate and uniform blend produced by intergrinding of the Portland cement and limestone.

Even when tested and approved, do not mix cement from different mills in individual batches or use cement from different mills in alternate batches of concrete. Subject to the above restrictions, the Engineer may allow the use of cements from different mills for any structure or individual elements of a structure, provided color contrasts resulting from their usage is minimal or is otherwise unobjectionable and identification of the location of concrete containing the different cements is satisfactorily maintained.

Store cement to prevent damage from the elements. Provide weatherproof storage facilities with sufficient storage capacity that cements from different mills or of different types will not become intermixed.

Provide an acceptable means for obtaining samples, from either the cement silo, weigh hopper, or truck.

The Engineer will reject cement that for any reason has become damaged through contamination, partial set, or which contains lumps of caked cement. The Engineer may reject the entire contents of a container when it contains damaged cement.

801.02 NON-SPECIFICATION CEMENT. The Department accepts cement on the basis of manufacturer's certification attesting to type and conformance to the applicable ASTM specification. The Engineer will take check samples. When the check samples do not conform to these specifications, the Department will make deductions as shown in the following table. When a sample fails more than one test, the Department will make the total deduction as the sum of deductions up to a maximum of 100 percent.

TEST	MAXIMUM DEVIATION FROM REQUIREMENT (PERCENT)	DEDUCTION RATE BASED ON INVOICE COST OF CEMENT
Autoclave Expansion	0.08	12.5% per 0.01% deviation
Fineness by air permeability	10	20% per 2% deviation
Air Content for Non-Air Entrained Cement	± 8	0-4 free, thereafter 25% Per 1% Deviation
Compressive Strength	15	20% per 3% deviation
Time of Set	20	25% per 5% deviation
Magnesium Oxide (MgO)	0.3	33.3% per 0.1% deviation
Sulfur Trioxide (SO ₃)	0.4	0.1% free and then 33.3% per 0.1% deviation
Loss on Ignition	0.75	20.0% per 0.15% deviation
Insoluble Residue	0.75	20.0% per 0.15% deviation
Tricalcium Aluminate (C ₃ A)	1.5	33.3% per 0.5% deviation
Silicon Dioxide (SiO ₂)	3.0	33.3% per 1% deviation
Aluminum Oxide (Al ₂ O ₃)	1.0	20.0% per 0.2% deviation
Ferric Oxide (Fe ₂ O ₃)	1.0	20.0% per 0.2% deviation

SECTION 802 — ADMIXTURES FOR CONCRETE

802.01 REQUIREMENTS. Provide admixtures conforming to the following requirements:

802.01.01 Air-Entraining. ASTM C260, except the chloride content (as Cl) shall not exceed one percent by weight. The Department may require tests for bleeding, time of setting, and length change.

802.01.02 Water-Reducing and Retarding. ASTM C494, Type D, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight.

802.01.03 Water-Reducing. ASTM C494, Type A, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight.

802.01.04 Water-Reducing and Accelerating. ASTM C494, Type E, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight. Use water reducing and accelerating admixture only when the Engineer has reviewed proposed procedures for mixing, handling, and placing the concrete, and has given written permission to proceed.

802.01.05 Water-Reducing, High Range. ASTM C494, Type F, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight.

802.01.06 Water-Reducing, High Range and Retarding. ASTM C494, Type G, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight.

802.01.07 Accelerating. ASTM C494, Type C, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight.

802.01.08 Retarding. ASTM C494, Type B, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight.

802.01.09 Special Performance. ASTM C494, Type S, except the relative durability factor shall not be less than 90 and the chloride content (as Cl) shall not exceed one percent by weight. The manufacturer shall provide data to substantiate the specific performance characteristic stated by the manufacturer.

802.02 APPROVAL. Manufacturers are required to submit their individual admixtures and participate in the National Transportation Product Evaluation Program (NTPEP) for Concrete Admixtures. Current test data must be posted in NTPEP DataMine. Select admixtures from the Department's List of Approved Materials. The Department places admixtures on the list based on evidence of compliance with requirements when determined by tests performed by the Department and review of NTPTP test data. For air-entraining admixtures that are aqueous solutions of Vinsol Resin, manufacturers shall submit a certification in the following form:

This is to certify that the product (trade name) as manufactured and

sold by (company) is an aqueous solution of Vinsol Resin that has been neutralized with sodium hydroxide. The ratio of sodium hydroxide to Vinsol Resin is one part of sodium hydroxide to (number) parts of Vinsol Resin. The percentage of solids based on the residue dried at 105 °C is (number). No other additive or chemical agent is present in this solution.

The Engineer will not require testing of admixtures included on the Department's List of Approved Materials at the time of their use unless there is indication in actual field use of harmful effects on the properties of the concrete or when the Engineer considers testing necessary for other reasons. The chemical equivalence ranges stated in ASTM C260 and ASTM C294 will apply.

The Department will continue to include an admixture on the list contingent upon satisfactory performance in actual project use, continued product submittal to NTPEP, and an annual certification containing the following information:

- 1) A statement that the admixture to be furnished during the particular calendar year is of the same composition as that previously approved for inclusion on the approved list.
- 2) A statement that the admixture conforms to the appropriate requirements of ASTM C260 or ASTM C494, as applicable.
- 3) A statement that the chloride content (as Cl) does not exceed one percent by weight.
- 4) A statement that notification will be made to the Division of Materials of any changes in composition before furnishing the material to projects.

SECTION 803 - WATER

803.01 DESCRIPTION. This section describes the requirements for water used in mixing or curing concrete, emulsified asphalt or other similar materials.

803.02 GENERAL. Use water for mixing or curing concrete, emulsified asphalt, or other similar materials that is reasonably clean and free from oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. The Engineer may test the water at any time for its suitability for a particular use.

The Engineer will ordinarily accept water supplied by public distribution systems without testing.

The Engineer will require testing of mixing water for use in concrete when not from a public distribution system.

Provide water that when tested by KM 64-226 does not contain impurities in excess of the following limits:

Chloride Content (as Cl)	1000	parts per million (ppm)*
Sulfate	3000	ppm
Alkalies	600	ppm
Total Solids	50,000	ppm
pH	7 - 9	pH units

*Chloride content maximum for prestressed concrete and bridge decks is 500 ppm.

SECTION 804 — FINE AGGREGATES

804.01 GENERAL. Fine aggregates include, but at the discretion of the Engineer are not limited to, natural sand, crushed sand, conglomerate sand, mortar sand, mineral filler, and lightweight aggregates where permitted.

The Department's List of Approved Materials includes the Aggregate Source List and the list of Class A and Class B Polish-Resistant Aggregate Sources, the Concrete Aggregate Restriction List and the Lightweight Aggregate Source List.

804.01.01 Natural Sand. Provide fine granular material resulting from the natural disintegration of rock.

804.01.02 Crushed Sand. Provide fine granular material resulting from crushing of stone or gravel.

804.01.03 Conglomerate Sand. Provide natural materials primarily processed to the desired sizes, without crushing. Conglomerate sand may include some material which has been produced by crushing larger pieces of the parent material.

804.01.04 Mortar Sand. Provide natural, crushed, or conglomerate sand suitable for use in cement mortar.

804.01.05 Mineral Filler. Provide limestone dust, cement, fly ash, or other inert mineral matter.

804.01.06 Slag. Provide blast furnace slag sand where permitted. The Department will allow steel slag sand only in asphalt surface applications.

804.02 APPROVAL. Provide fine aggregates from sources included on the Aggregate Source List meeting the description and requirements specified in this section.

The Department will consider a source for inclusion on the Aggregate Source List when the aggregate producer complies with KM 64-608 and provides the following:

- 1) A Quality Control Plan.
- 2) A satisfactory laboratory facility with all necessary testing equipment.
- 3) A Qualified Aggregate Technician to perform the required testing.

When a supplier wishes to supply sand only for asphalt mixtures, Items 1, 2 and 3 above will be waived. The Department may add the source to the Aggregate Source List and restrict its use to asphalt mixtures.

Obtain the Department's approval before furnishing aggregate from sources not on the Aggregate Source List. The Department will sample the aggregate during stockpiling and test according to the Department's Manual of Field Testing and Sampling Practices.

The Department will reject aggregate when excessive variation of gradation or physical properties cause unworkable mixtures, mixture control problems, or non-conformance to the finished product or mixture requirements.

The Department will reject contaminated aggregate when the Engineer deems it could be detrimental to the finished product.

804.03 CONCRETE. Provide natural, crushed, or conglomerate sand. The Engineer may allow other sands.

Use natural or conglomerate sands as fine aggregates in concrete intended as a wearing surface for traffic.

All concrete fines conform to the following:

- 1) Sand Equivalent - 80 (minimum).
- 2) Soundness - 10% loss (maximum).
- 3) Friable Particles - 3.0% (maximum).
- 4) Coal plus Lignite - 0.5% (maximum).
- 5) Uncompacted Voids⁽¹⁾ - 47.0% (maximum).
- 6) Organic Impurities - Not darker than the standard.
- 7) Mortar Strength⁽²⁾ - 95% at 7 calendar days (minimum).
- 8) Gradation⁽¹⁾:

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 inch	100
No. 4	90-100
No. 16	45-85
No. 50	5-25
No. 100	0-8

⁽¹⁾ The Department will permit fine aggregates exceeding when they are used in a combination that meets requirements.

⁽²⁾ The Department will require testing for mortar strength only for sand not passing the test for organic impurities and will supersede the requirement for organic impurities.

The Department will waive the requirements for gradation, sand equivalent, and uncompacted voids for concrete pipe.

804.04 ASPHALT MIXTURES. Provide natural, crushed, conglomerate, or blast furnace slag sand, with the addition of filler as necessary, to meet gradation requirements. The Department will allow any combination of natural, crushed, conglomerate or blast furnace slag sand when the combination is achieved using cold feeds at the plant. The Engineer may allow other fine aggregates.

804.04.01 Sand for Mixtures.

- 1) Gradation - 100 percent passing the 3/8 inch sieve with more than 50 percent passing the No. 4 sieve.
- 2) Coal Plus Lignite - 5.0 percent maximum.
- 3) Soundness - 15 percent maximum.

804.04.02 Mineral Filler. Ensure 100 percent passes the No. 16 sieve and at least 30 percent passes the No. 200 sieve.

804.04.03 Polish-Resistant Aggregate. Provide fine aggregates required for polish-resistant applications from a Class A or B Polish-Resistant Aggregate Source as required. In addition to these listed sources, the Department will consider natural sand, conglomerate sand, and crushed gravel sand meeting the requirements of Section 804 to be Class A polish-resistant.

Provide a signed certification from the aggregate producer for the manufactured polish-resistant fine aggregate stating that the aggregate is supplied from the approved parent material as found on the Department's List of Approved Materials, Polish-Resistant Aggregate Source List and Guidelines on the Division of Materials' webpage.

804.04.04 Requirements for Combined Aggregates.

- A) **Uncompacted Voids.** Provide aggregates for Superpave mixtures meeting the

minimum voids content as listed in the Superpave Fine Aggregate Consensus Property Requirements table.

- B) Sand Equivalent.** Provide aggregate having a sand equivalent value of 45 or greater for the portion of the total combined aggregates passing the No. 4 sieve. Provide aggregates for Superpave mixtures meeting the minimum sand equivalent limits as listed in the Superpave Fine Aggregate Consensus Property Requirements table.

The sand equivalent limits specified in this section apply to aggregates in the final mixture. The Department will normally take samples from stockpiled aggregates or aggregate cold feeds, including mineral filler, for acceptance testing. When these tests do not meet the required values, make trial runs through the plant to provide material for sampling which is intended for the final mixture.

The Department may waive the sand equivalent requirement provided the portion of the combined aggregate passing the No. 40 sieve is non-plastic according to AASHTO T 90.

SUPERPAVE FINE AGGREGATE CONSENSUS PROPERTY REQUIREMENTS				
AADTT Class	Design AADTT	Uncompacted Void Content of Fine Aggregate (Percent), ⁽¹⁾		Sand Equivalent (Percent), Minimum
		Minimum (Depth From Surface)		
		≤ 100 mm	> 100 mm	
2	<600	40.0	40.0	45
3	600 to 2999	45.0	40.0	45
4	>3000	45.0	45.0	50

⁽¹⁾ Performed according to AASHTO T 304, Method A.

- C) Friable Particles.** Limit friable particles, excluding sandstone, to a maximum of 1.0 percent of the total combined aggregates.
- D) Absorption.** Provide total combined fine aggregates having a water absorption of no more than 4.0 percent.

804.04.05 Microsurface. Provide 100% total combined aggregate conforming to the requirements of ASTM D 6372 with sampling and testing according to 804.11.

- A)** Sand Equivalent – 65 (minimum)
B) Soundness – 15% loss (maximum)
C) Wear (Procedure D) – 35% loss (maximum)
D) Wet Sieve, conform to the following gradations:

Sieve Size	Type II	Type III	Stockpile Tolerance
	% Passing	% Passing	
3/8 inch	100	100	
No. 4	90-100	70-90	± 5%
No. 8	65-90	45-70	± 5%
No. 16	45-70	28-50	± 5%
No. 30	30-50	19-34	± 5%
No. 50	18-30	12-25	± 4%
No. 100	10-21	7-18	± 3%
No. 200	5-15	5-15	± 2%

804.04.06 Cold Patch Asphalt Mixtures.

- 1) Provide 100% crushed aggregate.
- 2) Soundness – 12% loss (maximum).

804.05 MORTAR SAND. Provide natural sand, crushed sand, or conglomerate sand conforming to Subsection 804.03 with the exception of Uncompacted Voids and Gradation. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 8	100
No. 50	10-40
No. 100	0-10

804.06 EPOXY SEAL COATS. Provide either natural or conglomerate sand having an insoluble content of 90 percent or greater. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 16	100
No. 50	10-40
No. 100	0-5

804.07 EPOXY SAND SLURRY. Provide silica sand containing no less than 90 percent insolubles. Ensure the sand is rounded to subangular, clean, dry and non-friable. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 8	100
No. 50	0-40
No. 100	0-5

The Department may allow material not meeting this gradation if it produces a workable mixture and an acceptable slurry seal.

804.08 PIPE BEDDING. Provide natural, crushed, or conglomerate sand having a sand equivalent of 20 or greater. The Department may waive the sand equivalent requirement when the portion passing the No. 40 sieve is non-plastic according to AASHTO T 90. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 inch	100
No. 100	0-15

804.09 UNDERDRAINS, EMBANKMENT DRAINAGE BLANKET, AND NATURAL SAND FOR DRAINAGE AND BACKFILL. Provide natural sand having a sand equivalent of 70 or greater. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 inch	100
No. 4	75-100
No. 100	0-8

804.10 GRADATION ACCEPTANCE OF NON-SPECIFICATION FINE AGGREGATE. When reasonably acceptable work has been produced using the aggregate in question, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the aggregate not conforming to gradation requirements may be left in place, the Department will accept the aggregate at a reduction in the Contract unit bid price for the work containing the aggregate according to the following procedures. The Department will not consider these procedures a means to continue accepting non-specification aggregates.

The Department will base the reduction on the invoice price for the aggregate at the source. When satisfactory invoices are not furnished, the Department will use current bin prices for that source on file with the Cabinet's Division of Purchases. The maximum deduction for non-specification material, which is allowed to remain in place, is 50 percent.

When aggregate fails to conform to gradation on more than one sieve, the Department will apply the largest payment reduction of the out-of-specification sieves represented.

The Department will define a lot based on the smallest definable quantity of material represented by acceptance test results, either passing results or failing results, or both. Normally, the Department will average all test results for the lot to determine the test result for payment according to the deduction tables. However, when test results are not reasonably uniform the Department will not average the high and low test results within a lot. The Department will assign each test result to equal quantities in new smaller lots in proportion to the number of tests representing the original lot. When daily tests are performed, the lot will be a day's production unless the Department defines a smaller lot.

When 2 consecutive lots contain non-specification material, discontinue the use of the aggregate until the Department makes a decision concerning the overall acceptability of the aggregate from that source.

The Department will not impose a reduction in payment for quantities less than 50 tons unless the Engineer deems it necessary.

GRADATION - CONCRETE SAND					
Payment Reduction	Sieve Size-Percent Passing				
	3/8 inch	No. 4	No. 16	No. 50	No. 100
0%	100	90-100	45-85	5-25	0-8
10%			43-44	3-4	
10%	98-99	88-89	86-87	26-27	9
20%			42	2	
20%	97	87	88	28	10
30%			41	1	
30%	96	86	89	29	11
50%			40	0	
50%	95	85	90	30	12

GRADATION - MINERAL FILLER		
Payment Reduction	Sieve Size-Percent Passing	
	No. 16	No. 200
0%	100	30 minimum
10%	98-99	29
20%	97	28
30%	96	27
50%	95	26

GRADATION - MORTAR SAND			
Payment Reduction	Sieve Size-Percent Passing		
	No. 8	No. 50	No. 100
0%	100	10-40	0-10
10%		8-9	
10%	98-99	41-42	11
20%		7	
20%	97	43	12
30%		6	
30%	96	44	13
50%		5	
50%	95	45	14

GRADATION - SAND FOR EPOXY SEAL COAT			
Payment Reduction	Sieve Size-Percent Passing		
	No. 16	No. 50	No. 100
0%	100	10-40	0-5
10%		8-9	
10%	98-99	41-42	6
20%		7	
20%	97	43	7
30%		6	
30%	96	44	8
50%		5	
50%	95	45	9

GRADATION - PIPE BEDDING		
Payment Reduction	Sieve Size-Percent Passing	
	3/8 inch	No. 100
0%	100	0-15
10%	98-99	16
20%	97	17
30%	96	18
50%	95	19

GRADATION - UNDERDRAINS, EMBANKMENT DRAINAGE BLANKET, AND NATURAL SAND FOR DRAINAGE AND BACKFILL			
Payment Reduction	Sieve Size-Percent Passing		
	3/8 inch	No. 4	No. 100
0%	100	75-100	0-8
10%	98-99	73-74	9
20%	97	72	10
30%	96	71	11
50%	95	70	12

804.11 SAMPLING AND TESTING. The Department will sample and test according to the following methods when applicable:

Absorption (Fine Aggregate)	KM 64-605
Chemical Analysis	KM 64-224
Coal and Lignite	KM 64-615
Dry Sieve Analysis	AASHTO T 27
Friable Particles	AASHTO T 112
Insoluble Content (Fine Aggregate)	ASTM D 3042
LA Abrasion (grading D)	AASHTO T 96
Mortar Strength	AASHTO T 71
Organic Impurities	AASHTO T 21
Plastic Limit and Plasticity Index	AASHTO T 90
Sampling	KM 64-601
Sand Equivalent	AASHTO T 176
Sieve Analysis of Mineral Filler	AASHTO T 37
Sodium Sulfate Soundness	KM 64-610
Uncompacted Voids (Method A)	AASHTO T 304
Wet Sieve Analysis	KM 64-620 or AASHTO T 11 (Procedure B)/AASHTOT 27

SECTION 805 — COARSE AGGREGATES

805.01 GENERAL. Coarse aggregates include, but at the discretion of the Engineer are not limited to, crushed stone and crushed or uncrushed gravel. Includes lightweight aggregates or slag where permitted.

The Department's List of Approved Materials includes the Aggregate Source List, the list of Class A and Class B Polish-Resistant Aggregate Sources, the Concrete Aggregate Restriction List and the Lightweight Aggregate Source List.

805.02 APPROVAL. Provide coarse aggregates from sources included on the Aggregate Source List meeting the description and requirements specified in this section.

The Department will consider a source for inclusion on the Aggregate Source List when the aggregate producer complies with KM 64-608 and provides the following:

- 1) A Quality Control Plan.
- 2) A satisfactory laboratory facility with all necessary testing equipment.
- 3) A Qualified Aggregate Technician to perform the required testing.

Obtain the Department's approval before furnishing aggregate from sources not on the Aggregate Source List. The Department will sample the aggregate during stockpiling and test according to the Department's Manual of Field Testing and Sampling Practices.

The Department will reject aggregate when excessive variation of gradation or physical properties causes unworkable mixtures, mixture control problems, or non-conformance to the finished product or mixture requirements.

Coarse aggregates are subject to preliminary source approval.

805.03 GENERAL REQUIREMENTS. Provide coarse aggregates that are free of objectionable amounts of clay lumps, dirt coatings, and foreign material. The Department will reject contaminated aggregate when the Engineer deems it could be detrimental to the finished product.

805.03.01 Soundness and Shale. Conform to the following table:

AGGREGATE USE	SHALE PERMITTED ⁽¹⁾ (MAXIMUM %)	SOUNDNESS REQUIREMENT (MAXIMUM %)
<u>Portland Cement Concrete Mixtures</u>		
Aggregate for Bridge Decks, Bridge Deck Overlays Bridge Barrier Walls and Precast Products	1.0	9
All Other Concrete Uses	2.0	12
<u>Asphalt Mixtures</u>		
Aggregate for Polish Resistant Surfaces and Asphalt Surface Under OGFC:		
Limestone and Dolomite	1.0	9
Other Aggregate Types	2.0	12
Cold Patch Mixtures	2.0	12
All Other Asphalt Mixtures	2.0	15
<u>Other Uses</u>		
Sizes No. 610 or 710 When Used for Aggregate Surfacing, Traffic Bound Base, and Maintenance	5.0	18
Riprap and Channel Lining	2.0	12
DGA & CSB	2.0	15
All Other Uses	2.0	15

⁽¹⁾ The Department will determine shale quantity by visual estimation for Riprap and Channel Lining and according to KM 64-604 for all other aggregate.

805.03.02 Physical Properties. Conform to the following:

Wear (Except Slag and Sandstone)	40% (maximum)
Wear (Sandstone)	50% (maximum)
Wear (Slag)	60% (maximum)
Friable Particles	1.0% (maximum)
Unit Weight (Slag)	70 lbs/ft ³ (minimum)

805.03.03 Gradation. Where the Department specifies or permits designated sizes of coarse aggregates, provide aggregates meeting the grading limits indicated for the various sizes listed in the Sizes of Coarse Aggregates table. When the Contract does not specify

sizes or combinations of aggregate for various types of construction, furnish aggregate according to the Aggregate Size Use table. The Department will allow blending of same source/same type aggregate to achieve designated sizes when precise procedures are used such as cold feeds, belts, weigh hoppers, or equivalent.

805.03.04 Erodible or Unstable Material. Treat as applicable. The Department considers Size No. 57 or larger aggregate, except crushed or uncrushed gravel, non-erodible. The Department considers the following materials to be erodible or unstable:

- 1) Friable sandstone. The Engineer determines when sandstone is friable or non-friable.
- 2) Crushed or uncrushed gravel, any size.
- 3) Crushed coarse aggregate smaller than Size No. 57.
- 4) Any material with 50 percent or more passing the No. 4 sieve.

805.04 CONCRETE. Provide crushed stone or crushed or uncrushed gravel. The Department will allow any combination of crushed stone, crushed or uncrushed gravel when the combination is achieved in the concrete plant weigh hopper. Conform to the following:

	<u>Max. Pct. by Wt.</u>
Friable Particles	1.0
Finer than No. 200	2.0
Coal and Lignite	0.5
Lightweight particles (Gravel) (Sp. Gr. Less than 2.40)	4.0
Lightweight particles (Limestone) (Sp. Gr. Less than 2.40)	1.0

The Department will waive the requirements for gradation and finer than No. 200 for concrete pipe.

Do not use aggregate produced from an individual production lift until the Department obtains the finished product results from the Concrete Beam Expansion Test Method KM 64-629. If beam expansion is greater than 0.06 percent at 6 months, the Department will reject the production lift for use in concrete applications.

The Department will not require tests for Concrete Beam Expansion from an individual production lift if the individual ledges are accessible for hand sampling and the lift is acceptable based on petrographic examination of the hand samples. The Department will accept a production lift if no more than 20 percent of the total lift footage is considered potentially alkali carbonate reactive upon petrographic inspection.

805.04.01 Concrete Applications Where Exposure to Saturation and Freeze-Thaw Exists The Department will subject coarse aggregates that are to be used in any concrete application where exposure to saturation and freeze-thaw exists such as ;PC base, JPC pavement, JPC shoulders, bridge decks, concrete overlays, sidewalks and precast products to freeze-thaw testing according to KM 64-626. The Department will allow sources having expansions of 0.06 percent or less and a minimum of 80 percent durability factor to supply any size coarse aggregate listed in the Aggregate Size Use table, providing that size or a larger size has tested satisfactorily. When sources have expansions of more than 0.06 percent or a durability factor of less than 80 percent the Department will:

- 1) Reject the material.
- 2) Limit to the permitted sizes determined from acceptable freeze-thaw testing.
- 3) Allow the submittal of a proposal to the Engineer for production of acceptable coarse aggregate. The Department will require acceptable freeze-thaw test results before approving any proposal.

Provide a signed certification from the aggregate producer for the approved freeze-thaw coarse aggregate stating that the aggregate is supplied from the approved parent

material as found on the Department's List of Approved Materials and Concrete Aggregate Restriction List.

805.04.02 Lightweight Aggregate. When the Department allows lightweight aggregate conform to the following:

- 1) Dry Loose Unit Weight. As appropriate or as specified, AASHTO M 195, Table 2.
- 2) Gradation (by weight). Provide size specified, AASHTO M 195, Table 1.
- 3) Wear. 50 percent maximum.
- 4) Soundness. 9 percent loss maximum.
- 5) Friable Particles. 1.0 percent maximum.
- 6) Deleterious Particles. 1.0 percent maximum.
- 7) Freeze-Thaw Resistance. 85 percent minimum durability factor and 0.06 percent maximum length change according to KM 64-626.
- 8) Provide creep, shrinkage, and tensile splitting strength test data made on concrete produced from the lightweight aggregate when the Engineer requests.
- 9) If lightweight aggregate from an unapproved source is proposed for use, notify the Engineer of the aggregate source and proposed concrete mix design at least 10 weeks before any lightweight aggregate concrete is placed, so the Department may subject the lightweight aggregate to testing as outlined above, plus any additional testing as deemed necessary and indicated in AASHTO M 195. At the Department's option, suitable documentation of such testing by an independent testing laboratory may be accepted.

805.05 ASPHALT MIXTURES AND SEALS. Provide crushed stone, crushed gravel, or blast furnace slag. The Department will allow any combination of crushed stone, crushed gravel, or blast furnace slag when the combination is achieved using cold feeds at the asphalt plant. The Engineer may allow other coarse aggregates.

805.05.01 Absorption. Provide aggregates having a water absorption of no more than 3.0 percent for each size and type with the exception of blast furnace slag. When blast furnace slag is used, provide total combined aggregates having a water absorption of no more than 4.0 percent.

805.05.02 Crushed Particles. Applies to the total combined aggregates retained on a No. 4 sieve, including the material from the fine aggregate. Conform to the following:

- A) **Superpave Mixtures.** Minimum percent crushed requirements as listed in the Superpave Coarse Aggregate Consensus Property Requirements table.
- B) **Open-Graded Friction Courses.** Minimum 95 percent one or more crushed faces and 75 percent 2 or more crushed faces.
- C) **Seal Coats.** Minimum 90 percent one or more crushed faces.
- D) **Other Mixtures.** Unless otherwise specified, minimum 75 percent one or more crushed faces.

SUPERPAVE COARSE AGGREGATE CONSENSUS PROPERTY REQUIREMENTS						
AADTT Class	Design AADTT	Coarse Aggregate Angularity (Percent)				Flat and Elongated ⁽¹⁾ (Percent), maximum
		Minimum Depth From Surface				
		≤ 100 mm		> 100 mm		
		Crushed Faces		Crushed Faces		
		≥1	≥2	≥1	≥2	
2	<600	75	-	75	-	10
3	600 to 2999	95	90	80	75	10
4	≥ 3000	100	100	100	100	10

⁽¹⁾ Criterion based on a 5:1 maximum-to-minimum ratio.

805.05.03 Flat and Elongated. Provide aggregates for Superpave mixtures not exceeding the flat and elongated maximum as listed in the Superpave Coarse Aggregate Consensus Property Requirements table.

805.05.04 Finer Than No. 200 (Seals). Provide coarse aggregates having no more than 3.0 percent passing the No. 200 sieve.

805.05.05 Polish-Resistant Aggregate. Provide coarse aggregates required for polish-resistant applications from a Class A or Class B Polish-Resistant Aggregate Source, as applicable, based on mixture designation of aggregate type.

Provide a signed certification from the aggregate producer for the manufactured polish-resistant coarse aggregate stating that the aggregate is supplied from the approved parent material as found on the Department's List of Approved Materials, Polish-Resistant Aggregate Source List and Guidelines on the Division of Materials' webpage.

805.05.06 Cold Patch Mixtures. Provide 100% crushed aggregate.

805.06 DENSE GRADED AGGREGATE (DGA) AND CRUSHED STONE BASE (CSB). Provide crushed stone having a sand equivalent value of 30 or greater with mineral filler as needed to meet gradation requirements. The Department may waive the sand equivalent requirement when the portion passing the No. 40 sieve has a plasticity index of 4 or less according to AASHTO T 90.

805.07 FREE DRAINING BEDDING AND BACKFILL. Provide crushed stone or crushed or uncrushed gravel. The Department will allow a shale content of 5 percent providing the combined shale, friable particles, and minus No. 200 content does not exceed 5 percent. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
1 1/2 inch	100
No. 4	0-30

805.08 COARSE AGGREGATES FOR UNDERDRAINS. Furnish crushed or uncrushed aggregate, including pea gravel meeting the quality requirements of Section 805 with the following exception: The Department will allow a shale content of 5 percent providing the combined shale, friable particles, and minus No. 200 content does not exceed 5 percent. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
1 1/2 inch	100
No. 4	0-30
No. 100	0-5

805.09 COARSE AGGREGATE FOR ROCK DRAINAGE BLANKET. Provide crushed or uncrushed aggregate, including pea gravel, meeting the quality requirements of this section with the following additional requirement: Ensure the minus No. 200 content does not exceed 5 percent. When the material includes a significant amount of individual fragments greater than 1 1/2 inches, the Engineer may accept the minus No. 200 portion based on visual inspection. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
4 inch	100
No. 4	0-30

805.10 GRANULAR EMBANKMENT. Provide granular material up to 12-inch maximum size with a maximum shale content of 5 percent. Use either:

- 1) Engineer approved shot limestone or sandstone from roadway excavation, borrow excavation, or another approved source.
- 2) Crushed stone, crushed or uncrushed gravel, or crushed or natural sand meeting general requirements of Section 804 and this section, with a minus No. 200 content not exceeding 10.0 percent.

805.11 STRUCTURE GRANULAR BACKFILL. Provide crushed or uncrushed aggregate meeting the quality requirements of this section. When the material includes a significant amount of individual fragments greater than 1 1/2 inches, the Engineer may visually accept the minus No. 200 portion. Conform to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
4 inch	100
No. 4	0-10
No. 200	0-5

805.12 REINFORCED FILL MATERIAL. Obtain the Engineer's approval for material quality before use. Ensure the material is reasonably free of shale or other deleterious material. Conform to the following:

- A) **Gradation.** Conform to Subsection 805.11.
- B) **PH.** Between 5-10.
- C) **Chlorides.** Less than 200 parts per million.
- D) **Sulfates.** Less than 1,000 parts per million.
- E) **Angle of Internal Friction.** Greater than or equal to 34 degrees. When providing gap-graded materials, single size aggregates, uncrushed gravel, or blends including uncrushed gravel, furnish a test report showing the 34 degree minimum internal friction angle is met. Test sample according to AASHTO T 236 compacted to 95 percent of AASHTO T 99 Methods C or D at optimum moisture content. When such materials are approved, the Engineer will perform sampling and testing on the project as necessary to assure that the material furnished is closely similar to that approved.

805.13 SLOPE PROTECTION AND CHANNEL LINING.

805.13.01 Cyclopean Stone Riprap and/or Channel Lining Class III. Provide material meeting the general requirements of Section 805. Ensure that 100 percent passes

through a square opening of 16 inches by 16 inches, and no more than 20 percent passes through square openings of 8 inches by 8 inches. The Department may allow stones of smaller sizes for filling voids in the upper surface and dressing to the proper slope.

805.13.02 Crushed Aggregate Slope Protection. Provide aggregate meeting the general requirements of Section 805. Conform to the following gradation (Coarse aggregate sizes No. 1 and No. 2 conform to this requirement):

<u>Sieve Size</u>	<u>Percent Passing</u>
4 inch	100
2 1/2 inch	25-100
1 1/2 inch	0-15

805.13.03 Channel Lining, Class IA. Provide crushed stone meeting the general requirements of this section. Use a crusher, grizzly, or sieve with openings to produce a grading that 100 percent passes the 5 inch sieve, no more than 20 percent of the finished product passes through square openings 1 1/2 by 1 1/2 inches.

805.13.04 Channel Lining, Class II. Provide crushed stone meeting the general requirements of this section. Use a crusher, grizzly, or sieve with openings to produce a grading that 100 percent passes the 9-inch sieve, and no more than 20 percent of the finished product passes through square openings 5 by 5 inches.

805.13.05 Channel Lining, Class IV. Provide material excavated and prepared according to Section 204.

805.13.06 Stone for Gabions. Provide aggregate meeting the general requirements of this section and be of such gradation that 100 percent passes through a square opening of 12 by 12 inches and 100 percent is retained on a 4 inch sieve.

805.14 AGGREGATE SURFACING, TRAFFIC-BOUND BASE, AND MAINTENANCE. When providing size No. 610 or 710 coarse aggregate for aggregate surfacing (shoulders, entrances, mailbox turn outs, or similar items), traffic bound base and maintenance operations; furnish aggregate meeting the grading requirements in Sizes of Coarse Aggregates table, with no more than 12 percent finer than a No. 200 sieve.

When providing DGA for aggregate surfacing, traffic bound base, and maintenance operations conform to the grading requirement in Sizes of Coarse Aggregates table.

805.15 GRADATION ACCEPTANCE OF NON-SPECIFICATION COARSE AGGREGATE. Aggregate purchased for Department work must meet the requirements of this section. The Department may accept non-specification aggregate or work according to Subsection 105.04. When the Engineer determines that the aggregate not conforming to gradation requirements may be left in place, the Department will accept the aggregate at a reduction in the Contract unit bid price for the work containing the aggregate according to the following procedures. The Department will not consider these procedures a means to continue accepting non-specification aggregates.

The Department will base the reduction on the invoice price for the aggregate at the source. When satisfactory invoices are not furnished, the Department will use current bin prices for that source on file with the Cabinet's Division of Purchases. The maximum deduction for non-specification material which is allowed to remain in place is 50 percent. When aggregate fails to conform to gradation on more than one sieve, the Department will apply the largest payment reduction of the out-of-specification sieves represented.

The Department will define a lot based on the smallest definable quantity of material represented by acceptance test results, either passing results or failing results, or both. Normally, the Department will average all test results for the lot to determine the test result for payment according to the deduction tables. However, when test results are not reasonably uniform the Department will not average the high and low test results within a

lot. The Department will assign each test result to equal quantities in new smaller lots in proportion to the number of tests representing the original lot. When daily tests are performed, the lot will be a day's production unless the Department defines a smaller lot.

When 2 consecutive lots contain non-specification material, discontinue the use of the aggregate until the Department makes a decision concerning the overall acceptability of the aggregate from that source.

The Department will not impose a reduction in payment for quantities less than 50 tons unless the Engineer deems it necessary.

GRADATION - SIZE NO. 1					
Payment Reduction	Sieve Size-Percent Passing				
	4 inch	3 1/2 inch	2 1/2 inch	1 1/2 inch	3/4 inch
0%	100	90-100	25-60	0-15	0-5
10%			61-62		
10%	98-99	88-89	23-24	16-17	6-7
20%			22		
20%	97	87	63	18	8
30%			21		
30%	96	86	64	19	9
50%			20		
50%	95	85	65	20	10

GRADATION - SIZE NO. 2					
Payment Reduction	Sieve Size-Percent Passing				
	3 inch	2 1/2 inch	2 inch	1 1/2 inch	3/4 inch
0%	100	90-100	35-70	0-15	0-5
10%			33-34		
10%	98-99	88-89	71-72	16-17	6-7
20%			32		
20%	97	87	73	18	8
30%			31		
30%	96	86	74	19	9
50%			30		
50%	95	85	75	20	10

GRADATION - SIZE NO. 23				
Payment Reduction	Sieve Size-Percent Passing			
	3 inch	2 inch	1 inch	1/2 inch
0%	100	40-90	0-15	0-5
10%		38-39		
10%	98-99	91-92	16-17	6-7
20%		37		
20%	97	93	18	8
30%		36		
30%	96	94	19	9
50%		35		
50%	95	95	20	10

GRADATION - SIZE NO. 3					
Payment Reduction	Sieve Size-Percent Passing				
	2 1/2 inch	2 inch	1 1/2 inch	1 inch	1/2 inch
0%	100	90-100	35-70	0-15	0-5
10%			33-34		
10%	98-99	88-89	71-72	16-17	6-7
20%			32		
20%	97	87	73	18	8
30%			31		
30%	96	86	74	19	9
50%			30		
50%	95	85	75	20	10

GRADATION - SIZE NO. 357					
Payment Reduction	Sieve Size-Percent Passing				
	2 1/2 inch	2 inch	1 inch	1/2 inch	No. 4
0%	100	95-100	35-70	10-30	0-5
10%			33-34	8-9	
10%	98-99	93-94	71-72	31-32	6-7
20%			32	7	
20%	97	92	73	33	8
30%			31	6	
30%	96	91	74	34	9
50%			30	5	
50%	95	90	75	35	10

GRADATION - SIZE NO. 4					
Payment Reduction	Sieve Size-Percent Passing				
	2 inch	1 1/2 inch	1 inch	3/4 inch	3/8 inch
0%	100	90-100	20-55	0-15	0-5
10%			18-19		
10%	98-99	88-89	56-57	16-17	6-7
20%			17		
20%	97	87	58	18	8
30%			16		
30%	96	86	59	19	9
50%			15		
50%	95	85	60	20	10

GRADATION - SIZE NO. 467					
Payment Reduction	Sieve Size-Percent Passing				
	2 inch	1 1/2 inch	3/4 inch	3/8 inch	No. 4
0%	100	95-100	35-70	10-30	0-5
10%			33-34	8-9	
10%	98-99	93-94	71-72	31-32	6-7
20%			32	7	
20%	97	92	73	33	8
30%			31	6	
30%	96	91	74	34	9
50%			30	5	
50%	95	90	75	35	10

GRADATION - SIZE NO. 5					
Payment Reduction	Sieve Size-Percent Passing				
	1 1/2 inch	1 inch	3/4 inch	1/2 inch	3/8 inch
0%	100	90-100	20-55	0-10	0-5
10%			18-19		
10%	98-99	88-89	56-57	11-12	6-7
20%			17		
20%	97	87	58	13	8
30%			16		
30%	96	86	59	14	9
50%			15		
50%	95	85	60	15	10

GRADATION - SIZE NO. 57					
Payment Reduction	Sieve Size-Percent Passing				
	1 1/2 inch	1 inch	1/2 inch	No. 4	No. 8
0%	100	95-100	25-60	0-10	0-5
10%			23-24		
10%	98-99	93-94	61-62	11-12	6-7
20%			22		
20%	97	92	63	13	8
30%			21		
30%	96	91	64	14	9
50%			20		
50%	95	90	65	15	10

GRADATION - SIZE NO. 610				
Payment Reduction	Sieve Size-Percent Passing			
	1 1/2 inch	1 inch	1/2 inch	No. 4
0%	100	85-100	40-75	15-40
10%			38-39	13-14
10%	98-99	83-84	76-77	41-42
20%			37	12
20%	97	82	78	43
30%			36	11
30%	96	81	79	44
50%			35	10
50%	95	80	80	45

GRADATION - SIZE NO. 67					
Payment Reduction	Sieve Size-Percent Passing				
	1 inch	3/4 inch	3/8 inch	No. 4	No. 8
0%	100	90-100	20-55	0-10	0-5
10%			18-19		
10%	98-99	88-89	56-57	11-12	6-7
20%			17		
20%	97	87	58	13	8
30%			16		
30%	96	86	59	14	9
50%			15		
50%	95	85	60	15	10

GRADATION - SIZE NO. 68						
Payment Reduction	Sieve Size-Percent Passing					
	1 inch	3/4 inch	3/8 inch	No. 4	No. 8	No. 16
0%	100	90-100	30-65	5-25	0-10	0-5
10%			28-29	3-4		
10%	98-99	88-89	66-67	26-27	11-12	6-7
20%			27	2		
20%	97	87	68	28	13	8
30%			26	1		
30%	96	86	69	29	14	9
50%			25	0		
50%	95	85	70	30	15	10

GRADATION - SIZE NO. 710				
Payment Reduction	Sieve Size-Percent Passing			
	1 inch	3/4 inch	3/8 inch	No. 4
0%	100	80-100	30-75	0-30
10%			28-29	
10%	98-99	78-79	76-77	31-32
20%			27	
20%	97	77	78	33
30%			26	
30%	96	76	79	34
50%			25	
50%	95	75	80	35

GRADATION - SIZE NO. 78						
Payment Reduction	Sieve Size-Percent Passing					
	3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16
0%	100	90-100	40-75	5-25	0-10	0-5
10%			38-39	3-4		
10%	98-99	88-89	76-77	26-27	11-12	6-7
20%			37	2		
20%	97	87	78	28	13	8
30%			36	1		
30%	96	86	79	29	14	9
50%			35	0		
50%	95	85	80	30	15	10

GRADATION - SIZE NO. 8					
Payment Reduction	Sieve Size-Percent Passing				
	1/2 inch	3/8 inch	No. 4	No. 8	No. 16
0%	100	85-100	10-30	0-10	0-5
10%			8-9		
10%	98-99	83-84	31-32	11-12	6-7
20%			7		
20%	97	82	33	13	8
30%			6		
30%	96	81	34	14	9
50%			5		
50%	95	80	35	15	10

GRADATION - SIZE NO. 9-M				
Payment Reduction	Sieve Size-Percent Passing			
	1/2 inch	3/8 inch	No. 4	No. 8
0%	100	75-100	0-25	0-5
10%	98-99	73-74	26-27	6-7
20%	97	72	28	8
30%	96	71	29	9
50%	95	70	30	10

GRADATION - SIZE NO. 10			
Payment Reduction	Sieve Size-Percent Passing		
	3/8 inch	No. 4	No. 100
0%	100	85-100	10-30
10%			8-9
10%	98-99	83-84	31-32
20%			7
20%	97	82	33
30%			6
30%	96	81	34
50%			5
50%	95	80	35

GRADATION - SIZE NO. 11				
Payment Reduction	Sieve Size-Percent Passing			
	3/8 inch	No. 4	No. 8	No. 100
0%	100	40-90	10-40	0-5
10%		38-39	8-9	
10%	98-99	91-92	41-42	6-7
20%		37	7	
20%	97	93	43	8
30%		36	6	
30%	96	94	44	9
50%		35	5	
50%	95	95	45	10

GRADATION - CRUSHED STONE BASE							
Payment Reduction	Sieve Size-Percent Passing						
	2 1/2 inch	1 1/2 inch	3/4 inch	3/8 inch	No. 4	No. 30	No. 200
0%	100	90-100	60-95	30-70	15-55	5-20	0-8
5%		88-89	58-59	28-29	13-14	3-4	
5%	98-99		96-97	71-72	56-57	21-22	
10%		86-87	56-57	26-27	11-12	1-2	
10%	96-97		98	73	58	23	9
20%		84-85	54-55	24-25	9-10	0	
20%	95		99	74	59	24	10
30%		83	53	23	8		
30%	94		100	75	60	25	11

GRADATION - DENSE GRADED AGGREGATE						
Payment Reduction	Sieve Size-Percent Passing					
	1 inch	3/4 inch	3/8 inch	No. 4	No. 30	No. 200
0%	100	70-100	50-80	30-65	10-40	4-13
5%		68-69	48-49	28-29		
5%	98-99		81-82	66-67	41-42	14
10%		66-67	46-47	26-27	9	
10%	96-97		83-84	68-69	43-44	15
20%	95	65	45	25		3
20%			85	70	45	16
30%		64	44	24	8	2
30%	94		86	71	46	17

GRADATION - FREE DRAINING BEDDING AND BACKFILL		
Payment Reduction	Sieve Size-Percent Passing	
	1 1/2 inch	No. 4
0%	100	0-30
10%	98-99	31-32
20%	97	33
30%	96	34
50%	95	35

GRADATION - COARSE AGGREGATES FOR UNDERDRAINS			
Payment Reduction	Sieve Size-Percent Passing		
	1 1/2 inch	No. 4	No. 100
0%	100	0-30	0-5
10%	98-99	31-32	6
20%	97	33	7
30%	96	34	8
50%	95	35	9

GRADATION - COARSE AGGREGATE FOR ROCK DRAINAGE BLANKET		
Payment Reduction	Sieve Size-Percent Passing	
	4 inch	No. 4
0%	100	0-30
10%	98-99	31-32
20%	97	33
30%	96	34
50%	95	35

GRADATION - CRUSHED AGGREGATE SLOPE PROTECTION			
Payment Reduction	Sieve Size-Percent Passing		
	4 inch	2 1/2 inch	1 1/2 inch
0%	100	25-100	0-15
10%	98-99	23-24	16-17
20%	97	22	18
30%	96	21	19
50%	95	20	20

SIZES OF COARSE AGGREGATES																	
AMOUNTS FINER THAN EACH LABORATORY SIEVE (SQUARE OPENINGS) PERCENTAGE BY WEIGHT																	
Aggregate Size	Sieve Nominal ⁽¹⁾ Maximum Aggregate Size	4 inch	3 1/2 inch	3 inch	2 1/2 inch	2 inch	1 1/2 inch	1 inch	3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16	No. 30	No. 100	No. 200
1	3 1/4 inch	100	90-100		25-60		0-15		0-5								
2	2 1/2 inch			100	90-100	35-70	0-15		0-5								
23	2 inch			100		40-90		0-15		0-5							
3	2 inch				100	90-100	35-70	0-15		0-5							
357	2 inch				100	95-100	35-70	0-15		10-30		0-5					
4	1 1/4 inch					100	90-100	20-55	0-15		0-5						
467	1 1/4 inch					100	95-100	35-70	0-15		10-30	0-5					
5	1 inch						100	90-100	20-55	0-10	0-5						
57	1 inch						100	95-100	25-60	0-10		0-10	0-5				
610	1 inch						100	85-100	40-75			15-40					
67	3/4 inch							100	90-100		20-55	0-10	0-5				
68	3/4 inch							100	90-100		30-65	5-25	0-10	0-5			
710	3/4 inch							100	80-100		30-75	0-30					
78	1/2 inch								100	90-100	40-75	5-25	0-10	0-5			
8	3/8 inch									100	85-100	10-30	0-10	0-5			
9-M	3/8 inch									100	75-100	0-25	0-5				
10 ⁽²⁾	No. 4										100	85-100			10-30		
11 ⁽²⁾	No. 4										100	40-90	10-40			0-5	
DENSE GRADED AGGREGATE ⁽³⁾	3/4 inch							100	70-100		50-80	30-65			10-40		4-13
CRUSHED STONE BASE ⁽³⁾	1 1/4 inch				100		90-100		60-95		30-70	15-55			5-20		0-8

⁽¹⁾ Gradation performed by wet sieve KM 64-620 or AASHTO T 111/T 27.

⁽²⁾ Sizes show for convenience and are not to be considered as coarse aggregates.

⁽³⁾ Nominal Maximum Size is the largest sieve on the gradation table for an aggregate size on which any material may be retained.

AGGREGATE SIZE USE	
Type of Construction	Sizes to be Used
Asphalt Mixtures	See Section 400
Traffic-Bound Base	57, 610, 710, or DGA
JPC Base and Class P Concrete	57, 67, 68, 78, 8, or 9-M with fine aggregate as specified in Section 804.
Cement Concrete Structures and Incidental Construction	57, 67, 68, 78, 8, 9-M for Classes "A", "AA", "D", "D" Modified, "M1", "M2", and "B" (357 & 467 also for Class B). 8 or 9-M for Waterproofing Overlays. 67, 68, 78, 8, 9-M for all other Overlays and Classes "AAA" and "A" Modified; with fine aggregate as specified in Section 804.

805.16 SAMPLING AND TESTING. The Department will sample and test coarse aggregates at locations and frequencies that the Engineer determines. The Department will sample and test according to the following methods when applicable:

Absorption (Coarse Aggregate)	KM 64-607
Angle of Internal Friction	AASHTO T236 and T 99 Methods C or D
Chlorides	KM 64-243
Clay Lumps and Friable Particles	AASHTO T 112
Coal and Lignite	KM 64-615
Concrete Beam Expansion Test	KM 64-629
Dry Sieve Analysis	AASHTO T 27
Finer Than No. 200	KM 64-606 or AASHTO T 11 (Procedure B)
Flat and Elongated Particles	KM 64-630
Freeze/Thaw	KM 64-626
Insoluble Residue	KM 64-265
Lightweight Particles	AASHTO T 113
Percent Crushed Particles	KM 64-631
pH	KM 64-243
Plastic Limit and Plasticity Index	AASHTO T 90
Sampling	KM 64-601
Sand Equivalent	AASHTO T 176
Shale	KM 64-604
Sodium Sulfate Soundness (5 Cycles)	KM 64-610
Sulfates	KM 64-243
Unit Weight	AASHTO T 19
Wear	AASHTO T 96
Wet Sieve Analysis	KM 64-620 or AASHTO T 11 (Procedure B) and AASHTO T 27

SECTION 806 — ASPHALT MATERIALS

806.01 DESCRIPTION. The asphalt materials section covers performance-graded (PG) binders, emulsified asphalts, cut-back emulsions, and liquid asphalt for cold-patching mixtures. Provide the specified grade of material conforming to the requirements in this section from suppliers listed in the Department’s List of Approved Materials. Inclusion on the list of approved suppliers is obtained by following the guidelines of the Approved Supplier Certification (ASC) program contained in Kentucky Method (KM) 64-444, by following the guidelines of the Emulsified Asphalt Supplier Certification (EASC) program contained in KM 64-445, or by pretesting and approval. The Department may approve other types of asphalt materials provided they conform to the requirements of the type specified in the contract.

806.02 SAMPLING. The Department will sample all asphalt materials according to KM 64-404.

806.03 PG BINDERS. This subsection covers the requirements and pay schedules for PG binders.

806.03.01 General Requirements. Provide PG binders conforming to AASHTO M 332 with any differences found in the PG Binder Requirements and Price Adjustment Schedule. Contrary to M 332, PG 76-22 must have a minimum solubility of 97.0 percent. Do not use any form of recycled engine oil, including Recycled Engine Oil Bottoms (REOB), as a modifier in asphalt materials.

PG BINDER REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE						
PG 58-28 (PG 58S-28)						
Test	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ^(d)
Original Binder						
Dynamic Shear, $G^*/\sin\delta$	1.00 kPa Min.	1.00-0.95	0.94-0.90	0.89-0.85	0.84-0.80	< 0.80
Viscosity	3 Pa·s					
RTFO Residue						
Mass Loss, %	1.00 Max.	1.01-1.10	1.11-1.20	1.21-1.30	1.31-1.40	> 1.40
MSCR						
$J_{nr3.2}$, Max.	4.5 kPa ⁻¹	< 4.7	4.71-4.75	4.76-4.80	4.81-4.85	≥ 4.86
J_{nr_diff} , Max	75 %					
PAV Aging						
BBR						
Creep Stiffness	300 MPa Max.	300-315	316-330	331-345	346-360	> 360
m-value	0.300 Min.	0.290-0.300	0.285-0.289	0.280-0.284	0.275-0.279	< 0.274
Dynamic Shear, $G^*/\sin\delta$ @ 25 °C	5,000 kPa Max.	0-5,200	5,101-5,300	5,301-5,400	5,401-5,500	> 5,501

PG 64-22 (PG 64S-22)						
Test	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ⁽¹⁾
Original Binder						
Dynamic Shear, G*/sinδ	1.00 kPa Min.	1.00-0.95	0.94-0.90	0.89-0.85	0.84-0.80	< 0.80
Viscosity	3 Pa·s					
RTFO Residue						
Mass Loss, %	1.00 Max.	1.01-1.10	1.11-1.20	1.21-1.30	1.31-1.40	> 1.40
MSCR						
$J_{nr3.2}$, Max.	4.5 kPa ⁻¹	< 4.7	4.71-4.75	4.76-4.80	4.81-4.85	≥ 4.86
$J_{nr, diff}$, Max.	75 %					
PAV Aging						
BBR						
Creep Stiffness	300 MPa Max.	300-315	316-330	331-345	346-360	> 360
m-value	0.300 Min.	0.290-0.300	0.285-0.289	0.280-0.284	0.275-0.279	< 0.274
Dynamic Shear, G*·sinδ	5,000 kPa Max.	0-5,200	5,201-5,300	5,301-5,400	5,401-5,500	> 5,501
PG 76-22 (PG 64E-22)						
Test	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ⁽¹⁾
Original Binder						
Dynamic Shear, G*/sinδ	1.00 kPa Min.	1.00-0.95	0.94-0.90	0.89-0.85	0.84-0.80	< 0.80
Viscosity	3 Pa·s					
RTFO Residue						
Mass Loss, %	1.00 Max.	1.01-1.10	1.11-1.20	1.21-1.30	1.31-1.40	> 1.40
MSCR						
$J_{nr3.2}$, Max	0.5 kPa ⁻¹	< 4.7	4.71-4.75	4.76-4.80	4.81-4.85	≥ 4.86
$J_{nr, diff}$, Max	75 %					
Recovery, 3.2 kPa, %	60 Min.	≥58	56	55	54	< 53
PAV Aging						
BBR						
Creep Stiffness	300 MPa Max.	300-315	316-330	331-345	346-360	> 360
m-value	0.300 Min.	0.290-0.300	0.285-0.289	0.280-0.284	0.275-0.279	< 0.274
Dynamic Shear, G*·sinδ	6,000 kPa Max.	0-6,200	6,201-6,300	6,301-6,400	6,401-6,500	> 6,501

⁽¹⁾ If allowed to remain in place, the Department will review materials performing in this range on a project-by-project basis to determine if removal of the material is warranted.

806.03.02 Handling Requirements. Submit written instructions to the Division of Materials for handling requirements. Submit the Supplier's written instructions and requirements for the proper use and handling of the asphalt binder to the Engineer. Include tank requirements, construction equipment requirements, and storage and mixing temperature requirements. Submit material test data and a certification of conformance prior to shipping material.

806.03.03 Modification. Use only styrene-butadiene (SB) or styrene-butadiene-

styrene (SBS) modifiers. Poly-phosphoric acid may be added to modified binders to aid in cross-linking. Any use of recycled engine oil bottoms (REOB) or other engine oil derivatives in the manufacture or modification of a binder are strictly prohibited. All binders are to be homogeneous blends. Do not use in-line blending at the asphalt plant.

806.04 EMULSIFIED ASPHALTS. This subsection covers emulsified asphalts of the following grades:

- RS-2
- SS-1
- SS-1h
- CSS-1h
- AE-200
- HFRS-2
- HFMS-2

806.04.01 General Requirements. Furnish emulsified asphalts that are homogeneous, showing no separation of asphalt during normal handling or storage. The Engineer will reject emulsified asphalt that has been frozen.

806.04.02 Specific Requirements for Grades RS-2, SS-1, SS-1h, HFRS-2, HFMS-2. Conform to AASHTO M 140 with the following exceptions and requirements of the Emulsified Asphalt Requirements and Price adjustment Schedule except the cement-mixing test is not required.

806.04.03 Specific Requirements for Grade CSS-1h. Conform to AASHTO M 208 and requirements of the Emulsified Asphalt Requirements and Price adjustment Schedule except the cement-mixing test is not required.

806.04.04 Specific Requirements for Grade AE-200. Conform to the Emulsified Asphalt Requirements Schedule

806.04.05 Testing of Grades RS-2, SS-1, SS-1h, CSS-1h, AE200, HFRS-2, and HFMS-2. Perform tests according to AASHTO T 59. Use Tyrone Formation limestone as the reference aggregate for the coating test.

EMULSIFIED ASPHALT REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE							
Test	Grade	Specification	100% Pay	90% Pay	80% Pay	60% Pay	0% Pay
Viscosity, Saybolt Furol @ 77 °F, s	SS-1, SS-1h, CSS-1h	20-100	18-110	111-120	121-130	131-140	≥ 141
	AE-200	≥ 50	≥ 45	40-44	35-39	30-34	≤ 29
Viscosity, Saybolt Furol @ 122 °F, s	RS-2,			60-64	55-59	50-54	≤ 49
	HFRS-2	75-400	65-440	441-480	481-520	521-560	≥ 561
Residue by Distillation, %	SS-1, SS-1h, CSS-1h	≥ 57	≥ 56	55	54	53	≤ 52
	HFMS-2, HFRS-2, RS-2	≥ 65	≥ 64	61-63	58-60	55-57	≤ 54
Oil Distillates, %	AE-200	≥ 60	≥ 59	56-58	53-55	50-52	≤ 49
	AE-200	0-6	0-7	8-10	11-13	14-16	≥ 17
Demulsibility, %	RS-2	≥ 60	≥ 57	51-56	45-50	39-44	≤ 38
	HFRS-2	≥ 50	≥ 47	41-46	35-40	29-34	≤ 28
Residue Penetration	SS-1h, CSS-1h	40-90	37-98	34-36	31-33	28-30	≤ 27
	SS-1h, CSS-1h	40-90	37-98	99-108	109-120	121-130	≥ 131

	SS-1, HFMS-2	90-250	89-251	85-88 252-255	80-84 256-258	77-79 259-262	≤ 76 ≥ 263
	RS-2	90-150	89-151	85-88 152-155	80-84 156-158	77-79 159-162	≥ 76 ≥ 163
	HFRS-2	100-250	99-151	95-98 152-155	90-94 156-158	87-89 159-162	≥ 86 ≥ 163
Float Test @ 140 °F, s	AE-200, HFRS-2, HFMS-2	≥ 1,200	≥ 1,100	1000-1,099	900-999	800-899	≤ 799
Coating Test, %	AE-200	≥ 95	≥ 90	85-89	80-84	75-79	≤ 74
Sieve, %	RS-2, HFRS-2, HFMS-2, SS-1, SS-1h, CSS-1h	≤ 0.10	≤ 0.30	0.31-.45	0.46-0.60	0.61-0.75	≥ 0.76
Ductility, cm @ 77 °F	SS-1, SS-1h, CSS-1h RS-2, HFMS-2 HFRS-2,	≥ 40	≥ 38	35-37	32-34	29-31	≤ 28
Storage Stability, % ⁽¹⁾	SS-1, SS-1h, CSS-1h RS-2, HFRS-2, AE-200, HFMS-2	≤ 1.0					
Particle Charge	CSS-1h	Positive					
Ash Content, % ⁽¹⁾	SS-1, SS-1h, CSS-1h HFRS-2, RS-2, HFMS-2, AE-200	≤ 1.0					

806.05 POLYMER ASPHALT EMULSIONS. . These materials are designed to be used in microsurfacing, chipseals, and stress-absorbing membrane interlayers (SAMIs). Make the polymer modification to the base asphalt before the emulsification process. Ensure that polymer-modified asphalt emulsions conform to AASHTO M 316 and the following Polymer Asphalt Emulsion Requirements and Price Adjustment Schedule.

POLYMER ASPHALT EMULSION REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE							
Test	Grade	Specification	100% Pay	90% Pay	80% Pay	60% Pay	0% Pay
Viscosity @ 122 °F, SFS	CRS-2P	100 - 400	90 - 440	80-89 441-480	70-79 481-520	60-69 521-560	≤ 59 ≥ 561
Viscosity @ 77 °F, SFS	CQS-1hP	20 - 100	18 - 110	15-17 111-120	12-14 121-130	9-11 130-140	≤ 8 ≥ 141
Distillation Residue, %	CRS-2P	≥ 65	≥ 64	61-63	58-60	55-57	≤ 54
	CQS-1hP	≥ 62	≥ 61	58-61	55-57	53-54	≤ 52
Sieve, %	CRS-2P, CQS- 1hP	≤ 0.1	≤ 0.35	0.36-0.50	0.51-0.70	0.71-0.90	≥ 0.91
Softening Point, °F	CQS-1hP	≥ 135	≥ 134	132	130	128	≤ 127
Residue Penetration @ 77 °F	CRS-2P	90 - 150	89-151	85-88 152-155	80-84 156-158	77-79 159-162	≤ 76 ≥ 163

	CQS-1hP	40 - 90	37-98	34-36 99-108	31-33 109-120	28-30 121-130	≤ 27 ≥ 131
Residue Ductility @ 39 °F, cm	CRS-2P	≥ 30	≥ 28	25-27	22-24	20-21	≤ 19
Residue Ductility @ 77 °F, cm	CQS-1hP	≥ 40	≥ 38	35-37	35-34	30-31	≤ 29
% Recovery @ 77 °F	CRS-2P	≥ 60	≥ 57	54-56	51-53	48-50	≤ 47
% Recovery @ 50 °F	CQS-1hP	≥ 50	≥ 47	44-46	41-43	38-40	≤ 37
% Demulsibility	CRS-2P	≥ 40	≥ 35	32-34	29-31	26-28	≤ 25
Particle Charge	CRS-2P, CQS-1hP	Positive					
Storage Stability	CRS-2P	≤ 1					
Ash Content, %	CRS-2P, CQS-1hP	≤ 1.0					

806.06 ASPHALT COATING AND PAVING FOR METAL PIPE, PIPE ARCHES, AND ARCHES. These requirements apply to all corrugated metal pipe, pipe arches, and arches that are required to be asphalt-coated or coated and paved, except field-assembled structural plate pipe and pipe arches as specified in Section 612.

806.06.01 Asphalt Coating Material. Furnish asphalt coating material conforming to AASHTO M 190. The Department will obtain random samples of the asphalt coating material for analysis. The Department will reject all material not conforming to AASHTO M 190.

806.07 LIQUID ASPHALT FOR COLD-PATCHING MIXTURES. Ensure that the liquid asphalt material furnished under this subsection provides satisfactory coating properties, workability, and adherence characteristics for patching during cold and damp weather in either asphalt or concrete pavement surfaces. Furnish patching mixtures made with liquid asphalt or KP-6 that is capable of being stored for at least 6 months before being used and that is readily workable at all ambient temperatures above 25 °F.

With each shipment of material, provide test results certifying that the materials furnished conform to the following KP-6 Requirements table. Additionally, take a one-gallon sample from each transport as specified in the Materials Field Sampling and Testing Manual from the Department's Division of Materials. Ship the sample to the Division of Materials by any expedient means of transport. Obtain the Division of Materials' approval before using the liquid asphalt.

KP-6 REQUIREMENTS								
Property	Test Method	Specification	100% Pay	90% Pay	80% Pay	60% Pay	0% Pay	
Flash Point, °F	AASHTO T 48	≥ 200	≥ 195	190 - 194	188-189	186 - 187	≤ 185	
Water, %	AASHTO T 55	≤ 0.2	≤ 0.5	0.6 – 1.0	1.1 – 1.2	1.3 - 1.5	≥ 1.6	
680 °F Distillation	AASHTO T 78							
Temperature (°F)	Vol. of Total Distillate, %							Vol. of Original Sample, %
to 437	None							None
to 500	0 - 0.5							0 - 5
to 600	10 - 65							0 - 25
Residue From Distillation @ 680 ° F(% Volume by Difference)		72 - 95	76-96					
Tests on Residue from Distillation								
Modified Penetration With Cone ⁽¹⁾	ASTM D 5	180 min.						
Ductility, 39 °F, 1 cm/minute	AASHTO T 51	100 min.						
Ash Content, %	AASHTO T 111	≤ 1.0						

⁽¹⁾ Ensure the cone conforms to ASTM D 217, except that the interior construction may be modified as necessary. Ensure the total moving weight of the cone and attachments is 150 ± 0.1 g.

806.08 FIELD TOLERANCES. The Department, according to established criteria, allows tolerance limits to be applied to field samples. These limits are incorporated into the price adjustment schedules. These tolerances are for field samples only and will not apply to certification samples.

806.09 ACCEPTANCE. The Department will normally perform field quality acceptance testing on samples obtained at the project site or Contractor's storage facility. When required by the Department, the asphalt supplier shall send, at his expense, representative samples of materials stored at the source terminal or refinery to the Department's Division of Materials.

When the Department accepts asphalt materials by pretesting and certification, provide two copies of the bill-of-lading/load ticket with each hauling unit. The bill-of-lading/load ticket will contain the material's lot number, a statement of the quantity of materials within each load by weight and volume, and other information as required by KM 64-444 or KM 64-445. The Contractor and Department's representative will each receive copies at the point of delivery.

Do not use asphalt materials that are not properly covered by certification or otherwise tested and approved by the Department. When asphalt materials not of the specified grade, not appropriately certified, or not conforming to the applicable requirements when tested become incorporated into projects, the Engineer will, according to Section 105, evaluate the work affected and require adjustment of pay quantities or corrective work as deemed appropriate.

806.09.01 Acceptance of Non-Specification Asphalt Materials. Furnish asphalt materials purchased for Department work conforming to the requirements of this section. The Department will apply the following procedures only when reasonably acceptable work has been produced using the material in question, as provided in Subsection 105.04. When the use of non-specification material results in an inferior or unsatisfactory product, remove and replace the material at no expense to the Department, or at the Vendor's expense when materials are purchased directly by the Cabinet.

The Department may accept, at a reduced Contract price, asphalt materials not of the specified grade, not appropriately certified, or not conforming to the applicable requirements when check-tested after an evaluation of the work. However, the Department will not consider these procedures as a means to continue accepting non-specification material.

The Department will determine the price adjustment based on the delivered cost of the material. If the liquid asphalt has been incorporated into the project as an asphalt mixture, the deduction will be applied to the posted price of asphalt item.

When the material is not of the specified grade or not appropriately certified, the Department may deduct the full cost of the material.

When the material fails to conform to the applicable requirements, the Department will normally make deductions according to the pay schedules in this section. As provided in Subsection 806.08, the Department has established field tolerances for determining the acceptability of failing material at no price deduction. The Department will determine the frequency of check-sampling and testing on pretested material. When available, the Department will make deductions for failing test results based on the average of two check samples representing the material in question. When a sample fails on two or more tests, the Department may add the deductions, but the total deduction will not exceed 100 percent.

806.10 TIME LIMITATION ON APPROVALS. The Department will test materials in storage at the terminal as deemed necessary. Additionally, the Department will require the retesting, and re-approval, of materials not incorporated into the work within one month (2 months for PG binders) of the shipment date.

SECTION 807 — JOINT MATERIALS

807.01 DESCRIPTION. This section covers joint sealers and joint fillers of various types. The Department may approve other types of joint materials provided they conform to the requirements of the type specified in the Contract.

807.02 SAMPLING. The Department will sample all materials according to the Materials Field Sampling and Testing Manual from the Department’s Division of Materials.

807.03 JOINT SEALERS.

807.03.01 Hot-Poured, Elastic Joint Sealers. Furnish hot-poured, elastic joint sealers that meet or exceed the requirements of ASTM D 6690, Type II and the following table. Provide a certification of conformance with each lot of sealer.

HOT-POURED, ELASTIC JOINT SEALER REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE						
Test	Specification	100% Pay	90 % Pay	80 % Pay	60% Pay	0% Pay
Cone Penetration	90 max.	91-92	93-94	95-96	97-98	≥ 99
Softening Point, °C	80 min.	79-79.9	78-78.9	77-77.9	76-76.9	< 76
Resilience, %	60 min.	59-58	57-56	55-54	53-52	≥ 51
Bond, Non-immersed	Pass					

807.03.02 Expansion Joint Seals

A) **Seals.** Expansion joint seals shall be “V Seal” type or “pre-compressed silicone and foam” type. Preformed neoprene compression joint seals are not acceptable. Approved expansion joint seals are listed on the Department’s List of Approved Materials. The size of each expansion joint seal shall be approved by either the Department’s Division of Structures or Division of Maintenance, Bridge Preservation Branch.

B) **Adhesives.** Seal adhesives shall be per manufacturer’s recommendations.

807.03.03 Preformed, Expansion Joint Strip Seals With Lubricant Adhesive.

Furnish preformed, expansion joint strip sealers of approved design for the applicable joints to be sealed. Furnish sealers and lubricant adhesives that conform to the following requirements as applicable.

A) **Sealers.** Furnish sealers that conform to ASTM D 5973 with the following exceptions and additions:

- 1) The Department’s Division of Materials and Division of Bridge Design will approve the design of the expansion joint strip sealers. Approved sealers will be placed on the Department’s List of Approved Materials. Obtain the Department’s approval for sealers not on the List of Approved Materials before shipping to the project.
- 2) Ensure that the manufacturer provides sealers accurately marked at 12-inch intervals to determine elongation after installation.
- 3) Ensure that the sizes of sealers used in JPC pavement comply with the applicable Standard Drawings.

4) Ensure each lot number is accompanied by a certification stating conformance with this Subsection.

B) Lubricant. As recommended by the sealer manufacturer, provide lubricant that is compatible with the sealer, concrete, and steel. Ensure conformance to ASTM D 2835 when working with concrete pavements.

807.03.04 Joint Sealer for Rigid Pipe.

A) Butyl Rubber Sealants. Furnish butyl rubber sealants conforming to the requirements in ASTM C990, Section 6.2. Ensure each lot number is accompanied by a certification of conformance.

BUTYL RUBBER SEALANT REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE							
Test	Test Method	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ⁽¹⁾
Cone Penetration, 77 °F	ASTM D 217	50-120	121-125	45-49 126-130	40-44 131-135	35-39 136-140	≤ 34 ≥ 141
Cone Penetration, 32 °F	ASTM D 217	30	27-29	24-26	21-23	18-20	≥ 17
Specific Gravity, 77 °F	AASHTO T 229	1.15 – 1.40	1.10 min. 1.45 max.	1.00-1.09 1.46-1.50	1.04-1.08 1.51-1.55	1.00-1.03 1.56-1.60	≤ 0.99 ≥ 1.61
Ductility, 77 °F	AASHTO T51	5.0 min.	4.5 min.	4.0	3.5	3.0	≤ 2.9
Volatile Matter, %	AASHTO T 47	3 max.	3.5 max.	4.0	4.5	5.0	≥ 5.1
Ash, %	AASHTO T111	30 min.	28 min.	26-27	24-25	22-23	≤ 21
Bitumen, %	ASTM D 4	50 min.	48 min.	46-47	44-45	42-43	≤ 41
Flash Point °F	ASTM D 92	375 min.	370 min.	365-369	360-364	355-359	≤ 354

⁽¹⁾ If allowed to remain in place, the Department will review materials in this range on a project-by-project basis to determine if removal of the material is warranted.

B) Rubber Gaskets. Furnish rubber gaskets conforming to the requirements in ASTM C 1619, Class C. Ensure each lot number is accompanied by a certification of conformance.

RUBBER GASKET REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE							
Test	Test Method	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ⁽¹⁾
Tensile Strength, psi	ASTM D 412	1200 min.	1150 min.	1100-1149	1050-1099	1000-1049	≤ 999
Elongation, %	ASTM D 412	350 min.	325 min.	300-324	275-299	250-274	≥ 249
Hardness, Shore A	ASTM			33-34	30-32	28-29	≤ 27
	D 2240	40-60	35-65	66-67	68-69	70-72	≥ 73
Oven Aged Tensile Reduction, %	ASTM D 412	15 max.	17 max.	17.1-17.5	17.6-18.0	18.1-18.5	≥ 18.6

Oven Aged, Elongation Reduction, %	ASTM D 412	20 max.	22 max.	22.1-22.5	22.6-23.0	23.1-23.5	≥ 23.6
Compression Set, %	ASTM D395	25 max.	27 max.	27.1-27.5	27.6-28.0	28.1-28.5	≥ 28.6
Water Absorption, %	ASTM D 471	10 max.	12 max.	12.1-12.5	12.6-13.0	13.1-13.5	≥ 13.6

⁽¹⁾ *If allowed to remain in place, the Department will review materials in this range on a project-by-project basis to determine if removal of the material is warranted.*

807.03.05 Silicone Rubber Sealants. Provide material conforming to the following requirements and tables.

- A) Non-Sag and Self-Leveling Silicone Sealant.** Furnish sealant in a one-part silicone formulation which does not require a primer for bonding to concrete. Use a compound that is compatible with the surface to which it is applied. Do not use acid-cure sealants on concrete. Apply the sealant with a pressure applicator that forces it into the joint. Ensure self-leveling silicone, which is suitable for joints of one-inch width or less, exhibits a smooth, level surface with no indication of bubbling. Ensure each lot number is accompanied by a certification stating conformance to this Subsection. Provide material that conforms to ASTM D 5893 with the following exceptions and additions:
- 1) Non-sag tensile stress and elongation samples will be cured for 7 days.
 - 2) Non-sag durometer hardness will be determined at 73 ± 4 °F.
 - 3) The non-sag, tack-free time requirement is 20 – 90 minutes.
 - 4) The self-leveling relative tack-free time, according to ASTM C 679, will be a maximum of 60 minutes.
- B) Rapid-Cure Silicone Sealant.** Use sealant that is: (1) furnished as a two-part, rapid-cure, cold-applied, ultra-low-modulus, self-leveling, 100-percent silicone rubber sealant; (2) flexible over a wide temperature range; and (3) suitable for use in concrete-to-concrete, concrete-to-steel, and steel-to-steel joints. Provide material meeting the requirements of the following table. Ensure each lot number is accompanied by a certification stating conformance with this Subsection.
- C) Accessory Items.** Use a closed-cell, polyethylene foam, back-up rod that is compatible with the sealant. Ensure no bond or reaction occurs between the back-up rod and sealant.
- D) Approvals.** Ensure that each lot of sealant is delivered in containers plainly marked with the manufacturer's name or trademark and a lot number. Ensure that the manufacturer furnishes certified test results of each lot of joint sealant shipped to each project. The Department does not require tests for ozone and UV resistance, or movement capability and adhesion, on every lot, but ensure that every lot is accompanied by certified results of the latest tests performed. Ensure that the manufacturer indicates the date of shipment on each lot. Do not use material after six months from the date of shipment from the manufacturer without first having the material sampled and tested. The Department will take routine check samples of silicone sealant during application and test it to verify the material's acceptability. Provide equipment suitable for obtaining representative check samples from the silicone sealant at a frequency determined by the Materials Field Sampling and Testing Manual from the Department's Division of Materials.
- The Engineer may accept the foam back-up rod on the project by visual inspection.

Use rapid-cure silicone sealant conforming to the following table:

RAPID-CURE SILICONE JOINT SEALANT REQUIREMENTS		
Test	Test Method	Specification
Extrusion Rate, g/minute	ASTM C 1183	200 – 550
Non-Volatile Content, %	ASTM C 792	93 min.
Relative Tack-Free Time, minutes	ASTM C 679	20 max.
Elongation, % ⁽¹⁾	ASTM D 412	600 min.
Tensile Stress (100% elongation), psi ⁽¹⁾	ASTM D 412	3 – 20
Tensile Adhesion, %	ASTM D 5329	600 min.
Bond (10 cycles at 100% and –50%)	ASTM C 719	No Failure
Accelerated Weathering	ASTM C 793	No Change

⁽¹⁾ Allow a cure time of 48 hours at 77 °F and 50 % relative humidity.

807.04 JOINT FILLERS.

807.04.01 General. Furnish preformed fillers in a single piece for the full depth and width required for the joint unless otherwise authorized. When the Engineer authorizes the use of more than one piece for a joint, fasten the abutting ends securely, and hold them accurately to shape.

807.04.02 Preformed Sponge Rubber and Cork Expansion Joint Fillers. Furnish preformed sponge rubber and cork joint fillers that conform to AASHTO M 153 for Type I (sponge rubber), Type II (cork), or Type III (self-expanding cork) as specified.

807.04.03 Preformed Asphalt Expansion Joint Fillers. Furnish preformed asphalt joint fillers that conform to AASHTO M 213. Ensure that the asphalt filler is free from water and does not foam when heated to the flash point. Provide a certification of conformance for each material.

807.04.04 Longitudinal Joint Adhesives. Provide a hot-applied longitudinal joint adhesive that meets the requirements found in the following table.

Pavement Joint Adhesive Specification and Price Adjustment Schedule						
Test	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ⁽¹⁾
Viscosity, 400 ° F (Pa*s)			3.0-3.4	2.5-2.9	2.0-2.4	≤1.9
ASTM D 3236	4.0-10.0	3.5-10.5	10.6-11.0	11.1-11.5	11.6-12.0	≥12.1
Cone Penetration, 77 ° F			54-56	51-53	48-50	≤ 47
ASTM D 5329	60-100	57-103	104-106	107-109	110-112	≥ 113
Flow, 140 ° F (mm) ASTM D 5329	≤ 5.0	≤ 5.5	5.6-6.0	6.1-6.5	6.6-7.0	≥ 7.1
Resilience, 77 ° F (%) ASTM D 5329	≥ 30	≥ 28	26-27	24-25	22-23	≤ 21
Tensile Adhesion, 77 ° F (%) ASTM D 5329	≥ 500	≥ 490	480-489	470-479	460-469	≤ 459
Softening Point, ° F AASHTO T 53	≥ 171	≥ 169	166-168	163-165	160-162	≤ 159
Ductility, 39 ° F (cm) ASTM D 113	≥ 30.0	≥ 29.0	28.0-28.9	27.0-27.9	26.0-26.9	≤ 25.9

⁽¹⁾ If allowed to remain in place, the Department will review materials performing in this range on a project-by-project basis to determine if removal of the material is warranted.

807.05 FIELD TOLERANCES. The Department, according to established criteria, will allow tolerance limits to be applied to field samples. These limits are incorporated into the price adjustment schedules. These tolerances are for field samples only and will not apply to certification samples.

807.06 ACCEPTANCE. The Department will normally perform field quality acceptance testing on samples obtained at the project site or Contractor's storage facility. When required by the Department, the sealer supplier shall send, at his expense, representative samples of materials stored at the source to the Department's Division of Materials.

When the Department accepts materials by pretesting and certification, provide two copies of the bill-of-lading/load ticket with each delivered unit. The bill-of-lading/load ticket, at a minimum, will contain the material's lot number and a statement of the quantity of materials within each load. In addition, materials pretested by the Department will include the assigned SiteManager identification number in the shipment documentation. The Contractor and Department's representative will each receive copies at the point of delivery.

Do not use materials that are not properly covered by certification or otherwise tested and approved by the Department. When materials not appropriately certified or not conforming to requirements when tested become incorporated into projects, the Engineer will, according to Section 105, evaluate the work affected and require adjustment of pay quantities or corrective work as deemed appropriate.

807.06.01 Acceptance of Non-Specification Joint Materials. Furnish joint materials purchased for Department work conforming to the requirements of this section. The Department will apply the following procedures only when reasonably acceptable work has been produced using the material in question, as provided in Subsection 105.04. When the use of non-specification material results in an inferior or unsatisfactory product, remove and replace the material at no expense to the Department, or at the Vendor's expense when materials are purchased directly by the Cabinet.

The Department may accept, at a reduced Contract price, joint materials not appropriately certified, or not conforming to the applicable requirements when check-tested, after an evaluation of the work. However, the Department will not consider these procedures as a means to continue accepting non-specification material.

The Department will determine the price adjustment based on the delivered cost of the material.

When the material is not appropriately certified, the Department may deduct the full cost of the material.

When the material fails to conform to the applicable requirements, the Department will normally make deductions according to the pay schedules included in this section. As provided in Subsection 807.04, the Department has established field tolerances for determining the acceptability of failing material at no price deduction. The Department will determine the frequency of check-sampling and testing on pretested material. The Department will make deductions for failing test results based on the average of two check samples representing the material in question. When a sample fails on two or more tests, the Department may add the deductions, but the total deduction will not exceed 100 percent.

NON-SAG AND SELF-LEVELING SILICONE SEALANT REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE						
Test	Specification	100% Pay	90% Pay	80% Pay	60% Pay	0% Pay
Tack-Free Time, minutes Non-Sag		15-19	12-14	9-11	6-8	≤ 5
	20-90	91-95	96-98	99-101	102-104	≥ 105
Self-Leveling	300 max.	301-310	311-320	321-330	331-340	≥ 341
	60 max.	61-65	66-68	69-71	72-74	≥ 75
Relative Tack-Free Time, minutes ⁽¹⁾		8	7	6	5	≤ 4
Durometer Hardness, Shore A ⁽²⁾	10-25	27	28	29	30	≥ 31
Tensile Stress (150% Elongation), psi ²	45 max.	46-50	51-53	54-56	57-59	≥ 60
Elongation, % ²	600 min.	≥ 550	525-549	500-524	475-499	≤ 474
Shump, inches ⁽³⁾	0.30 max.	≥ 0.32	0.33-0.34	0.35-0.37	0.38-0.40	≥ 0.41
Non-Volatile Content, %	90 min.	≥ 90	88-89	86-87	84-85	≤ 83
Flow ⁽⁴⁾	No flow					
Extrusion Rate, inches ³ /minute ⁽⁴⁾	≥ 3.5					
Accelerated Weathering ⁽⁴⁾	No change					
Bond ⁽⁴⁾	No failure					
Shelf Life	6 months					

⁽¹⁾ For self-leveling silicone only.

⁽²⁾ Seven day cure for non-sag and twenty-one day cure for self-leveling material.

⁽³⁾ For non-sag silicone only.

⁽⁴⁾ For certification purposes only.

807.07 TIME LIMITATION ON APPROVALS. The Department will test materials in storage at the Contractor's site as deemed necessary. Additionally, the Department will require the retesting, and re-approval, of materials not incorporated into the work according to the time limitations specified in the Materials Field Sampling and Testing Manual from the Department's Division of Materials.

SECTION 808 — WATERPROOFING MATERIALS

808.01 DESCRIPTION. This section covers materials for use in waterproofing. The Department may approve other types of waterproofing materials provided they conform to the requirements of the type Contract specifies.

808.02 SAMPLING. The Department will sample all materials according to the Materials Field Sampling and Testing Manual from the Department's Division of Materials.

808.03 ASPHALT MOP COAT. Furnish material that conforms to ASTM D 449, as specified in the Asphalt Mop Coat Requirements and Price Adjustment Schedule. Use Type I, II, or III material as the Contract specifies.

808.04 ASPHALT WATERPROOFING PRIMER. Furnish material that conforms to ASTM D 41 and ensure the supplier provides certification of conformance.

808.05 WATERPROOFING MEMBRANES.

808.05.01 Waterproofing Membranes for Bridge Decks.

A) **Fiberglass Waterproofing Membrane.** Furnish a fiberglass waterproofing membrane that is a one-step waterproofing and reflective-crack suppression system for bridge decks. The one-step system is comprised of a high strength, fiberglass-reinforced, factory coating with an asphalt polymer and a strongly bonding contact adhesive on one side that bonds to the surface being treated. Ensure the supplier provides certification that the fiberglass waterproofing membrane conforms to the following table:

FIBERGLASS WATERPROOFING MEMBRANE REQUIREMENTS		
Property	Test Method	Specification
Tensile Strength, lb/in (longitudinal and transverse)	ASTM D 4632	44 min.
Pliability @ -25 °F, 1" mandrel	ASTM D 146	Pass
Moisture, %	ASTM D 146	1 max.
Permeability, perms	ASTM E 96 (B)	0.5 max.

B) **Polypropylene Waterproofing Membrane.** Furnish a polypropylene waterproofing membrane that is a one-step waterproofing and reflective-crack suppression system for bridge decks. The system is comprised of a polypropylene non-woven fabric with a top-coating of asphalt and a rubberized asphalt adhesive on the bottom to bond with the surface being treated. Ensure the supplier provides certification that the membrane conforms to ASTM D 6153, Type III and the following table:

POLYPROPYLENE WATERPROOFING MEMBRANE REQUIREMENTS		
Property	Test Method	Specification
Grab Tensile Strength, lb ⁽¹⁾	ASTM D 4632	50 min.
Elongation, %	ASTM D 4632	20 min.
Pliability, -25 °F ⁽²⁾	ASTM D 146	Pass
Puncture Resistance, lb.	ASTM E 154	200 min.
Permeability, perms	ASTM E 96 (B)	0.05 max.

⁽¹⁾ One inch distance between grips and 12 in/min test speed.

⁽²⁾ 180 degree bend on ¼ inch mandrel.

808.05.02 Layered, Fiber-Reinforced Waterproofing Membrane for Concrete Joints and Precast Items. Furnish a plastic film and mesh-reinforced mastic polyethylene membrane for sealing open expansion joints, concrete expansion joints, cracked culverts, or for waterproofing in backfill situations. Ensure the supplier provides certification that this material conforms to ASTM C 877, Type II, excluding the steel straps.

808.08 FIELD TOLERANCES. The Department, according to established criteria, will allow tolerance limits to be applied to field samples. These limits are incorporated into the price adjustment schedules. These tolerances are for field samples only.

808.09 ACCEPTANCE. The Department will normally perform field quality acceptance testing on samples obtained at the project site of Contractor's storage facility. When required by the Department, the supplier shall send, at his expense, representative samples of materials stored at the source to the Department's Division of Materials.

When the Department accepts materials by pretesting and certification, provide two copies of the bill-of-lading/load ticket with each delivered unit. The bill-of-lading/load ticket, at a minimum, will contain the material's lot number and a statement of the quantity of materials within each load. In addition, materials pretested by the Department will include the assigned SiteManager identification number in the shipment documentation. The Contractor and Department's representative will each receive copies at the point of delivery.

Do not use materials that are not properly covered by certification or otherwise tested and approved by the Department. When materials not appropriately certified or not conforming to the applicable requirements when tested become incorporated into projects, the Engineer will, according to Section 105, evaluate the work affected and require adjustment of pay quantities of corrective work as deemed appropriate.

808.10 ACCEPTANCE OF NON-SPECIFICATION WATERPROOFING MATERIALS. Furnish waterproofing materials purchased for Department work conforming to the requirements of this section. The Department will apply the following procedures only when reasonably acceptable work has been produced using the material in question, as provided in Subsection 105.04. When the use of non-specification material results in an inferior or unsatisfactory product, remove and replace the material at no expense to the Department, or at the Vendor's expense when materials are purchased directly by the Cabinet.

The Department may accept, at a reduced Contract price, waterproofing materials not appropriately certified, or not conforming to the applicable requirements when check-tested, after an evaluation of the work. However, the Department will not consider these procedures as a means to continue accepting non-specification material.

The Department will determine the price adjustment based on the delivered cost of the material.

When the material is not appropriately certified, the Department may deduct the full cost of the material.

When the material fails to conform to the applicable requirements, the Department will normally make deductions according to the pay schedules included in this section. As provided in Section 808.07, the Department has established field tolerances for determining the acceptability of failing material at no price deduction. The Department will determine the frequency of check-sampling and testing on pretested material. The Department will make deductions for failing test results based on the average of 2 check samples representing the material in question. When a sample fails on two or more tests, the Department may add the deductions, but the total deduction will not exceed 100 percent.

808.11 TIME LIMITATION ON APPROVALS. The Department will test materials in storage at the Contractor's site as deemed necessary. Additionally, the Department will require the retesting, and re-approval, of materials not incorporated into the work according to the time limitations specified in the Materials Field Sampling and Testing Manual from the Department's Division of Materials.

ASPHALT MOP COAT REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE							
Property	Specification	100%Pay	90 %Pay	80 %Pay	70 %Pay	50%Pay ⁽¹⁾	
Type I							
Softening Point, °F		115-140	113-114 141-142	111-112 143-144	109-110 145-146	107-108 147-148	≤ 106 ≥ 149
		Penetration	32 °F	5 min.	5	4	3
	77 °F	50-100	48-49	46-47	44-45	42-43	≤ 41
	115 °F		100 min.	101-102	103-104	105-106	107-108
Flash Point, °F		450 min.	98-99	96-97	94-95	92-93	≤ 91
Ductility, cm		450 min.	448-449	446-447	444-445	442-443	≤ 441
Solubility, %		30 min.	29	27-28	25-26	23-24	≤ 22
		99 min.	98	96-97	94-95	92-93	≤ 91
Type II							
Softening Point, °F		145-170	143-144 171-172	141-142 173-174	139-140 175-176	137-138 177-178	≤ 136 ≥ 179
		Penetration	32 °F	10 min.	9	8	7
	77 °F	25-50	24	23	22	21	≤ 20
	115 °F		130 max.	51	52	53	54
Flash Point, °F		450 min.	131	132	133	134	≥ 135
Ductility, cm		450 min.	448-449	446-447	444-445	442-443	≤ 441
Solubility, %		10 min.	9	8	7	6	≤ 5
		99 min.	98	96-97	94-95	92-93	≤ 91
Type III							
Softening Point, °F		180-200	178-179 201-202	176-177 203-204	174-175 205-206	172-173 207-208	≤ 171 ≥ 209
		Penetration	32 °F	10 min.	9	8	7
	77 °F	20-40	19	18	17	16	≤ 15
	115 °F		100 max.	41	42	43	44
Flash Point, °F		475 min.	101	102	103	104	≥ 105
Ductility, cm		475 min.	473-474	471-472	469-470	467-468	≤ 466
Solubility, %		2 min.	2			1	0
		99 min.	98	96-97	94-95	92-93	≤ 91

⁽¹⁾ If allowed to remain in place, the Department will review materials performing in this range on a project-by-project basis to determine if removal of the material is warranted.

**SECTION 809 — STRUCTURAL PLATES FOR PIPES, PIPE
ARCHES, AND ARCHES**

809.01 CORRUGATED STEEL STRUCTURAL PLATE AND ACCESSORIES.
Conform to AASHTO M 167. Coat with asphalt material conforming to Subsection 806.06.
The Department will sample and test the material according to its current practices.

809.02 ALUMINUM ALLOY STRUCTURAL PLATE AND ACCESSORIES.
Conform to AASHTO M 219. The Department will sample and test the material according
to its current practices.

SECTION 810 — PIPE AND PIPE ARCHES

810.01 DESCRIPTION. This section covers the various types of pipe and pipe arches for use on highway projects.

810.02 APPROVAL. Select pipe or pipe arches supplied by a producer that is listed on the List of Approved Materials. All producers of pipe and pipe arches must conform to KM 115. These requirements may be obtained from the Division of Materials.

810.03 REINFORCED CONCRETE PIPE.

810.03.01 Pipe Class.

- A) **Circular.** Furnish circular reinforced concrete pipe conforming to AASHTO M 170 for Class I, Class II, Class III, Class IV, and Class V. Furnish a D-load pipe conforming to AASHTO M 242 when specified in the Contract.
- B) **Elliptical.** Furnish horizontal and vertical elliptical reinforced concrete pipe conforming to AASHTO M 207 for Class HE-A, Class HE-I, Class HE-II, Class HE-III, Class HE-IV, Class VE-V, Class VE-VI, Class V-II, Class VE-III, and Class VE-IV.
- C) **Arch.** Furnish reinforced concrete pipe arch conforming to AASHTO M 206 for Class A-II, Class A-III, and Class A-IV.

810.03.02 Aggregates. Conform to Section 804 and 805.

810.03.03 Cement. Use any type conforming to Section 801.

810.03.04 Concrete. Submit concrete mix designs to Central Office Materials.

810.03.05 Extra Protection. Furnish concrete pipe with extra protection to inhibit corrosion when required by the Standard Drawings for culvert pipe, storm sewer pipe, and entrance pipe. Furnish concrete pipe with extra protection for all other types of pipe when specified in the Contract. Use reinforced concrete pipe conforming to Subsection 810.03.01 A) for Classes III, IV, and V; Subsection 810.03.01 B) for Classes HE-II, HE-III, HE-IV, VE-II, VE-III, and VE-IV; and Subsection 810.03.01 C) for Classes A-II, A-III, and A-IV. Use concrete having a minimum compressive strength of 6,000 psi at the time of acceptance. Use Wall B or Wall C as necessary.

When using one line of reinforcement, place it 1/2 of the shell thickness from the inner surface of the pipe. When using 2 lines of reinforcement, place each line so that the nominal protective covering of concrete is one inch from the outer surface of the pipe and 1 3/4 inches from the inner surface. The Department will allow a variation tolerance of $\pm 1/2$ inch with a minimum protective covering of one inch from the inner surface in all cases.

810.03.06 Identification and Markings. Mark pipe sections according to AASHTO M 170 or M 207 as applicable for identification. For all pipe sizes greater than 30 inch diameter, mark the inside wall with a stencil identifying the class of pipe. The Stencil identification shall be placed at the top of the inside wall (out of flow line) and shall be a minimum of 3 inches in height.

Additionally, mark "EP" on each section of pipe manufactured by the extra protection requirements.

Provide shipment approval form containing the following information:

- 1) Project Number and county.
- 2) Name of Contractor.
- 3) The size, class, and quantity of pipe shipped.

- 4) The dates of manufacture of the pipe.
- 5) A signed statement that the pipe is from a tested and approved lot.

The Engineer will check pipe joints to determine if the information on the approval form or shipping ticket corresponds to the pipe actually received. Correct all discrepancies before using pipe.

810.03.07 Defects. The Department will reject pipe for any of the following reasons.

- 1) Exposed steel in walls, fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.
- 2) Defects that indicate imperfect proportioning, mixing, or molding.
- 3) Surface defects indicating honey-combed or open texture.
- 4) Damaged or cracked ends that prevent a satisfactory joint.
- 5) A continuous crack, regardless of its position in the wall of the pipe, having a surface width of 0.01-inch or more and extending 12 inches or more.
- 6) Incorrect steel placement or inadequate steel quantity in reinforced concrete pipes

810.04 CORRUGATED METAL PIPE.

810.04.01 Coating Requirements. Use asphalt coating and paving as extra protection to inhibit corrosion for the pH values shown on the Standard Drawings for culvert pipe, storm sewer pipe and entrance pipe. Coat and pave sanitary sewer pipe and all other pipe when specified in the Contract. Coat and pave the invert according to Subsection 806.06. Use asphalt material conforming to Subsection 806.06. Coat and pave the pipe according to AASHTO M 190.

Use polymer precoated galvanized corrugate metal pipe when the pH is greater than 9 or less than 5 according to the Standard Drawings. Manufacture according to AASHTO M 245, with a minimum grade of 10/10. Fabricate the sheets into pipe sections according to AASHTO M 36.

The Department will allow exceptions for coating on storm sewer pipe and entrance pipe as specified in the Standard Drawings.

810.04.02 Inlet and Outlet Requirements. Finish all pipe ends in a neat manner to allow safe handling and contact with the pipe. Unless the pipe is asphalt coated, paint the ends with inorganic zinc primer. When using 14 gauge or thinner sheets to fabricate helical lockseam or welded seam pipe, reroll the inlet and outlet end with at least 4 complete corrugations. Match mark all pipe that is 54 inches or larger in diameter.

810.04.03 Pipe Type. Furnish steel pipe conforming to AASHTO M 36 and aluminum alloy pipe conforming to AASHTO M 196 for types shown below:

- A) **Circular.** Type I or Type IR.
- B) **Arch.** Type II or Type IIR.
- C) **Underdrain.** Type III.

810.04.04 Coupling Bands. Furnish bands with annular or helical corrugation conforming to AASHTO M 36 and the requirements of 701.03.05.

810.04.05 Slotted Drain Pipe. Furnish pipe according to Subsection 810.04.03 A) with the addition of a grate assembly to provide openings in the top of the pipe as specified in the Plans. Apply asphalt coating after slotted drain pipe is fabricated. Provide material for slotted drain pipe from a supplier on the Department's List of Approved Materials. Furnish one of the following types of grate assemblies:

- A) **Type I.** The grate assembly is fabricated from structural steel, galvanized

according to AASHTO M 111 after fabrication, and forms a continuous drain slot when 2 or more joints of pipe are banded together.

- B) Type II.** The grate assembly is fabricated from 14 gauge steel, galvanized according to AASHTO M 218, and laterally supported by a minimum of one foot, measured laterally, of concrete on each side.

810.04.06 Defects. The Department will reject pipe for any of the following reasons.

- 1) Variation from centerline.
- 2) Elliptical shape in pipe intended to be round.
- 3) Dents or bends in the metal.
- 4) Lack of rigidity.
- 5) Low asphalt coating thickness on coated pipe.
- 6) Cracks or lack of coating adhesion on coated pipe.
- 7) Insufficient coating to provide a smooth level flow line on fully lined pipe and pipe with a paved invert.
- 8) Paved sections with less than 25 percent coverage of the pipe circumference.

810.05 SMOOTH METAL PIPE.

810.05.01 Cast Iron Pressure Pipe. Conform to ASTM A 377.

810.05.02 Welded and Seamless Steel Pipe for Bridge Floor Drains. Furnish 6-inch diameter round standard weight pipe conforming to ASTM A 53, ASTM A 500, or ASTM A 501 with a minimum wall thickness of 0.28 inches.

810.05.03 Black and Hot-Dipped Galvanized Welded and Seamless Steel Pipe for Ordinary Uses. Furnish pipe conforming to ASTM A 53 of the size and weight specified in the Contract. The Department will allow plain or threaded end finish.

810.05.04 Aluminum Alloy Extruded Structural Pipe. For pipe with internal connections, conform to ASTM B 221, Schedule 40, Alloy 6063-T52 for railing and ASTM B210, Schedule 40, Alloy 6063-T832 for posts.

For pipe with welded connections, conform to ASTM B221, Schedule 40, Alloy 6061-T6 or ASTM B210, Schedule 40, Alloy 6061-T6.

810.06 Thermoplastic Pipe.

810.06.01 Polyvinyl Chloride (PVC) Pipe.

- A) Pipe Underdrain.** Furnish perforated pipe for underdrains conforming to AASHTO M 304. Ensure all fittings and pipe are made from the same base material. Submit a manufacturer's certification that the pipe conforms to AASHTO M 304 to the Division of Materials annually. Use integral bell and spigot type joints with elastomeric seal joints and smooth inner walls.
- B) Culvert Pipe, Storm Sewer, and Entrance Pipe.** Furnish pipe and pipe fittings conforming to AASHTO M 304. Manufacture from low filler PVC plastic having a minimum ASTM 1784 cell classification of 12454. Use pipe fittings furnished by the pipe manufacturer.
- C) Sliplining Pipe (Rehabilitation).** Furnish pipe conforming to ASTM F949. Manufacture from low filler PVC plastic having a minimum ASTM 1784 cell classification of 12454B or 12454C. Use integral bell and spigot type joints with a STAB-JOINT bell coupler filling flush with the outer wall surface.

810.06.02 Corrugated High Density Polyethylene (HDPE) Pipe.

- A) **Pipe Underdrain.** Furnish perforated pipe for underdrains conforming to AASHTO M 252. Use only Type S for edge drain outlet pipe. Use caps, bands, and other fittings that are of the same material as the pipe. Submit a manufacturer's certification that the pipe conforms to AASHTO M 252 to the Division of Materials annually. Use a length that minimizes the number of joints in a run or line and facilitates shipment, handling, and installation. Use snap-in-place bands or a split band taped in place with polyethylene tape for pipe-to-pipe connections as the Engineer directs. Cap remote ends with a snap-in-place cap. Use non-perforated pipe when specified in the Contract or when the Engineer directs.
- B) **Culvert Pipe, Storm Sewer, and Entrance Pipe.** Provide pipe from a manufacturer that participates in the National Transportation Product Evaluation Program (NTPEP) for HDPE Pipe. Ensure the pipe and pipe fittings conform to AASHTO M 294, Type S or D. Use pipe fittings furnished by the pipe manufacturer. Use pipe couplings conforming to AASHTO M 294 and that are Department approved. When corrugations are spiral, use match marks, specially cut ends, or other acceptable methods to facilitate alignment of the corrugations at connections. Provide a minimum gap between adjacent sections of pipe. Submit a manufacturer's certification that the pipe conforms to resin requirements of AASHTO M 294 to the Division of Materials annually. Provide certification from the manufacturer with each shipment that the pipe conforms to AASHTO M 294. Use only Department approved pipe. The Department will perform all sampling and testing deemed necessary, either at the plant or on the project.

810.06.03 Corrugated Polypropylene (PP) Pipe. Furnish pipe from a manufacturer that participates in the National Transportation Product Evaluation Program (NTPEP) for PP Pipe and is included on the List of Approved Materials. Ensure the pipe and pipe fittings conform to AASHTO M 330, Type S or D. Use pipe fittings furnished by the pipe manufacturer. Elastomeric gaskets shall comply with the requirements specified in ASTM F477. Use pipe couplings conforming to AASHTO M 330 and that are Department approved. Submit a manufacturer's certification that the pipe conforms to resin requirements of AASHTO M 330 to the Division of Materials annually. Provide certification from the manufacturer with each shipment that the pipe conforms to AASHTO M 330.

SECTION 811 — STEEL REINFORCEMENT

811.01 CLASSIFICATION AND CONDITION. This specification covers bars, welded steel wire fabrics, bar mats, steel wire, prestressing strands, and load transfer assemblies. Ensure that these materials, when incorporated into the work, are reasonably free from dirt, paint, oil, grease, loose-thick rust, or other foreign substance and, when deemed necessary, are cleaned to the satisfaction of the Engineer. The Department will not require cleaning when these materials exhibit tight, thin, or powdery rust.

Reject reinforcement rusted sufficiently to cause it to fail specified physical properties or prestressing strands displaying pits visible to the naked eye.

811.02 BARS. For all bar reinforcement use Grade 60 deformed bars except as indicated for the following items:

- A) **JPC Pavement Tie Bars, Paved Ditches, Steps, Flume Inlets, Integral Curb, Right-of-Way Markers, Transverse Bars for Bar Mats, Piles, Cribbing, Small Drainage Structures, Pipe Headwalls, or Manhole Tops.** Use Grade 40, 50, or 60 deformed bars.
- B) **Steel Piling Encasement and Spiral Reinforcement for Precast (non-prestressed) Piling.** Use Grade 40, 50 or 60 plain or deformed bars.
- C) **Spiral Reinforcement (excluding piles).** Use Grade 60 deformed or plain bars.

811.02.01 Requirements. Furnish bar reinforcement for bridges, cast-in-place culverts, and cast-in-place retaining walls that conforms to ASTM A 615 (billet) or ASTM A 996 (rail). ASTM A 706 steel is acceptable with prior approval of the Division of Materials. Do not weld any steel bar reinforcement unless it is ASTM A 706 rebar. The Engineer will accept anrail steel bar reinforcement in straight lengths only. Do not use rail steel reinforcement where field bending is allowed or required.

Furnish bar reinforcement for other uses that conform to either ASTM A 706 (weldable), ASTM A 615 (billet), ASTM A 996 (rail), or ASTM A 617 (axel).

811.02.02 Testing and Acceptance. Identify all shipments of steel reinforcement by the producer's heat or test identification numbers. Obtain bar reinforcement from manufacturers included on the Department's List of Approved Materials. To be included on this list, Fabricators shall conform to KM 64-101 and shall participate in the National Transportation Product Evaluation Program (NTPEP) for Reinforcing Steel. Current data must be posted in NTPEP DataMine.

811.03 HOOK BOLTS AND ANCHOR BOLTS. Conform to the design and dimensions provided in the Standard Drawings. Furnish hook tie-bolts that, when assembled as a unit, are capable of sustaining an axial load of 14,000 pounds or greater.

811.04 PLAIN WELDED WIRE REINFORCEMENT (WWR). Conform to ASTM A 1064.

811.05 DEFORMED WELDED WIRE REINFORCEMENT. Conform to ASTM A 1064.

811.06 BAR MATS. Conform to ASTM A 184 and fabricate by welding deformed Grade 60 weldable bars.

811.07 STEEL WIRE. Conform to AASHTO M 32.

811.08 PRESTRESSING STRANDS. Ensure that Uncoated Seven-Wire Stress Relieved Strand for Prestressed Concrete conforms to AASHTO M 203, Grade 270 or low

relaxation strand Grade 270 as specified.

811.09 LOAD TRANSFER ASSEMBLIES (CONTRACTION AND EXPANSION).

The Department will approve the design of assemblies before delivery to the project. The Department will approve assemblies incorporating the typical features depicted by the Standard Drawings. The Department will reject assemblies at any time that deviate from previously approved designs and manufacturing procedures. Shop fabricate all assemblies.

Where chair bars fit over ends of dowel bars, form them to obtain a snug fit over the end of the dowel bar not welded to the chair bar.

Control welding to prevent a significant reduction in the areas of the dowel bars or the wires. Modify the load-transfer assemblies furnished for slip form construction to allow for approximately 4 inches of clearance between the assemblies and the slip forms. Accomplish this by welding the outer leg of the chair at an angle of approximately 90 degrees with the upper and lower spacer bars.

811.09.01 Chair, Spacer, Aligning Bars, and Upper Tie Bars. Furnish steel for these items that conforms to AASHTO M 32.

811.09.02 Dowel Bars. Furnish dowel bars that are plain round bars conforming to ASTM A 706, A 615, A 996, or A 617 with respect to mechanical properties only. Provide either Grade 40, 50 or 60 steel. Saw cut the free ends of the dowels and ensure that they are free of burrs or projections. Broken or sheared ends are acceptable with prior approval of the Division of Materials. Coat dowel bars according to AASHTO M 254 with the following exceptions for Type B coatings:

- 1) ensure that the thickness is 12 ± 3 mils,
- 2) subject the coated dowel bars to a bend test (KM 64-102),
- 3) use a bond breaker from the Department's List of Approved Materials for load transfer assemblies,
- 4) the maximum pull-out load shall not exceed 2,500 pounds,
- 5) loose dowel bar ends that have been saw cut (broken or sheared if permitted) shall be epoxy coated.

Use any Type B Coatings that are on the Department's List of Approved Materials for epoxy coating materials, and apply them (except for thickness) according to Subsections 811.10.03 and 811.10.04.

The Department will inspect and accept dowel bars with Type B coatings as specified in Subsection 811.10.06. Obtain a Certificate of Compliance as specified in Subsection 811.10.07.

811.09.03 Dowel Bar Sleeves. Furnish a sleeve for each dowel bar used with expansion joints. Place these sleeves on alternate and opposite ends of the dowels. Furnish sleeves manufactured from sheet metal or metal tubing having a minimum thickness of .010 inch, 32 gage. Ensure that they are of such length as to cover no less than 2 inches nor more than 3 inches of the dowel, have a closed end, fit the dowel bar snugly, and are of such design as to provide an unobstructed expansion space of no less than one inch to allow movement of the dowel bar.

811.09.04 Fabrication Tolerance. Ensure that the longitudinal alignment of dowel bars in load transfer assemblies is within 1/4 inch in 18 inches of the specified alignment.

When checked along the total length of the dowels, allow the deviation to be $0 \pm 1/4$ inch for assemblies on a zero degree skew, and $3 \pm 1/4$ inch for assemblies on a 9.5 degree skew.

811.10 EPOXY COATED STEEL REINFORCEMENT. Conform to ASTM A 775.

811.10.01 Uncoated Bars. Ensure that the deformed steel bars conform to the applicable requirements of Subsections 811.01 and 811.02. In addition, blast clean all surfaces of the steel bars to a near-white surface finish according to SSPC-SP 10. Blast clean to produce a surface having a profile no greater than 3 mils. Immediately before application of the coating, ensure that the blast cleaned surface corresponds with either pictorial standard A SP 10, B SP 10, or C SP 10 of SSPC-Vis 1, and the surfaces are free of all dust and grit.

811.10.02 Epoxy Coating Material. Select the epoxy coating material for reinforcing steel from the Department's List of Approved Materials. Ensure that the coating material conforms to the prequalification requirements of ASTM A 775. Submit documentation in the form of test results from a private testing laboratory verifying that the coating material conforms to ASTM A 775 to the Division of Materials to gain approved list status.

Select and furnish the powdered epoxy resin of the same material and quality as the resin which has been previously submitted for prequalification. Ensure that the resin manufacturer annually furnishes a written certification to the Division of Materials that attesting to the sameness of the powdered epoxy resin.

Obtain the approval of the Engineer for epoxy material for touch-up and repair work. Ensure that the epoxy material furnished by the epoxy manufacturer is compatible with the coating material and inert in concrete, and is suitable for use in the field.

811.10.03 Application of Epoxy Coating Material. Ensure the epoxy application is performed by an epoxy coater that is certified and participating in the CRSI (Concrete Reinforcing Steel Institute) certification program. Apply the powdered epoxy resin to the blast cleaned steel bars within 8 hours after blast cleaning and before any visible rusting of the near-white surfaces appears. Apply the resin as an electrostatically charged dry powder sprayed onto the grounded steel bars by electrostatic sprays. Ensure that the steel bars are at the temperature recommended by the powdered epoxy resin manufacturer at the time of the application of the coating.

After coating the bars, give them the thermal treatment recommended by the manufacturer of the powdered epoxy resin to provide fully cured coating on the bars. Touch up all uncoated areas of electrical contact points as directed.

Ensure that the epoxy coating applied to the bars is uniform and smooth with 90 percent of the film thickness measurements falling between 7 and 12 mils for bar sizes Nos. 3 to 5 and 7 to 16 mils for bar sizes Nos. 6 to 18 after curing, when checked according to KM 64-102.

The Department will reject the coated bars for either an insufficient or excessive film thickness or a partially cured coating.

811.10.04 Properties of the Coated Bars. Ensure that the coated bars, after curing, display a continuous, flexible, and abrasion resistant coating as determined by the following.

- A) **Continuity of Coating.** After curing, check all bars visually for defects in the coating such as holes, voids, delaminations, contamination, and damaged areas. In addition, check for "holidays" (pinholes not visually discernible) according to KM 64-102. When any bar has more than 2 defects or "holidays" per linear foot or a total defective area exceeding 0.25 percent of the surface area per linear foot, repair the defects or "holidays" with the touch-up material. When any bar has more than 5 defects or "holidays" per linear foot or a total defective area exceeding 0.5 percent of the surface area per linear foot, the Department will reject the bar.
- B) **Flexibility of Coating.** The Department will evaluate the flexibility of the coating by bending tests according to KM 64-102. Ensure that the coated bars are capable of being bent to 180 degrees for bar sizes Nos. 3 to 11 and 90 degrees for bar sizes Nos. 14 to 18 (after rebound) over a mandrel, without any visible evidence of cracking the coating.
- C) **Recleaning.** Do not remove the coating from rejected bars for the purpose of

recoating by any process involving temperatures higher than 500 °F.

- D) **Color of Coating.** For all epoxy coatings use a light color that will provide a distinct contrast with the color of cleaned steel, and the color of rusted steel.

811.10.05 Fabrication of Coated Bars. Fabricate the steel bars into the shapes and lengths specified on the bridge plans either before or after coating. When performing fabrication after coating the bars, repair any damage to the coating. Repair the coating on straight portions of the bars when damaged or bare areas exceed 0.25 percent of the coated area per linear foot or when individual damaged areas are in the order of 0.063 square inch, 1/4 inch by 1/4 inch or larger. When repairing coating, clean and repair all damaged and bare areas on the straight portion of the bar. When the amount of repair in the straight portion of a bar exceeds 2 percent of the surface area per linear foot the Department will reject the bar.

Repair coating within each bent area of the bar when bond loss and damage exceed 0.25 percent of the surface area within each bent area or when individual damaged areas are in the order of 0.063 square inch, 1/4 inch by 1/4 inch or larger. When repairing coating, clean and repair all damage within each bent area. When the amount of repair in a particular bent portion of a bar exceeds 2 percent of the surface area, the Department will reject the bar. It is not necessary to repair hairline cracks that do not have bond loss or other minor damage on fabrication bends.

Do not allow the amount of touch-up area for repair of defects and necessary overlap to exceed 5 percent of the surface area of the bar per meter for straight bars.

Do not allow the amount of touch-up area for repair of defects and necessary overlap to exceed 10 percent of the surface area of the bar per linear foot for bent portions of bars.

The Department will approve of all cleaning and repair methods and materials. Coat the ends of the coated bars cut during fabrication with the epoxy used for repairs. Repair the damaged areas and the coating of the ends of cut bars within 24 hours and before any visible rusting appears.

Obtain the Department's approval for any additional requested splices to accommodate lengths suitable for coating. Make requested additional splices at no additional expense to the Department.

Coat all areas receiving touch-up material, including ends with a minimum thickness of 5 mils. The Department will allow a maximum thickness of 16 mils in repair of overlap areas.

Extend touch-up material, applied to sheared or sawn bar ends to coat the resulting damaged area, up to a maximum of 7 inches from the end of the bar. When the sheared or sawn surface conforms to the specifications after touch-up, the Department will not count the bar end and first 7 inches from the bar end in determining the percent of repair area.

811.10.06 Inspection and Acceptance. Before subjecting them to blast cleaning and coating with the powdered epoxy resin, confirm that uncoated steel bars are from a manufacturer on the Department's List of Approved Materials for Reinforcing Steel Manufacturers. The Department may inspect and test all materials at the coating plant, and after delivery to the project.

Use an epoxy coater to apply the coating that is on the Department's List of Approved Materials. To be approved, epoxy coaters must conform to KM 64-101 and KM 64-102.

If the Department's inspection or testing indicates that material furnished to a Department project materially differs from the specification requirements, the Department will review and reconsider the approval of the epoxy coater's quality control program.

811.10.07 Documentation. Ensure that each shipment of epoxy coated steel reinforcement is accompanied by documentation prepared by the epoxy coater according to KM 64-101.

811.11 ACCEPTANCE PROCEDURES FOR NON-SPECIFICATION REINFORCING STEEL. Ensure that all reinforcing steel conforms to the requirements of this section. However, when non-specification reinforcing steel is inadvertently incorporated into the work before completion of testing, the Department may accept the material with a reduction in pay, provided the failure is marginal and will not cause poor performance.

When the failure is excessive, then remove the reinforcing steel, and replace it unless the Engineer determines that the reinforcing steel can remain in place with a 100 percent reduction rate. The Department will apply the largest payment reduction when the material fails to meet more than one specification requirement. The Department will calculate the payment reduction on the invoice cost of the material delivered at the project site. The Department will reject reinforcing steel that fails and has not been incorporated into the work.

YIELD STRENGTH				
% of Requirement	97% - 100% or more	91% - 96%	86% - 90%	85% or less
Reduction Rate	0%	20%	50%	⁽¹⁾

TENSILE STRENGTH				
% of Requirement	97% - 100% or more	91% - 96%	86% - 90%	85% or less
Reduction Rate	0%	20%	50%	⁽¹⁾

ELONGATION				
% of Requirement	97% - 100% or more	91% - 96%	86% - 90%	85% or less
Reduction Rate	0%	20%	50%	⁽¹⁾

WEIGHT PER FOOT				
% of Requirement	94% - 100% or more	89% - 93%	86% - 88%	85% or less
Reduction Rate	0%	20%	50%	⁽¹⁾

EPOXY COATING THICKNESS				
Thickness (mils) Nos. 3 to 5	7 - 13	14 - 15	0 - 6 Over 16	
Nos. 6 to 18	7-16	17-18	0-6 Over 19	
Reduction Rate	0%	25%	⁽¹⁾	

⁽¹⁾ Remove and replace the reinforcing steel unless the Engineer determines that the steel can remain in place at a 100% reduction rate.

SECTION 812 — STRUCTURAL STEELS

812.01 STRUCTURAL STEEL SHAPES, PLATES, BARS, AND FASTENERS.

Conform to Charpy V-notch toughness requirements for structural steel for load carrying members in bridges when specified in the Plans.

812.01.01 Structural Steel, All Types. Conform to AASHTO M 270 (ASTM A 709), Grades 36, 50 50W, 70W, HPS70W and 100W. When the supplementary requirement of this specification are specified, they exceed the requirements of ASTM A 36, A 514, A 572, A 588, and ASTM A 852.

- A) **Structural Steel.** Conform to AASHTO M 270 Grade 36, ASTM A 709 Grade 36, or ASTM A 36.
- B) **High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality.** Conform to AASHTO M 270 Grade 50, or ASTM A 709 Grade 50, or ASTM A 572.
- C) **High-Strength Low-Alloy Structural Steel with Minimum Yield Point to 4 Inches Thick.** Conform to AASHTO M 270 Grade 50W, ASTM A 709 Grade 50W, or ASTM A 588.
- D) **Quenched and Tempered Low-Alloy Structural Steel Plate with 485 MPa Minimum Yield Strength to 4 Inches Thick.** Conform to AASHTO M 270 Grade 70W, ASTM A 709 Grade 70W, or ASTM A 852.
- E) **High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding.** Conform to AASHTO M 270 Grade 100/100W, ASTM A 709 Grade 100/100W, or ASTM A 514.
- F) **High-Strength Low-Alloy, Quenched and Tempered Structural Steel Plate.** Conform to ASTM A 709 Grade HPS70W.

812.01.02 Hot-Rolled Carbon Steel Sheets and Strip of Structural Quality, Grade 33 (Corrugated Steel Plank for Bridge Floors). Conform to ASTM A 1011.

812.01.03 Cold Rolled Carbon Steel Sheet of Structural Quality, Grade “D” (40 ksi) (Corrugated Steel Plank for Bridge Floors). Conform to ASTM A 1008.

812.01.04 Steel Sheet Piling. Conform to AASHTO M 202 (ASTM A 328).

812.01.05 Frames and Grates (for Catch Basins, Inlets, Outlets, and Manholes). Use steel in these items that conforms to A36 or A572 to the following properties:

Yield Strength	36 ksi. minimum
Tensile Strength	58 ksi minimum
Elongation in 2-inch specimen	21 percent minimum

812.01.06 Hollow Structural Sections (HSS). Conform to ASTM A500.

SECTION 813 — MISCELLANEOUS METALS

813.01 PINS AND ROLLERS. Use steel specified in the AASHTO LRFD Bridge Design Specifications conforming to ASTM A108, ASTM A668 or ASTM A709, Grades 36, 50, or 50W.

813.02 STEEL CASTING. Conform to AASHTO M 103, Grade 70-36 (ASTM A 27).

813.03 EXPANDING STEEL MANHOLE RISERS. Use an approved type that expands to fit tightly and rigidly within the existing frame.

813.04 GRAY IRON CASTINGS. Conform to ASTM A48, Class 30-B.

813.05 MALLEABLE CASTINGS. Conform to ASTM A 47. Use the grade specified.

813.06 RIGHT-OF-WAY MONUMENTS. See section 726.

813.07 LEAD PLATES. Manufacture plates from lead conforming to ASTM B 29.

813.08 ALUMINUM.

813.08.01 Cast Aluminum Sand Castings. Conform to ASTM B 26, Alloy 356.0-T6.

813.08.02 Aluminum Alloy Permanent Mold Castings. Conform to ASTM B 108.

813.08.03 Aluminum Alloy Sheet and Plate. Conform to ASTM B 209.

813.08.04 Aluminum Alloy Extruded Bars, Rods, Shapes and Tubes. Conform to ASTM B 221, Alloy 6061-T 6511 or Alloy 6063-T 6.

813.08.05 Aluminum Alloy Rolled or Extruded Shapes. Conform to ASTM B 308, Alloy 6061-T6.

813.08.06 Aluminum Alloy Seamless Pipe. Conform to ASTM B 241, Alloy 6061-T 6 and 6063-T 6.

813.08.07 Aluminum and Aluminum Alloy Bars, Rods, and Wire Bolts. Conform to ASTM F 468, Alloy 2024-T 4. Give finished bolts a minimum anodic coating of 0.0002 inch.

813.08.08 Aluminum Nuts. Conform to ASTM F 467, Alloy 6061-T6 or 6062-T 9. Give finished nuts a minimum anodic coating of 0.0002 inch.

813.08.09 Welding Rods. Conform to AWS A5.10.

813.09 STEEL BOLTS, NUTS, AND WASHERS.

813.09.01 Carbon Steel Bolts and Nuts. Conform to ASTM A 307. Nuts conform to AASHTO M 291.

813.09.02 High-Strength Steel Bolts, Nuts, and Washers. Mark all bolts, nuts, and washers according to the appropriate ASTM Specifications. Assure all bolts, nuts, washers and miscellaneous metals are kept dry, free from debris, and lubricated. If using galvanized bolts, nuts, or washers, measure the thickness of the zinc coating. Take measurements on the wrench flats or top of bolt head.

Submit mill test reports for all steel used in the manufacture of the bolts, nuts, or

washers to the Department for approval. Include with the mill test reports the place where the material was melted and manufactured. The Department will take field samples for testing to verify compliance with this section.

Ship bolts, nuts, and washers (where required) from each rotational-capacity lot in the same container. If there is only one production lot number for each size of nut and washer, the Department will allow shipping of the nuts and washers in separate containers. Permanently mark each container with the rotational-capacity lot number to allow identification at any stage before installation. Supply the appropriate mill test report, manufacturer's certified test report, or distributor's certified test report to the Engineer before beginning installation.

For bolts, nuts, and washers, conform to the following dimensions:

BOLT AND NUT DIMENSIONS ⁽¹⁾					
Nominal Bolt Size in D	Bolt Dimensions in			Nut Dimensions in	
	Heavy Hexagon Structural Bolts			Heavy Hexagon Nuts	
	Width Across Flats F	Height H	Thread Length T	Width Across Flats W	Height H
1/2	7/8	5/16	1	7/8	31/64
5/8	1 1/16	25/64	1 1/4	1 1/16	39/64
3/4	1 1/4	15/32	1 3/8	1 1/4	47/64
7/8	1 7/16	35/64	1 1/2	1 7/16	55/64
1	1 5/8	39/64	1 3/4	1 5/8	63/64
1 1/8	1 13/16	11/16	2	1 13/16	1 7/64
1 1/4	2	25/32	2	2	1 7/32
1 3/8	2 3/16	27/32	2 1/4	2 3/16	1 11/32
1 1/2	2 3/8	15/16	2 1/4	2 3/8	1 15/32

⁽¹⁾ANSI Standards B 18.2.1 and B 18.2.2 shall govern tolerance to these dimensions.

WASHER DIMENSIONS IN MILLIMETERS ⁽¹⁾							
Circular Washers					Square of Rectangular Beveled Washers for American Standard Beams and Channels		
Bolt Size	Nominal Outside Diameter ⁽²⁾	Nominal Diameter of Hole	Thickness		Minimum Side Dimension	Mean Thickness	Slope or Taper in Thickness
			Min.	Max.			
1/2	1 1/16	17/32	0.097	0.177	1 3/4	5/16	1:6
5/8	1 5/16	21/32	0.122	0.177	1 3/4	5/16	1:6
3/4	1 15/32	13/16	0.122	0.177	1 3/4	5/16	1:6
7/8	1 3/4	15/16	0.136	0.177	1 3/4	5/16	1:6
1	2	1 1/16	0.136	0.177	1 3/4	5/16	1:6
1 1/8	2 1/4	1 1/4	0.136	0.177	2 1/4	5/16	1:6
1 1/4	2 1/2	1 3/8	0.136	0.177	2 1/4	5/16	1:6
1 3/8	2 3/4	1 1/2	0.136	0.177	2 1/4	5/16	1:6
1 1/2	3	1 5/8	0.136	0.177	2 1/4	5/16	1:6
1 3/4	3 3/8	1 7/8	0.178 ⁽³⁾	0.28 ⁽³⁾	—	—	—
2	3 3/4	2 1/8	0.178	0.28	—	—	—

⁽¹⁾ANSI Standard B 18.22.1 Type A washer tolerances apply to the nominal dimensions for outside diameter and hole diameter.

⁽²⁾May be exceeded by 1/4 inch.

⁽³⁾3/16 inch nominal.

- A) **Bolts.** Conform to ASTM F3125 Grade A325 or ASTM F3125 Grade A490 as applicable.

HARDNESS NUMBER				
Bolt Size (in)	Brinell		Rockwell C	
	Min.	Max.	Min.	Max.
1/2 - 1	253	319	25	34

Perform proof load testing according to ASTM F 606 Method 1 at the minimum frequency specified in ASTM F3125 Grade A325.

Perform wedge testing on full size bolts according to ASTM F 606 paragraph 3.5 at the minimum frequency specified in ASTM A 325. If bolts are to be galvanized, perform tests after galvanizing.

Plain bolts must be oily to touch when delivered and installed.

- B) **Nuts.** Conform to ASTM A 194 as applicable or AASHTO M 291. If nuts are to be galvanized (hot dip or mechanically galvanized), use heat treated Grade 2H, DH, or DH3.

For plain (ungalvanized) nuts, use Grades 2, C, D, or C3 with a minimum Rockwell hardness of 89 HRB (or Brinell Hardness 180 HB), or heat treated Grades 2H, DH, DH3.

For nuts that are to be galvanized, overlap the nuts the minimum amount required for proper assembly allowing the nut to assemble freely on the bolt in the coated condition. Overlap the nuts according to the mechanical requirements of ASTM A563 and the rotational-capacity test requirements of this section.

Lubricate galvanized nuts with a lubricant containing a dye that contrasts with the color of the galvanizing.

Perform proof load testing according to ASTM F 606, paragraph 4.2 at the

minimum frequency specified in ASTM A 563 or ASTM A 194. If nuts are to be galvanized, perform tests after galvanizing, overtapping, and lubricating.

- C) **Washers.** Conform to ASTM F436. If supplying galvanized washers, perform hardness testing after galvanizing. Remove coating before taking hardness measurements.
- D) **Direct Tension Indicators.** Conform to ASTM F959.
- E) **Rotational-Capacity Test.** Perform rotational-capacity tests on all black or galvanized (after galvanizing) bolt, nut, and washer assemblies by the manufacturer or distributor before shipping. Perform additional rotational-capacity tests on each lot at job sit. Use washers as part of the test even though they may not be required as part of the installation procedure. Perform the following:
 - 1) Perform rotational-capacity testing according to ASTM F 3125.
 - 2) Test each combination of bolt production lot, nut lot, and washer lot, shipped as a rotational-capacity lot, as an assembly. Where washers are not required by the installation procedures, the Department will not require lot identification for them.
 - 3) Assign a rotational-capacity lot number to each combination of lots tested.
 - 4) Test at least 2 assemblies per rotational-capacity lot.
 - 5) Assemble the bolt, nut and washer assembly in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device. For bolts too short to be assembled in the Skidmore-Wilhelm Calibrator, test them according to 14) below.
 - 6) Tighten the fastener assembly to the tensions listed below (-0/+2kips)

PRETENSION REQUIREMENTS		
Diameter (inches)	120 ksi min. Tension (kips)	150 ksi min. Tension (kips)
1/2	1	1
5/8	2	2
3/4	3	4
7/8	4	5
1	5	6
1 1/8	6	8
1 1/4	8	10
1 3/8	10	12
1 1/2	12	15

- 7) Match-mark the bolt, nut, and faceplate of the calibrator.
- 8) Tighten the fastener assembly to at least the minimum installation tension in the table below and record both the tension and the torque. The torque shall be read with the nut in motion. The torque shall not exceed $0.25PD$ where P =tension in pounds and D =diameter(in.)/12=bolt diameter in feet. Maximum torque values at minimum tension are provided in the table below. For tensions exceeding minimum tension, use the formula $(0.25PD)$ to calculate maximum torque.

MAXIMUM TORQUE AT MINIMUM DESIGN TENSION				
Diameter (inches)	120 ksi min. Min. Tension (kips)	120 ksi Max. Torque @ Min. Tension (ft-lbs)	150 ksi min. Min. Tension (kips)	150 ksi min. Max. Torque @ Min. Tension (ft-lbs)
1/2	12	125	15	156
5/8	19	247	24	312
3/4	28	437	35	546
7/8	39	710	49	893
1	51	1062	64	1333
1 1/8	64	1502	80	1875
1 1/4	81	2120	102	2656
1 3/8	97	2779	121	3466
1 1/2	118	3688	148	4625

- 9) Further tighten the nut to the rotation listed below. The rotation is measured from the initial marking in step 7. Assemblies that strip or fracture prior to this rotation fail the test.

Bolt Length	Up to 4D	>4D to 8D	>8D to 12D
120 ksi min.	240 degrees	360 degrees	420 degrees
150 ksi min.	240 degrees	300 degrees	360 degrees

- 10) Ensure the tension reached at the above rotation is $> 1.15 \times$ minimum installation tension. The minimum values are noted below.

TENSION				
Diameter (inches)	120 ksi min. Req. Installation Tension (kips)	120 ksi min. Turn Test Tension (kips)	150 ksi min. Req. Installation Tension (kips)	150 ksi min. Turn Test Tension (kips)
1/2	12	14	15	17
5/8	19	22	24	28
3/4	28	32	35	40
7/8	39	45	49	56
1	51	59	64	74
1 1/8	64	74	80	92
1 1/4	81	94	102	117
1 3/8	97	112	121	139
1 1/2	118	136	148	170

- 11) Loosen and remove the nut. The nut shall turn on the threads to the position it was in during the test. The nut does not need to turn the full length of the

- threads. Inability to turn the nut by hand indicates a thread failure. Broken bolts fail the test.
- 12) The assembly passes the RC test if all samples meet the requirements of steps 6-11.
 - 13) The lot is non-conforming if the assembly fails to pass the following requirements:
 - a) Exceeding the maximum allowable torque in step 8.
 - b) Inability to reach rotation required in step 9.
 - c) Inability to remove the nut after installing to the rotation in step 9.
 - d) Failure to provide the tension required in step 10 after full rotation.
 - e) Shear failure of the threads as determined by visual examination of bolt and nut threads following removal.
 - f) Torsional or tension failure of bolt.
 - g) Note that elongation of the bolt, in the threads between the nut and the bolt head is to be expected and does not constitute a failure.
 - 14) Test bolts too short for assembly in a Skidmore-Wilhelm Calibrator in a steel joint.
 - 15) Pretension the assembly in the steel joint. The torque used shall not exceed the torque permitted in the table below.

PRETENSION TORQUE VALUES		
Diameter (inches)	120 ksi min. Torque (ft-lbs)	150 ksi min. Torque (ft-lbs)
1/2	30	36
5/8	58	74
3/4	100	126
7/8	164	204
1	246	308
1 1/8	346	432
1 1/4	490	610
1 3/8	642	796
1 1/2	850	1062

- 16) Match mark the nut, bolt, and plate.
- 17) Prevent the bolt head from rotating and tension the bolt by rotating the nut the rotation specified in the table below. Take a torque reading at the required rotation with the nut in motion.

Bolt Length	Up to 4D	>4D to 8D
All Grades	120 degrees	180 degrees

- 18) The torque measurement taken in step 17 shall not exceed the torque listed in the following table:

MAXIMUM TORQUE VALUES		
Diameter (inches)	120 ksi min. Torque (ft-lbs)	150 ksi min. Torque (ft-lbs)
1/2	150	180
5/8	290	370
3/4	500	630
7/8	820	1020
1	1230	1540
1 1/8	1730	2160
1 1/4	2450	3050
1 3/8	3210	3980
1 1/2	4250	5310

Assemblies that exceed the above torque values fail the test. These torque values are based on the assumed tension of 1.15 x minimum installation tension.

- 19) Further tighten the nut the additional rotation listed below:

Bolt Length	Up to 4D	>4D to 8D
120 ksi min.	120 degrees	180 degrees
150 ksi min.	90 degrees	120 degrees

Assemblies that strip or fracture prior to this rotation fail the test.

- 20) Loosen and remove the nut. There shall be no signs of shear failure, stripping, or torsional failure. The nut shall turn on the threads to the position it was in during the test. The nut does not need to run the full length of the threads. Inability to turn the nut by hand is considered a thread failure. Broken bolts fail the test.
- 21) The assembly shall be considered nonconforming if the assembly fails to pass any of the following requirements:
- Exceeding the maximum allowable torque in step 18.
 - Failure to achieve the required rotation in step 19.
 - Inability to remove the nut after installing to the rotation in step 19.
 - Shear failure of the threads as determined by visual examination of the bolt and nut threads following removal.
 - Torsional or torsional/tensional failure of the bolt.
 - Note that elongation of the bolt, in the threads between the nut and the bolt head is to be expected and does not constitute a failure.

The Department will not require an inspection agency present during testing; however, the manufacturer or distributor performing the tests shall certify that the results recorded are accurate. The Engineer reserves the right to witness testing on request.

Ensure that the lot number appearing on the shipping package for bolts, washers, and nuts corresponds to the lot number identified on the distributor's and manufacturer's certification.

Provide the Engineer with the certified test report from the manufacturer or distributor performing the rotational-capacity test. Include the following information:

- a) The lot number of each of the items tested.
- b) The rotational-capacity lot number.
- c) A statement that the items conform to this section and the Contract.
- d) The results of the tests.
- e) The location and date of the tests.
- f) The location where the bolt assembly components were manufactured.

813.09.03 Corrosion-Resisting Steel Bolts and Set Screws. Fabricate bolts and screws from bars conforming to ASTM A 276. Use Types 302 or 304 for steel machine bolts to attach aluminum posts to concrete and for steel set screws for aluminum railings.

813.09.04 Stainless Steel Hardware, Bolts, Nuts, and Washers. Conform to ASTM A 320.

813.09.05 Cadmium Coatings for Steel Anchor Bolts, Nuts, and Washers. Conform to ASTM B 766, Class 12, Type II.

813.09.06 Anchor Bolts for Bearings and Anchorages. Conform to ASTM A449 Type 1 or ASTM F1554 Grade 105.

813.10 WELDING MATERIAL, PROCEDURES, AND INSPECTION. For bridges comply with the ANSI/AASHTO/AWS D1.5 Bridge Welding Code with modifications and additions as specified in the Plans.

For other steel structures comply with the AWS Structural Welding Code D1.1 with modifications and additions as specified in the Plans. For aluminum structures comply with the AWS Structural Welding Code-Aluminum D1.2.

813.11 STUD SHEAR CONNECTORS. Conform to AASHTO M 169 (ASTM A 108, Grade 1015).

813.12 MATTRESSES AND GABIONS. Conform to ASTM A 975, Style 1 or ASTM A 974, Style 1 or 2. Use wire with a minimum elongation of 10 percent of the length of the wire when tested according to ASTM A 370 without reducing the diameter or tensile strength of the wire.

Supply lacing wire in sufficient quantity to ensure that all required tying, connecting, and lacing can be performed. For Department direct purchases, supply an amount of lacing wire equal to or greater than 8 percent of the weight of the units.

Fabricate the mattress units to the dimensions required by the Contract. The Department will accept mattresses with dimensions within ± 3 percent of the ordered width.

813.12.01 Mattress Units. As an alternate to lacing wire, the Engineer will allow mattress unit fasteners, from the Department's List of Approved Materials, that conform to mattress unit manufacturer's recommended assembly and connection instructions.

Subdivide the mattress units into compartments a maximum of 3 feet in length extending over the full width of the mattress unit by inserting diaphragms made of the same mesh as the rest of the mattress unit. Secure the diaphragms in position on the bottom with a continuous spiral wire at the factory so no additional tying at this joint is necessary.

813.12.02 Gabion Baskets. As an alternate to lacing wire, the Engineer will allow gabion unit fasteners, from the Department's List of Approved Materials, that conform to mattress unit manufacturer's recommended assembly and connection instructions.

Supply diaphragms of the same material composition as the gabion to form individual cells of equal length and width when the gabion length exceeds its width.

813.12.03 Acceptance. Assure all bolts, nuts and washers are kept dry, free from debris, and lubricated. Miscellaneous steel, bolts, and steel shipments not maintained in new condition will be rejected. The Department will test each shipment for wire size and zinc coating, and will perform any other Engineer ordered tests. The Department will accept shipments based on laboratory testing and the Engineer's visual inspection.

SECTION 814 — GUARDRAIL SYSTEMS

814.01 DESCRIPTION. This section covers material requirements for corrugated sheet steel beams and accessories for guardrail, terminal sections, guardrail posts, offset blocks, end treatments, and timber guard posts.

814.02 BEAMS AND ACCESSORIES. Conform to AASHTO M 180. Hardware for Type I, II, or III beams may be either hot-dip galvanized, electrogalvanized, or mechanically galvanized. Galvanize hardware according to AASHTO M 232. Galvanize beams according to AASHTO M 180. The Engineer will reject beams with zinc oxide (white rust) in amounts deemed objectionable. Furnish Type II beams of either Class A, 0.105 inch thick or Class B, 0.135 inch thick as specified in the Contract.

814.03 TERMINAL SECTIONS. Conform to AASHTO M 180 and the details shown on the Standard Drawings. Furnish Type 2 sections of either Class A, 0.105 inch thick or Class B, 0.135 inch thick as specified in the Contract.

814.04 GUARDRAIL POSTS. Provide either steel or timber, and use the same type throughout the Project.

814.04.01 Steel Guardrail Posts. Fabricate from steel conforming to ASTM A 36 for the wide flange shapes. Punch or drill holes for connector bolts before galvanizing. Galvanize all posts according to AASHTO M 111.

814.04.02 Timber Guardrail Posts. .Furnish either square sawn or round timber guardrail posts. Conform to the nominal dimensions shown on the Standard Drawings. The Engineer will allow a minus 2-inch tolerance from the specified nominal length. Saw the butts of all posts square, and finish the tips as specified in the Contract.

Bore bolt holes to a driving fit for the bolts. Frame, bore, and trim, as much as is practical, before giving the posts a preservative treatment. When it is necessary to bore or cut the posts after treatment, or when any treated surface has been badly scarred, treat the cut or scarred surface according to AWP A M4.

Treat the posts with preservative according to AWP A U1, Section B, Paragraph 4.1 as applicable for guardrail posts. Use only one type throughout the project unless otherwise approved by the Engineer.

Use any of the species of wood for round or square posts covered under AWP A U1. When furnishing oak posts, treat with creosote or creosote solution according to AWP A U1, Section B, Paragraph 4.1 for "Above Ground, Soil or Fresh Water Exposure."

See Subsection 818.01 for inspection, testing and acceptance procedures for Timber Guardrail Posts.

A) Square Sawn Posts. Ensure the posts, in the direction parallel to the axis of the bolt holes, do not exceed the dimensions specified in the Contract by more than 1/4 inch.

Use posts that have straight grain, and that have a slope of the grain not deviating more than one inch in 12 inches from being parallel to any face when measured over the middle one-half of the length. The Engineer will not accept posts having a crook exceeding 1/2 inch in 10 feet. Limit wane to one end of the post only, and do not allow it to extend more than 10 feet from that end. Do not reduce the flat width of any face by more than 25 percent at the point of most wane. Do not use wood with ant tunnels, woodpecker holes, plugged holes, or any large unsightly gaps. The Department will allow wood with grub and worm holes less than 1/2 inch in average diameter, provided that the sum of the diameters of all holes in any 12 inches of post length does not exceed 1/4 the nominal width of the face. Do not use posts showing signs of powder post beetle infestation. The

Engineer will not limit the use of posts that have grub holes appearing entirely on the surface of the post and that do not penetrate to more than 1/2 inch in maximum depth.

Do not use posts with knots greater than 3/8 the nominal width of the face, measured by the smallest diameter. Do not allow the sum of the diameters of all knots in any 6 inches of post length to exceed 3/4 the nominal width of the face. Do not allow the sum of the diameter of all knots appearing within the middle half of the length of any face to be greater than 4 times the size of the largest knot allowed in that face. The Department will allow posts with unsound knots no larger than half the maximum allowable size for sound knots and no more than 1 1/2 inches in depth, provided that the surrounding wood is not affected by the decay. Do not use posts that have clusters of knots where the maximum distortion of the grain around the cluster exceeds the maximum allowable size for one knot.

Entirely confine shakes within the ends of the post, without extending to any face. Measure the shake as the sum of the 2 adjoining sides of the smallest rectangle that will completely enclose the shake. Measure the sides of the rectangle parallel to the faces of the post. Do not allow shakes to occur in more than one annual ring or to extend to more than 3/4 of the circumference of the annual ring in boxed heart. Do not allow total shake measurement to exceed one-half the width of the face.

Do not use posts with splits greater in length than the width of the face. Do not use posts with a check or series of contiguous checks having a width of 8 mm or greater at the surface and more than 3 inches in depth at any point and extending more than 3/4 of the length of the post from one end. The Engineer will determine the depth of checks by the penetration of a probe 1/64 inch thick and 1/4 inch wide. The Engineer will consider the extent of a check or series of contiguous checks to end at the last point where the opening does not exceed 1/8 inch in width and is no more than 3/4 inch in depth.

Do not use any post having a shake that does not exceed the maximum limits for shakes as specified herein, but contains a check which penetrates to the annual ring in which the shake occurs.

B) Round Posts. Peel all posts for their full length, and remove all outer and inner bark. Shave all knots and projections smooth and flush with the surface of the surrounding wood.

Ensure that the posts are a constant diameter not less than 1/4 inch under the nominal diameter.

Do not use posts that have short or reverse bends, one way sweeps exceeding one inch, and winding twists that are unsightly and exaggerated. The Engineer will not allow more than 10 percent of the number of pieces of any shipment to contain the maximum sweep.

Do not use posts with unsound, loose or hollow knots. The Department will allow use posts that have sound knots when the diameter of any one knot or when the combined diameters of 2 or more knots occurring in the same cross section are no greater than 1/3 of the diameter of the post at that cross section.

Ensure that posts are close grained and do not show spiral grain exceeding 1/8 turn in 5 feet.

Do not use posts with seasoning checks that penetrate the interior of the post to a depth greater than 1/3 of the diameter at any point, or which measure more than 1/4 inch in width at any point.

Do not use posts that have ring shakes, sap rot, bird pecks, insect holes, pitch pockets, or pitch streaks, and other defects that will impair the strength of the post, or give it an unsightly appearance.

814.05 OFFSET BLOCKS. Use the size, and when specified, the type the Contract specifies.

814.05.01 Wood. Conform to 814.04 for material properties.

814.05.02 Composite Plastic. Select composite offset blocks conforming to this section and assure blocks are from a manufacturer included on the Department's List of Approved Materials. Use blocks that are uniform in composition throughout the product and consist of at least 70 percent plastic by weight. Rubber is an acceptable alternative to plastic in their composition. Use sufficient additives to inhibit photo degradation. The Department will consider 2 percent carbon black to be a minimum. Ensure the blocks conform to the Manual for Assessing Safety Hardware (MASH) Test Level 3 requirements.

814.06 MATERIALS FOR END TREATMENTS. Conform to Subsections 814.02 through 814.05 for common components, and, except where otherwise provided, ensure they are of the same class and type as required for the guardrail to which they are attached. Galvanize all non-corrosion-resistant metals used in end treatments according to AASHTO M 111 or AASHTO M 232 as applicable. For proprietary end treatments, all materials shall conform to the manufacturer's specifications. For other materials, comply with the following requirements:

- A) **Anchorage Systems.** Furnish anchorage systems that have a minimum breaking strength of 40,000 pounds. The anchorage system may employ either a cable assembly or continuous steel rod or other system of equal or greater strength when approved. For cable assemblies, use cable that is 3/4-inch (6 by 19) wire rope conforming to AASHTO M 30, Class C. Provide swage fittings as required by the Standard Drawings and include studs as required. Ensure that eye bolts conform to ASTM A 489 and are of either Type 1 or Type 2. For wire rope clips use a commercial grade capable of being torqued to a minimum of 130 foot-pounds.
Use commercial grade wire rope thimbles.
- B) **Anchor and Miscellaneous Plates.** Fabricate from steel conforming to Subsection 812.01.01.
- C) **Miscellaneous Hardware.**
 - Bolts ASTM A 307
 - Nuts ASTM A 563, Grade A or better
- D) **Steel Sheet (for rail plates and mounting brackets).** Conform to ASTM A 1011, Type SS, Grade 36
- E) **Tubular Sections (for posts and blocks).** Conform to ASTM A 500, Grade B or ASTM A 501.
- F) **Concrete.** Conform to Section 601, Class A.
- G) **Welded Wire Fabric.** Use welded wire fabric for concrete reinforcement that is W3 by W3, 6 by 6-inch conforming to Subsection 811.04. The Department may allow other approved types of steel reinforcement.

SECTION 815 – GEOGRID REINFORCEMENT

815.01 DESCRIPTION. This section describes geogrid physical requirements for reinforcement of subgrade and aggregate bases.

815.02 GENERAL. Furnish geogrid, formed by a punch and drawn method, composed of polypropylene or high-density polyethylene resins.

815.03 PHYSICAL REQUIREMENTS. Furnish geogrid conforming to the Required Geogrid Properties Table.

Required Geogrid Properties^{1, 2, 3}				
Property	Test Method	Required Value		
		<i>English</i>		<i>Metric</i>
Strength at 2% Strain	ASTM D 6637	410	lb/ft	6.0 kN/m
Strength at 5% Strain	ASTM D 6637	810	lb/ft	11.8 kN/m
Ultimate Tensile Strength	ASTM D 6637	1310	lb/ft	19.2 kN/m
Minimum Opening Size ⁴	Direct Measure	0.5	in	12.7 mm
Maximum Opening Size ⁵	Direct Measure	3.0	in	76.2 mm
Junction Strength	GASTM 7737-11	93% Ultimate tensile strength		
Ultraviolet Stability	ASTM D 4355	70% at 500 hrs		
Separation	ASTM D 422	D15 of aggregate above geogrid < 5 x D85 subgrade and D50 of aggregate ≤ 25 x D50 of subgrade. Otherwise use a separation geotextile with geogrid		
NOTES:				
1. Acceptance of geogrid material shall be based on ASTM D 4759.				
2. Acceptance shall be based upon testing of either conformance sample obtained using Procedure A of ASTM D 4354, or based on manufacturer's certifications and testing of quality assurance sample obtained using Procedure B of ASTM D 4354.				
3. Minimum use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the table). Lot samples according to ASTM D 4354.				
4. Minimum opening size must be ≥ D50 of aggregate above geogrid to provide interlock.				
5. Maximum opening size must be ≤ 2 x D85 of aggregate above geogrid to prevent aggregate from penetrating into the subgrade				

SECTION 816 — WOVEN-WIRE FENCING MATERIALS

816.01 DESCRIPTION. This section covers the materials for use in construction of woven-wire fences.

816.02 GENERAL. Galvanize all ferrous materials used in a complete installation of fence, except aluminum coated fabric, aluminum coated posts and braces, or aluminum coated barbed wire. Galvanize all iron and steel hardware according to AASHTO M 232. Galvanize other components as designated. Where it is not practical to secure a specimen of measurable area or uniform thickness for determining the weight of zinc coating, ensure that all such galvanizing withstands 4 dips of the Preece Test as set out in ASTM A 239. Ensure that post caps and socket type brace connections are galvanized malleable iron, or other approved type, and designed to exclude moisture from inside posts or rails.

816.03 WOVEN WIRE FABRIC. Ensure that the woven wire fabric is either zinc-coated steel or aluminum-coated steel. Provide the size and style of fabric specified in the Contract.

Use zinc-coated steel fabric that conforms to ASTM A 116 and that has a Class 3 coating.

Use aluminum-coated steel fabric that conforms to ASTM A 116.

816.04 BARBED WIRE. Use either zinc-coated steel, aluminum-coated steel, or aluminum alloy. Use barbs of 4-point pattern spaced at intervals of 5 inches. The wire for barbs may be either round or half-round.

816.04.01 Zinc-Coated Steel. Conform to ASTM A 121. Use size 0.099-inch diameter or heavier with Class 3 coating. The Department will allow high tensile strength barbed wire provided it conforms to ASTM A 121, and the following exceptions: (1) nominal diameter of 0.067 inch for the coated line wires and 0.057 inch for the coated barbs; (2) minimum weight of zinc coating of 0.75 ounces per square foot for line wires and 0.70 ounces per square foot for barbs; and (3) minimum tensile strength of 475 pounds for each individual strand of the line wire.

816.04.02 Aluminum-Coated Steel. Use either Type I or Type II conforming to ASTM A 121. Use size 0.099 inch diameter or heavier.

816.04.03 Aluminum Alloy. Use 2 strands of 0.110 inch nominal diameter or heavier wire strands having minimum tensile strength of 42,000 psi, minimum yield strength of 35,000 psi and minimum elongation of 10 percent.

816.05 BRACE WIRE. Conform to ASTM A 824 except provide a minimum weight of coating of 0.6 ounce per square foot. Use size 0.148-inch nominal diameter or larger.

816.06 FABRIC TIES. Use either a minimum 0.109-inch nominal diameter galvanized steel conforming to ASTM F 626, except ensure that the minimum weight of coating is 0.6 ounces per square foot, or 0.148-inch nominal diameter aluminum alloy.

816.07 FENCE POSTS AND BRACES.

816.07.01 Steel Posts and Braces. Conform to ASTM F 1043, ASTM F 1083, and the Standard Drawings.

When the Contract specifies a thermoplastic acrylic coating, apply a chromate conversion coating at the manufacturer's recommended rate. Ensure that the coating is designed for pretreatment of galvanized coatings. After pretreating, electrostatically apply the thermoplastic acrylic coating with a minimum dry film thickness of 0.3 mils.

816.07.02 Stud T Post. Conform to ASTM A 702.

816.07.03 Wood Posts and Braces. Treat wood fence posts and braces with preservative and ensure that they are made of timber cut from live, sound, standing trees. Ensure that round or half-round posts and braces are preservative treated according to and are of the species covered by AWP A U1, Section B, Paragraph 4.1. Ensure that sawed posts and braces are preservative treated according to and are of the species covered by AWP A C 2 for "Soil or Fresh Water Exposure".

Use posts that are round, half-round, or square-sawed.

Ensure that wood for fence posts is sound and free from decay, excessive knots, seasoning checks, and end splits that will affect serviceability. The Department will allow sound knots, provided the width of the knot does not exceed one-third the diameter of a round post at the point where it occurs, or one-third the width of any face of a sawed post, or a maximum of 2 1/2 inches. The Department will reject wood with season checks that penetrate more than one-third of the diameter of the piece or which have a width of more than 1/4 inch.

Use round posts and half-round posts that are free of multiple crooks. The Department will allow crooks in one plane only, provided that a straight line between the centers of the butt and tip does not deviate more than 2 inches from the center of the post at any point. Ensure that crooks in square-sawed posts do not exceed one inch in 5 feet.

Cleanly peel round posts and remove all bark. Strips of inner bark that are less than 1/2 inch wide and 3 inches long may remain on the peeled post. Trim all protruding knots flush with the sides and remove all spurs and splinters. In machine peeling operations, follow the natural taper of round posts. Manufacture half-round posts by sawing in half the round posts complying with the above manufacturing methods.

Square cut the ends of all posts unless the Engineer allows driving. When driving is specified or allowed, point the butt end before receiving preservative treatment. Do not allow the length of the point to exceed 1.5 times the diameter or width of face, as applicable.

A) Line Posts. Use line posts with a length of 7 feet and a minus one-inch tolerance. Use line posts that are either round, half-round, or square-sawed; however, furnish the same type section for all line posts throughout the project.

Ensure that round posts have a minimum diameter of 4 inches. Ensure that half-round posts have a minimum face of 6 inches and a minimum radius of 2 3/4 inches. Cut square-sawed posts to 4-inch by 4-inch, $\pm 1/8$ inch.

B) End, Corner, Gate, Brace, and Pull Posts. Do not use lengths less than 8 feet. Use either round or square-sawed posts; however, furnish the same type section for all of these types throughout the project. Ensure that round posts have a minimum diameter of 8 inches. Cut square-sawed posts to 8-inch by 8-inch, $\pm 1/8$ inch.

C) Braces. Conform to all requirements for line posts, except use braces that are either round or square-sawed and furnish them in the lengths specified in the Plans.

816.07.04 Untreated Wood Posts. Furnish untreated wood posts of Osage-Orange, Black Locust, Red Cedar, White Oak, or of other approved species, and ensure that posts conform to all applicable requirements of Subsection 816.07.03. Use untreated wood posts only when specified in the Contract.

816.08 GATES. Fabricate gate frames to the size and dimensions specified in the Contract. Ensure that pipe used in frames conforms to Subsection 816.07.01. Weld or otherwise construct all joints to form a rigid and water-tight frame.

Furnish all gates complete with approved hinges, latches, and auxiliary braces as required.

Fit gate frames with a fabric that conforms to the same requirements as the corresponding fence.

The Department may approve the use of gates fabricated of other materials.

SECTION 817 — CHAIN LINK FENCING MATERIALS

817.01 DESCRIPTION. This section covers materials for use in the construction of fences of chain link fabric. The Department will allow 3 optional types of fabric; zinc-coated steel, aluminum-coated steel, or aluminum alloy (Type I, II, or III fabric, respectively). Use vinyl coated fabric (Type IV) only when specified in the Contract.

817.02 REQUIREMENTS. Conform to AASHTO M 181 for all materials except steel posts and barbed wire.

817.02.01 Fabric. Use 0.148-inch nominal diameter wire woven in 2-inch mesh. Coat Type I fabric to conform to Class D. Furnish fabric for fences 4 feet and 6 feet high that has the top selvages knuckled and bottom selvage knuckled or twisted and barbed. Furnish fabric for fences 8 feet high or higher with both top and bottom selvages twisted and barbed.

817.02.02 Barbed Wire. Conform to Subsection 816.04.

817.02.03 Post Caps and Socket Type Brace Connections. Use galvanized malleable iron, or other approved type, designed to exclude moisture from inside posts and rails.

817.02.04 Posts, Rails, Gate Frames and Expansion Sleeves. With zinc-coated steel fabric or with aluminum-coated steel fabric, use either zinc-coated steel or zinc-acrylic coated steel. With aluminum alloy fabric, use aluminum alloy. Furnish steel posts that comply with Subsection 816.07.01.

817.02.05 Fabric Ties. Use either a minimum 0.148-inch nominal diameter aluminum alloy or 0.120-inch nominal diameter galvanized steel.

817.02.06 Hog Rings and Tension Wire. With zinc-coated steel fabric or with aluminum-coated steel fabric use zinc-coated steel wire or aluminum-coated steel wire. Ensure that steel ties and wire conform to ASTM F 626, except that the minimum weight of coating is 0.6 ounces per square foot. With aluminum alloy fabric, use aluminum alloy wire.

817.02.07 Miscellaneous Fittings and Hardware. With zinc-coated steel fabric or with aluminum-coated steel fabric use zinc-coated steel. With aluminum alloy fabric, use aluminum alloy.

SECTION 818 — WOOD PRODUCTS

818.01 INSPECTION, TESTING, AND ACCEPTANCE. The Engineer will visually inspect and approve all treated wood products before use on the project. The Division of Materials will grade inspect, sample, and test all treated wood products before their use on the project if the plant producing the wood materials is located within the Commonwealth or a 100-mile driving distance of its borders. When obtaining treated wood materials from a plant outside this 100-mile distance, have an independent treated-wood testing company approved by the Division of Materials grade inspect, sample, and test the wood treated material at no expense to the Department. Obtain a report prepared by the independent testing firm that grade inspected, sampled and tested the treated wood material, and submit it to the Division of Materials at least 15 days before using the wood materials on the project.

Use only treated wood that has been cut to size before treating. Treat field sawn surfaces according to AWWA M4.

818.02 BOARDS. Boards are defined as being less than 2-inch in nominal thickness and one inch or more in width. Only use boards that are one of the available grades established by either the Southern Pine Inspection Bureau (SPIB) or the West Coast Lumber Inspection Bureau (WCLIB). The Contract will designate the grade and applicable inspection bureau.

818.03 DIMENSION LUMBER. Dimension lumber is limited to surfaced softwood lumber of nominal thickness from 2-inch through 4-inch. Only use dimension lumber for framing members such as joists, planks, rafters, studs, and small timbers.

Use only dimension lumber boards that are one of the available grades established by either the SPIB or the WCLIB. The Contract will designate the grade and applicable inspection bureau.

818.04 TIMBERS, 5-INCH BY 5-INCH AND LARGER. Use only timbers that are of one of the available grades established by either the SPIB or the WCLIB. The Contract shall designate the dimensions, grade, species, and applicable inspection bureau.

818.05 STRUCTURAL LUMBER. Conform to the AASHTO Standard Specifications for Highway Bridges.

818.06 BRIDGE PLANKING AND ROUGH LOCAL HARDWOODS.

818.06.01 Species. Use only bridge planking that is White Oak, Red Oak, or Southern Yellow Pine.

The term "White Oak" includes White Oak, Chestnut Oak, Post Oak, Burr Oak, Swamp Chestnut Oak, Swamp White Oak, Live Oak, Chinquapin Oak, and other less known varieties of oak of this character.

The term "Red Oak" includes Red Oak, Black Oak, Southern Red Oak, Willow Oak, Water Oak, Pin Oak, Cherrybark, or Swamp Red Oak, and other less known varieties of oak of this character.

Southern Yellow Pine may be any species except Field or Loblolly.

818.06.02 Quality of White Oak or Red Oak. The Engineer will not approve wood for use that has splits, rot, or unsound knots. Use only pieces that are sawed full to specified sizes and lengths, with square edges except wane (bark or the lack of wood) as follows. The Engineer will allow wane on one corner on 30 percent of the pieces in any shipment, not to exceed 15 percent of the width of the face on which it appears. The Engineer will allow this grade with sound stains, scattered worm holes or grub holes not materially affecting the strength of the piece and sound bird pecks, or their equivalent; sound knots or their equivalent not exceeding in diameter 25 percent the width of the face in which they appear. Use only boxed heartcenter wood products. Cut pieces not large enough to box the

heartcenter outside the heart except that sizes 2 to 6 inches in thickness, 6 inches wide and wider, may show heart on one face only, in 30 percent of the pieces in any shipment.

818.06.03 Quality of Southern Yellow Pine. Conform to the SPIB grades as follows:

- A) **Structural Light Framing (2-inch by 2-inch to 4-inch by 4-inch).** Provide No. 1 Dense.
- B) **Structural Joists and Planks (3-inch by 8-inch or 4-inch by 6-inch).** Provide No. 1 Dense.
- C) **Stress Rated Timbers (5-inch by 5-inch and larger).** Provide No. 1 SR.

818.06.04 Dimensions and Tolerances. Use rough timber that is cut full size as specified, sawed true with parallel faces. The Engineer will allow no more than 25 percent of a lot or shipment to be scant 1/4 inch in thickness and no more than 10 percent of a lot or shipment may be scant 1/4 inch in width.

Ensure that dressed dimensions for both oak and pine material conform to Southern Pine Inspection Bureau thicknesses and widths for Dimension Lumber.

818.06.05 Rough Local Hardwood. This subsection covers hardwood lumber and timber that is produced locally. Use only White Oak, Red Oak, or Beech hardwood. Where hardwood material is intended to be used inside, the Department will allow other species of hardwood that are suitable for the intended use, when such species are specified.

- 1) Use only material that is cut from live standing trees and is free from any form of decay.
- 2) The Department does not require seasoned material.
- 3) Cut all pieces to a square edge with no less than 75 percent heart, girth measurement, for full length of the piece.
- 4) Saw all material to the full nominal dimensions.
- 5) Ensure that all knots are tight and sound. Do not allow any material with a knot of greater diameter than half of the width of the face on which it occurs. Allow only one maximum knot, or small knots aggregating in diameter of one maximum knot, in each one-foot length of timber.
- 6) Ensure that all material is reasonably free from crook and warp.
- 7) Do not allow any piece that has a shake, crack, or split which extends over half through the narrow face of the piece.
- 8) Do not allow any boxed heart in pieces less than 3 inches in thickness.
- 9) The Engineer will reject material having any defect or combination of defects that seriously impairs the strength or that renders it unsatisfactory for the intended use.

818.07 PRESERVATIVE TREATMENT. When the Contract specifies preservative treatment of wood products, treat according to AWPA U1, Section A. Provide preservative conforming to AWPA U1, Section A as the Contract specifies.

Do not use creosote or creosote solutions with wood required to be paintable.

When the Contract specifies pentachlorophenol preservative, use heavy petroleum solvent when the Contract does not require painting. Use light petroleum solvent when the Contract requires that the wood is to be paintable.

Do not use water-borne preservatives where the wood will be in contact with water unless recommended by AWPA specifications.

Follow the guidelines set in AWPA M4 for the care of preservative treated wood products.

SECTION 819 —TUNNEL LINING MATERIALS

819.01 DESCRIPTION. This section covers materials requirements for steel plates and fittings to be used for lining tunnels. Refer to the Contract for sectional properties.

819.01.01 Steel Plates. Use base metal for steel plates that conforms to the chemical requirements of ASTM A 1011. Ensure that the flat plate, before cold forming, conforms to the following minimum mechanical properties:

Tensile Strength	42,000 psi
Yield Strength	28,000 psi
Elongation, 2 inches	30%

Ensure that nominal plate dimensions provide the sectional properties shown in the current edition of the AASHTO Standard Specifications for Highway Bridges. For thickness tolerances, conform to Table 6 of AASHTO M 167. Provide steel liner plates of additional thickness or protect by coatings or other means when specified in the Contract for resistance to abrasion or corrosion.

819.01.02 Bolts and Nuts. Do not use any bolts and nuts with lapped seams that are less than 5/8 inch in diameter. Provide bolts conforming to ASTM A 449 for plate thicknesses equal to or greater than 0.209 inch and A 307 for plate thickness less than 0.209 inch. Provide nuts conforming to ASTM A 307, Grade A.

Only use bolts and nuts with 4-flanged plates of no less than 1/2 inch in diameter for plate thicknesses to and including 0.179 inch and no less than 5/8 inch in diameter for plates of greater thickness.

SECTION 820 — TIMBER POLES

820.01 REQUIREMENTS. Provide poles of Southern Pine conforming to ANSI Specification 05.1. Provide poles of the length and ANSI size classification specified in the Contract. The Department will not allow sweep exceeding one inch in 10 feet or double sweep.

Treated timber poles shall meet all the general requirements of this subsection and shall be treated with pentachlorophenol (oil borne) or CCA (water borne) preservative as noted in AASHTO M133 in accordance with requirements of the current AWPA standards.

Treat poles with pentachlorophenol conforming to AWPA P35 according to AWPA U1 or CCA conforming to AWPA P23 according to AWPA U1. Ensure that net retention is no less than 0.75 pounds per cubic foot on the outer 1/2-inch and no less than 0.45 pounds per cubic foot in the 1/2 to one-inch zone with average retentions of no less than 0.80 and 0.50 pounds per cubic foot, respectively.

Follow the guidelines for the care of preservative treated wood products as set in AWPA M4.

820.02 ACCEPTANCE. The Department will inspect, test and accept poles according to Subsection 818.01.

SECTION 821 — STRUCTURAL COATINGS

821.01 DESCRIPTION. This section covers requirements for structural coating systems used in bridge construction and maintenance.

821.02 GENERAL REQUIREMENTS. Select structural coatings systems conforming to this section and included on the Department's List of Approved Materials. Use only coating system components that are factory mixed and delivered ready for use. Do not allow the use of partial kits. Sediment formed during shipment must be easily dispersed with a power mixer to produce a smooth, uniform coating having good spreading characteristics. Reject coatings that excessively gel, or cakes in the container.

Ensure the coatings produce a smooth uniform finish without sags or streaks. Ensure successive coating applications, i.e. intermediate coat to prime coat, differ in color a minimum of 10.0ΔE*. The following colors are standard colors for use in the production of structural coatings. The name and Federal Standard 595B color number provided are for reference only. Manufacturers are to produce finish coat colors that comply within 2.0 ΔE* of the L* a* b* values listed below or as specified in the contract.

Color	Fed Standard 595B No.	L*	a*	b*
Gray	X6187	48.17	-3.54	-0.87
Camo Green	X4172	45.17	-12.70	9.86
Dark Green	X4066	24.95	-35.59	5.82
Grass Green	X4272	58.30	-21.64	12.26
Light Blue	n/a	66.56	-7.26	-20.10
Medium Blue	X5180	39.35	-0.12	-42.76
Kentucky Blue	X5095	35.44	9.83	-48.11
Buttercream Yellow	X3798	88.41	-1.92	35.02
Yellow	X3618	81.82	-0.57	57.55
Light Beige	X6521	74.71	1.92	9.88
Aluminized Silver	n/a	66.56	-0.59	-0.33
Maroon	X0160	33.65	28.49	6.61
Light Gray For Concrete	X6492	74.94	-1.54	3.92

Store coatings at temperatures above 32 °F and below the most restrictive maximum ambient air temperature for the coating system stated on the coating manufacturer's product data sheets. Equip storage areas with high-low thermometers capable of measuring and recording the appropriate temperature range. Do not store coating systems in direct sunlight. The Engineer will reject or retest coatings exposed to temperatures outside this range.

821.03 APPROVAL. The Department will approve structural coating systems based on performance data obtained in accordance with KM 64-266.

821.04 SAMPLING AND TESTING. The Department will sample and test each shipment of each lot of coating delivered to the project in accordance with the Department's Materials Field Sampling Manual. Allow the Department 10 working days from the date received by the Division of Materials to test and approve samples. Retest coatings that are not used within 6 months from their approval. Additionally, retest coatings that are stored between painting seasons. Remove rejected coatings from the job site before starting painting operations.

821.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of approved structural coatings delivered for use on projects. Clearly state the manufacturer and product name as listed in the Department's List of Approved Materials. Identify the lot number(s), expiration date, and

quantity of each coating or coating component.

821.06 ACCEPTANCE. The Department will accept structural coating systems based on verification of inclusion on the Department's List of Approved Materials, compliance of the manufacturer's certification, verification the coatings will not exceed the expiration date, and acceptable tests results obtained by the Department in accordance with Table 1.

821.07 ACCEPTANCE OF NON-SPECIFICATION COMPLIANT COATINGS. The Department may accept coatings found to be in non-conformance to the Specification Acceptance Range at a reduction in pay, see Table 1. Coatings with analytical test results not in conformance to the Specification Acceptance Range but within the Acceptance Range with Deduction may be accepted for incorporation into the project with applicable reductions in pay. Deductions are cumulative to a maximum of 60% reduction in pay applied to the Contractors' invoiced unit cost for the coating. Coatings with 3 or more analytical tests resulting in non-conformance to the Specification Acceptance Range or any analytical test result exceeding the Acceptance Range with Deduction will be rejected and removed from the project. Do not allow transfer of structural coating materials between projects that have analytical test results in the Acceptance Range with deduction.

821.08 Table 1.

COATINGS PRICE ADJUSTMENT SCHEDULE			
Analytical Test	Specification Acceptance Range	Acceptance Range with Deduction	Deduction Applied to Unit Cost
Density ASTM D1475	Target Value ± 0.25 lbs/gal	Target Value ± 0.26 to 0.50 lbs/gal	20%
Viscosity ASTM D562	Target Value ± 10 KU		
Weight Solids ASTM D2369	Target Value ± 2.0%	Target Value ± 2.1 to 3.0%	30%
Volume Solids ASTM D2697	Target Value ± 2.0%	Target Value ± 2.1 to 3.0%	30%
Pigment ASTM D2698 ASTM D 3723	Target Value ± 2.0%	Target Value ± 2.1 to 3.0%	30%
Metallic Pigment Content ASTM D521	Target Value ± 2.0%	Target Value ± 2.1 to 3.0%	30%
Volatile Organic Compounds ASTM D3960	450 g/L Maximum		
Color ASTM D2244	2.0 ΔE*Maximum	2.1 to 3.0 ΔE* Maximum	10%
Contrast Ratio (at 5miles wft.)	0.98 Minimum		
Color Differential	10.0 ΔE*Minimum	9.9 to 8.0 ΔE* Minimum	10%
Gloss ASTM D523	Target Value ± 10 Gloss Units		
Sag Resistance ASTM D4400	Target Value ± 20%		
Drying Schedule ASTM D1640	Target Value ± 20%		
Pot Life	Target Value ± 10 KU		
MEK	3 Minimum		
Resin Content ASTM D1652 ASTM D2074 AASHTO TP67	Target Value ± 0.5%	Target Value ± 0.6 to 0.8%	30%

SECTION 822 — ELASTOMERIC BEARING PADS

822.01 ELASTOMERIC BEARING PADS. Furnish elastomeric bearing pads conforming to the design and dimensions as specified in the Plans and to the AASHTO LRFD Bridge Construction Specifications, Section 18.

Use bearings that are low temperature Grade 3 with durometer hardness of 50 and that conform to the load test requirements corresponding to Design Method A.

SECTION 823 — CONCRETE CURING MATERIALS

823.01 GENERAL. This section lists the various types of curing materials allowed for concrete and the materials requirements applicable to each. The Department will provide specifications governing the particular type or types of curing materials allowed for specific classes of construction in the Contract or other sections of these specifications.

823.02 LIQUID MEMBRANE FORMING COMPOUNDS. Products must have completed testing through the National Transportation Product Evaluation Program (NTPEP) for Concrete Curing Compounds in order to remain on or to be placed on the Department's List of Approved Materials.

Ensure that all curing compounds Conform to ASTM C309 and are from a Department approved manufacturer.

- 1) Type 1-D (Clear with fugitive dye or translucent with fugitive dye), Class A or Class B.
- 2) Type 2 (White pigmented), Class A or Class B. Supply Type 2 curing compounds in agitating type drums, except the Department will not require agitating type containers when Type 2 curing compound is supplied in 5 gallon pails.

The Department will accept curing compounds on the basis of certification of their conformance to this section and their being from an approved manufacturer. The Department will reject curing compounds from an unapproved manufacturer and require their removal from the project site.

823.02.01 Acceptance Procedures for Non-Specification Curing Compounds. The Department may test project samples. When non-specification curing compounds are inadvertently incorporated into the work the Department will accept the material with a reduction in pay. The Department will apply the largest payment reduction when the material fails to meet more than one specification requirement. The Department will calculate the payment reduction on the invoice cost of the material delivered at the project site.

MOISTURE LOSS PAYMENT REDUCTION				
kg/square meter	0.00-0.55	0.56-0.65	0.66-0.75	0.76 or more
Reduction Rate	0%	20%	30%	50%

REFLECTANCE PAYMENT REDUCTION				
% Reflectance	60.0% or more	50-59.9%	40.0-49.9%	39.9% or less
Reduction Rate	0%	20%	30%	50%

823.03 BURLAP CLOTH. Conform to AASHTO M 182, Class 4.

823.04 CURING PAPER (Regular or White). Conform to ASTM C171.

823.05 WHITE POLYETHYLENE FILM (White Opaque). Use white polyethylene film of either single sheet construction conforming to ASTM C171 or laminated construction consisting of 2 sheets of white polyethylene reinforced with synthetic fiber cords, providing the total thickness of polyethylene, exclusive of the cords, averages no less than 4 mils and the sheeting conforms to all other applicable requirements of ASTM C171.

Incorporate the reinforcing cords diagonally in 2 directions and ensure that the number of cords averages 24 per linear foot in each direction.

823.06 WHITE BURLAP - POLYETHYLENE SHEET. Conform to ASTM C171.

823.07 CURING BLANKETS. Use curing blankets that consist of a top layer of white copolymer material and a bottom layer of absorbent, non-woven, synthetic fabric. Ensure that the layers are securely bonded together so there will be no separation of the layers during handling and curing of the concrete. When tested according to ASTM C171, ensure that moisture loss does not exceed 0.010grams per square centimeter and that reflectance is at least 70 percent.

SECTION 824 — MASONRY MATERIALS

824.01 CONCRETE MASONRY UNITS (FOR CONSTRUCTION OF CATCH BASINS AND MANHOLES). Conform to ASTM C 139.

824.02 PRECAST REINFORCED CONCRETE MANHOLE SECTIONS. Conform to ASTM C 478, KM 64-115 and the Standard Drawings. For flat top slabs, a tongue and groove design is optional. The Department will allow the use of lightweight aggregate provided that it conforms to subsection 805.04.02.

824.03 CONCRETE BUILDING BRICK. Conform to ASTM C 55.

824.04 CONCRETE FACING BRICK. Conform to ASTM C1634.

824.05 SEWER AND MANHOLE LEVELING BRICK. Conform to ASTM C32. The Department will waive the requirement for saturation coefficient for Grades SM and MS. Ensure that the dimensions are of the specified standard size.

824.05.01 Sewer Brick. Use Grade SS or SM.

824.05.02 Manhole Brick. Use Grade MS or MM.

824.05 FINISHING HYDRATED LIME. Conform to ASTM C 206.

SECTION 825 - DE-ICERS

825.01 DESCRIPTION. This section covers deicers used for ice/snow removal and road conditioning purposes.

825.02 GENERAL. Provide deicers which conform to this section. Provide independent analysis data and certification showing compliance to 40 CFR 261 for leachable heavy metals for each deicer annually. Report the total concentration of each heavy metal present and the test method used for each determination.

825.03 CALCIUM CHLORIDE. Conform to ASTM D 98 for the following:

A) Type S (Solid)

Grade N3. Class B.

Grade N4. Class B.

B) Type L (Liquid). Ensure a minimum calcium chloride content of 32%.

825.04 SODIUM CHLORIDE. Furnish sodium chloride in a free flowing condition and conforming to the following chemical and physical requirements:

825.04.01 Sodium Chloride Content. Ensure a minimum sodium chloride content of 95.0%.

825.04.02 Moisture Content. Ensure the moisture content of the sodium chloride does not to exceed 2.0%.

825.04.03 Gradation.

Sieve Size	Mass % Passing
19.0 mm (3/4in.)	...
12.5 mm (1/2in.)	100
9.5 mm(3/8in.)	95 to 100
4.75 mm (No. 4)	20 to 90
2.36 mm (No. 8)	10 to 60
600 µm (No. 30)	0 to 15

825.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of deicer delivered for use. Clearly state the manufacturer, product name, actual test results showing conformance to the stated requirements, date of compliance analysis to 40 CFR 261 for leachable heavy metals and quantity of deicer.

825.05 ACCEPTANCE. The Department will accept deicers based on compliance of manufacturer's certification and visual inspection by the Engineer. The Department reserves the right to sample and test deicers, at the Engineers discretion, in accordance with the Department's Field Sampling and Testing Manual. The Department will conduct testing of calcium chloride deicers in accordance with KM 64-222 and of sodium chloride deicers in accordance with KM 64-225.

SECTION 826 - EPOXY RESIN SYSTEMS

826.01 GENERAL. Conform to ASTM C 881, except as specified in Subsections 826.01.01, 826.01.02, and 826.01.03. Provide materials, of all types, of the Grade and Class required for the intended use. Types are as follows:

- A) **Type III.** Use in epoxy-sand slurry, as a binder in epoxy mortars or epoxy concretes.
- A) **Type IV.** Use for installing dowels into hardened portland cement concrete or hardened Portland cement concrete to hardened Portland cement concrete.
- A) **Type V.** Use for bonding plastic portland cement concrete to hardened portland cement concrete.

826.01.01 Epoxy-Sand Slurry for Concrete Bridge Deck Overlays. Conform to ASTM C 881, Type III or AASHTO M 200, Class II.

826.01.02 Reinforcing Bar Grout Adhesives. The Department will allow reinforcing bar grout adhesives, from the Department's List of Approved Materials, as an alternate to Type IV epoxies for doweling reinforcing bars into hardened concrete.

- A) Category I. Conform to KM 64-209 utilizing a maximum one-hour cure time.
- B) Category II. Conform to KM 64-209 utilizing a maximum 24-hour cure time.

826.01.03 Structural Adhesives with Extended Contact Time. The Department will allow structural adhesives, from the Department's List of Approved Materials, as an alternate to Type V epoxies for bonding plastic portland cement to hardened portland cement concrete.

826.02 APPROVAL. The Department will approve epoxy resin systems based on review of required independent laboratory data and Department conducted testing. Submit independent laboratory data conducted within one year of the date of product submittal for Department approval. Obtain Department approval for each epoxy resin system every five years.

826.02.01 ASTM C881 Epoxy. The Department will approve ASTM C881 epoxy for Type, Class, and Grade based on the manufacturer's submission of independent laboratory data showing the actual test values for the ASTM specification requirements and submission of a product sample from a production lot for testing. C881 Type IV analysis shall include re-bar pull testing in accordance with KM64-209.

826.02.02 AASHTO M 200. The Department will approve AASHTO M200 epoxy based on the manufacturer's submission of independent laboratory data showing the actual test values for the AASHTO M 200 specification requirements for Class II and submission of a product sample from a production lot.

826.02.03 Reinforcing Bar Grout Adhesives. The Department will approve non-epoxy Reinforcing Bar Grout Adhesives based on testing conducted by the Department in accordance with KM64-209.

826.02.04 Structural Adhesives with Extended Contact Time. The Department will approve Structural Adhesives with Extended Contact Time based on the manufacturer's submission of independent laboratory data showing the actual test values for the ASTM C881 specification requirements for Type V, with the following modifications and submission of a product sample from a production lot.

- A) **Gel Time** (Minimum) 90 Minutes
- B) **Compressive Strength** (ASTM C109) (Minimum)
7-Day 5,000 psi

A) Bond Strength (ASTM C882 Modified*) (Minimum)

14-Days

0 Hour Contact Time	2,000 psi
16 Hours Contact Time	1,500 psi

*ASTM C882 is modified to allow for 16 hours contact time. Contact time is the time allowed between application of the bonding agent and placement of the plastic concrete.

826.03 PACKAGING. Package the 2 components in separate containers. Identify the containers as “Component A - Contains Epoxy Resin” and “Component B - Contains Hardener.” Include on the container the following information:

- 1) Type, mixing directions, and usable temperature range.
- 2) Name of the Manufacturer.
- 3) Lot or batch number.
- 4) Date of packaging.
- 5) Type of pigmentation.
- 6) Quantity contained in pounds and gallons.
- 7) Potential hazards according to the Federal Hazardous Products Labeling Act.

826.04 CERTIFICATION. Submit manufacturer’s certification stating conformance to the requirements of this Section for each shipment of approved epoxy resin system delivered for use on projects. Clearly state the manufacturer, product name, type, class, grade, and category; as appropriate for each epoxy resin system as listed in the Department’s List of Approved Materials. Identify the lot number(s), expiration date, and quantity of each component of epoxy resin system.

826.05 ACCEPTANCE. The Department will accept epoxy resin systems based on verification of inclusion on the Department’s List of Approved Materials, compliance of the manufacturers certification and verification the epoxy resin system has not exceeded the expiration date. The Department reserves the right to sample and test epoxy resin systems, at the Engineer’s discretion, in accordance with the Department’s Field Sampling and Testing Manual.

SECTION 827 — EROSION CONTROL MATERIALS

827.01 DESCRIPTION. This section covers the requirements for various materials used for erosion control.

827.02 AGRICULTURAL LIMESTONE. Conform to the requirements and provisions of the Kentucky Department of Agriculture. The Department of Agriculture furnishes a test report and any required weight penalties to each agricultural limestone producer. Furnish the Engineer with a copy of the test report, current within 9 months, as the basis of approval. The Engineer may sample any agricultural limestone that appears to be of questionable quality upon visual inspection.

827.03 FERTILIZER. Provide commercial fertilizer that complies with the Kentucky Fertilizer Law, and contains the plant nutrients of nitrogen, available phosphoric acid, and soluble potash as specified in the Contract. Ensure that bagged fertilizer displays the following information on the bag or on a sticker or tag attached to the bag:

- 1) Net Weight
- 2) Brand and Grade
- 3) Guaranteed Analysis
- 4) Name and Address of Manufacturer

Ensure that the manufacturer includes a statement with the bulk fertilizer (dry or liquid) that contains the same information required for the bagged fertilizer.

Provide either bagged or bulk (dry or liquid) fertilizer manufactured and sold under the jurisdiction of the Division of Regulatory Services of the University of Kentucky Agricultural Experiment Station. The Department must sample, test, and approve any other fertilizer prior to its use.

827.04 SEED. Conform to the requirements outlined in the . “Kentucky Seed Law and Provisions for Seed Certification in Kentucky” and the “Regulations under the Kentucky Seed Law”, with following exceptions:

- 1) Obtain seed only through registered dealers that are permitted for labeling of seed.
- 2) Ensure all deliveries and shipments of premixed seed are accompanied with a master blend sheet.
- 3) Ensure all bags and containers have an acceptable seed tag attached.
- 4) The Department may sample the seed at the job site at any time.

REQUIREMENTS FOR SEEDS			
	Purity (Min. %)	Germination (Min. %) Including Hard Seed and Dormant Seed	Hard Seed (Max. %) Allowed in Germination
Grasses			
Bentgrass (<i>Argrostis palustris</i>)	98	85	-
Bermudagrass, common (<i>Cynodon dactylon</i>)	97	85	-
Bluegrass, Kentucky (<i>Poa pratensis</i>)	98	85	-
Brome, smooth (<i>Bromus inermis</i>)	95	80	-
Canarygrass, reed (<i>Phalaris arundinacea</i>)	95	80	-
Fescue, chewings (<i>Festuca rubra</i> var. <i>commutata</i>)	97	85	-
Fescue, hard (<i>Festuca trachyphlla</i>)	97	85	-
Fescue, meadow (<i>Festuca elatior</i>)	97	85	-
Fescue, red (<i>Festuca rubra</i>)	97	85	-
Fescue, tall (<i>Festuca arundinacca</i>)	97	85	-
Orchardgrass (<i>Dactylis glomerata</i>)	97	85	-
Redtop (<i>Agrostis alba</i>)	95	80	-
Ryegrass, annual, common or Italian (<i>Lolium multiflorum</i>)	97	85	-
Ryegrass, perennial (<i>Lolium perenne</i>)	97	85	-
Lovegrass, Weeping (<i>Eragrostis curvula</i>)	96	80	-
Oat (<i>Avena Sativa</i>)	98	85	-
Rye (<i>Secale cereale</i>)	98	85	-
Timothy (<i>Phleum pratense</i>)	98	85	-
Wheat, common (<i>Triticum aestivum</i>)	98	85	-
Legumes			
Alfalfa (<i>Medicago sativa</i>)	98	85	25
Clover, alsike (<i>Trifolium hybridum</i>)	97	85	25
Clover, ladino (<i>Trifolium repens</i>)	98	85	25
Clover, white (<i>Trifolium repens</i>)	98	85	25
Crownvetch (<i>Coronilla varia</i>)	97	85	25
Lespedeza, Korean (<i>Lespedeza stipulacea</i>)	97	85	20
Lespedeza, Sericea (<i>Lespedeza cuneata</i>)	97	85	20
Sweetclover, white (<i>Melilotus alba</i>)	98	85	25
Sweetclover, yellow (<i>Melilotus officinalis</i>)	98	85	25
Partridge Pea (<i>Cassia fasciculata</i>)	97	85	20
Trefoil, birdsfoot (<i>Lotus corniculatus</i>)	97	85	25
Native Grasses			
Little Bluestem (<i>Schizachyrium scoparium</i>)	85	80	-
Big Blustem (<i>Andropogon gerardii</i>)	85	80	-
Indian Grass (<i>Sorghastrum nutans</i>)	85	80	-
Switchgrass (<i>Panicum virgatum</i>)	85	80	-

Do not use seed (grasses, native grasses, and legumes) if the weed seed is over one percent, total germination (including hard seed) is less than 80 percent, if the seed test date is over 9 months old exclusive of the month tested, or if the limits of noxious weed seed is exceeded.

Ensure that noxious weed seeds contained in any seed or seed mixture does not exceed the maximum permitted rate of occurrence per pound.

<u>Kind of Noxious Weed</u>	<u>Max. No. Seeds (per pound)*</u>
Balloon Vine (<i>Cardiospermum halicacabum</i>)	0
Purple Moonflower (<i>Ipomoea turbinata</i>)	0
Canada Thistle (<i>Cirsium Arvense</i>)	0
Johnsongrass (<i>Sorghum halepense</i> and <i>Sorghum almum</i> and perennial rhizomatous derivatives of these species)	0
Quackgrass (<i>Elytrigia Repens</i>)	0
Annual Bluegrass (<i>Poa annua</i>)	120
Buckhorn Plantain (<i>Plantago lanceolata</i>)	120
Corncockle (<i>Agrostemma githago</i>)	18
Dodder (<i>Cuscuta</i> spp.)	18
Giant Foxtail (<i>Setaria faberii</i>)	18
Oxeye Daisy (<i>Chrysanthemum leucanthemum</i>)	120
Sorrel (<i>Rumex acetosella</i>)	120
Wild Onion and Wild Garlic (<i>Allium</i> spp.)	18

* *Seed or seed mixtures that contain in excess of 120 total noxious seeds per pound is prohibited*

Wildflower seed shall not be planted until approved by the Engineer.

827.05 MULCH MATERIALS. Use material for mulching that is baled wheat, oat, barley, or rye straw, or excelsior wood fibers. Ensure that mulch material is reasonably free from weed seeds, stolons, foreign matter, or chaff, and does not contain any Johnson Grass, Canada Thistle, Quack Grass, or Nodding Thistle. Ensure that the mulch material is reasonably bright in color and not musty, moldy, or otherwise of low quality, and does not contain chemicals toxic to plant growth.

Use excelsior wood fibers that consist of fibers cut from sound green timber. Ensure that the cut is made in a manner to provide maximum strength of fiber, but is at a slight angle to the natural grain of the wood so as to cause splintering of the fiber when weathering occurs. Use fibers with the following approximate physical properties: width 0.02 to 0.04 inch, thickness 0.02 to 0.04 inch, and length 4 to 6 inches.

827.06 ASPHALT MATERIALS FOR MULCH. Use either SS-1 or SS-1h conforming to Section 806 except that the Department may waive retesting as provided by Subsection 806.04. The Engineer may reject asphalt materials that fail to disperse properly or otherwise fail to provide satisfactory results.

827.07 EROSION CONTROL BLANKET. Use a blanket from the Department's List of Approved Materials. Use a machine constructed curled wood fiber mat with two-sided netting. Ensure the blanket is smolder resistant without the use of chemical additives.

- A) **Dimensions.** Furnish in strips with a minimum width of 4 feet and length of 50 feet.
- B) **Weight.** Ensure a minimum mass per unit area of 7.25 ounces per square yard according to ASTM D 6475.
- C) **Fill.** Ensure the fill is evenly distributed throughout the blanket.
Use curled wood fiber of consistent thickness with at least 80 percent of its fibers 6 inches or longer in length.
- D) **Netting.** Use photodegradable extruded plastic mesh or netting, with a maximum spacing width of one inch square, on both sides of the blanket. Secure the netting by stitching or other method to ensure the blanket retains its integrity.
- E) **Staples.** Use steel wire U-shaped staples with a minimum diameter of 0.09 inches (11 gauge), a minimum width of one inch, and a minimum length of 6 inches. Use

a heavier gauge when working in rocky or clay soils and longer lengths in sandy soils. Provide staples with colored tops when requested by the Engineer.

F) Performance.

- 1) C-Factor. Ensure the ratio of soil loss from protected slope to ratio of soil loss from unprotected is ≤ 0.15 for a slope of 3:1 when tested according to ASTM D 7101 (2-inch/hour for 30 minutes).
- 2) Shear Stress. Ensure the blanket can sustain a minimum shear stress of 1.75 pounds per square foot without physical damage or excess erosion (> 0.5 inches soil loss) when tested according to ASTM D 7207.

827.08 TEMPORARY SILT FENCE.

- A) **Posts.** Use either hardwood or steel greater than 4 feet in height. For hardwood, provide a minimum 1 1/2-inch by 1 1/2-inch cross section that is straight enough to provide a fence without noticeable misalignment. For steel, provide a 1 1/4- inch by one-inch T-section with projections to fasten wire and fabric in position.
- B) **Woven or Welded Wire Fabric.** Conform to Section 816 or 811. Provide fabric with a minimum height of 2 feet 8 inches. Require at least 6 horizontal wires spaced 6 1/4 inches or closer with the top and bottom wires 0.134 inch or larger and all other wires 0.1 inch or larger. Require 0.1 inch or larger vertical wires spaced 12 inches or closer.
- C) **Geotextile Fabric.** Conform to AASHTO M 288 for temporary silt fence. Provide fabric with a height of 3 feet.
- D) **Fasteners.** Use No. 9, one inch long wire staples and/or fabric ties that conform to Subsection 816.06.

827.09 NETTING AND STAPLES. Conform to the Standard Drawings and the Plans. The Engineer may accept netting and staples on the basis of visual inspection.

827.10 TOPSOIL. Topsoil is the portion of the soil profile defined technically as the "A" horizon by the Soil Science Society of America. Use loose, friable, topsoil that is free of stones 1 inch or greater in overall dimensions, admixture of subsoil, refuse, stumps, roots, brush, weeds, and other material that prevent the formation of a suitable seed bed. Before stripping the topsoil, inspect for existing vegetation. Do not use topsoil from sites having Johnson Grass, Canada Thistle, Quack Grass, Nodding Thistle, or excessive amounts of other noxious weeds, or their rhizomes. The Department will sample the soil and determine the textural classification according to the US Department of Agriculture system, the particle size according to KM 64-519, the organic content according to KM 64-243, and the pH according to ASTM D 4972. Acceptable topsoil composition is:

Clay	40% maximum
Silt	70% maximum
Sand	60% maximum
Organic Material	2% minimum, 10% maximum
pH	6.0 minimum, 7.0 maximum

827.11 SOD. Use sod that is either well-rooted Kentucky Bluegrass or Tall Fescue sod. However, obtain the Engineer's approval prior to using Tall Fescue sod in residential areas. Use sod that is completely free from noxious weeds and reasonably free from other objectionable grasses and weeds and stones or other foreign materials detrimental to the development and future maintenance of the sod. Obtain sod from sources that are covered with grass having a maximum height of 3 inches. Obtain approval of the selected source prior to cutting.

SECTION 828 — MASONRY COATING MATERIALS

828.01 DESCRIPTION. This section covers requirements for materials to be used as surface finishes for designated surfaces of cement concrete structures. The masonry coatings must hide form marks, patches, and other minor irregularities and prevent deterioration, spalling, and other damage to the concrete due to the action of the weather and deicing chemicals.

828.02 APPROVAL. Select masonry coatings from the Department's List of Approved Materials. Use a material that is readily recognizable by its name, trademark, container, or other feature. Conform to the Department's testing criteria to be placed on or remain on the Department's List of Approved Materials.

For initial approval submit representative samples, color chip (see Subsection 828.02.05), and duplicate copies of certified test reports to the Division of Materials for review and approval. An independent testing laboratory acceptable to the Department shall perform the tests described herein on representative samples of the material. Tests listed herein are the minimum testing requirements to be met. When requested in writing, the Engineer may accept materials based on conformance to the same type of test but differing on minor procedural points. Attach copies of test procedures which differ from those stated herein. In addition to the material, provide brochures or booklets containing detailed instructions and explanatory remarks about surface preparation, application procedures, and other pertinent operations. The Department will allow masonry coating, on those areas designated to receive masonry coating to serve as a curing membrane, provided water retention requirements of ASTM C309 are met, the product technical literature permits its use as a curing membrane, and the product is so identified on the List of Approved Materials.

The Department will continue to include the masonry coatings on the list contingent upon receiving an annual certification containing the following information:

- 1) A statement that the masonry coating to be furnished during the particular calendar year is of the same composition as that previously approved for inclusion on the approved list.
- 2) A statement that the masonry coating conforms to the appropriate requirements of the Kentucky Standard Specifications for Road and Bridge Construction.
- 3) A statement that notification will be made to the Division of Materials of any changes in composition for review and approval before furnishing the material to projects.

828.02.01 Freeze-Thaw Test. Cast and cure 3 concrete specimens no less than 4 by 4 by 6 inches. Moist cure specimens for 14 days and then dry in room air at 60 to 80 °F for 24 hours before applying masonry coating. Ensure that there is no excessive oil on specimen forms. Coat sides of specimens (brush permitted) according to the manufacturer's directions at a rate of 50 ± 10 square feet per gallon and cure at room temperature for 48 hours; after which:

- 1) Immerse in water at room temperature 60 to 80 °F for 3 hours and remove.
- 2) Place in cold storage at -15 °F for one hour and remove.
- 3) Thaw at room temperature 60 to 80 °F for one hour.
- 4) Repeat steps 1), 2), and 3) to complete a total of 50 cycles. At the end of 50 cycles of the Freeze-Thaw Test, ensure that the coated specimens shows no visible defects.

828.02.02 Accelerated Weathering. Test according to ASTM D 822. Apply at an application rate of 50 ± 10 square feet per gallon. Test for 335 hours in an Atlas Type XW Sunshine Arc Weatherometer or for 500 hours in an Atlas Type DMC Enclosed Violet

Carbon Arc Weatherometer or equivalent. Perform the test in 120-minute cycles consisting of 102 minutes of light and 18 minutes of light and demineralized water. At the end of the exposure test, ensure that there is no checking, cracking, or loss in film integrity, and no other film defects. Ensure that the coating shows no more than very slight color change.

828.02.03 Salt Spray Resistance. Apply the masonry coating to concrete at a rate of 50 ± 10 square feet per gallon, and test the coating according to ASTM B 117. Expose the coating to a 5 percent sodium (salt) solution for 300 hours, and maintain it at 90 ± 2 °F during the period of exposure. Ensure that it shows no loss of adhesion or deterioration at the end of the 300 hours.

828.02.04 Fungus Growth Resistance. Ensure that the masonry coating passes a fungus resistance test as described by Federal Specification TT-P-29. After a minimum incubation period of 21 days, ensure that no growth is exhibited on the coating.

828.02.05 Color. Color shall match Federal Standard 595B standard color FS 36492 or as specified in the contract.

SECTION 829 —HARDWARE FOR TIMBER STRUCTURES

829.01 GENERAL. Furnish fasteners that are industry recommended for the timber type being used. Fasteners shall include nails, spikes, bolts, dowels, washers, and lag screws.

829.02 BOLTS. Use machine bolts having square heads and nuts, and ensure that screw threads make a close fit in the nuts. Furnish machine bolts, drift-bolts, and dowels of either wrought iron or medium steel. Designate the weight of bolts as “American Standard Regular.”

829.03 WASHERS. Furnish washers that either are cast O-gee or malleable castings or are cut from medium steel or wrought-iron plate, as specified in the Contract.

829.04 NAILS. For nails, use cut or round wire of standard form. Furnish cut or wire spikes, or boat spikes, as specified in the Contract.

SECTION 830 — RETROREFLECTIVE MATERIALS

830.01 DESCRIPTION. This section covers the requirements for retroreflective materials used on signs, delineators, and channelizing devices (drums, cones, barricades, and tubular markers).

830.02 GENERAL REQUIREMENTS. Ensure that all materials and prepared sign faces are free from cracks, tears, ridges, humps, discoloration, or other objectionable blemishes. Use sign sheeting materials that present a finished surface suitable for receiving stenciled messages, paint overlays, or film overlays. Provide only retroreflective sign sheeting materials that conform to Federal Specification L-S-300C for solvent, heat, cold, and humidity resistance. The Department will reject signs and traffic control devices that do not conform to the requirements of this section.

830.02.01 Delineator Sheeting. Provide the size, color, and shape specified in the Contract.

- A) **Barrier Wall Delineator.** Use retroreflective sheeting conforming to ASTM D 4956, Type IX, Class 1.
- B) **Guardrail Delineator.** Use retroreflective sheeting conforming to ASTM D 4956, Type IX, Class 1.
- C) **Delineator Post.** Use retroreflective sheeting conforming to ASTM D 4956, Type IX, Class 1.

830.02.02 Barricade Sheeting. Use retroreflective sheeting conforming to ASTM D 4956, Type III or IV, Class 1.

830.02.03 Drum Sheeting. Use retroreflective sheeting conforming to ASTM D 4956, Type III or IV, Class 1 or 3.

830.02.04 Cone and Tubular Marker Sheeting. Use retroreflective sheeting conforming to ASTM D 4956, Type III or IV, Class 1 or 3.

830.02.05 Roll Up Sign Sheeting. Use retroreflective sheeting conforming to ASTM D 4956, Type VI, Class 5. Use fluorescent orange sheeting for warning signs in construction zones.

830.02.06 Permanent Sign Sheeting. Use retroreflective sheeting conforming to ASTM D 4956, Types III, IV, IX, or XI. Use the appropriate type and color of sheeting as specified in the plans. If not addressed in the plans, use type and color in conformance with the Traffic Operations Guidance Manual.

830.02.07 Construction Sign Sheeting. For warning signs in construction zones, use retroreflective sheeting conforming to ASTM D 4956, Types IV, VIII, IX, or XI and that is fluorescent orange in color. For regulatory and guide signs in construction zones, use retroreflective sheeting conforming to subsection 830.02.06.

830.03 APPROVAL. The Department will approve retroreflective sheeting materials based on KM 64-204 and conformance to this section.

830.04 FIELD PERFORMANCE. The Department will consider the retroreflective sheeting defective if any of the following conditions are observed:

- 1) When viewed from a moving vehicle under normal day and night driving conditions, sheeting has deteriorated to the extent that the sign or device is ineffective for its intended purpose.
- 2) Sheeting no longer meets the minimum criteria for retained retroreflectivity
- 3) For permanent signs, the time between sign installation and the manufacture date exceeds one-year.

Traffic control devices found to have defective sheeting shall be replaced at the discretion of the Engineer with no additional cost to the Department.

830.05 PACKAGING. Ensure that all materials are suitably and substantially packaged and have the name and address of the manufacturer or vendor, contract or purchase order number, kind of material, trade name, date of manufacture, lot and run number, color, and net contents plainly marked on each package or container.

830.06 CERTIFICATION. Submit retroreflective sheeting manufacturer's certification stating conformance to the requirements of this section for fabricated signs, delineators, channelizing devices, or other applications of retroreflective sheeting delivered for use on projects. Clearly state the manufacturer, product name and product code as listed in the Department's List of Approved Materials, sheeting type, sheeting color, sheeting lot number, sheeting expiration date, and quantity.

830.07 ACCEPTANCE. The Department will accept retroreflective sheeting based on verification of inclusion on the Department's List of Approved Materials and conformance of the manufacturer's certification. The Department reserves the right to sample and test retroreflective sheeting, at the Engineers discretion, in accordance with the Department's Materials Field Sampling Manual.

SECTION 831 — CONSTRUCTION ZONE TEMPORARY MARKING TAPES

831.01 DESCRIPTION. This section covers pavement marking material designed to provide reflective delineation in construction zones. This section covers the following types of marking material:

- A) **Type A.** Non-removable Pavement Marking Tape.
- B) **Type B.** Removable Pavement Marking Tape.

831.02 GENERAL.

831.02.01 Manufacture. Use a material consisting of a weather and traffic-resistant reflective film on a backing precoated with a pressure-sensitive adhesive.

831.02.02 Adhesive. Use a precoated pressure-sensitive adhesive that does not require a liner or activation.

831.02.03 Application Properties. Ensure that the material adheres to asphalt and concrete surfaces, when applied according to the manufacturer's recommendations, at or above surface temperatures of 40 °F. Ensure that the material does not require any protective devices such as traffic cones or barricades after application. Do not allow re-use of previously installed material.

831.02.04 Conformability and Thickness. Use material that is thin, flexible, formable, and remains conformed to the texture of the pavement surface following application. Ensure that the thickness of the material furnished is within 2 mils of the thickness of the material submitted for approval. Use tape with a minimum width of 4 inches.

831.02.05 Miscellaneous Requirements. Ensure that the supplied material is of good appearance, free from cracks, with edges true, straight, and unbroken. Make the material available in rolls with no more than 3 splices per 50 yards of length. Package the material according to accepted commercial standards. Ensure that the supplied material is capable of being stored at temperatures up to 100 °F for a period of one year after purchase without adversely affecting the physical properties stated in this section.

831.03 APPROVAL. The Department will approve temporary marking tapes based on conformance to KM 64-207 and the requirements of this section. The Department may remove temporary marking tapes from the Department's List of Approved Materials for poor field performance in Kentucky.

831.04 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of approved temporary marking tapes delivered for use on projects. Clearly state the manufacturer, product name, product code and color as listed in the Department's List of Approved Materials. Identify the lot number(s), expiration date and quantity delivered.

831.05 ACCEPTANCE. The Department will accept temporary marking tapes based on verification of inclusion on the Department's List of Approved Materials, compliance of the manufacturer's certification, verification the expiration date will not be exceeded, and visual inspection of the temporary marking tape installation. The Department reserves the right to sample and test temporary marking tape, at the discretion of the Engineer, in accordance with the Department's Field Sampling and Testing Manual.

SECTION 832 — SIGN POSTS

832.01 GENERAL. This section covers the material requirements for Type I and II sign posts. Type I posts are perforated square steel tube (PSST) sign posts. Type II posts are U-channel sign posts. Provide posts in lengths as specified in one foot increments with a tolerance of \pm one inch.

Sign support systems shall be successfully crash tested in accordance with NCHRP Report 350 or be Manual for Assessing Safety Hardware (MASH) certified.

Ensure that posts are straight, smooth, and free from any defects affecting their strength, durability, or appearance. Ensure that all holes and ends are free from burrs and sharp edges and that ends are cut square.

832.02 TYPE I SIGN POSTS. Use hot rolled carbon sheet steel of structural quality that conforms to ASTM A 1011, Grade 50 minimum. Posts shall have a minimum yield strength of 60,000 psi after cold-forming.

832.02.01 Fabrication. Fabricate the post from square tube formed of steel, rolled to size and welded directly in the corner by high frequency resistance welding and externally scarfed to agree with corner radii. Provide the following sizes:

Outside Dimensions (in.)	Corner Radii (in.)	Wall Thickness Gauge (in.)	Weight (lb/ft)
2 by 2	5/32	12 (0.105)	2.42
2 ¼ by 2 ¼	5/32	12 (0.105)	2.77
2 ½ by 2 ½	5/32	12 (0.105)	3.14

Provide 7/16-inch diameter holes on the centerline of all 4 sides, space on one-inch centers along the entire post length beginning 1 inch from the top. Ensure holes are in true alignment and opposite each other directly and diagonally.

Ensure consecutive sizes of square tubes will freely telescope for 10 feet or more of their length without the necessity of matching any particular face to any other face.

832.02.02 Finish. Conform to ASTM A 653, G90, Structural Quality, Grade 340, Class 1. Galvanize both the interior and the exterior of the post. Coat the corner weld with zinc after the scarifying operation. Coat the steel with a chromate conversion coating and a clear organic polymer topcoat.

832.02.03 Tolerances. The Department may reject material falling outside any of the following tolerances:

- A) **Outside Dimensions.** \pm 0.010 inch. Measure at least 2 inches from the end of the tube.
- B) **Wall Thickness.** \pm 0.011 inch.
- C) **Holes.** \pm 0.016 inches in diameter.
- D) **Convexity and Concavity.** Ensure that no sides exceed \pm 0.01 inch. Measure in the center of the flat side relative to the corner.
- E) **Square.** Ensure sides are 90 degrees to each other within \pm 0.015 inch.
- F) **Twist.** Ensure twist does not exceed 0.075 inch in any three-foot length.
- G) **Straight.** Ensure deviation does not exceed 1/16th of an inch in any three-foot length.
- H) **Corner Radii.** 5/32 \pm 0.016 inch.

832.02.04 Type D Breakaway Supports. When omni-directional breakaway supports are required for Type I posts, use Type D breakaway supports from the Department's List of Approved Materials.

832.03 TYPE II SIGN POSTS. Use hot wrought steel conforming to the physical properties of ASTM A 499-89, Grade 60 minimum, and conforming to the chemical requirements of ASTM A 1 for rails of nominal weight of 91 lbs per yard or greater. Posts shall have a minimum yield strength of 60,000 psi. For permanent sign installations, use Type II posts that weigh 3 lbs/ft.

Type II sign posts that do not comply with these properties may be furnished if approved by the Engineer. If alternative posts are desired, submit a written request for approval and include a description of the physical and chemical properties of the proposed sign posts. Include documentation that the proposed sign support system has been successfully crash tested in accordance with NCHRP Report 350 or Manual for Assessing Safety Hardware (MASH) certified.

832.03.01 Fabrication. Fabricate posts from uniform, modified, flanged channel sections.

Provide 3/8-inch diameter holes on the centerline, space on one-inch centers along the entire post length beginning one inch from the top. Align holes horizontally and vertically to accommodate back to back post installations.

Ensure that the area of contact between the posts and sign is symmetrical about the vertical axes of both sign and post and that the back side furnishes a solid bearing surface the entire length of the post for back to back installation.

832.03.02 Deflection. Test for deflection as simple beams, with the flanges in compression, on non-restricting supports 2 feet apart. Apply a load of 3,500 pounds at the center of the span at a deflection rate not to exceed 0.3 inch per minute. Transmit the load to the beam through a one-inch minimum diameter pin laid across the flanges. With the designated load applied, ensure that the deflection at the center does not exceed 0.18 inch. One minute after removal of the load, ensure that the deflection does not exceed 0.018 inch.

832.03.03 Finish. Galvanize according to ASTM A 123 after fabrication.

832.03.04 Lap Splices. If splicing of Type II posts is desired or necessary (based on manufacturer's recommended installation procedures), provide recommended splice detail from the post manufacturer. Splices shall be successfully crash tested in accordance with NCHRP Report 350 or be Manual for Assessing Safety Hardware (MASH) certified. Splicing of Type II posts shall require the approval of the Engineer.

832.03.05 Omni-Directional Breakaway Supports. When omni-directional breakaway supports are required for Type II posts, use supports that are recommended by the post manufacturer of the posts. Omni-directional supports shall be successfully crash tested in accordance with NCHRP Report 350 or be Manual for Assessing Safety Hardware (MASH) certified. Use of omni-directional breakaway supports with Type II posts shall require the approval of the Engineer.

832.04 PACKAGING. Securely fasten posts of the same type and length in bundles of 2,000 pounds or less in a manner that is easily handled by a fork lift and that prevents slipping during handling and shipping. The Engineer will reject posts whose finish is excessively damaged due to slipping, rubbing, or other reasons.

832.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of sign posts. Include documentation regarding manufacturer's recommended installation procedures and NCHRP 350 compliance or MASH certification. Provide manufacturer's certification to the requirements of this section for any splicing or omni-directional breakaway supports used

with Type II posts.

832.06 ACCEPTANCE. The Department will accept sign posts based on conformance of the manufacturer's certification. The Department reserves the right to sample and test sign posts at the Engineer's discretion.

SECTION 833 — SIGN SUBSTRATES

833.01 ALUMINUM.

833.01.01 Panel Signs. Conform to ASTM B 221, Alloy 6063-T6. Fabricate signs from 12-inch wide extrusions and, if specified, compatible 6-inch wide extrusions. When a 6-inch extrusion is specified, use it as the bottom panel of the sign. Typical cross sections and minimum weights per foot are specified in the Plans. Use compatible side extrusions on all sign edges. Prepare surfaces of extrusions composing the sign face to receive retroreflective background material according to the extrusion and retroreflective material manufacturers' recommendations. Provide all remaining surfaces of extrusions and side extrusions with a soft matte finish.

833.01.02 Sheeting Signs. Conform to ASTM B 209, Alloy 6061-T6 or 5052-H38. Fabricate signs of the size and shape specified. Provide a thickness of 125 mils if any single edge dimension of the sign exceeds 3 feet. If no single edge dimension exceeds 3 feet, provide a thickness of 80 mils. Prepare the side of the sheet to be used as the sign face to receive retroreflective background material according to the sheeting and retroreflective material manufacturer's recommendations.

SECTION 834 — LIGHTING

834.01 GENERAL. This section covers the requirements for lighting materials. Materials shall be approved by Engineer prior to utilization on a project. Certain lighting materials are included on the Department's List of Approved Materials.

834.02 CONCRETE. Use Class A concrete. Conform to Subsections 601.02 and 601.03.

834.03 STEEL REINFORCEMENT. Steel reinforcement shall have minimum yield strength of 60,000 psi and meet ASTM A615.

834.04 GROUND RODS. Provide composite shaft ground rods consisting of a pure copper exterior that has been inseparably, molten-welded to a steel core. Use copper-clad style ground rods with a minimum plating thickness of 10 mils. Rods shall be certified to conform to ANSI/NEMA GR1. Equip the rods with copper or bronze clamps that are the correct size for the rod being used.

834.04.01 Conventional Poles, Lighting Cabinets, and Services. Use rods with a minimum diameter of 5/8 inch and a minimum length of 8 feet.

834.04.02 High Mast Lighting Poles. Use rods with a minimum diameter of 3/4 inch and a minimum length of 10 feet.

834.05 CONDUIT. Ensure the conduit is the size specified on the plans and detail sheets.

834.05.01 Rigid Steel and Fittings. Provide conduit from the Department's List of Approved Materials. Use rigid steel conduit fittings that: are zinc coated, meet the requirements of ANSI C-80.1, and have UL6 Certification.

834.05.02 Schedule 40/80 PVC and Fittings. Provide conduit from the Department's List of Approved Materials. Use schedule 80 polyvinyl chloride fittings having the same chemical and physical properties as the conduit with which it is to be used and meeting the requirements of UL 514B. Use joints that are made in accordance with the manufacturer's recommendations. Each conduit and fitting shall bear the Underwriters Laboratories, Inc. label. Other components shall conform to the following: Boxes UL514C, Covers UL514D, and Enclosures UL50. All PVC bushings shall be end bell type.

834.05.03 Stainless Steel and Fittings. Use stainless steel meeting the requirements of ASTM A240/A240M. Use joints that are made in accordance with the manufacturer's recommendations. Each conduit and fitting shall bear the Underwriters Laboratories, Inc. label.

834.05.04 Aluminum and Fittings. Use aluminum meeting the requirements of ANSI C80.5, and UL 6A. Use fittings meeting the requirements of NEMA 3R and UL 514B. Use joints that are made in accordance with the manufacturer's recommendations. Each conduit and fitting shall bear the Underwriters Laboratories, Inc. label.

834.05.05 Conduent. Use conduent that conforms to UL 514B and NEMA 3R. Fittings shall conform to UL6/ANSI C80.1 and shall be fabricated with the same materials as the conduit connected to it.

834.05.06 Conduit Straps. Use two-hole conduit straps. Fittings shall conform to UL6/ANSI C80.1 and shall be fabricated with the same materials as the conduit connected to it.

834.05.07 Test/Pipe Plugs. Provide test/pipe plugs that are galvanized steel, ABS plastic, or aluminum mechanical type with a wing nut for actuation of a compression plate and o-ring for a good seal. Provide the test/pipe plug with a rubber grommet that expands inside the conduit to seal the conduit.

834.06 DUCTED CABLE.

834.06.01 Cable. Use stranded annealed copper cable conforming to ASTM B8 and ASTM B3 and rated for 600 volts. Use material that conforms to either the applicable requirements of ICEA Standard S-19-81, with thermoplastic insulation of GRS rubber base conforming to Appendix K(A) of ICEA and listed by UL as Type USE-2 for direct burial; or the application requirements of ICEA Standard S-66-524, with thermo-setting insulation of cross link polyethylene conforming to the requirement of Column "A" of ICEA and listed by UL as Type USE-2. Use cable and conductors that are preinstalled in the duct. Outside insulation of wire shall state "PROPERTY OF KYTC 502-564-0501".

834.06.02 Duct. Use polyethylene duct with a minimum tensile strength of 3,000 psi for secondary cable underground. Provide for 40 percent maximum fill. Conform to NEMA TC7 EPEC-A. The color code of the duct shall be gray for DOT.

834.07 ELECTRICAL JUNCTION BOX (BELOW GROUND). Provide a junction box & cover that meets or exceeds ANSI/SCTE 77 2017, tier 15. Provide a junction box marked "Lighting". If junction box has signal and main service wires, the box shall be marked as "Lighting/Electric". Covers shall be attached with a minimum of two 3/8 inch stainless steel hex head lag bolts and washers. Stackable boxes are permitted. Use lids with a nonslip surface with pull slots for ease of removal.

834.07.01 Type A. The top dimension of the junction box shall be at least 25 inches by 15 inches. The depth shall be at least 27 inches. The cover shall be at least 2 inches in depth.

834.07.02 Type B. The top dimension of the junction box shall be at least 20 inches by 15 inches. The depth shall be at least 12 inches. The cover shall be at least 1 3/4 inches in depth.

834.07.03 Type C. The top dimension of the junction box shall be at least 38 inches by 26 inches. The depth shall be at least 30 inches. The cover shall be at least 3 inches in depth.

834.07.04 Aggregate. Use #57 aggregate below the depth of the junction box. The aggregate shall conform to AASHTO M43.

834.07.05 Geotextile Filter Fabric Type IV. Conform to Section 843.

834.08 ELECTRICAL JUNCTION BOX BARRIER WALL. Construct junction boxes from a 1/4 inch A36 steel plate and the junction box cover from a 1/8 inch A36 plate. Junction boxes shall be at least 2 feet 1/2 inch in length, 6 inches in height, and 9 3/8 inches in depth. The steel shall be bent inward on the top and sides so that the bolts/nuts can be installed for the cover. The bottom portion of the junction box shall have a 1/4 inch slope so that the junction box can drain on the bottom side. The cover shall be at least 2 feet 1/2 inch by 6 1/3 inches. There shall be at least five 1/2 inch holes added to the cover with three on the top of the cover at least 4 1/4 inches (8 inch spacing) from the side and one hole on each side, 4 inches from the top of the cover. All holes in the cover shall be at same location as the welded stainless steel nuts on the junction box. Provide boxes that have been galvanized in accordance with ASTM A123. Fittings shall be UL listed and CSA-certified concrete tight on the outside of the junction box conduit connection. Use 5 3/8 inches UNC x 1 inch stainless steel hex head bolts for the cover connection to the junction box. Five additional spare bolts shall be placed in each junction box. Each hex bolt shall have a corresponding tack weld 3/8 inch stainless steel nut connected to the 1 inch tab at the top/sides of the junction box. There shall be a 1/4 inch thick by 1 inch closed-cell neoprene gasket installed along the top and the sides that have bolts installed. All gaskets shall be attached to the junction box with an adhesive recommended by the manufacturer of the gasket. There shall be a 1/8 inch by 1 1/2 inch by 1 1/2 inch mounting tab with a 1/2 inch hole welded to the box on each top side of the junction box. There shall be conduit knockouts for the conduit that is required in the contract.

834.09 ELECTRICAL JUNCTION BOX ABOVE GROUND. Construct junction boxes from a 1/4 inch A36 steel plate and the junction box cover from a 1/8 inch A36 plate. The junction box shall be at least 8 inches in length, 6 inches height, and 4 inches in depth. Fittings shall be UL listed and CSA-certified concrete tight on the outside of the junction box conduit connection. Use a sealing lock nut and a conduit bushing on the inside for all conduit penetrations. Grounding lug shall be installed on the side wall of the junction box. The lug should be centered and be sized to receive all the wire sizes that are indicated on the plan sheet. Boxes shall have no knockouts or as required. Use at least four 3/8 inch UNC by 1 inch stainless steel hex head bolts for the cover connection to the junction box. Four additional spare bolts shall be placed in each junction box. If a box is enlarged, additional bolts, equally spaced along the rim of the box, shall be required. Each hex bolt shall have a corresponding tack weld 3/8 inch stainless steel nut connected to the 1 inch tab at the top of the junction box. If a larger box than the above dimensions is utilized, contact the Division of Traffic Operations for verification of preferred bolt pattern. There shall be a 1/4 inch thick by 1 inch closed-cell neoprene gasket installed along the top that has bolts installed. All gaskets shall be attached to the junction box with an adhesive recommended by the manufacturer of the gasket.

834.10 WIRE. For all multiple circuit roadway lighting wires, use single-conductor AWG copper wire of sizes specified in the Contract. Use stranded wire for all circuit conductors, except for ground wires connected directly to ground rods, between bushings, and connected to electrical cabinets. Outside insulation of wire shall state "PROPERTY OF KYTC 502-564-0501".

834.10.01 Conventional Lighting. Use No. 12 AWG copper wire as leads and grounding from pole bases to luminaire head. Use a green insulated grounding conductor from the grounding system to the grounding terminal in luminaire. All wire shall be rated as Type USE-2 (UL rated) with the exception of wire that goes from the fuse connector kit to the luminaire head which can be TYPE THHN-2 or THWN-2 (UL rated).

834.10.02 High Mast Lighting. All wire shall be rated as Type USE-2 (UL rated) except for the electrical power cord that runs from the bottom of the high mast pole to the luminaire ring junction box. The high mast power cord shall be a four conductor #8 AWG or 3 conductor #10 AWG, type SO, extra flexible, rated for 600 volts.

834.10.03 Service. All wire shall be rated as Type USE-2 (UL rated). Install copper service entrance conductors on the service poles sized as specified by the NEC.

834.10.04 Markings and Color Code. All grounding conductors 6 AWG and smaller shall be insulated in green color per NEC for all circuit grounds.

834.10.05 Ground Wire. All grounding wires shall be #4 bare solid copper wire. This wire shall be connected to bonding bushings, ground rods, poles, services, and electrical cabinet grounds.

834.11 FUSED CABLE CONNECTOR KIT. Use a fused connector kit that completely encloses and protects the fuse against damage from water and weather. Use a spring loaded contact between the fuse and fuse holder. Ensure that the springs are not a part of the current carrying circuit. Ensure that line and load side terminals of the fused connector kit positively connect to the conductors. Ensure that the fused connector kit can be repeatedly disconnected without damage to the watertight seals and terminals or without a reduction in conductivity. Provide a fused connector kit designed to break away without damage. Construct the load side housing to retain the fuse when disconnected, and permanently mark it "LOAD" or "LOAD SIDE". Use fast-acting and high interrupting capacity type fuses with a rating of 6 amperes.

834.12 FUSES. Use fast-acting and high interrupting capacity type fuses. Use 13/32 inch by 1.5 inch fuses that are rated for 600 volts. Use fuses that protect circuits having a fault current capacity of up to 100,000 amperes AC. Use fuses tested to carry 110 % of their rated capacity and that open at 135% in one hour or less.

834.13 SPLICING. There shall be no split bolts allowed for circuit wiring. Terminals strips or ground lugs are allowed for grounding. The splices shall be waterproof and shall be of the correct size for the wire used.

834.13.01 Two or Multiple Way Splices. Use Raychem GTAP-2(B18) splice kit or approved equal.

834.13.02 One Way Splices. Use butt splices that are copper and of the correct conductor range. Vinyl mastic insulating pad shall be self-fusing, rubber-based insulating compound laminated to a flexible, all-weather grade PVC 7 mils backing per ASTM D1000. The pad shall be designed to insulate, moisture-seal, and pad all electrical connections up to 600 volts. Pad shall resist abrasion, moisture, alkalis, acids, copper corrosion, and varying weather conditions including sunlight. Pad shall be compatible with all solid dielectric cable insulations, and splicing compounds and shall be suitable for both indoor and outdoor applications over a temperature range of zero degrees to 100 degrees F without loss of physical or electrical properties. Pad shall also meet ASTM D257 and D570 for composite backing and mastic. Pad shall be 3M 2200 series or approved equal. Use 3M brand #88 electrical tape or approved equal.

834.14 MARKERS FOR BURIED CABLE. Use 24 inches by 24 inches by 4 inches deep pre-cast concrete markers with letters, numbers, and arrows cast in the concrete. Impress the word "Lighting", appropriate directional arrow, and circuit identification number on each marking slab. Use letters that are neat, clearly legible, and approximately 4 inches high and 3 inches wide. Ensure that the stroke is 0.5 inch wide and 0.25 inch deep. Do not pour markers in place or chisel letters in concrete. No substitution of rural Right of Way markers will be allowed. Class A concrete shall be used.

834.15 LIGHTING POLES. Lighting pole design shall be in accordance with loading and allowable stress requirements of AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 2013-Sixth Edition with current interims. Provide materials and products that are manufactured in the United States of America. Luminaire poles shall meet or exceed 2014 NEC Sections 410.30 and 410.64. Mounting hardware shall meet or exceed ASTM F1554-7e1, grade 55 with a yield strength of 105 KSI.

Install a 4 inch by 4 inch Arc Flash Warning sticker on the center of the outer side of the handhole cover. The sticker shall be a Metalcraft PLY695 Premium STYLEMARK label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC53FL pressure sensitive adhesive. The sticker shall have two colors of black and custom color orange.

834.15.01 Conventional Poles. Provide conventional poles that consist of a tapered pole having a base affixed to the lower end, a bracket arm (if required), and a transformer base. Furnish an opening near the top of the pole to provide for a cable entrance from the pole to the bracket arm to provide a smooth cable guide (rubber grommet) for wiring. Equip the top of the pole with a weatherproof, removable top cap shall with stainless steel fasteners. Provide this base with four slotted holes to receive the anchor bolts and four tapped holes for securing the bolt covers. Also provide four removable bolt covers. A ground lug shall be located immediately opposite the hand hole and shall be tapped for a 3/8 inch 16 UNC ground bolt. A ground lug shall be supplied with the pole. All poles shall have a vibration dampening system. Ensure that the pole manufacturer provides permanent marking on the pole base or other suitable location, giving the pole design number and other identification data so poles may be compared with material brochures or drawings. Provide each pole with a 4 inch by 6 inch handhole at a height of between 12 inches and 18 inches above the pole base. Provide an aluminum handhole cover secured with stainless steel screws. If the pole is used for a top mounted fixture, the tenon shall be sized according to the manufacturer of the fixture being installed. The minimum diameter of the tenon shall be 1 1/4 inch.

Provide a detailed analysis and schematic of the pole that is stamped and certified by a Professional Engineer licensed in the Commonwealth of Kentucky. The detailed analysis shall include, but not be limited to, the following calculations:

- 1) Group I, II, and III load combinations as listed in Table 3.4-1 of the AASHTO Standard Specifications.
- 2) Dimensions and weights for all attachments. This includes areas used for: wind, ice (total exterior area of the attachments) and fatigue loads, drag coefficients, projected areas, velocity pressures, and wind forces for each segment.
- 3) For group loads II and III, which have wind loads, calculations for controlling "worst case" wind direction for any aspect of the design (anchor bolts, pole sizing, etc.). Loads shall be positioned to produce maximum effect. Wind load is applied in the same direction as the tension.

- 4) All structural properties for poles, anchor bolts, and base plates. This includes the pole's diameter, thickness, section modulus, moment of inertia, and cross sectional area.
 - 5) Calculations for each member including: loads, section properties, member forces (axial, shear, bending, and torsion), member deflections (angular and 835-3 linear), member stresses (actual and allowable), and the combined stress ratio (csr).
- A) **Aluminum Poles.** Shall be constructed of spun-tapered seamless 6061 or 6063 alloy aluminum tubing that is heat treated to meet a T6 temper. A weatherproof, removable top cap shall be provided with stainless steel fasteners. Pole anchor base shall be cast from A356 alloy aluminum and shall be heat treated to meet a T6 temper. All hardware pertaining to the pole shall be stainless steel fasteners. Welding shall conform to the latest edition of ANSI/AWS D1.2, Structural Welding Code-Aluminum (2014). Workmanship requirement of Class I structures shall be specified for tubular support structures. Class II workmanship requirements may be specified where more rigid controls are desired.
- B) **Steel Poles.** Shall be constructed of commercial quality carbon steel tubing with a minimum yield of 55,000 psi. Pole shaft shall conform to ASTM A595 Grade A. Pole shaft shall have a uniform wall thickness of 11 gauge (0.1196 inch). Pole anchor base shall be fabricated from carbon steel plate that conforms to ASTM A36. All hardware pertaining to the pole shall be stainless steel or galvanized zinc fasteners. All welds shall be structural welds. Welding design and fabrication shall be in accordance with the AWS Structural Welding Code D1.1-Steel (2015).
- C) **Stainless Poles.** Shall be constructed of commercial quality stainless steel tubing. Pole shaft shall conform to ASTM A240/A240M Grade-201LN and shall have a uniform wall thickness of 12 gauge (0.1196 inch). A weatherproof, removable top cap shall be provided with stainless steel or galvanized zinc fasteners. Pole anchor base shall be fabricated from stainless steel plate that conforms to ASTM A240/A240M Grade-201LN. All hardware pertaining to the pole shall be stainless steel or galvanized zinc fasteners. Luminaires shall have a maximum EPA of 1.5 square feet and a maximum weight of 40 pounds. All welds shall be structural welds. Welding design and fabrication shall be in accordance with the AWS Structural Welding Code D1.6-Stainless Steel (2007).

834.15.02 Brackets. Use single member bracket arms for 4 foot and 6 foot mast arm assemblies. Use single or double member bracket arms for 8 foot mast arm assemblies. Use double pipe assemblies for 10, 12, and 15 foot mast arm assemblies. Double pipe assemblies consist of upper and lower members securely joined by means of vertical struts. Provide the pole end of the bracket arm with a cast or plate footing or clamp for positioning the assembly on the pole. The attachment point from arm to pole shall provide a weather resistant raceway for wiring (rubber grommet).

- A) **Steel.** All welds shall be structural welds. Welding design and fabrication shall be in accordance with the AWS Structural Welding Code D1.1-Steel (2015). Arm shall be made from ASTM A595 Grade-A steel and supplied in 11 gauge (0.1196 inch) thickness.

The arm and pole plates shall be constructed of hot rolled carbon steel meeting structural conditions of ASTM A36. High strength structural hex head

bolts, lock washers, and flat washers of galvanized or stainless steel shall be used to attach the arm to the pole.

- B) Aluminum.** Welding shall conform to the latest edition of ANSI/AWS D1.2, Structural Welding Code-Aluminum (2014). Workmanship requirement of Class I structures shall be specified for tubular support structures. Class II workmanship requirements may be specified where more rigid controls are desired.

The arm and pole plates shall be constructed of spun-tapered seamless 6061 or 6063 alloy aluminum tubing and shall be heat treated to meet a T6 temper. The attachment point from arm to pole shall provide a weather resistant raceway for wiring (rubber grommet). All hardware pertaining to the pole shall be stainless steel fasteners. Arm anchor base shall be cast from A356 alloy aluminum. The anchor base shall be heat treated to meet a T6 temper.

- C) Stainless Steel.** All welds shall be structural welds. Welding design and fabrication shall be in accordance with the AWS Structural Welding Code D1.6-Stainless Steel (2007). Bracket shall conform to ASTM A240/A240M Grade-201LN and have a uniform wall thickness of 12 gauge (0.1196 inch). The arm and arm plates shall be constructed of ASTM A240/A240M Grade-201LN structural quality stainless steel. High strength structural hex head bolts of galvanized or stainless steel shall be used to attach the arm to the pole. The attachment point from arm to pole shall provide a weather resistant raceway (rubber grommet) for wiring.

834.15.03 Transformer Bases. Provide aluminum bases that conform to AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 2013-Sixth Edition with current interims. Ensure that each base has the following outside dimensions (+/- 1 inch): 17 inches high, 15 inches by 15 inches square bottom, and 12 inches by 12 inches square top. Ensure that bases have a trapezoidal door with the following minimum dimensions (+/- 1 inch): 11 inches high, 9 inches across the bottom, and 7.5 inches across the top. Construct the door of a high density polyethylene material in a color that matches the base. Provide each base with four of the following galvanized steel components: loose bearing plates (anchor washers), lock washers, and connecting bolts/nuts. Use connecting bolts of the same diameter and strength as the anchor bolts. Submit mill test reports on the connecting bolts. The manufacturer shall specify the bolt circle and physical dimensions of the base bottom to ensure a proper foundation fit. Provide each transformer base with a 1/2 inch, 13 UNC tapped hole or other suitable provisions for grounding purposes.

Install a 4 inch by 6 inch Arc Flash Warning sticker centered at the top on the outside of each door. The sticker shall be Metalcraft PLY695 Premium STYLEMARK label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC53FL pressure sensitive adhesive. The sticker shall have two colors of black and custom color orange. The wording on the arc flash sticker shall be: "WARNING. Arc Flash Hazard. Appropriate PPE required. Failure to comply can result in death or injury. Refer to NFPA 70E."

834.15.04 High Mast Poles. Use loading based on a basic wind speed of 90 mph with a design life/recurrence interval of 50 years and designed to fatigue category of I.

Use welds that are in accordance with sections 1 through 8 of the American Welding Society (AWS) D1.1 Structural Welding Code-Steel (2015). Use tackers and welders that are qualified in accordance with the code. Use tube longitudinal seam welds that are free of cracks and excessive undercuts, performed with automatic processes, and visually

inspected. Inspect longitudinal welds with magnetic particle examination techniques. Inspect ultrasonically and radiographically the circumferential butt welded pole and arm splices.

Provide calculations and drawings that are stamped and certified by a Professional Engineer licensed in the Commonwealth of Kentucky.

Provide poles on the Contract that are of the same design and manufacturer. Use poles that are designed for twelve fixtures per pole. Use the combined effective projected area (EPA) and weight of the fixtures and lowering device that are determined by the fixture manufacturer.

Provide calculations that include the pole, base plate, and anchor bolt analysis. Provide pole calculations that are analyzed at the pole base, along the pole at 5 foot intervals, and at each slip joint splice. A detailed analysis of the pole shall be submitted. The detailed analysis shall include, but not be limited to, the following calculations:

- 1) Provide Group I, II, III, and IV load combinations as listed in Table 3.4-1 of the AASHTO Standard Specifications.
- 2) Provide dimensions and weights for all attachments. This includes areas used for wind, ice and fatigue loads, drag coefficients, projected areas, velocity pressures, and wind force for each segment.
- 3) For Group Loads II, III, and IV, which have wind loads, provide calculations for each controlling "worst case" wind direction that controls any aspect of the design (anchor bolts, pole sizing, etc.).
- 4) Provide all structural properties for poles, anchor bolts, and base plates. This includes the pole's diameter, thickness, section modulus, moment of inertia, and cross sectional area.
- 5) Calculations for each member shall include loads, section properties, member forces (axial, shear and bending), member deflections (angular and linear), member stresses (actual and allowable), and the combined stress ratio (CSR).
- 6) Fatigue calculations shall be shown for all fatigue related connections. Provide the corresponding detail, stress category, and example from Table 11.9.3.1-1 in the AASHTO Standard Specifications. In fatigue calculations, the effective throat thickness of a complete joint penetration groove weld shall be the thickness of the thinner part joined per AISC J2.1a.

Provide a pole section that conforms to ASTM A595 Grade A with a minimum yield strength of 55 KSI or ASTM A572 with a minimum yield strength of 55 KSI. Use tubes that are round or 16 sided with a 4 inch corner radius, a constant linear taper of 0.144 inches/foot, and that contain only one longitudinal seam weld. Circumferential welded tube butt splices and laminated tubes are not permitted. Provide pole sections that are telescopically slip fit assembled in the field to facilitate inspection of interior surface welds and the protective coating. The minimum length of the telescopic slip splices shall be 1.5 times the inside diameter of the exposed end of the female section. Use longitudinal seam welds as recommended in Section 5.15.2 of the AASHTO Standard Specifications. The thickness of the transverse base shall not be less than 2 inches. Plates shall be integrally welded to the tubes with a telescopic welded joint or a full penetration groove weld with backup bar.

The handhole cover shall be removable from the handhole frame. On the frame side, opposite the hinge, provide a mechanism on the handhole cover/frame to place the Department's standard padlock as specified in Subsection 834.26. The handhole frame shall have two stainless studs installed opposite the hinge to secure the handhole cover. Secure cover with stainless steel wing nuts and washers. The handhole cover shall be manufactured from 0.25 inch thick galvanized steel (ASTM A153) and have a neoprene rubber gasket that

is permanently secured to the handhole frame to insure weathertight protection. The hinge shall be adjustable and manufactured from 7 gauge stainless steel. The minimum clear distance between the transverse plate and the bottom opening of the handhole shall not be less than the diameter of the bottom tube of the pole but needs to be at least 15 inches. Provide materials that are hot-dip galvanized to the requirements of either ASTM A123 (fabricated products), ASTM A153 (hardware items), or ASTM F2329.

834.16 LOWERING DEVICE FOR HIGH MAST POLES. Use a head frame assembly that is fabricated from galvanized structural steel or stainless steel. The head frame assembly shall mount to the high mast pole tenon and shall be secured with stainless steel set screws. Ensure compatibility between the lowering device and pole. Provide a head frame assembly that is stop latched with three lifting cables used to raise and lower the luminaire ring. For lifting cables, use 0.18 inch diameter stainless steel 19 x 7 or 7 x 19 Strand Core aircraft cables manufactured according to MIL W-83140 or approved equal. Support each lifting cable by two sheaves (pulleys) that are manufactured of cast steel, forged steel, or molybdenum disulfide reinforced nylon and supported by smooth stainless steel shafts. Machine the sheave groove 0.007 inch larger than the nominal diameter of the cable. Use sheaves that incorporate oil impregnated sintered bronze bushings. Provide a head frame assembly cover, shaped to shed water, that is constructed of copper free spun aluminum or clear UV stabilized acrylic. Support power cord by a minimum of seven Teflon or Delrin rollers. Terminate cord with a 4 conductor 50 AMP twist lock connector on the free end and 600 volt terminal block in the ring enclosure. Provide a single throw, double pole breaker with a 100 AMP frame for 480 volt operation. Amperage rating shall be 15A for towers with four or less luminaires, 20A for towers with six luminaries, and 30A for towers with eight to ten luminaires.

834.16.01 Luminaire Ring. Provide a luminaire ring that is constructed of 6 feet by 2 feet galvanized structural steel. Prewire the luminaire ring and include a weatherproof junction box and test receptacle for ground level testing of the luminaires. If a special cable is required for ground level testing, supply one cable with each portable power unit specified on the contract. Provide a ring that includes the appropriate number of installed 2 inch steel luminaire mounting tenons. Provide a luminaire ring that has spring loaded iris arms or spring loaded rollers to keep the ring concentric around the pole during raising and lowering. Design the iris arms as shown on the specification sheets in the plans. Provide spring and spring mounting hardware that are stainless steel. Provide a latching mechanism that consists of three high strength, marine grade aluminum latch housings and three stainless steel latch pins. Each latch will include a spring to compensate for pole deflection. Latching and unlatching shall be accomplished by alternately raising and lowering the luminaire ring. Latching may also be accomplished by rotation of the latch pin or travel of the pin through a mechanical circuit. Provide latch housing that are an enclosed design with the only opening at the bottom. Provide housing with a flared entrance bell to align the latch pin. Include a reflective indicator flat that indicates when the latching is complete.

834.16.02 Winch Assembly. Provide a winch assembly that consists of a winch drum and gearbox mounted in the pole and an external power unit. Provide a winch that has a load rating of at least 1,200 pounds with a gear ratio of not less than 30:1. Include a failsafe brake system to prevent freewheeling of the winch drum. Provide a portable external power unit that consists of a drill motor, torque limiter, step down transformer for 480 volt operation, and a remote switch. The remote switch shall have a cord that is 20 feet long so that the operator can back away from the pole. Ensure the power and winch unit are fully compatible with the Holophane LD-5 portable lowering device or approved equal.

834.17 ANCHOR BOLTS. The anchor bolt design shall follow NCHRP Report 494 Section 2.4 and NCHRP 469 Appendix A specifications. Anchor bolts shall be designed for the orientation that would provide the maximum stress on any individual bolt. Use anchor bolts that conform to the requirement of ASTM F1554-7e1. Hooked smooth anchor bolts shall be Grade 55 while straight headed bolts may be Grade 55 or 105. Anchor bolts shall be fully galvanized. Provide each anchor bolt with two galvanized hex nuts as well as one flat and one lock washer. Provide nuts that equal or exceed the proof load of the bolts strength. Provide bolts that are hot-dip galvanized to the requirements of either ASTM A123 (fabricated products), ASTM A153 (hardware items), or ASTM F 2329 (hardware items). Protect anchor bolt threads from damage during shipping. Provide Mill Test Reports on anchor bolts.

834.18 LUMINAIRES. Use luminaires that provide light levels conforming to AASHTO's Roadway Lighting Design Guide, 2005 Edition with current interims.

834.18.01 Conventional. Provide luminaires that are arranged for IES type II distribution or as otherwise specified in the contract. Provide a 2 inch slip-fitter for mounting. Mainline fixtures shall be 250 watt HPS or LED equivalent and shall be mounted on 40 foot poles. Ramp fixtures shall be 150 watt HPS or LED equivalent and shall be mounted on 30 foot poles.

- A) **High Pressure Sodium.** Provide a waterproof sticker mounted on the bottom of the housing that is legible from the ground and that indicates the wattage of the fixture by providing the first two numbers of the wattage. The types of HPS luminaires are as follows:

Type A - 100 watt high-pressure sodium horizontal roadway luminaires
Type B - 150 watt high-pressure sodium horizontal roadway luminaires
Type C - 250 watt high-pressure sodium horizontal roadway luminaires
Type D - 400 watt high-pressure sodium horizontal roadway luminaires

- B) **Light Emitting Diodes.** Provide a waterproof sticker mounted on the bottom of the housing that is legible from the ground and that indicates the type and the IES pattern of the fixture.

Type A - LED equivalent to 100 watt HPS horizontal roadway luminaires
Type B - LED equivalent to 150 watt HPS horizontal roadway luminaires
Type C - LED equivalent to 250 watt HPS horizontal roadway luminaires
Type D - LED equivalent to 400 watt HPS horizontal roadway luminaires

834.18.02 High Mast. Fixtures shall be 1,000 watt HPS/LED equivalent mounted on 100/120 foot poles or 400 watt HPS/LED equivalent mounted on 80 foot poles with lowering devices. Provide luminaires that meet the following criteria:

- 1) Average maintained: 0.60 to 0.80 foot-candles on roadway surface
- 2) Minimum maintained: 0.20 foot-candles on roadway surface
- 3) Uniformity ratio: $\leq 4:1$ on roadway surface

Provide a 0.20 isofootcandle trace covering all roadway surfaces. Provide the trace from taper to taper on each mainline and crossroad. All criteria must be met with original locations of poles on the plan sheet.

Use high mast luminaires that are of the same manufacturer on the same project. Use specified number of luminaires per pole. Adding luminaires to the pole shall not be allowed.

- A) **High pressure sodium.** Provide luminaires that are arranged for IES type II distribution or as otherwise specified in the contract. Provide a waterproof sticker mounted on the side of the housing that is legible from the ground and that indicates the wattage of the fixture by providing the first two numbers of the wattage. Use a total light loss factor of 0.65 for closed fixtures and 0.80 for open bottom fixtures.
- B) **Light Emitting Diodes.** Provide luminaires that are arranged for IES type II or V distribution or as otherwise specified in the contract. Provide a waterproof sticker mounted on the side of the housing that is legible from the ground and that indicates the wattage of the fixture by providing the first two numbers of the wattage.

834.18.03 Light Emitting Diode (LED) Luminaires.

A) **Specifications.** Specifications for LED luminaires are as follows:

- 1) Luminaires shall be listed by a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. The testing laboratory must be listed by OSHA in its scope of recognition for the applicable tests being conducted as required by this specification. A list of recognized testing labs for products sold in the United States may be found on the U.S. Department of Labor's web site: <http://www.osha.gov/>.
- 2) Luminaires shall be listed and labeled by a NRTL or CSA as being in compliance with UL 1598 and as being suitable for use in wet locations.
- 3) Key components, including LED drivers, LED light sources, and surge protection devices, shall be RoHS compliant.
- 4) Luminaires shall have an International Electrotechnical Commission (IEC) 529 Ingress Protection (IP) rating of IP 65 or greater.
- 5) Luminaires shall be in compliance with Electro Magnetic Interference (EMI) requirements as defined by FCC 47 Sub Part 15; CISPR15, CISPR22 Class A (120 volt min.), EN61000-3-2, 3-3, 4-4, and 4-5.
- 6) Luminaires shall be tested according to the most current version of Illuminating Engineering Society of North America (IESNA) LM-79.
- 7) Luminaires shall have lumen maintenance measured in accordance the most current version of IESNA LM-80.
- 8) Luminaires shall have long term lumen maintenance documented according to the most current version of IESNA TM-21.
- 9) Fixtures shall have a die-cast aluminum housing.
- 10) Finish of luminaires shall be corrosion resistant with a polyester powdercoat of 2.5 mil nominal thickness. Finish shall pass per ASTM D1654 after 3,000 hours of testing per ASTM B117.
- 11) All hardware on the exterior of the housing, including cover and latch, shall be stainless steel, zinc, or steel with zinc alloy electroplate and chromate top coat.
- 12) Luminaires shall be easy to open when properly mounted and shall have readily accessible internal parts. Tools shall not be required to access all internal parts.

- 13) Luminaires shall have a vibration rating of 3G per the American National Standard (ANSI) IEEE C136.31, Table 2 Roadway Lighting Equipment-Luminaire Vibration for normal, bridge, and overpass applications.
- 14) Luminaire shall be designed to allow water shedding.
- 15) Luminaire shall have a passive cooling method to manage thermal output of LED light engine and power supply.
- 16) Luminaires shall have a label per ANSI C136.22 that states operating voltage and current range. The label must be clearly visible on the inside of the housing.
- 17) Luminaires shall fully operate in a temperature range of -40 degrees C up to 40 degrees C (-40 degrees F to 104 degrees F).
- 18) Luminaires shall have an integral power supply (electronic driver). The power supply shall not have a manual, field-adjustable setting for current output.
- 19) Luminaires shall have a power supply (electronic driver) that will operate on a 480 volt single phase at 60 hertz.
- 20) Luminaires shall have a power supply (electronic driver) that has a power factor of 0.90 or greater at full load.
- 21) Luminaires shall have a power supply (electronic driver) that has total harmonic distortion of 20% or less at full load.
- 22) Luminaires shall have power supply (electronic driver) output ripple of less than 10%.
- 23) Luminaires shall have power supply (electronic driver) with a rated life of 100,000 hours with a luminaire operated at an ambient temperature of 25 °C (77 °F).
- 24) Luminaires shall have an isolated power supply (electronic driver) output.
- 25) Luminaires shall have a power supply (electronic driver) that has thermal overload protection.
- 26) Luminaires shall have a power supply (electronic driver) that is self-limited short circuit protected and overload protected.
- 27) Luminaires shall not use any active thermal cutback in order to achieve a higher thermal performance.
- 28) Luminaires shall have a power supply (electronic driver) that is terminated with quick disconnect wire harnesses for easy maintenance. Wire nut termination is not acceptable.
- 29) Luminaires shall have a terminal block for terminating wiring to the luminaire. The terminal block shall be a 3 station, tunnel lug terminal board that will accommodate #6 thru #18 AWG pole wire.
- 30) Fixtures shall have a surge protection that meets 10KV/5KA per ANSI/IEEE C62.41.
- 31) Luminaires shall have life rating on all electrical components of 100,000 hours or greater when operated at full lumen output at 25 degrees C.
- 32) All LED components shall be L70 rated when operated in a luminaire at 25 degrees C (77 degrees F) at 100,000 hours.
- 33) Electrical components shall be protected per ANSI/IEEE standard C62.41 for Class C applications.
- 34) LEDs shall fully operate in a temperature range -40 degrees C to 40 degrees C (-40 degrees F to 104 degrees F).
- 35) LEDs shall lose no more than a 15% optical intensity of initial delivered lumens due to thermal loading when operated at 25 °C (77 °F).
- 36) LEDs shall deliver an average 80% of initial delivered lumens after 70,000 hours of operation when operated at 25 °C (77 °F).

- 37) LEDs shall have a rated life of 100,000 hours when operated at 25 °C (77 °F).
- 38) LEDs shall have a minimum Luminaire efficacy of 120 lumens/watt.
- 39) For conventional lighting, the Correlated Color Temperature (CCT) shall be 4000K with a variance of 250K, white, that conforms to LM-79. For high-mast lighting, the Correlated Color Temperature (CCT) shall be 5000K with a variance of 250K, white, that conforms to LM-79.
- 40) The minimum color rendering index (CRI) shall not be less than 70.
- 41) The optics shall have a completely sealed optical system.
- 42) The optical system shall have an International Electrotechnical Commission IP rating of 66 or greater.
- 43) Illuminating Engineering Society of North America (IESNA) Uplight rating shall not exceed 0.
- 44) The TM-21 Report must show the drive current used for the submitted luminaire. The report can show a larger drive current to represent a worst case scenario.
- 45) The Lumen Maintenance Life L80 from the TM-21 Report must not be below 80% at 70,000 hours and 25 °C (77 °F).
- 46) The manufacturer shall provide certified test laboratories IES photometrics which verify light levels. Product submittal shall be accompanied by IES TM-21 compliant test reports from a CALiPER qualified or NVLAP accredited testing laboratory for the specific model being submitted.
- 47) The luminaire shall be equipped with a shorting cap and a 7-pin photocontrol receptacle that meets ANSI 2013 standard C136.41.

B) Warranty. The Manufacturer shall ensure that the LED Luminaires have a minimum standard warranty of 10 years for all parts, materials, paint finish, and shipping (both ways) required to repair or replace the luminaire. The warranty shall begin upon the date the luminaire is received. The warranty shall be transferable. The warranty shall cover all failures including:

- 1) Failure in luminaire LED, housing, wiring, connections, and drivers.
- 2) More than 10 percent decrease in lumen output.
- 3) Significant change in light output color.

C) Technical Support. During the warranty period, technical support shall be available from the manufacturer via telephone within 24 hours of the time the call is made from the Department. This support shall be made available from factory certified personnel or factory certified installers at no additional charge to the Department.

D) Submittals. The minimum requirements of LED submittals are:

- 1) Luminaire specification sheet
- 2) LED driver specification sheet
- 3) LM-79 Luminaire photometric report
- 4) LM-79 in-situ test data to confirm thermal operating temperatures of the luminaire
- 5) LM-80 lumen maintenance report
- 6) TM-21 calculations as defined
- 7) Light Loss Factor (LLF). LLF shall be calculated for each fixture as follows:

$$LLF = LLD \times LDD$$

- LLD shall be the specified percentage of LED lumen maintenance at 70,000 hours at 25 °C (77 °F) from the Illuminating Engineering Society's LM-80 and TM-21 reports. These reports shall be submitted for verification.
 - LDD = 0.9
- 8) Uplight rating of the luminaire
 - 9) Written product warranty
 - 10) Certified test lab IES photometric reports
 - 11) IES electronic file
 - 12) Intensity and chromaticity data
 - 13) Instructions for installation and maintenance

834.19 LAMPS. Provide high-pressure sodium or light-emitting diode lamps with the following minimum initial light output:

- Type A - 9,500 lumens HPS or LED equivalent
- Type B - 16,000 lumens HPS or LED equivalent
- Type C - 28,000 lumens HPS or LED equivalent
- Type D - 50,000 lumens HPS or LED equivalent
- High Mast - 140,000 lumens or LED equivalent

834.20 BALLASTS. Provide a built in constant wattage transformer type ballast for specified voltage and wattage (high pressure sodium only).

834.21 STARTERS. Provide an igniter that is designed to work with all brands and types of 60 Hz HPS ballast and that directs the high voltage spike directly into the lamp without being directed to the lamp through the ballast windings. A cycling or extinguished lamp shall not adversely affect the igniter or the ballast. Provide an igniter that is totally epoxy encapsulated in a metal or plastic can. Ensure the igniter can be open circuit tested with power applied for 48 h at 100 °C with constant monitoring of the case temperature. Provide an igniter that is Payne-Sparkman ULI-050s or ULI-100s (or approved equal) that is appropriate for ballast wattage.

834.22 LIGHTING CONTROL CABINET. Provide aluminum control cabinet plus extension adaptor for circuit breakers, duplex receptacles, lights, transformers, contactors, fuses, and other control equipment. Provide a cabinet with all wiring and components approved by the manufacturer as an assembly or stamped and certified by a Professional Engineer licensed in the Commonwealth of Kentucky. Provide documentation from the manufacturer confirming that the cabinet, wiring, and all components are fabricated in compliance with the NEC. Manufacturer shall provide a warranty that the product furnished will perform in accordance with the requirements of the specifications and be warranted against defects in materials and/or workmanship for a period of 2 years. Warranty shall include shipping both ways.

834.22.01 Weatherproof Enclosure. Provide aluminum weatherproof enclosure with NEMA 3R rating and UL listed with an 18 inch extension adaptor. Fabricate enclosures and adaptor from 0.125 inch or thicker natural finished 5052 aluminum. Equip the enclosure with two adjustable "c" mounting channels on both of the side walls and the back wall of the enclosure. Provide a cabinet that has sufficient size to gain easy access to each component. Provide a rear aluminum panel that is a minimum of 27 inches wide by 42 inches high. The integrity of the cabinet walls should not be compromised except for where the conduit enters (preferably on the bottom) or for a weatherproof vent. The enclosure

door frame shall be double flanged out on all four sides. Provide exterior seams that are continuously welded and ground smooth. Provide welds that are neatly formed and free of cracks, blowholes, and other irregularities. Provide inside and outside edges of cabinet that are free of burrs. Provide a door restraint to prevent door movement in windy conditions. Provide the door with a gasket which forms a weather tight seal between the cabinet and door. Provide the door with a stainless steel continuous hinge. All exterior hardware shall be stainless steel. Provide interior hardware that is stainless steel or cadmium plated, type II, class I or equal. Provide a cabinet that is vented. Provide a cabinet door with a louvered air vent, filter-retaining brackets, and an easy to clean metal filter. Provide a cabinet door that is keyed with a factory installed standard no. 2 Corbin traffic control key. Welding shall conform to the latest edition of ANSI/AWS D1.2, Structural Welding Code-Aluminum (2014). Workmanship requirement of Class I structures shall be specified for tubular support structures. Class II workmanship requirements may be specified where more rigid controls are desired.

834.22.02 Mounting for Base Mounted. The mounting anchors to the concrete shall be galvanized steel per ASTM A153 or ASTM F2329 and be appropriate to secure the cabinet adaptor to the concrete. These anchors shall be isolated from the aluminum and steel connections to prevent corrosion. The adaptor connection shall use appropriate aluminum washers, lock washers, and bolts to secure the adaptor to the main lighting enclosure.

834.22.03 Mounting for Pole Mounted. Provide two aluminum brackets that are appropriate for the overall weight of the cabinet. The attachments bolts shall be appropriate aluminum washers, lock washers, and bolts to secure the both brackets on a wood pole or any other structure.

834.22.04 Light Fixture. Provide a light fixture with switch and bulb. Use a 120 volt fixture and utilize an LED bulb (equivalent to 60 watts minimum). Fixture shall be situated at or near the top of the cabinet and illuminate the contents of the cabinet.

834.22.05 Receptacle. Provide a 120 VAC GFI duplex receptacle in the enclosure with a separate 20 AMP breaker.

834.22.06 Magnetic Contactor. Provide magnetic contactors that are electrically held, 2 pole, sized as specified in the Contract, and that have a 120 volt coil. Protect each contactor coil by a 15 AMP fuse. Equip contactors with control switches for both automatic and manual actuation. Provide photoelectric switches for automatic actuation. Ensure that each switch has minimum rating of 125 volts, 15 amperes. Provide two pole, double throw switches that manually actuate. Solid state contactors may be used.

834.22.07 Control Transformers. Use control transformers that are one KVA, single phase, 240/480 volt primary, 120 volt secondary, dry type, 60 Hz, with primary winding isolated from secondary winding. Use transformers that are capable of indoor or outdoor installation. There shall be two in line fuses on the primary side (480 volt).

834.22.08 Photoelectric Control. Use photoelectric controls that are solid state cadmium sulfide type designed for use in 120 volt, 60 Hz circuits and rated for a resistive load of 1,000 watts. Use photoelectric controls with built-in surge protection and that are designed to provide an output circuit closure when photoelectric control components fail. Provide photoelectric controls and mounting bases that are twist-lock type. All mounting shall be weather resistant and provide protection from any water entering the cabinet. If the

photoelectric control is for an LED fixture, the contacts shall be made robust to allow the increase of in-rush current from the fixture. The photocell shall be mounted on top of the lighting control cabinet.

834.22.09 Secondary Lightning Arresters. Provide only secondary lightning arresters designed for use with the specified voltage and rated at 0-650 volts RMS.

834.22.10 Fuses. Conform to Subsection 834.12. Use 15 AMP fuses on light fixture and receptacle in the cabinet. Use a 6 AMP fuse between the main circuit breaker and the 480/120 volt control transformer.

834.22.11 Breakers. Branch breakers shall have lugs that can accept a maximum of #2 AWG Wire. Main Breakers shall have lugs that can accept a maximum of #2/0 AWG Wire. Circuit breaker shall be rated for 600 volts, be a molded case, and be panel-mounted. No din rail is allowed.

834.22.12 ARC Warning Sticker. Install a 4 inch by 6 inch Arc Flash Warning sticker 3 inches above each door handle. The sticker shall be a Metalcraft PLY695 Premium STYLEMARK label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC53FL pressure sensitive adhesive. The sticker shall have two colors of black and custom color orange.

834.22.13 One Way/Three Way Switches. The three-way switch shall be black, three position, 45 degree throw, and non-illuminated. The cover for the three-way switch shall have a "man-off-auto" legend. The one-way switch shall have "on/off" functionality and can be either a standard light switch or a door switch. Each switch shall be placed in a standard enclosure and shall have a front plate. Both switches shall be UL rated and rated for 120 volts.

834.23 WOOD POLES. Provide a class 5 pole that conforms to Section 820.

834.24 METER SOCKET. Provide a meter socket that has copper-aluminum line and load lugs. Socket shall be ring-less type with horn bypass. Provide a meter socket with a 1 inch bolt on hub, that is NEMA 3R UL rated for commercial use, and that accommodates overhead and underground feeds. The enclosure shall be stainless steel. Meter socket shall be certified by UL or third party that it meets North American Standards.

Install a 2 inch by 4 inch Arc Flash Warning sticker on the front of the meter base. The sticker shall be a Metalcraft PLY695 Premium STYLEMARK label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC53FL pressure sensitive adhesive. The sticker shall have two colors of black and custom color orange. The wording on the arc flash sticker shall be: "WARNING. Arc Flash Hazard. Appropriate PPE required. Failure to comply can result in death or injury. Refer to NFPA 70E."

834.25 SAFETY SWITCH. Provide a safety switch disconnect that is 3-wire, 600 volt, 2-pole, and 2-fuse in a NEMA 3R stainless steel enclosure. Provide an enclosure that has a 1 inch size bolt on hub. Provide a bolt pattern on the hub that aligns with predrilled holes on the enclosure. Provide a line cover shield. Provide a safety switch that is UL approved for commercial use and that is manufactured in the United States of America. Safety switch shall be marked in accordance with the National Electrical Code Article 230.66. The utility may require a safety switch before the meter socket on 480 volt installation.

Install a Maximum Available Fault sticker on the disconnect with the symmetrical RMS amperes and the date that this fault current is calculated. The sticker shall be 4 inches long and 4 inches wide and be a metalcraft PLY425 Premium Stylemark label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC778 pressure sensitive adhesive or approved equal.

Install a 2 inch by 4 inch Arc Flash Warning sticker on the disconnect. The sticker shall be a Metalcraft PLY695 Premium STYLEMARK label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC53FL pressure sensitive adhesive. The sticker shall have two colors of black and custom color orange. The wording on the arc flash sticker shall be: "WARNING. Arc Flash Hazard. Appropriate PPE required. Failure to comply can result in death or injury. Refer to NFPA 70E."

834.26 PADLOCKS. Provide a 1 3/4 inch wide, laminated steel body with 5/16 inch case hardened steel shackle, 4 pin tumbler, Master Lock No. 1KA, with 2.5 inch shackle. Provide locks that are keyed to series 2577. Provide two keys with each lock.

834.27 GROUNDING LUGS. Grounding lug shall be of bronze construction. Lug shall be UL listed. For conventional lighting, it shall be able to accommodate 5/8 inch ground rod and #4 AWG solid bare copper wire. For high mast lighting, it shall be able to accommodate 3/4 inch ground and #4 AWG solid bare copper wire. For high-mast lighting, an alternative grounding clamp may be used. The alternative grounding clamp shall be cast bronze or copper alloy construction with a clamp opening to accommodate 1 inch RS conduit. The wire terminal shall accommodate the required #4 AWG bare copper wire required for grounding. Clamp shall be UL listed.

834.28 BANDING. Banding shall be 3/4 inch, type 201 stainless steel. Banding shall be BAND-IT C206 or approved equal.

Banding tape buckles shall be type 201 stainless steel and be sized for 3/4 inch banding. Banding tape buckles shall be BAND-IT C256 or approved equal.

834.29 ANCHORS. Anchors shall be expanding type, made of steel, and be galvanized per ASTM A123.

834.29.01 30 Inch Long Rock Anchor. Anchors shall be 1.75 inches in diameter, triple eye, with 0.75 inch diameter rod having a minimum tensile strength of 23,000 pounds. Shall be a Maclean J3437 or approved equal.

834.29.02 53 Inch Long Rock Anchor. Anchors shall have a hole size of 1 7/8 inches, anchor closed size of 1 3/4 inches, anchor exposed size of 2 3/8 inches; rod diameter size of 3/4 inch; triple eye style; and have an ultimate strength rating of 23,000 pounds. Shall be a Joslyn J3438 or approved equal.

834.29.03 8-Way 135 Inch Anchor Rod. Anchors shall have an 8 inch hole with a 5/8 inch rod. Shall be a Chance #88135 or approved equal.

834.29.04 Rod. Rods shall be 5/8 inches in diameter, 7 feet long, with twin eye, and rated at 16,000 LBF ultimate. Shall be a Joslyn J7517 or approved equal.

834.30 MESSENGER/GUY/TETHER CABLE AND HARDWARE.

834.30.01 Messenger, Guy, and Tether Cable. Conform to Subsection 835.16.01.

834.30.02 Strandwise. Conform to Subsection 835.16.02.

834.30.03 Strandlink. Conform to Subsection 835.16.03.

834.30.04 Cable Rings. Conform to Subsection 835.16.04.

834.30.05 Bull Rings. Conform to Subsection 835.16.05.

834.30.06 Guy Guard. Conform to Subsection 835.16.06.

834.31 NAVIGATION LIGHTS. Navigation lights shall meet all requirements of the United States Coast Guard 33 CFR 322 and other regulatory agencies. Dual lamp housing, mounting, and swivels shall be cast silicon bronze. Stems and pull chains shall be stainless steel. All connections shall be sealed with waterproof gaskets and the assembly shall be rain tight. Lens shall be of permanent, rigid, heat resistant glass, 8 inch nominal outside diameter, standard marine Fresnel type 180° or 360°, and red or green as specified. Pivoting fixtures shall be suspended from the swivel on a stem made of 1 1/2 inch (i.d.) schedule 40 stainless steel pipe of required length to meet USCG requirements as noted in the plans. Stems over 5 feet long shall require a 60% counterweight. Swivel and pipe stem shall provide for all wiring to be completely contained inside the light assembly. Gaskets and o-rings shall be used to provide a weather tight assembly. Spindle shall be of stainless steel. An automatic latch shall hold the light securely in normal operating and service positions. A firm pull on the stainless steel pull chain shall automatically release the latch, allowing the fixture to pivot. As the light is raised, latch shall automatically engage to hold light in service position. Fixture shall be designed so that light may be pulled from either side. Assembly mounting shall be accomplished by using 1/2 inch diameter stainless steel bolts, nuts, and locking washers. All attachments to bridge steel members shall be separated from direct contact with steel members by a minimum 1/8 inch neoprene or mylar gasketing material to prevent corrosion caused by contact between dissimilar metals. This includes navigation fixtures, control cabinets, and all mounting brackets. This system can be 120 volt or 12 volt (solar).

834.31.01 Solar Powered. System shall utilize solar electric modules with storage batteries as the power source to provide continuous power for navigation lights at the specified locations on each bridge as well as sufficient power to operate the wireless monitoring system (approximately 10 watts per monitoring control panel location). The system shall operate at an average monthly insolation on a horizontal surface, insolation at tilt, and average monthly temperatures at each site.

A) **LED Lamp.** Lighting source shall be a 12 volt LED. There shall only be one LED on at a time, and lamp shall automatically switch to another LED when one goes out. The LEDs shall utilize ALINGaP (aluminum indium gallium phosphorus) technology for red and INGaN (Indium gallium nitride) for green/white indications, and shall be rated for 100,000 hours of continuous operation over a temperature range of -40 °C to + 74 °C. The LED modules shall be rated for a minimum life of 60 months and shall meet all parameters of this specification throughout the 60 month period. Two spare lamps shall be provided for each fixture.

B) **Solar Modules and Mounting Structure.** Solar electric panels shall be triple junction solar cells with an unbreakable construction. Panel shall be polymer

encapsulated. Glass encapsulation is not acceptable. The cells shall be encapsulated to protect from an environment consistent with these sites. Each module shall include a weather tight junction box for connecting the array output cable to the battery terminals. The modules shall be designed to provide rated power output for a minimum for fifteen years. Separate panels shall be installed for the upstream and downstream locations. Each panel shall be sized to provide the necessary wattage for the LED lighting fixtures, all control equipment, and 10 additional watts at 12 volts D.C. to power the separate monitoring system. There also should be enough solar power for the wireless router addressed in Subsection 834.31.03. Mounting brackets and arms shall be fabricated from stainless steel materials sufficient to provide necessary stability for the panel arrays. Panel orientation shall be adjustable to facilitate maximum solar input. All mounting hardware for attachment to the bridge shall be stainless steel.

- C) **Solar Controls.** Each solar control shall utilize a solid state integrated control unit capable of managing battery charging and navigation light output control. These functions shall be accomplished within a single cabinet with a monitoring system in each of the specified locations. The charge control portion of the control unit shall be designed such that it draws its power from the solar array only when power is available so as to reduce parasitic load on the system. Units shall use an ambient temperature sensor to adjust the charge termination point (temperature compensated charging) to prolong the battery life. The charge circuit shall employ a pulse-width modulation algorithm for charging the batteries and shall be of solid state series switch type configuration. On-board, short-circuit protection shall be provided. The controls shall have the ability to detect day and night through a photovoltaic array (dusk till dawn activator). The load control function shall incorporate a low voltage disconnect circuit to disconnect power to the control circuit if the battery voltage falls to a low state of charge (typically 20%). Use Morningstar SunSaver SS-20L or approved equal.
- D) **System Enclosure.** The enclosure shall be fabricated from Grade 316 Stainless Steel with a minimum thickness of 0.125 inch and be NEMA 3R rated. The cabinet shall provide screened louvered vents on each side of each compartment. The louver screening shall be Grade 316 stainless steel. An integral rain lip shall also be provided at the top of the main cabinet body to minimize entry of rain. The maintenance entrance shall be hinged and double-locking. The entrance shall be lined with a neoprene gasket around the entire edge. The entrance shall be secured with a Corbin #2 lock. The keyhole for this lock shall have a cover attached to the door with a single rivet. The battery component shall provide a minimum of 1/2 inch of insulating sheeting around the battery to minimize heat transfer between the battery and the enclosure wall. The cabinet shall be of sufficient size to house the battery and all control components (including monitoring system) and allow sufficient room for routine maintenance. Maximum size is 22 inches high by 24 inches wide by 24 inches deep.
- E) **Batteries.** Batteries shall be Absorbed Glass Mat, maintenance-free, and be non-spillable. Batteries shall be deep cycle marine batteries and shall be 12 volt, maximum 90 AMP-hour.
- F) **System Wiring.** The system shall feature a color coded wiring harness for both the lamps and solar array output. A keyed locking connector shall be utilized in the harness to allow the lamps to be quickly and easily disconnected from the

control electronics. An integral fuse assembly shall be included in the load positive wire of the harness. All connections shall be terminated with crimped spade terminals. The output harness for the solar array shall consist of a jacketed pair of conductors. Jackets shall be of UV resistant PVC or XLT material. Marine terminals shall be utilized for installation and maintenance. All wiring shall be incased in liquid-tight flexible metallic conduit. All conductors shall be sized in accordance with National Electrical Code, be appropriate to the solar array output current, and shall be Type THHN or THWN.

- G) **Conduit.** All conduit shall be minimum 3/4 inch liquid-tight flexible metallic conduit (LFMC) or Grade 316 Stainless Steel Rigid Conduit (SSRC).

834.31.02 Solar Battery Backup for 120 Volt Installation. System shall utilize existing electric service as the power source to provide continuous power for navigation lights at the specified locations as well as the wireless monitoring system. The system shall use a 12-volt solar powered battery backup to provide continuous power for navigation lights at the specified locations in the event of a power outage. The system shall operate at an average monthly insolation on a horizontal surface, insolation at tilt, and average monthly temperatures at each site. This system shall be able to power a DC LED bulb when the AC bulb has a power failure. The system shall be able to power the DC bulb up to 10 days without power. The system shall use a circuit to sense the 120 volt power failure and switch the navigation fixture to the battery backup state. The system shall have a monitoring system that is separate from the monitoring system for the 120 volt navigation lights. This system shall be able to turn on navigation fixtures just like using a photocell. Use K&K Systems or approved equal.

- A) **Solar Modules and Mounting Structure.** Solar electric panels shall be triple junction solar cells with an unbreakable construction (recommended 5 watt minimum). Panel shall be polymer encapsulated. Glass encapsulation is not acceptable. The cells shall be encapsulated to protect from an environment consistent with these sites. Each module shall include a weather tight junction box for connecting the array output cable to the battery terminals. The modules shall be designed to provide rated power output for a minimum for fifteen years.

Separate panels shall be installed for the upstream and downstream locations. Each panel shall be sized to provide the necessary wattage for the LED lighting fixtures, all control equipment, and 12 volts D.C. to power the separate monitoring system. There also should be a wireless system to route communication back to the main lighting cabinet. This monitoring system shall use the same router as the navigation monitoring system.

Mounting brackets and arms shall be fabricated from stainless steel structure materials sufficient to provide necessary stability for the panel arrays. Panel orientation shall be adjustable to facilitate maximum solar input. All mounting hardware for attachment to the bridge shall be stainless steel.

- B) **LED Lamp.** Conform to Subsection 834.31.01 A.
- C) **Solar Controls.** Conform to Subsection 834.31.01 C.
- D) **System Enclosure.** Conform to Subsection 834.31.01 D, but maximum size is 20 inches high by 15 inches wide by 6 inches deep. Minimum size shall be 16 inches high by 10 inches wide by 5 inches deep.

- E) **Batteries.** Batteries shall be Absorbed Glass Mat maintenance-free and be non-spillable. Batteries shall be deep cycle marine batteries and shall be 12 volt, maximum 18 AMP-hour.
- F) **Wiring.** Conform to Subsection 834.31.01 F.
- G) **Conduit.** Conform to Subsection 834.31.01 G.

834.31.03 Wireless monitoring. A system shall monitor the status of the individual navigation lighting units. The purpose of the monitoring system is to provide a complete, programmable, intelligent, networkable, and expandable low voltage monitoring system for the navigational lighting as described herein and as shown on the schematic drawings and schedules.

The monitoring system shall be a microprocessor based, addressable, networkable, intelligent, and low voltage lighting communication system for centralized monitoring. System shall include, but not be limited to: relays, controllers, light level sensors, radio frequency transceivers, low voltage control power and data line wiring, software, programming, custom graphical screens, and miscellaneous components as required for a complete, operable navigational monitoring system. All system components shall arrive at the job site completely factory pre-wired and ready for field installation. All connections shall be clearly and permanently labeled to facilitate correct and easy identification and installation of equipment.

Each monitoring system shall be wireless and will be powered by the 120 volt or 12 volt (if solar) feed inside the navigation control cabinet. The monitoring system shall be capable of sensing current flow, voltage, and fault conditions for the navigation lighting units. The central processing unit cabinet shall have the necessary communications equipment to relay information to the appropriate District Office by a wireless modem that is compatible with the Verizon network.

The external wireless router shall be Sierra Wireless Airlink GX450 with ethernet add-on or approved equal and shall support Verizon 3G/4G/LTE services for the camera installation. The antenna should be Laird Lp-800-2500-9NF sku393969, or approved equal, and include a DH wireless solutions AP-CCG-Q-S222-BL, or approved equal, for GPS locating. An internal wireless card can be utilized in lieu of the external wireless router.

All system components shall arrive at the job site completely factory pre-wired and ready for field installation. All connections shall be clearly and permanently labeled to facilitate correct and easy termination of equipment.

The monitoring system shall have a two year warranty on all parts and materials. The warranty shall start on the date of the acceptance of the installation by the Department.

System shall be capable of wireless monitoring within 1/2 mile line of sight distance in an urban environment or with wireless repeaters.

Fully programmable circuit diagnostic capability and alarming via Personal Computer (PC) shall be possible for all fixtures.

Radio network shall operate within an unlicensed FCC band, utilizing spread spectrum and frequency hopping technology. Radio network shall be transparent across Ethernet (LAN) platform.

All of the data accumulation transferred over the wireless RF network shall be automatically error checked. Systems that do not provide two-way error checking are not acceptable.

Password protected access via the modem shall be possible for interoperable connection from an off-site based PC for factory programming and support and owner access. System communications shall include the modem and bridge to the monitoring system. Factory programming and troubleshooting assistance shall be available via the

wireless modem. The system shall be capable of accepting any number of commands or command sequences while allowing programs to run continuously.

The monitoring system shall be able to email alerts regarding values for each node and alerts regarding connectivity issues. System shall be able to email alerts to a minimum of 30 email addresses at a minimum of one minute increments. The alerts shall be labelled for each node including minimum thresholds, maximum thresholds, actual current reading, and location of system. The monitoring system shall include web-based (internet browser) control. The web-based control application shall reside within the owner's secure server network and provide the capability to reset the alert/notification system (via the internet) to a user-defined default condition. This web-based control application shall not have any recurring maintenance costs by the cabinet.

The enclosure shall be fabricated from Grade 316 Stainless Steel with a minimum thickness of 0.125 inch and be NEMA 3R rated. The cabinet shall provide screened louvered vents on each side of each compartment. The louver screening shall be Grade 316 stainless steel. An integral rain lip shall also be provided at the top of the main cabinet body to minimize entry of rain. The maintenance entrance shall be hinged and double-locking. The entrance shall be lined with a neoprene gasket around the entire edge. The entrance shall be secured with a Corbin #2 lock. The keyhole for this lock shall have a cover attached to the door with a single rivet. The battery component shall provide a minimum of 1/2 inch of insulating sheeting around the battery to minimize heat transfer between the battery and the enclosure wall. The cabinet shall be of sufficient size to house the battery and all control components (including monitoring system) and allow sufficient room for routine maintenance. Maximum size is 20 inches high by 15 inches wide by 6 inches deep. Central control unit shall support up to 64,000 controllers networked on wireless systems. Programmed data being stored in static RAM shall be protected from loss during power failure. The CPU based real time clock shall be protected by a rechargeable NiCad or lithium battery capable of withstanding up to a thirty day power loss.

Provide wireless linking expandability with a wireless card slot in communication hub. Wireless link shall provide full function zone control and data accumulation, diagnostics, and include current sensing and voltage sensing.

Wireless communications shall be bidirectional. RF transceiver shall operate in an unlicensed FCC ISM band, FCC/IC certified. RF range shall be a minimum 1/2 mile line of sight. Surge Protection shall be a minimum 2,500 Volts to ground. Equipment shall operate at a voltage of 120 VDC. Equipment shall be capable of operating at temperatures ranging from -40 °C to 65 °C, at 95% relative humidity, and at a relative humidity ranging from 0-95%, non-condensing.

Provide Redundant RF link where specified, one for each transceiver used.

Provide custom graphical site screens using CAD drawings of the site provided by the Department to serve as backgrounds for the site zoom screens. Provide a custom graphical screen for each monitoring system, from which the user shall be able to access each fixture individually, view fixture status, diagnostic files, and data logs.

The monitoring system software shall allow data from the system to be logged and archived. Data shall be accessible via spreadsheet or database, and contain the following for both navigation and aviation obstruction lighting:

- 1) Voltage levels for each voltage sensor
- 2) Current drawn per fixture
- 3) True and Real Power
- 4) Time and date stamping as required by user

The manufacturer shall provide factory assembly and testing of all monitor stations and associated apparatus. Monitor modules shall be factory programmed per project

specifications. All required software shall be installed prior to factory shipment or uploaded from the factory via modem link.

An on-site factory start-up by a qualified technician shall be provided as a part of the system package. Start-up will not be performed until the system installation is complete and a wireless modem has been installed for the system. Start-up shall include a system inspection, additional software installation if necessary, program testing, training, and troubleshooting assistance. Support via modem from factory for direct system diagnosis and programming assistance shall be provided at no charge until such time as final acceptance of the complete system has been granted. The manufacturer shall provide a complete submittal package for approval prior to shipment. The package shall consist of product cut sheets and specifications, a bill of materials, warranty information, wire riser diagrams, and field wiring instructions. In addition to the submittals, a set of installation, operator, and maintenance manuals shall be shipped with the equipment.

834.32 AVIATION OBSTRUCTION LIGHTS. All aviation obstruction fixtures shall be bronze. All aviation fixtures shall be 1-810 or approved equal. The fixture shall meet all the requirements as recommended in FAA advisory circular 70/7460-1L. Lighting source shall be 120 volt or 12 volt LED and have dual lights with a relay to switch. A relay shall be installed so that only one light is on at any time. Upon burning out of the first light, the relay shall turn on the second light. Assembly mounting shall be accomplished by using 1/2 inch diameter stainless steel bolts, nuts, and locking washers. Attachments shall be made with Grade 316 stainless steel clamping devices or by drilling, anchoring, epoxying, and bolting to the concrete pier or concrete parapet. All aluminum attachments to bridge steel members shall be separated from direct contact with steel members by a minimum 1/8" neoprene or mylar gasketing material to prevent corrosion caused by contact between dissimilar metals. This includes aviation fixtures, control cabinets, and all mounting brackets. All conduit shall be 1 1/4 inch liquid-tight flexible metallic conduit (LFMC).

834.32.01 Solar Powered. Conform to Subsection 834.31.01.

834.32.02 Solar Battery Backup. Conform to Subsection 834.31.02.

834.32.03 Wireless Monitoring. Conform to Subsection 834.31.03.

834.33 WARNING TAPE. Provide tape that is 6 inches wide and 7.0 mils (nominal) thick. Provide tape that has a minimum tensile strength of 600 pounds per 6 inch width and that is color-coded and impregnated with alkali and acid stable, lead-free, organic pigments that are suitable for direct burial. Use tape that is ultraviolet colorfast and non-distorting with no elongation. Use tape that includes black lettering and symbols on a gray background that conforms to the APWA-ULCC national color code for DOT. Provide tape that continuously reads, "CAUTION: ELECTRIC LINE BURIED BELOW" alternating with a "No Digging" symbol.

834.34 WARRANTIES. Materials shall be warrantied as stated under individual material specifications. If not specifically addressed in other sections, warranty materials for a period of one year or provide the manufacturer's standard warranty, whichever is greater. Warranty shall include shipping both ways. The warranty shall begin the date that materials are received by the Department and shall be transferable.

834.35 DOCUMENTATION. With each unit purchased under this section, include one documentation package consisting of:

- 1) Complete schematic
- 2) Complete parts layout and list with full information as to availability of any custom or non-standard parts
- 3) Complete installation procedures
- 4) All applicable warranties and guarantees

SECTION 835 — ELECTRICAL TRAFFIC CONTROL DEVICES

835.01 GENERAL. This section covers the material requirements for electrical traffic control device components (including traffic signals, flashing beacons, and school flashers) that are supplied by the Contractor. Materials commonly provided by the Department are listed on the Project Install Items List (available on the Division of Traffic Operation's webpage) and are not addressed in these specifications. Certain materials for electrical traffic control devices are included on the Department's List of Approved Materials.

Materials shall comply with the Manual on Uniform Traffic Control Devices (MUTCD) and the Division of Traffic Operation's Traffic Signal Standard Detail Sheets. Materials shall be approved by the Engineer prior to utilization on a project. Once approval is given for a product, substitutions will only be permitted with written permission from the Engineer. If materials provided by the Contractor are not addressed in these specifications, contact the Division of Traffic Operations for approval before using on a project.

835.02 CONCRETE. Conform to Subsection 834.02.

835.03 STEEL REINFORCEMENT. Conform to Subsection 834.03.

835.04 GROUND RODS. Conform to Subsection 834.04. Use rods with a minimum diameter of 5/8 inch and a minimum length of 8 feet.

835.05 CONDUIT. Ensure the conduit is the size specified on the plans and detail sheets.

835.05.01 Rigid Steel and Fittings. Conform to Subsection 834.05.01.

835.05.02 Schedule 40/80 PVC and Fittings. Conform to Subsection 834.05.02.

835.05.03 Stainless Steel and Fittings. Conform to Subsection 834.05.03.

835.05.04 Aluminum and Fittings. Conform to Subsection 834.05.04.

835.05.05 Condulet. Conform to Subsection 834.05.05.

835.05.06 Conduit Straps. Conform to Subsection 834.05.06.

835.05.07 Test/Pipe Plugs. Conform to Subsection 834.05.07.

835.06 ELECTRICAL JUNCTION BOX. Conform to Subsection 834.07. Provide a junction box marked "Signal". If junction box has signal and main service wires, the box shall be marked as "Signal/Electric".

835.07 MAST ARM POLES. Pole diameter and wall thickness shall be calculated in accordance with AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 2013-6th Edition with current interims. For mast arm poles, provide fatigue classification that is Category II, in accordance with Table 11.6-1 from the AASHTO Standard Specifications with galloping and natural wind gusts, and with a 25 year design life in accordance with Table 3.8.3-2.

Provide poles and arms that conform to:

- 1) ASTM A595, grade A or B with minimum yield strength of 55 KSI, or
- 2) ASTM A572, grade 55, or
- 3) ASTM A53

Provide poles, anchor bolts, base plates, and all other hardware that are hot-dip galvanized per ASTM A123 or A153. Provide base plates that conform to ASTM A36, grade 36 or ASTM 572, grade 50.

Ensure transverse plates have a thickness greater than or equal to 2 inches. Provide a base plate for the vertical pole that fits inside a 36 inch diameter concrete base. The anchor bolt circle shall not be more than 24.5 inches. The diameter of anchor bolts shall not be more than 2.25 inches. The bottom pole diameter shall not be less than 16.25 inches.

Provide mill certifications as proof of compliance with the specifications. Provide poles that are anchor-based, hot-dipped galvanized inside and out. For anchor bolt design, pole forces shall be positioned in such a manner to maximize the force on any individual anchor bolt regardless of the actual anchor bolt orientation with the pole. Provide poles that are furnished complete with fully galvanized anchor bolts and hardware.

The pole handhole shall be 25 inches by 6.5 inches. The handhole cover shall be removable from the handhole frame. On the frame side opposite the hinge, provide a mechanism on the handhole cover/frame that would permit placement of the Department's standard padlock as specified in Subsection 834.26. The handhole frame shall have two stainless studs installed opposite the hinge to secure the handhole cover to the frame. Secure cover with with stainless steel wing nuts and washers. The handhole cover shall be manufactured from 0.25 inch thick galvanized steel (ASTM A153) and have a neoprene rubber gasket permanently secured to the handhole frame to insure weather-tight protection. The hinge shall be adjustable and manufactured from 7 gauge stainless steel. The minimum clear distance between the transverse plate and the bottom opening of the handhole shall not be less than the diameter of the bottom tube of the pole but needs to be at least 12 inches. Provide a copper, stainless steel, or brass grounding lug installed 180 degrees from the handhole opening and that is accessible from the handhole.

Use welds that are in accordance with sections 1 through 8 of the American Welding Society (AWS) D1.1 Structural Welding Code-Steel (2010). Use tackers and welders that are qualified in accordance with the code. Provide a tube that contains only one longitudinal seam weld. Use tube longitudinal seam welds that are free of cracks and excessive undercuts and performed with automatic processes. Visually inspect all welds. Inspect longitudinal welds with magnetic particle examination techniques.

Provide calculations and drawings that are stamped and certified by a Professional Engineer licensed in the Commonwealth of Kentucky. Provide materials and products that are manufactured in the United States of America. Provide shop drawings specifying pole height, arm length(s), bolt circle diameter, bolt diameter, and details of the handhole cover assemblies.

Provide mast arm poles that are of monotube design similar to the one depicted in the Contract.

Provide mast arms that have a maximum 3 degree rise. Arms should have a rise more than 1 degree. The diameter of the mast arm shall not be greater than 21 inches at the attachment to the pole. Mast arm poles shall include holes for attachment of necessary signal equipment (pedestrian signals, pedestrian detectors, supplemental signal heads, signs, cameras, etc.). No vibration mitigation device should be considered on mast arm poles. If specified, provide two, 2 inch blind half couplings installed 3 feet from the top of the pole.

Provide mast arm poles with a permanently affixed label 6 feet from the bottom of the base plate on the outside with the following information:

- 1) Manufacturer

- 2) Moment
- 3) Order number

Provide a detailed analysis of the pole. The detailed analysis shall be stamped and certified by a Professional Engineer licensed in the Commonwealth of Kentucky. The detailed analysis shall include, but not be limited to, the following calculations:

- 1) Group I, II, III, IV load combinations as listed in Table 3.4-1 of the AASHTO Standard Specifications.
- 2) Dimensions and weights for all attachments. This includes areas used for wind, ice (total exterior area of the attachments) and fatigue loads, drag coefficients, projected areas, velocity pressures, and wind forces for each segment.
- 3) For group loads II, III, and IV, which have wind loads, calculations for each controlling "worst case" wind direction for any aspect of the design (anchor bolts, pole sizing, etc.). For dual arm structures, the wind load shall be analyzed for the perpendicular to each arm and a 45 degree angle between the two arms for Group loads II and III.
- 4) All structural properties for poles, anchor bolts and base plates. This includes the pole's diameter, thickness, section modulus, moment of inertia, and cross sectional area.
- 5) Calculations for each member including: loads, section properties, member forces (axial, shear, bending, and torsion), member deflections (angular and linear), member stresses (actual and allowable), and the combined stress ratio (csr).
- 6) Fatigue calculations for all fatigue related connections. Provide the corresponding detail, stress category, and example from Table 11.9.3.1-1 of the AASHTO Standard Specifications. In fatigue calculations, the effective throat thickness of a complete joint penetration groove weld shall be the thickness of the thinner part joined, per AISC J2.1a.
- 7) Vertical deflection for galloping of arms. Shall be limited to 8 inches.
- 8) Horizontal deflection limits for vertical supports in Section 10.4.2.1 of the AASHTO Standard Specification.

835.08 WOOD POLES. Conform to Subsection 834.23.

835.09 ANCHOR BOLTS. Conform to Subsection 834.17. Provide mast arms with a minimum of six fully galvanized anchor bolts. There shall be two steel templates provided per pole. Depending on the design, one of the supplied templates might be critical for the structural integrity of the headed part of the anchor bolt. Templates shall be contained within a 26.5 inch diameter. All templates shall be fully galvanized to the requirements of ASTM A153.

835.10 BRACKETS. Conform to Subsection 834.15.02.

835.11 ARC FLASH WARNING STICKER. Install a 4 inch by 6 inch Arc Flash Warning sticker in the center of the outer side of mast arm pole doors. The sticker shall be Metalcraft PLY695 Premium STYLEMARK label (or approved equal) with 0.007 inch thickness, with UV white polycarbonate material, and with MC53FL pressure sensitive adhesive. The sticker shall have two colors of black and custom color orange.

835.12 ANCHORS. Conform to Subsection 834.29.

835.12.01 30 Inch Long Rock Anchor. Conform to Subsection 834.29.01.

835.12.02 53 Inch Long Rock Anchor. Conform to Subsection 834.29.02.

835.12.03 8-Way 135 Inch Anchor Rod. Conform to Subsection 834.29.03.

835.12.04 Rod. Conform to Subsection 834.29.04.

835.13 METER SOCKET. Provide a meter socket that is 125 AMP, that has copper-aluminum line, that is ringless, and that has load lugs. Provide a meter socket with a bypass. Provide a meter socket with a 1 inch bolt on hub that is NEMA 3R UL rated for commercial use, and that accommodates overhead and underground feeds. Meter socket shall be certified by UL or third party that it meets North American Standards.

Meter socket shall include an arc flash warning sticker that conforms to the one described in Subsection 834.24.

835.14 SAFETY SWITCH. Provide a safety switch disconnect that is 60 AMP, 250 volt, 3-wire, 2-pole, and 2-fuse in a NEMA 3R enclosure. Provide an enclosure that has a 1 inch size bolt on hub. Provide a bolt pattern on the hub that aligns with predrilled holes on the enclosure. Provide a line cover shield. Provide a safety switch that is UL approved and shall be marked in accordance with the National Electrical Code Article 230.66.

Disconnect shall include a Maximum Available Fault sticker that conforms to the one described in Subsection 834.25.

835.15 PADLOCKS. Conform to Subsection 834.26.

835.16 MESSENGER/GUY/TETHER CABLE AND HARDWARE.

835.16.01 Messenger, Guy, and Tether Cable. Provide messenger, guy, and tether cable that consists of "class A", zinc-coated, high-strength steel of the specified strength and extra galvanized per ASTM A475-03. Provide a minimum of 3/8 inch diameter and 7 strands with minimum breaking strength 10,800 pounds. Use 10,800 pound or 15,400 pound wire.

835.16.02 Strandwise. Provide a strandwise that has an automatic jaw type dead-end for 3/8 inch galvanized steel messenger. Use Reliable #5202L or approved equal.

835.16.03 Strandlink. Provide a strandlink that is a splice for 3/8 inch galvanized steel messenger. Use Reliable #5042 or approved equal.

835.16.04 Cable Rings. Provide cable rings that are designed for installation on a 3/8 inch-7 strand galvanized steel messenger cable. Provide cable rings that are fabricated from round edge high carbon steel wire that are galvanized after forming. Provide wire size that is 0.090 inch x 0.190 inch (nominal). Provide 3 inch (nominal) cable ring size to accommodate a 2 inch (maximum) cable bundle size. Provide cable rings that are designed to be installed and removed without tools and without damage to the messenger cable.

835.16.05 Bull Rings. Provide bull rings that are weldless 1 inch steel with a nominal I.D. of 4 inches. Provide a bull ring for the working load limit as specified in contract. Provide working load limits as follows: Type A-10,800 pounds and Type B-15,400 pounds.

835.16.06 Guy Guard. Guy guard shall be 8 feet long, made of yellow plastic, and be fully rounded.

835.17 WIRE AND CABLE. Use wire and cable that is plainly marked in accordance with the provisions of the National Electrical Code.

835.17.01 Ground Wire. Ground wires connected directly to ground rods, cabinets, transformer bases, services, poles and between bushings shall be copper grounding conductors that are 4 AWG, solid, and bare unless otherwise specified. All grounding conductors 6 AWG and smaller shall be insulated in green color per NEC for all circuit grounds.

835.17.02 Service Wire. Use service entrance conductors that are 6 AWG, stranded, copper, and Type USE-2. Use conductors that are colored coded according to the National Electric Code.

835.17.03 Signal Cables. Provide signal cables that are 14 AWG, stranded, and copper with the number of conductors indicated. Cables shall conform to IMSA 19-1. Use 3, 4, 5, or 7 conductors (5 and 7 being the most common) as specified in the Contract.

835.17.04 Loop Wire. Provide loop wire that is 14 AWG, stranded, copper and that conforms to IMSA 51-7.

835.17.05 Loop Lead-In Cable. Provide loop lead-in cable that is 14 AWG, stranded, copper, paired conductors, electrically shielded, and that conforms to IMSA 19-2. This cable shall only be 1 pair.

835.17.06 Radio Cable. Provide RG-213/U coaxial cable consisting of pre-assembled cable with connectors. Provide connectors that are crimp type, silver plated with gold center pin, and that have Teflon/TPX insulation. The copper wire shall be stranded. Provide a connector that is waterproof. Use RF Industries RFN 1006 3E or approved equal.

835.17.07 Video Cable. Provide video cable that is #20 AWG, 75 Ohms, and solid conductor. Use Belden 8281 or approved equal.

835.17.08 Video Power Cable. Cable shall be a #22 stranded copper cable with six conductors, UL 2464, and PVC coating.

835.17.09 Ethernet Cable. Use General Cable GenSpeed 5000 CAT 5e Outside Plant Cable 8 wire PN: 5136100 or approved equal. The cable shall meet or exceed the following specifications:

Performance:

- ANSI/TIA/EIA 568B (Category 5e)
- MIL-C-24640A Water Penetration
- Propagation Delay: 583 ns @ 100 MHz
- Return Loss @ 100 MHz: 20.1 DB
- Frequency Range: 1-350 MHz

Physical characteristics:

- Nominal Outside Diameter: 0.230 in
- Insulation Type: Polyolefin
- Maximum Pulling Tension: 25 lbs
- Maximum DC Resistance: 9.38 Ohms/100m
- Mutual Capacitance @ 1kHz: 17 pF/100m

- Operating Temperature: -45 °C to 80 °C

835.17.10 Splicing. Conform to Subsection 834.13.

835.18 TRAFFIC LOOP ENCAPSULANT. Provide a non-shrink, non-stringing, moisture cure, one-part, polyurethane traffic loop encapsulant suitable for use in both asphalt and concrete pavements. Encapsulant shall provide a void-free encapsulation for detector loop wires and adequate compressive yield strength and flexibility to withstand heavy vehicular traffic and normal pavement movement. Use one-quart tubes of loop sealant that are suitable for use with a standard caulking gun.

The Engineer may reject the product if any physical property renders the material unsuitable. Ensure that the cured encapsulant has the following properties:

TRAFFIC LOOP ENCAPSULANT REQUIREMENTS AND PRICE ADJUSTMENT SCHEDULE						
Test	Specification	100% Pay	90% Pay	80% Pay	70% Pay	50% Pay ⁽¹⁾
Hardness ⁽³⁾ (ASTM D 2240)	35-65	30-70	25-29 71-75	20-24 76-80	15-19 81-85	≤ 14 ≥ 86
Tensile Strength, psi ⁽³⁾ (ASTM D 412)	150 min.	145 min.	140-144	135-139	130-134	≤ 129
Elongation, % ^(2,3) (ASTM D 412)	125 min.	120 min.	115-119	110-114	105-109	≤ 104
Density, lb/gal (ASTM D 1875)	9.00-11.00	8.50-11.50	8.30-8.49 11.51-11.60	8.20-8.29 11.61-11.70	8.10-8.19 11.71-11.80	≤ 8.09 ≥ 11.81
Tack-free Time, hours (ASTM C 679)	24 max.	24.5 max.	24.6-25.0	25.1-25.5	25.6-26.0	≥ 26.1
Complete Dry Time, hours (KM 64-447)	30 max.	30.5 max	30.6-31.0	31.1-31.5	31.6-32.0	≥ 32.1
Chemical Interactions: (KM 64-446)						
Motor Oil	No Effect					
Deicing Chemicals	No Effect					
Gasoline	Slight Swell					
Hydraulic Brake Fluid	No Effect					

⁽¹⁾ If allowed to remain in place, the Department will review materials performing in this range on a project-by-project basis to determine if removal of the material is warranted.

⁽²⁾ Tested at a 2- inch per minute pull rate.

⁽³⁾ 7-day cure

835.19 NON-SHRINK GROUT. Provide non-shrink grout from the Department’s List of Approved Materials.

835.20 BACKER ROD. Provide backer rod that has closed cell polyethylene foam. Provide a backer rod that is 1/2 inch diameter. Provide backer rod that has the minimum density of 2.0 pounds/cubic feet using the ASTM D 1622 test method and tensile strength of 50 PSI using the ASTM D 1623 test method. Provide backer rod that has the maximum water absorption of 0.03 gm/cc using ASTM C 1016 test method.

835.21 WARNING TAPE. Conform to Subsection 834.33.

835.22 LIGHTING POLES. Conform to Subsection 834.15.

835.23 BANDING. Conform to Subsection 834.28.

835.24 GROUNDING LUGS. Conform to Subsection 834.27.

835.25 HUB PLATES. Use aluminum hub plates.

835.25.01 Hub Plate Without Conduit Hub. Use hub plate with 1.5 inch NPS. Use Pelco Products SE-0357 or approved equal.

835.25.02 Hub Plate With Conduit Hub. Use hub plate with 1.5 inch NPS and 1.25 inch NPT conduit hub. There shall be an aluminum threaded plug for the conduit hub. Use Pelco Products SE-0382 or approved equal.

835.26 CELL ANTENNA. Antennas shall work with all major cell phone companies.

835.26.01 AP Double Cell Antenna Magnetic/Threaded Bolt Mount. Use AP-CCG with magnetic mount, AP-CCG with Threaded Bolt mount, or approved equal.

Antennas shall meet the following requirements:

- Dimensions: A 2 inch (51 mm), B 4 inch (102 mm), and C 6.8 inch (173 mm)
- Mounting Styles: Magnetic or threaded bolt
- Frequencies: Cellular/LTE = 824-896 MHz; 1850-1995 MHz; 698-798 MHz; 1710-1770 MHz; 2110-2170 MHz; 2570-2620 MHz GPS = 1575.42 MHz
- VSWR: 1.5:1 or less at resonant point
- Gain: 3.0 dBi
- Radiation Pattern: OMNI Directional
- Polarization: Vertical
- Radome: Glass Filled Polypropylene
- Cable Length: 15 feet (4.5 m) (Adhesive and Threaded Bolt Mount)
- Temperature: -40 °C to 85 °C (-40 °F to +185 °F) operating and storage
- Humidity: (non-condensing) - 5% to 95% operating and storage
- Military Spec MIL-STD 810 conformance to thermal, mechanical shock, and humidity

835.26.02 Welded Wideband Directional Antenna. Use Comtelco Y42700WB or approved equal.

Antennas shall meet the following requirements:

- Termination Options: Type A: 12 inch Teflon pigtail with N connector
- Gain: 10dBi/8dBd Frequency @ VSWR 698-2800MHz
- F to B Ratio: 20dB
- Vert Beamwidth: 40°
- Horiz Beamwidth: 40°
- Power Rating: 150 watts
- Impedance: 50 ohms
- Material: Aluminum booms, 3/16 inch solid welded elements
- Radome: 3 inch UV inhibited ABS
- Length: 13.5 inches
- Weight: 2 pounds
- Mounting: 2 1/2 inch mast maximum
- Flat Plate Area: 0.12 square feet
- Wind Rating: 125 MPH Wind Load: 8.1 pounds
- N-Female, Includes Mounting Hardware

835.27 FUSED CABLE CONNECTOR KIT. Conform to Subsection 834.11.

835.28 WARRANTIES. Conform to Subsection 834.34.

835.29 DOCUMENTATION. Conform to Subsection 834.35.

SECTION 836 - DURABLE PREFORMED PAVEMENT MARKINGS TYPE I TAPE

836.01 GENERAL. Use preformed pavement marking material consisting of white or yellow films with retroreflective optics incorporated to provide immediate and continuing retroreflection.

Use preformed pavement marking material capable of adhering to new dense and open graded asphalt surfaces, during the paving operation, or portland cement concrete by a pre-coated pressure sensitive adhesive. The Engineer may require a primer to precondition the pavement surface. Ensure that the markings conform to pavement contours by the action of traffic. Ensure that, after application, the markings are immediately ready for traffic.

Ensure that these markings provide long term reflectivity, as determined in the following performance requirements, when applied according to the manufacturer's instructions.

Ensure that the preformed markings are suitable for use one year after the date of receipt when stored according to the manufacturer's recommendations.

836.02 REQUIREMENTS.

836.02.01 Composition. Use retroreflective preformed pavement markings consisting of a mixture of high quality polymeric materials, pigments, and retroreflective optics distributed throughout its base cross sectional area.

836.02.02 Reflectance. Ensure that the white and yellow markings have the following minimum reflectance values as measured according to the testing procedures of ASTM E 1701. Measure the coefficient of retroreflective luminance and express the value as millicandelas per square meter per lux [(mcd/m²)lx⁻¹].

MINIMUM REFLECTANCE			
Color	Entrance Angle	Observation Angle	Minimum Reflectance
White	88.76°	1.05°	500 minimum
Yellow	88.76°	1.05°	500 minimum

836.02.03 Skid Resistance. Ensure that the surface of the retroreflective material provides an initial minimum skid resistance value of 45 BPN when tested according to ASTM E 303.

836.02.04 Patchability. Ensure that the pavement marking material is capable of use for patching worn areas of the same type according to the manufacturer's recommendations.

836.02.05 Material Quality. Replace any material used as longitudinal or intersection markings that fails minimum reflectivity values or fails due to loss of adhesion or complete wear through. Minimum replacement zone is 300 feet of roadway length or one intersection marking.

836.03 APPROVAL. The Department will approve Type I pavement marking tape based on conformance to KM 64-207 and this section.

836.04 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of approved Type I pavement marking tape for use on projects. Clearly state the manufacturer, product name and product code and color as listed in the Department's List of Approved Materials. Identify the lot number(s), expiration date, and quantity delivered.

836.05 ACCEPTANCE. The Department will accept Type I pavement marking tape based on verification of inclusion on the Department's List of Approved Materials, compliance of the manufacturer's certification, and visual inspection of the installation of the Type I pavement marking tape.

**SECTION 837 - EXTRUDED THERMOPLASTIC
PAVEMENT MARKING MATERIALS**

837.01 GENERAL. This section covers extruded thermoplastic pavement marking materials for permanent applications.

837.02 DROP ON BEADS. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

837.03 APPROVAL. Select materials that conform to the composition and physical characteristic requirements below when evaluated in accordance with AASHTO T-250 or other test methods as cited. The Department will sample and evaluate for approval each lot of thermoplastic material delivered for use per contract prior to installation of the thermoplastic material. Do not allow the installation of thermoplastic material until it has been approved by the Division of Materials. Allow the Department a minimum of 10 working days to evaluate and approve thermoplastic material from the date received by the Division of Materials.

837.03.01 Composition. Use a maleic-modified glycerol ester resin (alkyd binder) to formulate the thermoplastic material. Ensure the pigment, pre-mix beads, and filler are uniformly dispersed in the resin. Use material that is free from all dirt and foreign material. Annually provide independent analysis data and certification for each formulation stating the total concentration of each heavy metal present, the test method used for each determination, and compliance to 40 CFR 261 for leachable heavy metals content.

COMPOSITION (Percentage by Weight)		
Component	White	Yellow
Binder, ⁽¹⁾	18.0 min.	18.0 min.
Glass Beads (Premixed)	30 - 40	30 - 40
Titanium Dioxide	10.0 min.	—
Calcium Carbonate & Inert Fillers ⁽²⁾	42.0 max.	50.0 max.
Heavy Metals Content	Comply with 40 CFR 261	Comply with 40 CFR 261

⁽¹⁾Use a binder that consists of a mixture of synthetic resins, at least one being solid at room temperature, and high boiling point plasticizers. Ensure that at least one-third of the binder composition is solid maleic-modified glycerol ester resin and is not less than 8 percent by weight of the entire material formulation. Do not use alkyd binder that contains petroleum based hydrocarbon resins.

⁽²⁾The manufacturer may choose the amount of calcium carbonate and inert fillers, providing all other requirements of this section are met.

837.03.02 Physical Characteristics. For thermoplastic material heated for 4 hours at 425°F under agitation, conform to the following requirements.

- A) **Color.** As determined with a spectrophotometer using D65 illuminant with a 45 degree entrance angle and 0 degree observation angle geometry.

CIELAB Color Coordinates		
	Yellow	White
Daytime Color (CIELAB) Spectrophotometer using illuminant D65 at 45° illumination and 0° viewing with a 2° observer	L* 81.76 a* 19.79 b* 89.89 Maximum allowable variation 6.0ΔE*	L* 93.51 a* -1.01 b* 0.70 Maximum allowable variation 6.0ΔE*
Nighttime Color (CIELAB) Spectrophotometer using illuminant A at 45° illumination and 0° viewing with a 2° observer	L* 86.90 a* 24.80 b* 95.45 Maximum allowable variation 6.0ΔE*	L* 93.45 a* -0.79 b* 0.43 Maximum allowable variation 6.0ΔE*

- B) **Flowability.** Ensure that the white thermoplastic material has a maximum residue of 18 percent and the yellow thermoplastic material has a maximum residue of 21 percent.
- C) **Set Time.** Use material that, when applied at a temperature range of 415 ± 15 °F and thickness of 40 to 120 mils, sets to bear traffic in not more than 2 minutes when the air and road surface temperature is approximately $\geq 50 \pm 3$ °F, and not more than 10 minutes when the air and road surface temperature is approximately $< 50 \pm 3$ °F.
- C) **Softening Point.** Ensure that the thermoplastic material has a softening point of 215 ± 15 °F.
- C) **Bond Strength.** Ensure that the bond strength of the thermoplastic material to concrete exceeds 180 psi.
- C) **Cracking Resistance at Low Temperature.** Ensure that the thermoplastic material shows no cracks when observed from a distance exceeding one foot.
- C) **Impact Resistance.** Ensure the impact resistance of the thermoplastic material is a minimum of 1.13 joules.
- C) **Flash Point.** Use thermoplastic material that has a flash point not less than 475 °F.

837.04 PACKAGING. Package thermoplastic material in suitable 50 pound containers to which the material shall not adhere during shipment or storage. Include a label stating that the thermoplastic material is to be maintained with a temperature range of 400 – 440°F during application. Provide the thermoplastic material in either block or granular form.

837.05 SHELF LIFE. Ensure that the thermoplastic material conforms to this section for a period of one year. Replace any thermoplastic material not conforming to the above requirements.

837.06 MANUFACTURER’S TESTING. Perform testing in accordance with AASHTO T-250 on a minimum of one composite sample per 10,000 pounds, or portion thereof, per lot of thermoplastic produced.

837.07 CERTIFICATION. Submit manufacturer’s certification stating conformance to the requirements of this section for each lot of extruded thermoplastic delivered for use on projects. Clearly state the manufacture, formulation identification, product name, color, date of manufacturer, lot number (s), expiration date, total quantity of lot produced, actual quantity of thermoplastic material represented, sampling method utilized to obtain the samples, and required manufacturer’s testing data for each composite sample tested to represent each lot produced.

837.08 ACCEPTANCE. The Department will accept extruded thermoplastic based on compliance of the manufacturer’s certification and conformance of test results obtained by the Department to the requirements of this section.

SECTION 838 — FLEXIBLE DELINEATOR POSTS

838.01 GENERAL. Furnish surface and ground mounted flexible delineator posts from the Department's List of Approved Materials. The Department considers the flexible delineator posts to include the post, reflective sheeting, and mounting hardware.

838.01.01 Retroreflective Sheeting. Conform to Section 830.

838.02 APPROVAL. The Department will approve flexible delineator posts which are in conformance to this Section

838.03 PACKAGING. Securely fasten posts of the same type and length in bundles of 2,000 pounds or less in a manner that is easily handled by a fork lift and that prevents slipping during handling and shipping. The Engineer will reject posts with excessively damaged finishes.

838.04 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of approved flexible delineator posts delivered for use on projects. Clearly state the manufacturer, product name, product code, and type (surface mount or ground mount) as listed in the Department's List of Approved Materials. Identify the lot number(s) and quantity of flexible delineator posts delivered.

838.05 ACCEPTANCE. The Department will accept flexible delineator posts based on verification of inclusion on the Department's List of Approved Materials and compliance of the manufacturer's certification.

SECTION 839 - KY TYPE I GLASS BEADS

839.01 GLASS BEADS. Use for application to reflective pavement markings. Conform to AASHTO M 247, moisture resistant specifications with the following additional requirements for gradation and percentage of rounds:

Gradation:	<u>Sieve Size</u>	<u>Percent Passing</u>
	No. 20	98-100
	No. 30	70-90
	No. 40	—
	No. 50	0-20
	No. 80	0-5

Rounds: 70% minimum for + 50 beads

839.01.01 Sampling. The Department will obtain random samples of all shipments that are intended for use by State Traffic Forces at the point of delivery. The Department will evaluate the beads for acceptance prior to use.

839.01.02 Composition. Manufacturers must provide certification stating compliance to Section 1504 of MAP 21.

839.01.03 Testing. The Department will test according to AASHTO M 247 and the following.

- A) **Chemical Resistance Test.** Place three, 0.1 to 0.2-ounce, samples of the beads in separate Pyrex-glass beakers or porcelain dishes. Cover one sample with distilled water; one with a 3N solution of sulfuric acid; and one with a 50 percent solution of sodium sulfide. Examine the samples microscopically after one hour of immersion. Reject the beads if they darken or “frost”.
- A) **Moisture Resistance Test.** Place approximately 2 pounds of glass beads in a clean cotton bag not treated with sizing material. Immerse the bag in water, completely covering the beads, for approximately 30 seconds. Remove the bag and wring free of excess water. Hang the bag in room air for 2 hours to dry. Transfer the beads slowly to a clean, dry, standard (4-inch stem, and a 1/4-inch diameter exit) glass funnel. Accept beads that flow freely through the funnel.

839.01.04 Approval. The Department will notify the vendor of acceptance when all testing is complete. The Department will evaluate beads used by the Contractor as part of the installed pavement marking in accordance with KM 64-201, KM 64-202, or KM 64-203 as applicable.

SECTION 840 — PAVEMENT MARKERS

840.01 DESCRIPTION. This section covers the material requirements for snow-plowable raised pavement markers, inlaid pavement markers, replacement lenses, and temporary surface-mounted raised pavement markers.

840.02 GENERAL. Use pavement markers conforming to the following types.

840.02.01 Type IV Markers. Type IV markers are lenses (mono or bi-directional) installed in grooves of inlaid markers and replacement lenses installed in Type V marker castings.

840.02.02 Type V Markers. Type V markers consist of an iron casting with a Type IV marker (mono or bi-directional) attached.

840.02.03 Type IVA Markers. Type IVA markers are surface-mounted lenses (mono or bi-directional) for temporary use in work zones.

840.03 APPROVAL. The Department will approve pavement markers based on conformance to KM 64-206 and the requirements of this section.

840.04 PACKAGING. Suitably and substantially package all materials with the name and address of the manufacturer and vendor, contract or purchase number, kind of material, trade name, and net contents plainly marked on each package.

840.05 CERTIFICATION. Submit a manufacturer's certification stating conformance to the requirements of this section for each shipment of pavement markers delivered for use on projects. Clearly state the manufacturer, product name, product code, type, and color as listed in the Department's List of Approved Materials. Identify the lot number(s) and quantity of pavement markers delivered. Provide a certification from the adhesive manufacturer stating the adhesive conforms to the requirements of the marker manufacturer and the minimum application temperature at which the adhesive can be successfully applied. Identify the lot number(s) and expiration date of the adhesive.

840.06 ACCEPTANCE. The Department will accept pavement markers based on verification of inclusion on the Department's List of Approved Materials and compliance of the manufacturer's certification. The Department will accept adhesive based on the compliance of the manufacturer's certification and verification that the adhesive has not exceeded its expiration date.

SECTION 841 —LATEX ADMIXTURE

841.01 DESCRIPTION. This section covers Styrene-Butadiene latex admixtures for concrete bridge deck overlays.

841.02 GENERAL. Use a certified independent laboratory to conduct annual testing and evaluation of Styrene-Butadiene latex admixtures as described in the Prequalification Test Program in the U.S. Department of Transportation Research Report No. FHWA-RD-78-35. Submit the certified test results along with a 5-gallon sample of the latex admixture to the Department's Division of Materials. Use a latex admixture that is produced in the United States. Use only latex admixtures that are free of chlorides.

841.03 APPROVAL. The Department will approve latex admixtures based upon conformance of the required independent laboratory data and test results obtained by the Department to the requirements of FHWA-RD-78-35 and this section.. Submit independent laboratory data conducted within one year of the date of product submittal for Department approval. Obtain Department approval for each latex admixture annually.

841.04 PACKAGING. Package and store the latex admixture in containers and storage facilities that protect the material from freezing and from temperatures above 85 °F. When storing outside of buildings during moderate temperatures, keep the material shaded and away from direct sunlight. Do not use any latex admixture exposed to freezing temperatures without approval from the Division of Materials.

841.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of latex admixture delivered for use on projects. Clearly state the manufacturer, product name, and product code as listed in the Department's List of Approved Materials. Identify the lot number(s), weight percent solids, pH, surface tension, expiration date, and quantity for each lot of latex admixture delivered.

841.06 ACCEPTANCE. The Department will accept latex admixtures based on verification of inclusion on the Department's List of Approved Materials and compliance of the manufacturer's certification. The Department reserves the right to sample and test latex admixtures, at the discretion of the Engineer, in accordance with the Department's Field Sampling and Testing Manual. Do not accept latex admixture that has been exposed to freezing temperatures.

SECTION 842 - PAVEMENT STRIPING PAINT

842.01 DESCRIPTION. This section covers quick-drying waterborne acrylic pavement striping paint for permanent applications.

842.02 GENERAL. Select waterborne acrylic paint that conforms to the composition requirements below. Annually provide independent analysis data and certification for each formulation stating the total concentration of each heavy metal present, the test method used for each determination, and compliance to 40 CFR 261 for leachable heavy metals content. Submit initial samples per formulation for approval before beginning striping operations on a yearly basis. The initial sample may be sent from the manufacturer of the paint.

PAINT COMPOSITION		
Property and Test Method	Yellow	White
Daytime Color (CIELAB) Spectrophotometer using illuminant D65 at 45° illumination and 0° viewing with a 2° observer	L* 81.76 a* 19.79 b* 89.89 Maximum allowable variation 4.0ΔE*	L* 93.51 a* -1.01 b* 0.70 Maximum allowable variation 4.0ΔE*
Nighttime Color (CIELAB) Spectrophotometer using illuminant A at 45° illumination and 0° viewing with a 2° observer	L* 86.90 a* 24.80 b* 95.45 Maximum allowable variation 4.0ΔE*	L* 93.45 a* -0.79 b* 0.43 Maximum allowable variation 4.0ΔE*
Heavy Metals Content	Comply with 40 CFR 261	Comply with 40 CFR 261
TiO ₂ ASTM D 4764	NA	10% by wt. of pigment min.
VOC ASTM D 2369 and D 4017	1.25-lb/gal max.	1.25-lb/gal max.
Contrast Ratio (at 15 mils wft.)	0.98	0.99

842.03 MANUFACTURER'S TESTING. Perform testing for Daytime and Nighttime Color, Contrast Ratio, Titanium Dioxide (white paints) and Volatile Organic Content (VOC) on each lot of waterborne acrylic paint to be delivered for use on projects.

842.04 SAMPLING. The Department will obtain samples of waterborne acrylic paint for compliance testing to the requirements of this section in accordance with the Department's Materials Field Sampling Manual.

842.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of waterborne acrylic paint delivered for use on projects. Clearly state the manufacturer, product name, product code, lot number(s), expiration date, color, sampling method, test results of manufacturer required testing, and quantity delivered.

842.06 ACCEPTANCE. The Department will accept waterborne acrylic paint based on compliance of the manufacturer's certification and conformance of test results obtained by the Department to the requirements of this section.

842.07 ACCEPTANCE PROCEDURES FOR NON-SPECIFICATION PAVEMENT STRIPING PAINT. When non-specification paint is inadvertently incorporated into the work the Department will accept the material with a reduction in pay. The percentage deduction is cumulative based on its compositional properties, but will not exceed 60 percent. The Department will calculate the payment reduction on the unit bid

price for the routes where the non-specification paint was used. Do not accept waterborne acrylic paint with a Daytime or Nighttime color variation greater than 6.0ΔE* or if the cumulative deduction exceeds 60 percent.

PAVEMENT STRIPING PAINT REDUCTION SCHEDULE					
Non-conforming Property	Color 4.1ΔE* to 6.0ΔE*	Heavy Metals	Ti O ₂	VOC	Contrast
Reduction Rate	10%	60%	10 %	60%	10%

Section 843 - Geotextile Fabrics

843.01 DESCRIPTION. This section covers requirements for geotextile fabrics for slope protection and channel lining, underdrains, subgrade or embankment foundation stabilization, and drainage blankets.

843.02 GEOTEXTILE FABRIC. Geotextiles shall meet the physical and chemical requirements of AASHTO M 288 (2015) for the specific applications, except as modified in the subsequent sections.

Ensure that the fabric, except wrapping placed directly against perforated pipe, is formed in widths of at least 6 feet. When necessary, sew sheets of fabric together to form required fabrics widths. Sew the sheets of fabric together at the point of manufacture or other approved locations.

The geotextile manufacturer or supplier (private label) is responsible for establishing and maintaining a quality control program to ensure compliance with this section. The manufacturer or supplier must participate in the National Transportation Product Evaluation Program (NTPEP) for Geotextile and Geosynthetics. Current data must be posted in NTPEP DataMine.

843.03 ACCEPTANCE. Select geotextiles from the Department’s List of Approved Materials. Obtain the Department’s approval for all material before incorporating it into the project.

843.04 PACKAGING. During all periods of shipment and storage, wrap the fabric in a heavy duty protective covering to protect the fabric from direct sunlight, ultraviolet rays, mud, dirt, dust, and debris. Additionally, store the fabric so that temperatures are below 140°F.

843.05 GEOTEXTILE FABRIC FOR SLOPE PROTECTION, CHANNEL LINING, AND STABILIZATION. Fabric used for slope protection, channel lining and stabilization shall meet AASHTO M 288 Class 1 strength requirements and conform to AASHTO M 288 section on permanent erosion control, with the exception of the minimum permittivity value being 1.0 sec⁻¹.

843.06 GEOTEXTILE FABRIC FOR SUBSURFACE DRAINAGE AND SEPARATION. Fabric used for subsurface drainage and separation shall conform to AASHTO M 288 Class 1 or 2 strength requirements and conform to AASHTO M 288 section on subsurface drainage requirements, with the exception of the minimum permittivity value being 1.0 sec⁻¹.

843.07 ACCEPTANCE PROCEDURE FOR NON-SPECIFICATION FABRIC. Ensure that all geotextile fabric conforms to the requirements of this section and the proposed application. However, when non-specification geotextile fabric is inadvertently incorporated into the work before completion of testing, the Department may accept the material with reduction in pay, provided the failure is marginal and will not cause poor performance. The Department will apply the largest payment reduction when the material fails to meet more than one specification requirement. The Department will calculate the payment reduction on the invoice cost of the material delivered at the project site. The Department will reject any fabric that fails and has not been incorporated into the work.

GRAB STRENGTH PAYMENT REDUCTION				
% of Requirement	100% or more	90%-99%	75%-89%	74% or Less
Reduction Rate	0%	25%	40%	*

TEAR STRENGTH PAYMENT REDUCTION				
% of Requirement	100% or more	90%-99%	75%-89%	74% or Less
Reduction Rate	0%	25%	40%	*

PUNCTURE STRENGTH PAYMENT REDUCTION				
% of Requirement	100% or more	90%-99%	75%-89%	74% or Less
Reduction Rate	0%	25%	40%	*

SEWN SEAM STRENGTH PAYMENT REDUCTION				
% of Requirement	100% or more	90%-99%	75%-89%	74% or Less
Reduction Rate	0%	25%	40%	*

** Remove and replace the fabric unless the Engineer determines the fabric can remain in place at a 100% reduction rate*

843.08 FASTENER PINS. The Engineer will accept fastener pins based on visual inspection on the project. Conform to the following:

- A) Underdrain Systems.** Use pins that are formed of No. 9 diameter or heavier steel wire and are at least on foot long with a 4-inch right angle bend on one end.
- B) Slope Protection, Channel Lining, Subgrade and Embankment Foundation Stabilization, and Wrapped Aggregate Drainage Blankets.** Provide fastener pins that are formed of 3/16 inch diameter or heavier steel, pointed at on end, with a head on the opposite end to retain a washer with a minimum diameter of 1 1/2 inches.

SECTION 844 — MINERAL ADMIXTURES FOR CONCRETE

844.01 FLY ASH REQUIREMENTS. For fly ash added to concrete mixtures as a separate ingredient, conform to ASTM C 618, Class F or Class C, except ensure that the loss on ignition does not exceed 3.0 percent or 6.0 percent for fly ash receiving an approved chemical treatment.

Concrete containing Class C fly ash may reduce sulfate resistance. Susceptibility to sulfate attack relates to the resistance factor, R. The value of R is defined as the ratio, $(CaO - 5.0)/(Fe_2O_3)$, as determined from the fly ash oxide analysis. A resistance factor (R) greater than 3.0 indicates a reduction in sulfate resistance. Do not use Class C fly ash having an R ratio greater than 3.0 in concrete where sulfate attack is possible unless the maximum expansion limits for moderate sulfate exposure found in the Supplemental Requirements of ASTM C618 are met.

844.02 APPROVAL.

844.02.01 Fly Ash. Select from the Department's List of Approved Materials for fly ash sources. To be placed on the list, furnish samples and ASTM C 618 test data developed over the previous 3 months, and conform to the requirements in KM 64-325.

844.02.02 Slag Cement. The Department's Division of Materials maintains a list of approved Slag Cement sources by producer. Furnish samples and ASTM C 989 test data for the previous six months and meet the following requirements to obtain approval.

- 1) Submit the slag cement supplier's quality control program to the Engineer for approval. The slag cement delivered to the project shall have uniform properties complying with this specification. Laboratories performing tests on slag cement for conformance to ASTM C 989 shall participate in the laboratory evaluation program conducted by the Cement and Concrete Reference Laboratory of ASTM.
- 2) Submit certification with each shipment of slag cement to document its compliance with this specification and ASTM C 989.
- 3) Submit actual ASTM C 989 test results for fineness, air content, slag activity index, sulfide sulfur content, and sulfate ion content with each shipment.

The Department reserves the right to perform all sampling and testing on slag cement that it deems necessary or desirable.

844.02.03 Silica Fume. The Department's Division of Materials maintains a list of approved silica fume admixtures by brand name and manufacturer. Furnish samples and ASTM C1240 test data for the previous six months and meet the following requirements to obtain approval:

- 1) Submit the silica fume supplier's quality control program to the Engineer for approval. The silica fume delivered to the project shall have uniform properties complying with this specification. Laboratories performing tests on silica fume for conformance to ASTM C1240 shall participate in the laboratory evaluation program conducted by the Cement and Concrete Reference Laboratory of ASTM.
- 2) Submit certification with each shipment of silica fume to document its compliance with this specification and ASTM C1240.
- 3) Submit actual ASTM C1240 tests results for the chemical and physical requirements with each shipment.

844.03 NON-SPECIFICATION FLY ASH. When either Class C or Class F sampled fly ash fails to meet specification requirements for loss on ignition (LOI), but the Engineer determines that concrete produced using the fly ash meets requirements for entrained air

and compressive strength, the Engineer will reduce the price by 5.0 percent of the Contractor's invoice cost of the fly ash for each 0.1 percent that the fly ash LOI is above the maximum allowed. This procedure is intended to provide for acceptance at a reduced Contract price when material is discovered to not meet specification requirements after work is performed, and is not intended as a means to utilize non-specification material.

The Engineer will accept fly ash on the basis of certification and being from an approved source and project samples passing the applicable requirements of ASTM C 618. Some variability or small departures from the requirements do not adversely affect properties of the finished product enough for removal and replacement. Therefore, the Department will use the following pay tables when deviations occur. When a sample fails more than one test, the Department will impose the largest reduction rate. The Department will calculate the payment reduction on the invoice cost of the fly ash delivered to the concrete plant or to the project site.

FINENESS PAYMENT REDUCTION				
% Retained on No. 325 Sieve	0-34	35-40	41-45	46 or more
Reduction Rate	0%	25%	50%	*

STRENGTH ACTIVITY INDEX PAYMENT REDUCTION				
Control with Cement (%)	75 or more	70-74	65-69	64 or less
Reduction Rate	0%	25%	50%	*

AUTOCLAVE EXPANSION PAYMENT REDUCTION				
Expansion ± (%)	0.8	0.9	1.0	1.1 or more
Reduction Rate	0%	25%	50%	*

WATER REQUIREMENT PAYMENT REDUCTION				
Control (%)	105 or less	106-110	111-115	116 or more
Reduction Rate	0%	25%	50%	*

CHEMICAL REQUIREMENTS PAYMENT REDUCTION				
SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃ (%) (Class F)	70 or more	65-79	60-64	59 or less
SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃ (%) (Class C)	50 or more	45-49	40-44	39 or less
SO ₃ (%)	0-5	6	7	8 or more
Moisture Content (%)	0-3	4	5	6 or more
Available Alkalies as (Na ₂ O) (%)	0-1.5	1.6	1.7	1.8 or more
Reduction Rate	0%	25%	50%	*

**Remove and replace finished product unless the Engineer determines that it can remain in place at a 100% reduction rate.*

SECTION 845 — FABRIC WRAPPED BACKFILL DRAIN MATERIALS

845.01 DESCRIPTION. Place fabric wrapped backfill drains at locations where depth to weep hole flowline is 30 feet or less.

845.02 FABRIC WRAPPED BACKFILL DRAIN. Select from the Departments List of Approved Materials.

845.02.01 Compressive Strength. Ensure the drain is capable of withstanding a compressive load of 5,000 pounds per square foot on the wide side, with a maximum deflection of 50 percent.

845.02.02 Core. Use a rectangular core at least 17 inches wide, with nominal thickness of at least 0.7 inch, consisting of molded plastic; or of a 3-dimensional structure of mono-filaments bonded at their intersections; or of 3/8-inch average diameter expanded polystyrene beads bound together with an adhesive compound, sufficiently open to allow free movement of water entering through the geotextile fabric, and manufactured specifically for drainage applications.

845.02.03 Wrapping. Wrap the core on all 4 sides with geotextile fabric conforming to the requirements of Section 843 - geotextile fabric for subsurface drainage and separation.

845.03 PACKAGING AND CARE. Wrap the drain in a protective covering to protect the fabric from direct sunlight, ultraviolet rays, temperatures greater than 140 °F, mud, dirt, dust, and debris during all periods of shipment and storage.

Completely cover with backfill material within 14 calendar days after placement. If completely backfilling the drain is not feasible, cover exposed portions with approved material to protect the fabric from direct sunlight. Remove and replace any drain not backfilled or suitably covered within 14 days after placing at no expense to the Department.

845.04 ACCEPTANCE. Furnish the manufacturer's certification to the Engineer stating the fabric wrapped backfill drains meets all requirements herein. The Engineer will accept the fabric wrapped backfill drains by certification and visual inspection.

SECTION 846 - DURABLE WATERBORNE PAINT

846.01 DESCRIPTION. This section covers quick-drying durable waterborne acrylic pavement striping paint for permanent applications. The paint shall be ready-mixed, one-component, 100% waterborne acrylic striping paint suitable for application on such traffic-bearing surfaces as Portland cement concrete, bituminous cement concrete, asphalt, tar, and previously painted areas of these surfaces.

846.02 GENERAL. Select durable waterborne acrylic paint that conforms to the composition requirements below. Annually provide independent analysis data and certification for each formulation stating the total concentration of each heavy metal present, the test method used for each determination, and compliance to 40 CFR 261 for leachable heavy metals content. Submit initial samples per formulation for approval before beginning striping operations on a yearly basis. The initial sample may be sent from the manufacturer of the paint.

The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer as determined by infrared spectral analysis. The acrylic resin used shall be a 100% cross-linking acrylic as evidenced by infrared peaks at wavelengths 1568, 1624, and 1672 cm-1 with intensities equal to those produced by an acrylic resin known to be 100% cross-linking.

PAINT COMPOSITION		
Property and Test Method	Yellow	White
Daytime Color (CIELAB) Spectrophotometer using illuminant D65 at 45° illumination and 0° viewing with a 2° observer	L* 81.76 a* 19.79 b* 89.89 Maximum allowable variation 4.0ΔE*	L* 93.51 a* -1.01 b* 0.70 Maximum allowable variation 4.0ΔE*
Nighttime Color (CIELAB) Spectrophotometer using illuminant A at 45° illumination and 0° viewing with a 2° observer	L* 86.90 a* 24.80 b* 95.45 Maximum allowable variation 4.0ΔE*	L* 93.45 a* -0.79 b* 0.43 Maximum allowable variation 4.0ΔE*
Heavy Metals Content	Comply with 40 CFR 261	Comply with 40 CFR 261
Titanium Dioxide ASTM D 4764	NA	10% by weight of pigment min.
VOC ASTM D 2369 and D 4017	1.25 lb/gal max.	1.25 lb/gal max.
Contrast Ratio (at 15 mils wft)	0.98	0.99

846.03 MANUFACTURER'S TESTING. Perform testing for Daytime and Nighttime Color, Contrast Ratio, Titanium Dioxide (white paints) and Volatile Organic Content (VOC) on each lot of durable waterborne acrylic paint to be delivered for use on projects.

846.04 SAMPLING. The Department will obtain samples of durable waterborne acrylic paint for compliance testing to the requirements of this section in accordance with the Department's Field Sampling and Testing Manual.

846.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of durable waterborne acrylic paint delivered for use on projects. Clearly state the manufacturer, product name, product code, color, sampling method, test results of manufacturer required testing, and quantity

delivered.

846.06 ACCEPTANCE. The Department will accept durable waterborne acrylic paint based on compliance of the manufacturer's certification and conformance of test results obtained by the Department to the requirements of this section.

846.07 ACCEPTANCE PROCEDURES FOR NON-SPECIFICATION DURABLE WATERBORNE PAVEMENT STRIPING PAINT. When non-specification paint is inadvertently incorporated into the work the Department will accept the material with a reduction in pay. The percentage deduction is cumulative based on its compositional properties, but will not exceed 60 percent. The Department will calculate the payment reduction on the unit bid price for the routes where the non-specification paint was used. Do not accept waterborne acrylic paint with a Daytime or Nighttime color variation greater than 6.0ΔE*.

DURABLE WATERBORNE PAVEMENT STRIPING PAINT REDUCTION SCHEDULE						
Non-conforming Property	Resin	Color 4.1ΔE* to 6.0ΔE*	Contrast	TiO₂	VOC	Heavy Metals Content
Reduction Rate	60%	10%	10%	10%	60%	60%