

Division 9 Materials

9-00 Definitions and Tests

9-00.1 Fracture

“Fractured aggregate is defined as an angular, rough, or broken surface of an aggregate particle created by crushing, or by other means. A face is considered a “fractured face” whenever one-half or more of the projected area, when viewed normal to that face, is fractured with sharp and well-defined edges: this excludes small nicks.

9-00.2 Wood Waste

Wood waste is defined as all material which, after drying to constant weight, has a specific gravity of less than 1.0.

9-00.3 Test for Mass of Galvanizing

At the option of the Engineer, the weight of zinc in ounce per square foot required by the various galvanizing Specifications may be determined by an approved magnetic thickness gage suitably checked and demonstrated for accuracy, in lieu of the other methods specified.

9-00.4 Sieves for Testing Purposes

Test sieves shall be made of either: (1) woven wire cloth conforming to ASTM E11, or (2) square-hole, perforated plates conforming to ASTM E323.

9-00.5 Dust Ratio

The dust ratio is defined as the percent of material passing the No. 200 sieve divided by the percent of material passing the No. 40 sieve.

9-00.6 Sand/Silt Ratio

The sand/silt ratio is defined as the percent of material passing the No. 10 sieve divided by the percent of material passing the No. 200 sieve.

9-00.7 Galvanized Hardware, AASHTO M232

An acceptable alternate to hot-dip galvanizing in accordance with AASHTO M 232 will be zinc coatings mechanically deposited in accordance with ASTM B695, providing the minimum thickness of zinc coating is not less than that specified in AASHTO M232, and the process will not produce hydrogen embrittlement in the base metal. Sampling and testing will be made by the Engineer in accordance with commonly recognized national standards and methods used in the laboratory of the Department of Transportation.

9-00.8 Sand Equivalent

The sand equivalent will be the average of duplicate determinations from a single sample. The sand equivalent sample will be prepared in accordance with the FOP for AASHTO T 176.

For acceptance, there must be a clear line of demarcation. If no clear line of demarcation has formed at the end of a 30-minute sedimentation period, the material will be considered as failing to meet the minimum specified sand equivalent.

9-00.9 Field Test Procedures

Field test procedures may be either a Standard Operating Procedure (SOP) or a Field Operating Procedure (FOP) for an AASHTO, ASTM, or WAQTC test procedure. A Field Operating Procedure is a technically equivalent abridged version of an AASHTO, ASTM, or WAQTC test procedure for use in field conditions. References to manuals containing all of these tests and procedures can be found in Section 1-06.2(1).

9-01 Cement**9-01.1 Types of Cement**

Cement shall be classified as portland cement, blended hydraulic cement, or rapid hardening hydraulic cement.

9-01.2 Specifications**9-01.2(1) Portland Cement**

Portland cement shall meet the requirements of AASHTO M85 or ASTM C150 Types I, II, or III portland cement, except that the cement shall not contain more than 0.75 percent alkalis by weight calculated as Na_2O plus $0.658 \text{ K}_2\text{O}$ and the content of Tricalcium aluminate (C_3A) shall not exceed 8 percent by weight.

The time of setting shall be determined by the Vicat Test method in accordance with AASHTO T 131 or ASTM C191.

9-01.2(1)A Low Alkali Cement

When low alkali portland cement is required, the percentage of alkalis in the cement shall not exceed 0.60 percent by weight calculated as Na_2O plus $0.658 \text{ K}_2\text{O}$. This limitation shall apply to all types of portland cement.

9-01.2(1)B Blended Hydraulic Cement

Blended hydraulic cement shall be either Type IP(X)(MS), Type IS(X)(MS), Type IT(PX)(LY), Type IT(SX)(LY), or Type IL(X) cement conforming to AASHTO M240 or ASTM C595, except that the portland cement used to produce blended hydraulic cement shall not contain more than 0.75 percent alkalis by weight calculated as Na_2O plus $0.658 \text{ K}_2\text{O}$ and shall meet the following additional requirements:

1. Type IP(X)(MS) – Portland-Pozzolan Cement where (X) equals the targeted percentage of fly ash, the fly ash is limited to a maximum of 35 percent by weight of the cementitious material; (MS) indicates moderate sulfate resistance.
2. Type IS(X)(MS) – Portland Blast- Furnace Slag Cement, where: (X) equals the targeted percentage of ground granulated blast-furnace slag, the ground granulated blast furnace slag is limited to a maximum of 50 percent by weight of the cementitious material; (MS) indicates moderate sulfate resistance.
3. Type IT(PX)(LY), where (PX) equals the targeted percentage of pozzolan, and (LY) equals the targeted percentage of limestone. The pozzolan (PX) shall be Class F fly ash and shall be a maximum of 35 percent. (LY) shall be a minimum of 5 percent and a maximum of 15 percent. Separate testing of each source of fly ash each at each proposed replacement level shall be conducted in accordance with ASTM C1012. Expansion at 180 days shall be 0.10 percent or less.
4. Type IT(SX)(LY), where (SX) equals the targeted percentage of slag cement, and (LY) equals the targeted percentage of limestone. (SX) shall be a maximum of 50 percent. (LY) shall be a minimum of 5 percent and a maximum of 15 percent. Separate testing of each source of slag at each proposed replacement level shall be conducted in accordance with ASTM C1012. Expansion at 180 days shall be 0.10 percent or less.
5. Type IL(X), where (X) equals the targeted percentage of limestone, and shall be a minimum of 5 percent and a maximum of 15 percent. Testing shall be conducted in accordance with ASTM C1012. Expansion at 180 days shall be 0.10 percent or less.

The source and weight of the fly ash or ground granulated blast furnace slag shall be certified on the cement mill test report or cement certificate of analysis and shall be reported as a percent by weight of the total cementitious material. The fly ash or ground granulated blast furnace slag constituent content in the finished cement will not vary more than plus or minus 5 percent by weight of the finished cement from the certified value.

Fly ash shall meet the requirements of Section 9-23.9 of these *Standard Specifications*.

Ground granulated blast furnace slag shall meet the requirements of Section 9-23.10 of these *Standard Specifications*.

Limestone shall meet the requirements of AASHTO M240 or ASTM C595.

9-01.2(2) Rapid Hardening Hydraulic Cement

Rapid hardening hydraulic cement shall meet the requirements of ASTM C 1600.

9-01.3 Tests and Acceptance

Cement may be accepted by the Engineer based on the cement mill test report number or cement certificate of analysis number indicating full conformance to the Specifications. All shipments of the cement to the Contractor or concrete supplier shall identify the applicable cement mill test report number or cement certificate of analysis number and shall be provided by the Contractor or concrete supplier with all concrete deliveries.

Cement producers/suppliers that certify portland cement or blended hydraulic cement shall participate in the Cement Acceptance Program as described in WSDOT Standard Practice QC 1. Rapid hardening hydraulic cement producers/suppliers are not required to participate in WSDOT Standard Practice QC 1.

Each mixing facility or plant utilizing portland cement shall be equipped with a suitable means or device for obtaining a representative sample of the cement. The device shall enable the sample to be readily taken in proximity to the cement weigh hopper and from a container or conveyor holding only cement.

Cement may be tested using samples taken at the job site by the Engineer for submission to the State Materials Laboratory for testing.

9-01.4 Storage on the Work Site

At the request of the Engineer, the Contractor shall provide test data to show that cement stored on site for longer than 60 days meets the requirements of Section 9-01. Tests shall be conducted on samples taken from the site in the presence of the Engineer. Test results that meet the requirements of Section 9-01 shall be valid for 60 days from the date of sampling, after which the Engineer may require further testing.

9-02 Bituminous Materials**9-02.1 Asphalt Material, General**

Asphalt furnished under these Specifications shall not have been distilled at a temperature high enough to produce flecks of carbonaceous matter, and upon arrival at the Work, shall show no signs of separation into lighter and heavier components.

The Asphalt Supplier of Performance Graded (PG) asphalt binder and emulsified asphalt shall have a Quality Control Plan (QCP) in accordance with WSDOT QC 2 "Standard Practice for Asphalt Suppliers That Certify Performance Graded and Emulsified Asphalts". The Asphalt Supplier's QCP shall be submitted and accepted by the WSDOT State Materials Laboratory. Once accepted, all changes to the QCP will require a new QCP to be submitted for acceptance. The Asphalt Supplier of PG asphalt binder and emulsified asphalt shall certify through the Bill of Lading that the PG asphalt binder or emulsified asphalt meets the Specification requirements of the Contract.

9-02.1(1) Vacant**9-02.1(2) Vacant****9-02.1(3) Vacant****9-02.1(4) Performance Graded (PG) Asphalt Binder**

PG asphalt binder meeting the requirements of AASHTO M 332 Table 1 of the grades specified in the Contract shall be used in the production of HMA. For HMA with greater than 20 percent RAP by total weight of HMA, or with any amount of RAS, the new asphalt binder, recycling agent and recovered asphalt (RAP and/or RAS) when blended in the proportions of the mix design shall meet the PG asphalt binder requirements of AASHTO M332 Table 1 for the grade of asphalt binder specified by the Contract. Grading designations for blended binder shall be directly related to the LTPPBIND calculated maximum pavement design temperature, minimum pavement design temperature, and the traffic level and load rate outlined in Sections 4.2.1 through 4.2.4 of AASHTO M 332 that are specified by the Contract. Grade bumping by using a lower J_{nr} value while testing the PG Asphalt Binder at the environmental temperature (AASHTO M 332 Table 1 Note a) is not permitted.

In addition to AASHTO M 332 Table 1 specification requirements, PG asphalt binders shall meet the following requirements:

		Additional Requirements by Performance Grade (PG) Asphalt Binders					
Property	Test Method	PG 58 S-22	PG 58 H-22	PG 58 V-22	PG 64 S-28	PG 64 H-28	PG 64 V-28
RTFO Residue: Average percent Recovery @ 3.2 kPa	AASHTO T 350 ¹			30% Min.	20% Min.	25% Min.	30% Min.
RTFO Residue ² : J _{nr} @ 3.2 kPa			2.0 > 0.7 kPa ⁻¹				

¹Specimen conditioned in accordance with AASHTO T 240 – RTFO.

The RTFO J_{nr diff} and the PAV direct tension specifications of AASHTO M 332 are not required.

9-02.1(5) Vacant

9-02.1(6) Cationic Emulsified Asphalt

Cationic Emulsified Asphalt meeting the requirements of AASHTO M 208 Table 1 of the grades specified in the Contract shall be used.

If the particle charge test for CSS-1 and CSS-1h is inconclusive, material having maximum pH value of 6.7 when tested in accordance with ASTM E C70 will be acceptable.

9-02.1(6)A Polymerized Cationic Emulsified Asphalt CRS-2P

CRS-2P shall be a polymerized cationic emulsified asphalt. The polymer shall be milled into the asphalt or emulsion during the manufacturing of the emulsified asphalt. CRS-2P shall meet the following requirements:

	AASHTO Test Method	Specifications	
		Minimum	Maximum
Viscosity @122°F, SFS	T 59	100	400
Storage Stability 1 day %	T 59		1
Demulsibility 35 ml. 0.8% Dioctyl Sodium Sulfosuccinate	T 59	40	
Particle Charge	T 59	positive	
Sieve Test %	T 59		0.30
Distillation			
Oil distillate by vol. of emulsion %	T 59 ¹	0	3
Residue	T 59 ¹	65	
Tests on the Residue From Distillation			
Penetration @77°F	T 49	90	250
Elastic Recovery %	T 301 ²	50	

¹Distillation modified to use 300 grams of emulsified asphalt heated to 350°F ± 9°F and maintained for 20 minutes.

²The residue material for T 301 shall come from the modified distillation per note 1.

9-02.1(7) Vacant

9-02.1(8) Flexible Bituminous Pavement Marker Adhesive

Flexible bituminous pavement marker adhesive is a hot melt thermoplastic bituminous material used for bonding raised pavement markers, recessed pavement markers, and flexible guide posts to the pavement.

The Contractor may submit a maximum of two flexible bituminous pavement marker adhesive lot samples per Contract for testing by the Contracting Agency at the Agency's expense. The Contractor shall allow 21 calendar days for the Contracting Agency to test each flexible bituminous pavement marker lot sample from when the sample is accepted by the State Materials Laboratory in Tumwater, Washington.

The Contractor may submit additional flexible bituminous pavement marker lot samples for testing by the Contracting Agency. All costs for the sampling, documentation and testing of the additional flexible bituminous pavement marker lot samples will be deducted from the Contract. The Contractor agrees to authorize the Engineer to deduct the documentation and testing costs from money due or coming due to the Contractor. The Contractor shall allow 45 calendar days for the Contracting Agency to test each additional flexible bituminous pavement marker lot sample from when the sample is accepted by the State Materials Laboratory in Tumwater, Washington.

When the Contractor submits multiple flexible bituminous pavement marker lot samples for testing, the Contractor shall provide a written priority for testing the samples.

The adhesive material shall conform to the following requirements when prepared in accordance with WSDOT SOP 318 in the WSDOT *Materials Manual* M 46-01:

Property	Test Method	Requirement
Penetration, 77°F, 100g, 5 sec, dmm	AASHTO T 49	30 Max.
Softening Point, F	AASHTO T 53	200 Min.
Rotational Thermosel Viscosity, cP, #27 spindle, 20 RPM, 400°F	AASHTO T 316	5000 Max.
Ductility, 77°F, 5 cm/minute, cm	AASHTO T 51	15 Min.
Ductility, 39.2°F, 1 cm/minute, cm	AASHTO T 51	5 Min.
Flexibility, 1", 20°F, 90 deg. Bend, 10 sec., 3/8" × 1" × 6" specimen	WSDOT T 432	Pass
Bond Pull-Off Strength	WSDOT T 426	Greater than 50 psi

9-02.2 Sampling and Acceptance

9-02.2(1) Certification of Shipment

Bituminous materials will be accepted by the Engineer based on the asphalt binder supplier's Certification of Compliance incorporated in their Bill of Lading. The Certification will include a statement certifying Specification compliance for the product shipped.

Failure to provide this Certification with the shipment shall be cause for rejection of the material. The following information is required on the Bill of Lading:

1. Date
2. Contract Number and/or Project Name
3. Grade of Commodity and Certification of Compliance
4. Anti-strip Type
5. Percent Anti-strip
6. Mass (Net Tons)
7. Volume (Gross Gallons)
8. Temperature of Load (F)
9. Bill of Lading Number
10. Consignee and Delivery Point
11. Signature of Supplier's Representative
12. Supplier (Bill of Lading Generator)
13. Supplier's Address
14. Refiner
15. Refiner's Location

The Bill of Lading shall be supplied at the time of shipment of each truck load, truck and trailer, or other lot of asphalt binder. In addition to the copies the Contractor requires, one copy of the Bill of Lading including the Certification Statement shall be sent with the shipment for agency use.

9-02.2(2) Samples

When requested by the Engineer, the asphalt supplier shall ship, by prepaid express or U.S. mail, samples of asphalt that represent current production.

9-02.3 Temperature of Asphalt

The temperature of paving asphalts in storage tanks when loaded for transporting shall not exceed the maximum temperature recommended by the asphalt binder manufacturer.

9-02.4 Anti-Stripping Additive

Anti-stripping additive shall be a product listed in the current WSDOT Qualified Products List (QPL).

Hydrated lime, when used in HMA as an anti-strip additive shall conform to the requirements of either AASHTO M 303 Type I or ASTM C1097.

9-02.5 HMA Additive

Additives for HMA shall be accepted by the Engineer.

9-03 Aggregates**9-03.1 Aggregates for Concrete****9-03.1(1) General Requirements**

Concrete aggregates shall be manufactured from ledge rock, talus, or sand and gravel in accordance with the provisions of Section 3-01.

Reclaimed aggregate may be used if it complies with the specifications for concrete. Reclaimed aggregate is aggregate that has been recovered from plastic concrete by washing away the cementitious materials.

Aggregates for Concrete shall meet the following test requirements:

Los Angeles Wear, 500 Rev.	35 max.
Degradation Factor (Structural and Paving Concrete)	30 min.
Degradation Factor (Other as defined in 6-02.3(2)B)	20 min.

Aggregates tested in accordance with AASHTO T 303 with expansion greater than 0.20 percent are Alkali Silica Reactive (ASR) and will require mitigating measures.

Aggregates tested in accordance with ASTM C1293 with expansion greater than 0.04 percent are Alkali Silica Reactive (ASR) and will require mitigating measures.

Aggregates for use in Commercial Concrete as defined in Section 6-02.3(2)B shall not require mitigation.

Mitigating measures for aggregates with expansions from 0.21 to 0.45 percent, when tested in accordance with AASHTO T 303, may be accomplished by using low alkali cement as per Section 9-01.2(1)A or by using 25 percent Class F fly ash by total weight of the cementitious materials. The Contractor may submit an alternative mitigating measure through the Engineer to the State Materials Laboratory for approval along with evidence in the form of test results from ASTM C1567 that demonstrate the mitigation when used with the proposed aggregate controls expansion to 0.20 percent or less. The agency may test the proposed ASR mitigation measure to verify its effectiveness. In the event of a dispute, the agency's results will prevail.

Mitigating measures for aggregates with expansions greater than 0.45 percent when tested in accordance with AASHTO T 303 shall include the use of low alkali cement per Section 9-01.2(1)A and may include the use of fly ash, lithium compound admixtures, ground granulated blast furnace slag or other material as approved by the Engineer. The Contractor shall submit evidence in the form of test results from ASTM C1567 through the Engineer to the State Materials Laboratory that demonstrate the proposed mitigation when used with the aggregates proposed will control the potential expansion to 0.20 percent or less before the aggregate source may be used in concrete. The agency may test the proposed ASR mitigation measure to verify its effectiveness. In the event of a dispute, the agency's results will prevail.

The use of fly ash that does not meet the requirements of Table 2 of AASHTO M 295 may be approved for use. The Contractor shall submit test results according to ASTM C1567 through the Engineer to the State Materials Laboratory that demonstrate that the proposed fly ash when used with the proposed aggregates and cement will control the potential expansion to 0.20 percent or less before the fly ash and aggregate sources may be used in concrete. The Contracting Agency may test the proposed ASR mitigation measure to verify its effectiveness. In the event of a dispute, the Contracting Agency's results will prevail.

ASTM C1293 sampling and testing must be coordinated through the WSDOT State Materials Laboratory, Documentation Section utilizing the ASA (Aggregate Source Approval) process. Cost of sampling, testing, and processing will be borne by the source owner.

9-03.1(2) Fine Aggregate for Concrete

Fine aggregate shall consist of natural sand or manufactured sand, or combinations thereof, accepted by the Engineer, having hard, strong, durable particles free from adherent coating. Fine aggregate shall be washed thoroughly to meet the specifications.

9-03.1(2)A Deleterious Substances

The amount of deleterious substances in the washed fine aggregate shall be tested in accordance with AASHTO M 6 and not exceed the following values:

Material finer than No. 200 Sieve	2.5 percent by weight
Clay lumps and friable particles	3.0 percent by weight
Coal and lignite	0.25 percent by weight
Particles of specific gravity less than 2.00	1.0 percent by weight

Organic impurities shall be tested in accordance with AASHTO T 21 by the glass color standard procedure and results darker than organic plate no. 3 shall be rejected. A darker color results from AASHTO T 21 may be used provided that when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with AASHTO T 71, is not less than 95 percent.

9-03.1(2)B Grading

Fine aggregate shall be graded to conform to the following requirements expressed as percentages by weight:

Sieve Size	Class 1 Percent Passing		Class 2 Percent Passing	
	Min.	Max.	Min.	Max.
3/8"	99	100	99	100
No. 4	95	100	95	100
No. 8	68	86		
No. 16	47	65	45	80
No. 30	27	42		
No. 50	9	20	10	30
No. 100	0	7	2	10
No. 200	0	2.5	0	2.5

For fine aggregate Class 1, individual test variations under the minimum or over the maximum will be permitted as follows, provided the average of three consecutive tests is within the Specification limits:

Sieve Size	Permissible percent of Variation in Individual Tests
No. 30 and coarser	2
No. 50 and finer	0.5

Within the gradation limits for fine aggregate Class 2, uniformity of gradation shall be limited to a range of plus or minus 0.20 of the reference fineness modulus. The reference fineness modulus shall be determined from a representative sample from the proposed source as submitted by the Contractor.

9-03.1(3) Vacant

9-03.1(4) Coarse Aggregate for Concrete

Coarse aggregate for concrete shall consist of gravel, crushed stone, or combinations thereof having hard, strong, durable pieces free from adherent coatings. Coarse aggregate shall be washed to meet the specifications.

9-03.1(4)A Deleterious Substances

The amount of deleterious substances in the washed coarse aggregate shall be tested in accordance with AASHTO M 80 and not exceed the following values:

Material finer than No. 200	1.0 ¹ percent by weight
Clay lumps and Friable Particles	2.0 percent by weight
Shale	2.0 percent by weight
Wood waste	0.05 percent by weight
Coal and Lignite	0.5 percent by weight
Sum of Clay Lumps, Friable Particles, and Chert (Less Than 2.40 specific gravity SSD)	3.0 percent by weight

¹If the material finer than the No. 200 sieve is free of clay and shale; this percentage may be increased to 1.5.

9-03.1(4)B Vacant**9-03.1(4)C Grading**

Coarse aggregate for concrete when separated by means of laboratory sieves shall conform to one or more of the following gradings as called for elsewhere in these Specifications, Special Provisions, or in the Plans:

Passing	AASHTO Grading No. 467		AASHTO Grading No. 4		AASHTO Grading No. 57		AASHTO Grading No. 67		AASHTO Grading No. 7		AASHTO Grading No. 8	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Sieve Size 2"	99	100	99	100								
1½"	95	100	90	100	99	100						
1"			20	55	95	100	99	100				
¾"	35	70	0	15			90	100	99	100		
½"					25	60			90	100	99	100
⅜"	10	30	0	5			20	55	40	70	85	100
No. 4	0	5			0	10	0	10	0	15	10	30
No. 8					0	5	0	5	0	5	0	10
No. 16											0	5

All percentages are by weight.

Where coarse aggregate size 467 is used, the aggregate may be furnished in at least two separate sizes in the allowable range. Coarse aggregate shall contain no piece of greater size than two times the maximum sieve size for the specified grading measured along the line of greatest dimension.

9-03.1(5) Combined Aggregate Gradation for Concrete

As an alternative to using the fine aggregate sieve grading requirements in Section 9-03.1(2)B, and coarse aggregate sieve grading requirements in Section 9-03.1(4)C, a combined aggregate gradation conforming to the requirements of Section 9-03.1(5)A may be used.

9-03.1(5)A Deleterious Substances

The amount of deleterious substances in the washed aggregates ¾ inch or larger shall not exceed the values specified in Section 9-03.1(4)A and for aggregates smaller than ¾ inch they shall not exceed the values specified in Section 9-03.1(2)A.

9-03.1(5)B Grading

The combined aggregate shall conform to the following requirements based upon the nominal maximum aggregate size.

Nominal Maximum Aggregate Size	3	2-½	2	1-½	1	¾	½	⅜	No. 4
3½"	99-100								
3"	93-100*	99-100							
2½"		92-100*	99-100						
2"	76-90		90-100*	99-100					
1½"	66-79	71-88		87-100*	99-100				
1"	54-66	58-73	64-83		82-100*	99-100			
¾"	47-58	51-64	55-73	62-88		87-100*	99-100		
½"	38-48	41-54	45-61		57-83		81-100*	99-100	
⅜"	33-43	35-47	39-54	43-64		60-88		86-100*	99-100
No. 4	22-31	24-34	26-39	29-47	34-54	41-64	48-73		68-100*
No. 8	15-23	16-25	17-29	19-34	22-39	27-47	31-54	39-73	
No. 16	9-17	10-18	11-21	12-25	14-29	17-34	20-39	24-54	28-73
No. 30	5-12	6-14	6-15	7-18	8-21	9-25	11-29	13-39	16-54
No. 50	2-9	2-10	3-11	3-14	3-15	4-18	5-21	6-29	7-39
No. 100	0-7	0-7	0-8	0-10	0-11	0-14	0-15	0-21	0-29
No. 200	0-2.0	0-2.0	0-2.0	0-2.0	0-2.0	0-2.0	0-2.0	0-2.0	0-2.5

*Nominal Maximum Size

All percentages are by weight.

Nominal maximum size for concrete aggregate is defined as the smallest standard sieve opening through which the entire amount of the aggregate is permitted to pass. Standard sieve sizes shall be those listed in ASTM C33.

The Contracting Agency may sample each aggregate component prior to introduction to the weigh batcher or as otherwise determined by the Engineer. Each component will be sieve analyzed separately in accordance with FOP for WAQTC/AASHTO T 27/T 11. All aggregate components will be mathematically re-combined by the proportions (percent of total aggregate by weight), provided by the Contractor on Concrete Mix Design Form 350-040.

9-03.2 Aggregate for Job-Mixed Portland Cement or Blended Hydraulic Cement Mortar

Fine aggregate for portland cement or blended hydraulic cement mortar shall consist of sand or other inert materials, or combinations thereof, accepted by the Engineer, having hard, strong, durable particles free from adherent coating. Fine aggregate shall be washed thoroughly to remove clay, loam, alkali, organic matter, or other deleterious matter.

The amount of deleterious substances in the washed aggregate shall not exceed the limit specified in Section 9-03.1(2)A.

9-03.2(1) Grading for Surface Finishing Applications

Fine aggregate shall be graded to conform to the following requirements expressed as percentage by weight:

Sieve	Percent Passing			
	Natural Sand		Manufactured Sand	
	Min.	Max.	Min.	Max.
No. 4	99	100	99	100
No. 8	90	100	90	100
No. 16	60	90	60	90
No. 30	35	70	35	70
No. 50	10	30	20	40
No. 100	0	5	10	25
No. 200	0	3	0	10

9-03.2(2) Grading for Masonry Mortar Applications

Fine aggregate shall be graded to conform to the following requirements expressed as percent age by weight:

Sieve	Percent Passing			
	Natural Sand		Manufactured Sand	
	Min.	Max.	Min.	Max.
No. 4	99	100	99	100
No. 8	95	100	95	100
No. 16	70	100	70	100
No. 30	40	75	40	75
No. 50	10	35	20	40
No. 100	2	15	10	25
No. 200	0	5	0	10

9-03.3 Vacant**9-03.4 Aggregate for Bituminous Surface Treatment****9-03.4(1) General Requirements**

Aggregate for bituminous surface treatment shall be manufactured from ledge rock, talus, or gravel, in accordance with Section 3-01. Aggregates for Bituminous Surface Treatment shall meet the following test requirements:

Los Angeles Wear, 500 Rev.	35 percent max.
Degradation Factor	30 min.

9-03.4(2) Grading and Quality

Aggregate for bituminous surface treatment shall conform to the requirements in the table below for grading and quality. The particular type or grading to be used shall be as shown in the Plans. All percentages are by weight.

The material shall meet the requirements for grading and quality when placed in hauling vehicles for delivery to the roadway, or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the Engineer.

Crushed Screening percent Passing					
	¾" - ½"	⅝" - No. 4	½" - No. 4	⅜" - No. 4	No. 4-0
1"	99-100				
¾"	95-100	99-100			
⅝"		95-100	99-100		
½"	0-20		90-100	99-100	
⅜"	0-5		60-85	70-90	99-100
No. 4		0-10	0-3	0-5	76-100
No. 10		0-3			30-60
No. 200	0-1.5	0-1.5	0-1.5	0-1.5	0-10.0
% fracture, by weight, min.	90	90	90	90	90

All percentages are by weight.

The fracture requirement shall be at least two fractured faces and will apply to the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T 335.

The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials.

Crushed screenings shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50 percent of the surface area of any sized material between successive laboratory sieves.

The portion of aggregate for bituminous surface treatment retained on a No. 4 sieve shall not contain more than 0.1 percent deleterious materials by weight.

Fine aggregate used for choke stone applications meeting the grading requirements of Section 9-03.1(2)B may be substituted for the No. 4-0 gradation.

9-03.5 Pea Gravel

When pea gravel is specified for structural shoring and cofferdams, grading shall conform to the requirements for AASHTO Grading No. 8 set forth in Section 9-03.1(4)C.

9-03.6 Vacant

9-03.7 Vacant

9-03.8 Aggregates for Hot Mix Asphalt

9-03.8(1) General Requirements

Aggregates for Hot Mix Asphalt shall meet the following test requirements:

Los Angeles Wear, 500 Rev.	30 percent max.
Degradation Factor, Wearing Course	30 min.
Degradation Factor, Other Courses	20 min.
Sand Equivalent	45 min.

Aggregate sources that have 100 percent of the mineral material passing the No. 4 sieve shall be limited to no more than 5 percent of the total weight of aggregate.

Aggregates shall be uniform in quality, substantially free from wood, roots, bark, extraneous materials, and adherent coatings. The presence of a thin, firmly adhering film of weathered rock will not be considered as coating unless it exists on more than 50 percent of the surface area of any size between consecutive laboratory sieves.

Aggregate removed from deposits contaminated with various types of wood waste shall be washed, processed, selected, or otherwise treated to remove sufficient wood waste so that the oven dried material retained on a No. 4 sieve shall not contain more than 0.1 percent by weight of material with a specific gravity less than 1.0.

9-03.8(2) HMA Test Requirements

Aggregate for HMA shall meet the following test requirements:

1. Vacant
2. The fracture requirements for the combined coarse aggregate shall apply to the material retained on the No. 4 sieve and above, when tested in accordance with FOP for AASHTO T 335.

ESAL's (millions)	# Fractured Faces	% Fracture
< 10	1 or more	90
≥ 10	2 or more	90

3. The uncompacted void content for the combined fine aggregate is tested in accordance with FOP for AASHTO T 304, Method A. The minimum percent voids shall be as required in the following table:

Traffic ESAL's (millions)	HMA Evaluation	
	Statistical	Commercial
< 3	40	40
≥ 3	44	40

4. The minimum sand equivalent for the aggregate shall be 45.

The mix design shall produce HMA mixtures when combined with RAP, RAS, coarse and fine aggregate within the limits set forth in Section 9-03.8(6) and mixed in the laboratory with the designated grade of asphalt binder, using the Superpave gyratory compactor in accordance with FOP for AASHTO T 312, and at the required gyrations for N initial, N design, and N maximum with the following properties:

Mix Criteria	HMA Class							
	¾ inch		½ inch		¾ inch		1 inch	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Voids in Mineral Aggregate (VMA), %	15.0		14.0		13.0		12.0	
Voids Filled With Asphalt (VFA), %								
ESAL's (millions)	VFA							
< 0.3	70	80	70	80	70	80	67	80
0.3 to < 3	65	78	65	78	65	78	65	78
≥ 3	73	76	65	75	65	75	65	75
Dust/Asphalt Ratio	0.6	1.6	0.6	1.6	0.6	1.6	0.6	1.6

Test Method	ESAL's (millions)	Number of Passes
Hamburg Wheel-Track Testing, FOP for AASHTO T 324	< 0.3	10,000
Minimum Number of Passes with no Stripping Inflection Point and Maximum Rut Depth of 10 mm	0.3 to < 3	12,500
	≥ 3	15,000
Indirect Tensile (IDT) Strength (psi) of Bituminous Materials FOP for ASTM D6931	175 Maximum	

	ESAL's (millions)	N initial	N design	N maximum
% Gmm	< 0.3	≤ 91.5	96.0	≤ 98.0
	0.3 to < 3	≤ 90.5	96.0	≤ 98.0
	≥ 3	≤ 89.0	96.0	≤ 98.0
Gyratory Compaction (number of gyrations)	< 0.3	6	50	75
	0.3 to < 3	7	75	115
	≥ 3	8	100	160

The mix criteria for Hamburg Wheel-Track Testing and Indirect Tensile Strength do not apply to HMA accepted by commercial evaluation.

When material is being produced and stockpiled for use on a specific contract or for a future contract, the uncompacted void content, fracture, and sand equivalent requirements shall apply at the time of stockpiling. When material is used from a stockpile that has not been tested as provided above, the Specifications for uncompacted void content, fracture, and sand equivalent shall apply at the time of its introduction to the cold feed of the mixing plant.

9-03.8(3) Grading

9-03.8(3)A Gradation

The Contractor may furnish aggregates for use on the same contract from multiple stockpiles. The gradation of the aggregates shall be such that the completed mixture complies in all respects with the pertinent requirements of Section 9-03.8(6).

Acceptance of the aggregate gradation shall be based on samples taken from the final mix.

9-03.8(3)B Gradation - Recycled Asphalt Pavement and Mineral Aggregate

The gradation for the new aggregate used in the production of the HMA shall be the responsibility of the Contractor, and when combined with recycled material, the combined material shall meet the gradation Specification requirements for the specified Class HMA as listed in Section 9-03.8(6) or as shown in the Special Provisions. The new aggregate shall meet the general requirements listed in Section 9-03.8(1) and Section 9-03.8(2). No contamination by deleterious materials shall be allowed in the old asphalt concrete used.

For HMA with greater than 20 percent RAP by total weight of HMA the RAP shall be processed to ensure that 100 percent of the material passes a sieve twice the size of the maximum aggregate size for the class of mix to be produced.

When any amount of RAS is used in the production of HMA the RAS shall be milled, crushed or processed to ensure that 100 percent of the material passes the ½ inch sieve. Extraneous materials in RAS such as metals, glass, rubber, soil, brick, tars, paper, wood and plastic shall not exceed 2.0 percent by mass as determined on material retained on the No. 4 sieve.

9-03.8(4) Vacant

9-03.8(5) Mineral Filler

Mineral filler, when used in HMA mix, shall conform to the requirements of AASHTO M 17.

9-03.8(6) HMA Proportions of Materials

The materials of which HMA is composed shall be of such sizes, grading, and quantity that, when proportioned and mixed together, they will produce a well graded mixture within the requirements listed below.

The aggregate percentage refers to completed dry mix and includes mineral filler when used.

Aggregate Gradation Control Points				
Sieve Sizes Percent Passing	¾ inch	½ inch	¼ inch	1 inch
1½"				99-100
1"			99-100	90-100
¾"		99-100	90-100	90 Maximum
½"	99-100	90-100	90 Maximum	
¾"	90-100	90 Maximum		
No. 4	90 Maximum			
No. 8	32-67	28-58	23-49	19-45
No. 200	2.0-7.0	2.0-7.0	2.0-7.0	1.0-7.0

9-03.8(7) HMA Tolerances, Specification Limits and Adjustments

- Job Mix Formula Tolerances and Specification Limits** – The constituents of the HMA mixture at the time of acceptance shall conform to the following tolerances and specification limits:

Job Mix Formula Aggregate Tolerance Limits		
Aggregate, Percent Passing	Statistical Evaluation	Visual Evaluation
1", ¾", ½" and ¾" sieves	± 6%	± 8%
No. 4 sieve	± 5%	± 8%
No. 8 sieve	± 4%	± 8%
No. 200 sieve	± 2%	± 3%

Voids in Mineral Aggregate (VMA) Tolerance Limit from the Minimum VMA Value in Section 9-03.8(2) HMA Test Requirements			
Statistical Evaluation			
HMA Class			
¾ inch	½ inch	¼ inch	1 inch
-0.5%	-0.5%	-0.5%	-0.5%

Specification Limits		
HMA Mix Property	Statistical Evaluation	Visual Evaluation
Asphalt Binder	- 0.4% to + 0.5%	± 0.7%
Air Voids, Va	2.5% minimum to 5.5% maximum	

These tolerance and specification limits constitute the allowable limits as described in Section 1-06.2. The tolerance limit for aggregate shall not exceed the limits of the control points, except the tolerance limits for sieves designated as 100 percent passing will be 99-100.

- Job Mix Formula Adjustments** – An adjustment to the aggregate gradation or asphalt binder content of the JMF requires approval of the Engineer. Adjustments to the JMF will only be considered if the change produces material of equal or better quality and may require the development of a new mix design if the adjustment exceeds the amounts listed below.
 - Aggregates** – The maximum adjustment from the approved mix design shall be 2 percent for the aggregate passing the 1½", 1", ¾", ½", ¾", and the No. 4 sieves, 1 percent for aggregate passing the No. 8 sieve, and 0.5 percent for the aggregate passing the No. 200 sieve. The adjusted JMF shall be within the range of the control points in Section 9-03.8(6).

- b. **Asphalt Binder Content** – The Engineer may order or approve changes to asphalt binder content. The maximum adjustment from the approved mix design for the asphalt binder content shall be 0.3 percent.

9-03.9 Aggregates for Ballast and Crushed Surfacing

9-03.9(1) Ballast

Ballast shall consist of crushed, partially crushed, or naturally occurring granular material from approved sources manufactured in accordance with the provisions of Section 3-01.

Aggregates for ballast shall meet the following test requirements:

Los Angeles Wear, 500 Rev	40 percent max.
Degradation Factor	15 min.

Ballast shall meet the following requirements for grading and quality when placed in hauling vehicles for delivery to the roadway or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the Engineer.

The portion of ballast retained on No. 4 sieve shall not contain more than 0.2 percent wood waste.

Sieve Size	Percent Passing
2½"	99-100
2"	65-100
1"	50-85
No. 4	26-44
No. 40	16 max.
No. 200	9.0 max.
Dust Ratio:	¾ max.
Sand Equivalent	35 min.

All percentages are by weight.

9-03.9(2) Permeable Ballast

Permeable ballast shall meet the requirements of Section 9-03.9(1) for ballast except for the following special requirements.

The grading and quality requirements are:

Sieve Size	Percent Passing
2½"	99-100
2"	65-100
¾"	40-80
No. 4	5 max.
No. 100	0-2
% Fracture	75 min.

All percentages are by weight.

The sand equivalent value and dust ratio requirements do not apply.

The fracture requirement shall be at least one fractured face and will apply the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T 335.

9-03.9(3) Crushed Surfacing

Crushed surfacing shall be manufactured from ledge rock, talus, or gravel in accordance with the provisions of Section 3-01. The materials shall be uniform in quality and substantially free from wood, roots, bark, and other extraneous material and shall meet the following quality test requirements:

Los Angeles Wear, 500 Rev.	35 percent max.
Degradation Factor – Top Course	25 min.
Degradation Factor – Base Course	15 min.

Crushed surfacing of the various classes shall meet the following requirements for grading and quality when placed in hauling vehicles for delivery to the roadway, or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the Engineer.

Sieve Size	Base Course	Top Course and Keystone
	Percent Passing	
1¼"	99-100	
1"	80-100	
¾"		99-100
⅝"	50-80	
½"		80-100
No. 4	25-45	46-66
No. 40	3-18	8-24
No. 200	7.5 max.	10.0 max.
% Fracture	75 min.	75 min.
Sand Equivalent	40 min.	40 min.

All percentages are by weight.

The fracture requirement shall be at least one fractured face and will apply to the combined aggregate retained on the No. 4 sieve in accordance with FOP for AASHTO T 335.

The portion of crushed surfacing retained on a No. 4 sieve shall not contain more than 0.15 percent wood waste.

9-03.9(4) Maintenance Rock

Maintenance rock shall meet all requirements of Section 9-03.9(3) for crushed surfacing top course except that it shall meet the following Specifications for grading:

Sieve Size	Percent Passing
⅝"	99-100
½"	90-100
No. 4	45-66
No. 40	10-25
No. 200	7 max.

All percentages are by weight.

9-03.10 Aggregate for Gravel Base

Gravel base shall consist of granular material, either naturally occurring or processed. It shall be essentially free from various types of wood waste or other extraneous or objectionable materials. It shall have such characteristics of size and shape that it will compact readily, and the maximum particle size shall not exceed $\frac{3}{8}$ of the depth of the layer being placed.

Gravel base shall meet the following requirements for grading and quality when placed in hauling vehicles for delivery to the roadway or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the Engineer.

Sieve Size	Percent Passing
2"	75-100
No. 4	22-100
No. 200	0-10
Dust Ratio:	$\frac{3}{8}$ max.
Sand Equivalent	30 min.

All percentages are by weight.

Gravel base material retained on a No. 4 sieve shall contain not more than 0.20 percent by weight of wood waste.

9-03.11 Streambed Aggregates

Streambed aggregates shall be naturally occurring water rounded aggregates. Aggregates from quarries, ledge rock, and talus slopes are not acceptable for these applications.

Streambed aggregates shall meet the following test requirements for quality:

Aggregate Property	Test Method	Requirement
Degradation Factor	WSDOT T 113	15 min.
Los Angeles Wear, 500 Rev.	AASHTO T 96	50% max.
Bulk Specific Gravity	AASHTO T 85	2.55 min.

Material for streambed aggregates shall be free of deleterious material. Deleterious material includes manufactured wood products, organic waste, coal, charcoal, or any other extraneous or objectionable material. At the discretion of the Engineer, the percent of deleterious materials may be determined visually or be tested in accordance with AASHTO T 194 or AASHTO T 267.

9-03.11(1) Streambed Sediment

Streambed sediment shall meet the following requirements for grading. If the Contractor proposes an alternate gradation, the Contractor shall submit a Type 2 Working Drawing consisting of 0.45 power maximum density curve of the proposed gradation. The alternate gradation shall closely follow the maximum density line and have Nominal Aggregate Size of no less than $1\frac{1}{2}$ inches or no greater than 3 inches. The exact point of acceptance will be determined by the Engineer.

Sieve Size	Percent Passing
$2\frac{1}{2}$ "	99-100
2"	85-100
1"	50-82
$1/2$ "	28-68
No. 40	10-20
No. 200	5.0-10.0

All percentages are by weight. The portion of sediment retained on $\frac{1}{2}$ " sieve shall not contain more than 0.2 percent wood waste.

9-03.11(2) Streambed Fine Sediment

Streambed fine sediment shall meet the following requirements for grading. If the Contractor proposes an alternate gradation, the Contractor shall submit a Type 2 Working Drawing consisting of 0.45 power maximum density curve of the proposed gradation. The alternate gradation shall closely follow the maximum density line and have Nominal Aggregate Size of no less than the No. 6 sieve or no greater than ¼ inch sieve. The exact point of acceptance will be determined by the Engineer.

Streambed Sediment	
Sieve Size	Percent Passing
No. 4	99-100
No. 10	46-86
No. 40	26-40
No. 200	10-20

All percentages are by weight. The portion of sediment retained on No. 10 sieve shall not contain more than 0.2 percent wood waste.

9-03.11(3) Streambed Sand

Streambed sand shall meet the following requirements for grading. If the Contractor proposes an alternate gradation, the Contractor shall submit a Type 2 Working Drawing consisting of 0.45 power maximum density curve of the proposed gradation. The exact point of acceptance will be determined by the Engineer. The alternate gradation shall closely follow the maximum density line and have Nominal Aggregate Size of no less than the ¾ inch or no greater than ¾ inch.

Streambed sand shall consist of natural unwashed material, having hard, strong, durable particles free from adherent coating or deleterious matter.

Sieve Size	Percent Passing
1/2"	99-100
3/8"	99-100
No. 4	90 Max
No. 8	32-67
No. 200	2-7

All percentages are by weight. The portion of sediment retained on No. 8 sieve shall not contain more than 0.2 percent wood waste.

9-03.11(4) Streambed Cobbles

Streambed cobbles shall be clean, naturally occurring water rounded gravel material. Streambed cobbles shall have a well-graded distribution of cobble sizes and conform to one or more of the following gradings as shown in the Plans:

Approximate Size ¹	Percent Passing				
	4" Cobbles	6" Cobbles	8" Cobbles	10" Cobbles	12" Cobbles
12"					99-100
10"				99-100	70-90
8"			99-100	70-90	
6"		99-100	70-90		
5"		70-90			30-60
4"	99-100			30-60	
3"	70-90		30-60		
2"		30-60			
1½"	20-50				
¾"	10 max.	10 max.	10 max.	10 max.	10 max.

¹Approximate Size can be determined by taking the average dimension of the three axes of the rock, Length, Width, and Thickness, by use of the following calculation:

$$\frac{\text{Length} + \text{Width} + \text{Thickness}}{3} = \text{Approximate Size}$$

Length is the longest axis, width is the second longest axis, and thickness is the shortest axis.

The grading of the cobbles shall be determined by the Engineer by visual inspection of the load before it is dumped into place, or, if so ordered by the Engineer, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load.

9-03.11(5) Streambed Boulders

Streambed boulders shall be hard, sound and durable material, free from seams, cracks, and other defects tending to destroy its resistance to weather. Streambed Boulders shall be rounded to sub-angular in shape and the thickness axis shall be greater than 60 percent of the length axis. Streambed boulders sizes are approximately as follows, see Plans for sizes specified:

Rock Size ¹	Approximate Size
Type One	12" – 18"
Type Two	18" – 28"
Type Three	28" – 36"
Type Four	36" – 48"
Type Five	48" – 54"
Type Six	54" – 60"

¹Approximate Size can be determined by taking the average dimension of the three axes of the rock, Length, Width, and Thickness, by use of the following calculation:

$$\frac{\text{Length} + \text{Width} + \text{Thickness}}{3} = \text{Approximate Size}$$

Length is the longest axis, width is the second longest axis, and thickness is the shortest axis.

9-03.12 Gravel Backfill

Gravel backfill shall consist of crushed, partially crushed, or naturally occurring granular material produced in accordance with the provisions of Section 3-01.

9-03.12(1) Gravel Backfill for Foundations**9-03.12(1)A Class A**

Gravel backfill for foundations, Class A, shall conform to the requirements of Section 9-03.9(1) for ballast or Section 9-03.9(3) for crushed surfacing base course.

9-03.12(1)B Class B

Gravel backfill for foundations, Class B, shall conform to the requirements of Section 9-03.10 for Gravel Base.

9-03.12(2) Gravel Backfill for Walls

Gravel backfill for walls shall consist of free draining granular material, essentially free from various types of wood waste or other extraneous or objectionable materials. It shall meet the following requirements for grading and quality when placed in hauling vehicles for delivery to the roadway or during manufacture and placement into a temporary stockpile. The exact point of acceptance will be determined by the Engineer.

Sieve Size	Percent Passing
4"	99-100
2"	75-100
No. 4	22-66
No. 200	5.0 max.
Dust Ratio: $\frac{\% \text{ Passing No. 200}}{\% \text{ Passing No. 40}}$	$\frac{2}{3}$ max.
Sand Equivalent	60 min.

All percentages are by weight.

That portion of the material retained on a No. 4 sieve shall contain not more than 0.20 percent by weight of wood waste.

9-03.12(3) Gravel Backfill for Pipe Zone Bedding

Gravel backfill for pipe zone bedding shall consist of crushed, processed, or naturally occurring granular material. It shall be free from various types of wood waste or other extraneous or objectionable materials. It shall have such characteristics of size and shape that it will compact and shall meet the following Specifications for grading and quality:

Sieve Size	Percent Passing
1½"	99-100
1"	75-100
¾"	50-100
No. 4	20-80
No. 40	3-24
No. 200	10.0 max.
Sand Equivalent	35 min.

All percentages are by weight.

If, in the opinion of the Engineer, the native granular material is free from wood waste, organic material, and other extraneous or objectionable materials, but otherwise does not conform to the Specifications for grading and Sand Equivalent, it may be used for pipe bedding for rigid pipes, provided the native granular material has a maximum dimension of 1½ inches.

9-03.12(4) Gravel Backfill for Drains

Gravel backfill for drains shall conform to the following gradings:

Sieve Size	Percent Passing
1"	99-100
¾"	80-100
⅜"	0-40
No. 4	0-4
No. 200	0-2

As an alternative, AASHTO grading No. 57 may be used in accordance with Section 9-03.1(4)C. Alkali silica reactivity testing is not required.

9-03.12(5) Gravel Backfill for Drywells

Gravel backfill for drywells shall conform to the following gradings:

Sieve Size	Percent Passing
1½"	99-100
1"	50-100
¾"	0-20
⅜"	0-2
No. 200	0-1.5

As an alternative, AASHTO grading No. 4 may be used in accordance with Section 9-03.1(4)C. Alkali silica reactivity testing is not required.

9-03.13 Backfill for Sand Drains

Backfill for sand drains shall conform to the following grading:

Sieve Size	Percent Passing
½"	90-100
No. 4	57-100
No. 10	40-100
No. 50	3-30
No. 100	0-4
No. 200	0-3.0

All percentages are by weight.

That portion of backfill retained on a No. 4 sieve shall contain not more than 0.05 percent by weight of wood waste.

9-03.13(1) Sand Drainage Blanket

Aggregate for the sand drainage blanket shall consist of granular material, free from wood, bark, or other extraneous material and shall meet the following requirements for grading:

Sieve Size	Percent Passing
2½"	90-100
No. 4	24-100
No. 10	14-100
No. 50	0-30
No. 100	0-7.0
No. 200	0-3.0

All percentages are by weight.

That portion of backfill retained on a No. 4 sieve shall contain not more than 0.05 percent by weight of wood waste.

9-03.14 Borrow**9-03.14(1) Gravel Borrow**

Aggregate for gravel borrow shall consist of granular material, either naturally occurring or processed, and shall meet the following requirements for grading and quality:

Sieve Size	Percent Passing
4"	99-100
2"	75-100
No. 4	50-80
No. 40	30 max.
No. 200	7.0 max.
Sand Equivalent	50 min.

All percentages are by weight.

Ballast may be substituted for gravel borrow for embankment construction.

9-03.14(2) Select Borrow

Material for select borrow shall consist of granular material, either naturally occurring or processed, and shall meet the following requirements for grading and quality:

Sieve Size	Percent Passing
6" ¹	99-100
3"	75-100
No. 40	50 max.
No. 200	10.0 max.
Sand Equivalent	30 min.

All percentages are by weight.

¹99 to 100 percent shall pass 4-inch-square sieve and 75 to 100 percent shall pass 2-inch sieve when select borrow is used in the top 2 feet of embankments or where Method C compaction is required.

9-03.14(3) Common Borrow

Material for common borrow shall consist of granular or nongranular soil and/or aggregate that is free of deleterious material. Deleterious material includes wood, organic waste, coal, charcoal, or any other extraneous or objectionable material. The material shall not contain more than 3 percent organic material by weight. At the discretion of the Engineer the percent of deleterious materials may be determined visually or be tested in accordance with AASHTO T 194 or AASHTO T 267. The plasticity index shall be determined using test method AASHTO T 89 and AASHTO T 90.

The material shall meet one of the options in the soil plasticity table below.

Soil Plasticity Table

Option	Sieve	Percent Passing	Plasticity Index
1	No. 200	0 - 12	N/A
2	No. 200	12.1 - 35	6 or Less
3	No. 200	Above 35	0

All percentages are by weight.

If requested by the Contractor, the plasticity index may be increased with the approval of the Engineer.

9-03.14(4) Gravel Borrow for Structural Earth Wall

All backfill material within the reinforced zone for structural earth walls shall consist of granular material, either naturally occurring or processed, and shall be free draining, free from organic or otherwise deleterious material. The material shall be substantially free of shale or other soft, poor durability particles, and shall not contain recycled materials, such as glass, shredded tires, concrete rubble, or asphaltic concrete rubble. The backfill material shall meet the following requirements for grading and quality:

Sieve Size	Geosynthetic Reinforcement percent Passing	Metallic Reinforcement percent Passing
4		99-100
2		75-100
1½"	99-100	
1"	90-100	
No. 4	50-80	50-80
No. 40	30 max.	30 max.
No. 200	7.0 max.	7.0 max.
Sand Equivalent	50 min.	50 min.

All percentages are by weight

Property	Test Method	Geosynthetic Reinforcement Requirements	Metallic Reinforcement Requirements
Los Angeles Wear 500 rev.	AASHTO T 96	35 percent max.	35 percent max.
Degradation Factor	WSDOT T 113	15 min.	15 min.
Resistivity	WSDOT T 417		3,000 ohm-cm, min.
pH	WSDOT T 417	4.5 - 9	5 - 10
Chlorides	AASHTO T 291		100 ppm max.
Sulfates	AASHTO T 290		200 ppm max.

If the resistivity of the gravel borrow equals or exceeds 5,000 ohm-cm, the specified chloride and sulfate limits may be waived.

Wall backfill material satisfying these grading and property requirements shall be classified as nonaggressive.

9-03.15 Native Material for Trench Backfill

Trench backfill outside the roadway prism shall be excavated material free of wood waste, debris, clods or rocks greater than 6 inches in any dimension.

9-03.16 Vacant

9-03.17 Foundation Material Class A and Class B

Foundation material Class A and Class B shall conform to the following gradations:

Sieve Size	Percent Passing	
	Class A	Class B
2½"	98-100	95-100
2"	92-100	75-100
1½"	72-87	30-60
¾"	27-47	0-5
⅜"	3-14	
No. 4	0-5	

All percentages are by weight.

9-03.18 Foundation Material Class C

Foundation material Class C shall consist of clean bank run sand and gravel, free from dirt, roots, topsoil, and debris and contain not less than 35 percent retained on a No. 4 sieve and with all stones larger than 2 inches in the longest dimension removed.

9-03.19 Bank Run Gravel for Trench Backfill

Trench backfill material shall consist of aggregate for gravel base, as specified in Section 9-03.10, excepting however, that 100 percent of the material shall pass a 2½-inch screen.

9-03.20 Test Methods for Aggregates

The properties enumerated in these Specifications shall be determined in accordance with the following methods of test:

Title	Test Method
FOP for AASHTO R 90 for Standard Practice for Sampling Aggregates	FOP for AASHTO R 90
Organic Impurities in Fine Aggregates for Concrete	AASHTO T 21
Clay Lumps and Friable Particles in Aggregates	AASHTO T 112
Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	AASHTO T 96
Material Finer than 0.075mm (No. 200) Sieve in Mineral Aggregates by Washing	AASHTO T 11
FOP for AASHTO for Determining the percentage of Fracture in Coarse Aggregates	FOP for AASHTO T 335
FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates	FOP for WAQTC T 27/T 11
FOP for AASHTO T 176 for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	FOP for AASHTO T 176
Method of Test for Determination of Degradation Value	WSDOT T 113
Particle Size Analysis of Soils	AASHTO T 88

9-03.21 Recycled Material**9-03.21(1) General Requirements**

Hot Mix Asphalt (HMA), Concrete Rubble, Recycled Glass (glass cullet), and Steel Furnace Slag may be used as, or blended uniformly with, naturally occurring materials for aggregates. The final blended product and the recycled material component included in a blended product shall meet the specification requirements for the specified type of aggregate. The Contracting Agency may collect verification samples at any time. Blending of more than one type of recycled material into the naturally occurring materials requires approval of the Engineer prior to use.

Prior to incorporating recycled materials into the work or storage on the job site, the Contractor shall provide a certification on the source of the recycled materials. Recycled materials obtained from the Contracting Agency's roadways will not require toxicity testing or certification for toxicity characteristics unless requested by the Engineer.

Recycled materials that are not from the Contracting Agency's roadways shall not be incorporated into the work or imported to the job site until the Contractor provides testing and certification for toxicity characteristics to the Engineer. The Contractor shall provide the following:

1. Identification of the recycled materials proposed for use.
2. Sampling documentation no older than 90 days from the date the recycled material is placed on the project. Documentation shall include a minimum of five samples tested for total lead content by EPA Method 6010. Total lead test results shall not exceed 250 ppm. Samples that exceed 100 ppm must then be prepared by EPA Method 1311, the Toxicity Characteristic Leaching Procedure (TCLP), where liquid extract is analyzed by EPA Method 6010B. The TCLP test must be below 5.0 ppm.
3. Certification that the recycled materials are not Washington State Dangerous Wastes per the Dangerous Waste Regulations, WAC 173-303.
4. Certification that the recycled materials are in conformance with the requirements of the *Standard Specifications* prior to delivery. The certification shall include the percent by weight of each recycled material.

9-03.21(1)A Recycled Asphalt Shingles

Recycled asphalt shingles shall be manufactured waste shingles and shall be non-asbestos containing material (ACM) as defined in 40 CFR 61 Subpart M and tested in accordance with 40 CFR part 763, subpart E, appendix E, Section 1, Polarized Light Microscopy (PLM) Test Method EPA/600/R-93/116 by a certified testing laboratory. The PLM Test Method to determine ACM content will be the standard PLM Test Method to determine ACM less than 1.0%. Additionally, the PLM 1000 Point Count Test Method to determine asbestos less than 0.1% is required. At a minimum, the laboratory testing for asbestos content will be certified by one or more the following: National Voluntary Laboratory Accreditation Program (NVLAP), American Industrial Hygiene Association IH Laboratory Accreditation, or Washington State Department of Ecology for analysis of asbestos in bulk material. The Contractor shall keep all ACM and asbestos test results on file and provide copies to the Engineer when submitting a HMA mix design for approval in accordance with Section 5-04. The Contractor shall provide the testing and certification for toxicity characteristics in accordance with Section 9-03.21(1) prior to delivery and placement of the recycled asphalt shingles and use of the RAS in HMA. The Contractor shall also provide a Safety Data Sheet (SDS) of the RAS specifically detailing all ingredients of the manufactured waste shingles. The ingredients list needs to include the amount of asbestos as well as all types of fibrous materials.

9-03.21(1)B Recycled Asphalt Pavement

For recycled materials incorporating hot mix asphalt, the product supplier shall certify that the blended material does not exceed the Maximum Allowable percentage of hot mix asphalt shown in Section 9-03.21(1)F. For RAP that is not from the Contracting Agency's roadway, the Contractor shall provide the testing and certification for toxicity characteristics in accordance with Section 9-03.21(1) prior to delivery and placement of the RAP and use of the RAP in HMA.

9-03.21(1)C Recycled Concrete Aggregate

Recycled concrete aggregates are coarse and fine aggregates manufactured from hardened concrete mixtures.

Recycled concrete aggregate may be used as coarse aggregate or blended with coarse aggregate for Commercial Concrete, Class 3000 concrete, or Cement Concrete Pavement. Recycled concrete aggregate shall meet all of the requirements for coarse aggregate contained in Section 9-03.1(4) or 9-03.1(5). In addition to the requirements of Section 9-03.1(4) or 9-03.1(5), recycled concrete shall:

1. Contain an aggregated weight of less than 1 percent of adherent fines, vegetable matter, plastics, plaster, paper, gypsum board, metals, fabrics, wood, tile, glass, asphalt (bituminous) materials, brick, porcelain or other deleterious substance(s) not otherwise noted;
2. Be free of components such as chlorides and reactive materials that are detrimental to the concrete, unless mitigation measures are taken to prevent recurrence in the new concrete;
3. Have an absorption of less than 10 percent when tested in accordance with AASHTO T 85.
4. For Cement Concrete Pavement mix designs using recycled concrete aggregates, the Contractor shall submit evidence that ASR mitigating measures control expansion in accordance with Section 9-03.1(1).

Recycled concrete aggregate shall be in a saturated condition prior to mixing.

Recycled concrete, of all forms, shall not be placed below the ordinary high-water mark of surface waters of the State.

9-03.21(1)C1 Recycled Concrete Aggregate Approval and Acceptance

Recycled concrete aggregate shall be from either a Tier 1, Tier 2 or Tier 3 Reclamation Facility meeting the requirements below:

Tier 1	
Approval Requirements	Approval of the Reclamation Facility is not required nor is it required to be on the WSDOT Qualified Products List.
Acceptance Requirements	Certification of toxicity characteristics in accordance with Section 9-03.21(1). Field acceptance testing in accordance with Section 3-04.
Approved to provide the following Aggregate Materials:	
9-03.10 Aggregate for Gravel Base 9-03.12(1)B Gravel Backfill for Foundations Class B 9-03.12(2) Gravel Backfill for Walls 9-03.12(3) Gravel Backfill for Pipe Zone Bedding 9-03.14(1) Gravel Borrow 9-03.14(2) Select Borrow 9-03.14(2) Select Borrow (greater than 3 feet below subgrade and side slope) 9-03.14(3) Common Borrow 9-03.14(3) Common Borrow (greater than 3 feet below subgrade and side slope) 9-03.17 Foundation Material Class A and Class B 9-03.18 Foundation Material Class C 9-03.19 Bank Run Gravel for Trench Backfill	

Tier 2: For WSDOT Recycled Concrete and WSDOT Return Concrete	
Approval Requirements	The Reclamation Facility shall be listed on the WSDOT Qualified Products List. The Reclamation Facility shall have a Quality Control Plan (QCP) in accordance with WSDOT QC 9 "Standard Practice for Approval of Reclamation Facilities of WSDOT Recycled Concrete and WSDOT Returned Concrete". The Reclamation Facility's QCP shall be submitted through the QPL Engineer and approved by the WSDOT State Materials Laboratory. Once accepted, changes to the QCP will require a new QCP to be submitted for acceptance. Evaluation of aggregate source properties (LA Wear and Degradation) for the recycled concrete aggregate is not required.
Acceptance Requirements	Certification of toxicity characteristics in accordance with Section 9-03.21(1), required if requested. Field acceptance testing in accordance with Section 3-04 is required. Provide certification in accordance with WSDOT QC 9 for every lot. A lot shall be no larger than 10,000 tons.
Approved to provide the following Aggregate Materials:	
Tier 1 aggregate materials 9-03.1 Coarse Aggregate for Commercial Concrete, Concrete class 3000, or Cement Concrete Pavement 9-03.9(1) Ballast 9-03.9(2) Permeable Ballast 9-03.9(3) Crushed Surfacing 9-03.12(1)A Gravel Backfill for Foundations Class A	

Tier 3: For Recycled Concrete Aggregates from Stockpiles of Unknown Sources	
Approval Requirements	<p>The Reclamation Facility shall be listed on the WSDOT Qualified Products List. The Reclamation Facility shall have a Quality Control Plan (QCP) in accordance with WSDOT QC 10 "Standard Practice for Approval of Reclamation Facilities of Recycled Concrete Aggregates from Stockpiles of Unknown Sources". The Reclamation Facility's QCP shall be submitted through the QPL Engineer and approved by the WSDOT State Materials Laboratory. Once accepted, changes to the QCP will require a new QCP to be submitted for acceptance.</p> <p>Evaluation of aggregate source properties (LA Wear and Degradation) for the recycled concrete aggregate is required.</p>
Acceptance Requirements	<p>Certification of toxicity characteristics in accordance with Section 9-03.21(1) is required.</p> <p>Field acceptance testing in accordance with Section 3-04 is required.</p> <p>Provide certification in accordance with WSDOT QC 10 for every lot. A lot shall be no larger than 10,000 tons.</p>
Approved to provide the following Aggregate Materials:	
<p>Tier 1 aggregate materials</p> <p>9-03.1 Coarse Aggregate for Commercial Concrete, Concrete class 3000, or Cement Concrete Pavement</p> <p>9-03.9(1) Ballast</p> <p>9-03.9(2) Permeable Ballast</p> <p>9-03.9(3) Crushed Surfacing</p> <p>9-03.12(1)A Gravel Backfill for Foundations Class A</p>	

9-03.21(1)D Recycled Glass (glass cullet)

Glass Cullet shall meet the requirements of AASHTO M 318 with the additional requirement that the glass cullet is limited to the maximum amounts set in Section 9-03.21(1)E for recycled glass. Prior to use the Contractor shall provide certification to the Engineer that the recycled glass meets the physical properties and deleterious substances requirements in AASHTO M 318. The Contractor shall provide the testing and certification for toxicity characteristics in accordance with Section 9-03.21(1) prior to delivery and placement of the recycled glass and use of the recycled glass in other materials.

9-03.21(1)E Steel Slag

The Contractor shall provide to the Engineer the steel furnace slag blends that will be used in the final product prior to use. Recycled steel furnace slag shall not be placed below the ordinary high-water mark of surface waters of the State. The Contractor shall provide the testing and certification for toxicity characteristics in accordance with Section 9-03.21(1) prior to delivery and placement of the steel slag and use of the steel slag in other materials.

9-03.21(1)F Table on Maximum Allowable percent (By Weight) of Recycled Material

Maximum Allowable percent (by weight) of Recycled Material					
		Recycled Asphalt Pavement	Recycled Concrete Aggregate	Recycled Glass (glass cullet)	Steel Slag
Fine Aggregate for Concrete	9-03.1(2)	0	0	0	0
Coarse Aggregates for Concrete	9-03.1(4)	0	0	0	0
Coarse Aggregate for Concrete Pavement	9-03.1(4)	0	100	0	0
Coarse Aggregate for Commercial Concrete and Class 3000 Concrete	9-03.1(4)	0	100	0	0
Aggregates for Hot Mix Asphalt	9-03.8	See 5-04.2	0	0	20
Ballast	9-03.9(1)	25	100	20	20
Permeable Ballast	9-03.9(2)	25	100	20	20
Crushed Surfacing	9-03.9(3)	25	100	20	20
Aggregate for Gravel Base	9-03.10	25	100	20	20
Gravel Backfill for Foundations - Class A	9-03.12(1)A	25	100	20	20
Gravel Backfill for Foundations - Class B	9-03.12(1)B	25	100	20	20
Gravel Backfill for Walls	9-03.12(2)	0	100	20	20
Gravel Backfill for Pipe Zone Bedding	9-03.12(3)	0	100	20	20
Gravel Backfill for Drains	9-03.12(4)	0	0	20	0
Gravel Backfill for Drywells	9-03.12(5)	0	0	20	0
Backfill for Sand Drains	9-03.13	0	0	20	0
Sand Drainage Blanket	9-03.13(1)	0	0	20	0
Gravel Borrow	9-03.14(1)	25	100	20	20
Select Borrow	9-03.14(2)	25	100	20	20
Select Borrow (greater than 3 feet below Subgrade and side slopes)	9-03.14(2)	100	100	20	20
Common Borrow	9-03.14(3)	25	100	20	20
Common Borrow (greater than 3 feet below Subgrade and side slopes)	9-03.14(3)	100	100	20	20
Foundation Material Class A and Class B	9-03.17	0	100	20	20
Foundation Material Class C	9-03.18	0	100	20	20
Bank Run Gravel for Trench Backfill	9-03.19	25	100	20	20

9-04 Joint Sealing Materials**9-04.1 Premolded Joint Fillers****9-04.1(1) Asphalt Filler for Contraction and Longitudinal Joints in Concrete Pavements**

Premolded joint filler for use in contraction and longitudinal joints shall be $\frac{3}{8}$ inch in thickness and shall consist of a suitable asphalt mastic encased in asphalt saturated paper or asphalt saturated felt. It shall be sufficiently rigid for easy installation in summer months and not too brittle for handling in cool weather. It shall meet the following test requirements:

When a strip 2 inches wide and 24 inches long is freely supported 2 inches from each end and maintained at a temperature of 70°F, it shall support a weight of 100 grams placed at the center of the strip without deflecting downward from a horizontal position more than 2 inches within a period of 5 minutes.

9-04.1(2) Premolded Joint Filler for Expansion Joints

Premolded joint filler for use in expansion (through) joints shall conform to either AASHTO M213 Specifications for "Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction", except that the requirement for water absorption is deleted, or ASTM D7174 Specifications for "Preformed Closed-Cell Polyolefin Expansion Joint Fillers for Concrete Paving and Structural Construction".

As an alternative to the above, a semi-rigid, non-extruding, resilient type, closed-cell polypropylene foam, preformed joint filler with the following physical properties as tested to ASTM D545 Standard Test Methods may be used.

Closed-Cell Polypropylene Foam Preformed Joint Filler		
Physical Property	Requirement	Test Method
Water Absorption	< 1.0%	ASTM D545
Compression Recovery	> 80%	ASTM D545
Extrusion	< 0.1 in.	ASTM D545
Density	> 3.5 lbs./cu.ft.	ASTM D545
Water Boil (1 hr.)	No expansion	ASTM D545
Hydrochloric Acid Boil (1 hr.)	No disintegration	ASTM D545
Heat Resistance °F	392°F ± 5°F	ASTM D545

9-04.1(3) Vacant**9-04.1(4) Elastomeric Expansion Joint Seals**

Premolded elastomeric expansion joint seals shall conform to the requirements of ASTM D2628 and shall be formed by an extrusion process with uniform dimensions and smooth exterior surfaces. The cross-section of the seal shall be shaped to allow adequate compressed width of the seal, as approved by the Engineer.

9-04.2 Joint Sealants**9-04.2(1) Hot Poured Joint Sealants****9-04.2(1)A Hot Poured Sealant**

Hot poured sealant shall be sampled in accordance with ASTM D5167 and tested in accordance with ASTM D5329.

9-04.2(1)A1 Hot Poured Sealant for Cement Concrete Pavement

Hot poured sealant for cement concrete pavement shall meet the requirements of ASTM D6690 Type IV, except for the following:

1. The Cone Penetration at 25°C shall be 130 maximum.
2. The extension for the Bond, non-immersed, shall be 100 percent.

Hot poured sealant for cement concrete pavement is acceptable for installations in joints where cement concrete pavement abuts a bituminous pavement.

9-04.2(1)A2 Hot Poured Sealant for Bituminous Pavement

Hot poured sealant for bituminous pavement shall meet the requirements of ASTM D6690 Type I or Type II.

Hot poured sealant for bituminous pavement is acceptable for installations in joints where cement concrete pavement abuts a bituminous pavement.

9-04.2(1)B Sand Slurry for Bituminous Pavement

Sand slurry is mixture consisting of the following components measured by total weight:

1. Twenty percent CSS-1 emulsified asphalt,
2. Two percent portland cement or blended hydraulic cement, and
3. Seventy-eight percent fine aggregate meeting the requirements of Section 9-03.1(2)B Class 2. Fine aggregate may be damp (no free water).

9-04.2(1)C Polymer Modified Asphalt Mastic

Polymer modified asphalt mastic shall be prepackaged polymer modified asphalt binder and aggregate meeting the requirements of ASTM D8260.

9-04.2(2) Poured Rubber Joint Sealer

The physical properties of the joint sealer, when mixed in accordance with the manufacturer's recommendations, shall be as follows:

1. Color: Gray or black.
- 2.¹ Viscosity: Must be pourable and self-leveling at 50°F.
- 3.¹ Application Life: Not less than 3 hours at 72°F and 50 percent relative humidity.
4. Set to Touch: Not more than 24 hours at 72°F and 50 percent relative humidity.
5. Curing Time: Not more than 96 hours at 72°F and 50 percent relative humidity.
6. Non-Volatile Content: Not less than 92 percent.
7. Hardness Rating (Durometer "Shore A"): 5-35.
8. Resiliency: Not less than 80 percent.
9. Bond test methods shall be in accordance with ASTM D5329.

¹Viscosity and application life may be waived providing the material is mixed and placed by a pump and mixer approved by the Engineer.

Suitable primer, if required by the manufacturer, shall be furnished with each joint sealer. The primer shall be suitable for brush or spray application at 50°F or higher and shall cure sufficiently at 50°F to pour the joint within 24 hours. It shall be considered as an integral part of the sealer system. Failure of the sealer in the test described herein, attributable to the primer, shall be grounds for rejection or re-testing of the sealer.

9-04.2(3) Single-Component Polyurethane Sealant

Single-Component Polyurethane sealant shall conform to ASTM C920 Type S Grade NS Class 25 Use M or ASTM C920 Type S Grade NS Class 35 Use M.

Single-Component Polyurethane sealant shall be compatible with the closed cell foam backer rod. When required, compatibility characteristics of sealants in contact with backer rods shall be determined by Test Method ASTM C1087.

9-04.2(3)A Closed Cell Foam Backer Rod

Closed cell foam backer rod for use with polyurethane sealant shall conform to ASTM C1330 Type C.

9-04.3 Joint Mortar

Mortar for hand mortared joints shall conform to Section 9-20.4(3) and consist of one part portland cement or blended hydraulic cement, three parts fine sand, and sufficient water to allow proper workability.

Cement shall conform to the requirements of AASHTO M 85, Type I or Type II.

Sand shall conform to the requirements of AASHTO M 45.

Water shall conform to the requirements of Section 9-25.1.

9-04.4 Pipe Joint Gaskets**9-04.4(1) Rubber Gaskets for Concrete Pipes and Precast Manholes**

Rubber gaskets for use in joints of concrete culvert or storm sewer pipe and precast manhole sections shall conform to the requirements of ASTM C443. Standard gaskets meeting the dimensions, tolerances, and physical requirements of ASTM C1619, Class C shall be used unless the plans require oil resistant gaskets meeting the dimensions, tolerances, and physical requirements of ASTM C1619, Class D.

9-04.4(2) Vacant**9-04.4(3) Gaskets for Aluminum or Steel Culvert or Storm Sewer Pipe**

Rubber gaskets for use with metal culvert or storm sewer pipe shall be continuous closed cell, synthetic expanded rubber gaskets conforming to the requirements of ASTM D1056, Grade 2B3. Butyl rubber gaskets for use with metal culvert or storm sewer pipe shall conform to the applicable requirements of ASTM C990.

9-04.4(4) Rubber Gaskets for Aluminum or Steel Drain Pipe

Gaskets for metal drain pipe shall be self-adhering, butyl-based, scrim-supported type. The gaskets shall be as described in the Standard Plan when specified.

9-04.4(5) Protection and Storage

Rubber gasket material shall be stored in a clean, cool place, protected from sunlight and contaminants. They shall be protected from direct sunlight at all times except during actual installation. Pipes with gaskets affixed shall be installed in the line within 28 days.

9-04.5 Flexible Plastic Gaskets

The gasket material shall be produced from blends of refined hydrocarbon resins and plasticizing materials reinforced with inert mineral filler and shall contain no solvents. It shall not depend on oxidizing, evaporating, or chemical action for adhesive or cohesive strength. It shall be supplied in extruded rope form of such cross section and size as to adequately fill spaces between the precast sections.

The gasket material shall be protected by a suitable removable two-piece wrapper so designed as to permit removing one half, longitudinally, without disturbing the other. Its composition and properties shall conform to those set forth below.

	Test Method	Minimum	Maximum
Bitumen (Petroleum plastic content)	ASTM D4	50	70
Ash-inert Mineral Matter	AASHTO T 11	30	50
Penetration	ASTM D217		
32°F (300gm) 60 sec		75	
77°F (150gm) 5 sec		50	120
115°F (150gm) 5 sec			150
Softening Point	AASHTO T 53	320°F	
Specific Gravity at 77°F	ASTM D71	1.20	1.35
Weight per gallon, lb		10.0	11.3
Ductility at 77°F (cm)	ASTM D113	5.0	
Flash Point COC, F	ASTM D93 REVA	600	
Fire Point COC, F	AASHTO T 48	625	
Volatile Matter	ASTM D6		2.0

9-04.6 Expanded Polystyrene

Expanded polystyrene shall be of a cellular molded type with a density of 1.5 plus or minus 0.25 pounds per cubic foot.

9-04.7 Expanded Rubber

Closed cell expanded rubber joint filler shall conform to ASTM D1056, Grade No. 2B3.

9-04.8 Flexible Elastomeric Seals

Flexible elastomeric seals for PVC drain pipe and underdrain pipe shall conform to the requirements of ASTM D3212.

9-04.9 Solvent Cements

Solvent cements for PVC underdrain pipe shall conform to the requirements of ASTM D2564.

9-04.10 Butyl Rubber and Nitrile Rubber

Butyl rubber shall conform to ASTM D2000, M1 BA 610. If the Engineer determines that the area will be exposed to petroleum products, Nitrile rubber shall be used and shall conform to ASTM D2000, M1 BG 610.

9-04.11 Butyl Rubber Sealant

Butyl rubber sealant shall conform to ASTM C990.

9-04.12 External Sealing Band

External sealing bands shall be Type II or III conforming to ASTM C877.

9-05 Drainage Structures and Culverts**9-05.0 Acceptance and Approval of Drainage Structures, and Culverts**

The Drainage Structure or Culvert may be selected from the Qualified Products List or submitted using a Request for Approval of Materials (RAM) in accordance with Section 1-06.

Certain drainage materials may be accepted by the Engineer based on a modified acceptance criteria when materials are selected from the Qualified Products List (QPL). The modified acceptance criteria are defined in the QPL for each material.

9-05.1 Drain Pipe**9-05.1(1) Vacant****9-05.1(2) Zinc Coated (Galvanized) or Aluminum Coated (Aluminized) Corrugated Iron or Steel Drain Pipe**

Zinc coated (galvanized) or aluminum coated (aluminized Type 2) corrugated iron or steel drain pipe shall meet the requirements of AASHTO M 36. The steel sheet thickness shall be 0.064 inch for 6-inch diameter and larger drain pipe. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M274 (ASTM A929).

9-05.1(2)A Coupling Bands

Coupling bands for zinc coated (galvanized) or aluminum coated (aluminized) corrugated iron or steel drain pipe shall meet the requirements of coupling bands for Type I pipe of AASHTO M 36, except that bands using projections (dimples) shall not be permitted. The bands shall be fabricated of the same material as the pipe, and with the same metallic protective treatment as the pipe.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges and those bands meeting the requirements of Section 9-05.4(7).

9-05.1(3) Corrugated Aluminum Alloy Drain Pipe

Corrugated aluminum alloy drain pipe shall meet the requirements of AASHTO M 196, without perforations.

9-05.1(3)A Coupling Bands

Coupling bands for corrugated aluminum alloy drain pipe shall meet the requirements of coupling bands for Type I pipe of AASHTO M 196, except that bands using projections (dimples) shall not be permitted. The bands shall be fabricated of the same material as the pipe.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges and those bands meeting the requirements of Section 9-05.5(5).

9-05.1(4) Vacant**9-05.1(5) PVC Drain Pipe, Couplings, and Fittings**

PVC drain pipe, couplings, and fittings shall meet the requirements of AASHTO M 278. The maximum size pipe shall be 8 inches in diameter.

**9-05.1(6) Corrugated Polyethylene Drain Pipe, Couplings, and Fittings
(Up to 10 inch)**

Corrugated polyethylene drain pipe, couplings, and fittings shall meet the requirements of AASHTO M 252 type C (corrugated both inside and outside) or type S (corrugated outer wall and smooth inner liner). The maximum size pipe shall be 10 inches in diameter.

Corrugated polyethylene drain pipe manufacturers shall participate in the National Transportation Product Evaluation Program (NTPEP) work plan for HDPE (High Density Polyethylene) Thermoplastic Pipe and be listed on the NTPEP audit website displaying they are NTPEP compliant.

**9-05.1(7) Corrugated Polyethylene Drain Pipe, Couplings, and Fittings
(12 inch Through 60 inch)**

Corrugated polyethylene drain pipe, couplings, and fittings 12 inch through 60 inch diameter maximum, shall meet the minimum requirements of AASHTO M 294 Type S or 12-inch through 24-inch diameter maximum shall meet the minimum requirements of AASHTO M 294 Type C.

Corrugated polyethylene drain pipe manufacturers shall participate in the National Transportation Product Evaluation Program (NTPEP) work plan for HDPE (High Density Polyethylene) Thermoplastic Pipe and be listed on the NTPEP audit website displaying they are NTPEP compliant.

9-05.2 Underdrain Pipe

9-05.2(1) Vacant

9-05.2(2) Vacant

9-05.2(3) Vacant

**9-05.2(4) Zinc Coated (Galvanized) or Aluminum Coated (Aluminized)
Corrugated Iron or Steel Underdrain Pipe**

Zinc coated (galvanized) or aluminum coated (aluminized type 2) corrugated iron or steel underdrain pipe shall meet the fabrication requirements of AASHTO M 36, except that perforations required in Class I, II, and III pipe may be located anywhere on the tangent of the corrugations provided the other perforation spacing requirements remain as specified. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M 274 (ASTM A929).

The pipe may conform to any one of the Type III pipes specified in AASHTO M 36, and perforations in Class I, II, and III pipe may be drilled or punched. The sheet thickness shall be 0.064 inch for 6 inch and larger diameter underdrain pipe.

9-05.2(4)A Coupling Bands

Coupling bands for zinc coated (galvanized) or aluminum coated (aluminized) corrugated iron or steel underdrain pipe shall meet the requirements of coupling bands for Type III pipe of AASHTO M 36. The bands shall be fabricated of the same material as the pipe and with the same metallic protective treatment as the pipe, if metallic bands are used.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges, universal bands (dimple bands), a smooth sleeve type coupler, and those bands meeting the requirements of Section 9-05.4(7). Smooth sleeve type couplers may be either plastic or steel suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets.

9-05.2(5) Perforated Corrugated Aluminum Alloy Underdrain Pipe

Perforated corrugated aluminum alloy underdrain pipe shall meet the requirements of AASHTO M 196, except that the perforations may be located anywhere on the tangent of the corrugations providing the other perforation spacing requirements remain as specified.

9-05.2(5)A Coupling Bands

Coupling bands for corrugated aluminum alloy underdrain pipe shall meet the requirements of coupling bands for Type III pipe of AASHTO M 196. The bands shall be fabricated of the same material of the pipe, if metallic bands are used.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges, universal bands (dimple bands), a smooth sleeve type coupler, and those bands meeting the requirements of Section 9-05.5(5). Smooth sleeve type couplers may be either plastic or aluminum alloy suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets.

9-05.2(6) Perforated PVC Underdrain Pipe

Perforated PVC underdrain pipe shall meet the requirements of AASHTO M 278. The maximum size pipe shall be 8 inches in diameter.

9-05.2(7) Perforated Corrugated Polyethylene Underdrain Pipe (Up to 10 inch)

Perforated corrugated polyethylene underdrain pipe shall meet the requirements of AASHTO M252, Type CP or Type SP. Type CP shall be Type C pipe with Class 2 perforations and Type SP shall be Type S pipe with either Class 1 or Class 2 perforations. Additionally, Class 2 perforations shall be uniformly spaced along the length and circumference of the pipe. The maximum size pipe shall be 10-inch diameter.

Perforated corrugated polyethylene underdrain pipe manufacturers shall participate in the National Transportation Product Evaluation Program (NTPEP) work plan for HDPE (High Density Polyethylene) Thermoplastic Pipe and be listed on the NTPEP audit website displaying they are NTPEP compliant.

9-05.2(8) Perforated Corrugated Polyethylene Underdrain Pipe (12-Inch Through 60-Inch Diameter Maximum), Couplings, and Fittings

Perforated corrugated polyethylene underdrain pipe (12-inch through 60-inch diameter maximum), couplings, and fittings shall meet the requirements of AASHTO M 294 Type CP or Type SP. Type CP shall be Type C pipe with Class 2 perforations and Type SP shall be Type S pipe with either Class 1 or Class 2 perforations. Additionally, Class 2 perforations shall be uniformly spaced along the length and circumference of the pipe.

Perforated corrugated polyethylene underdrain pipe manufacturers shall participate in the National Transportation Product Evaluation Program (NTPEP) work plan for HDPE (High Density Polyethylene) Thermoplastic Pipe and be listed on the NTPEP audit website displaying they are NTPEP compliant.

9-05.3 Concrete Culvert Pipe**9-05.3(1) Plain Concrete Culvert Pipe**

Plain concrete culvert pipe shall be round and shall conform to the requirements of AASHTO M 86, Class 2.

9-05.3(1)A End Design and Joints

All bell and spigot concrete culvert pipe shall be joined with rubber gaskets. The joints and gasket material shall meet the requirements of ASTM C990. Gasket material shall be handled and stored in accordance with Section 9-04.4(5).

The plane of the ends of the pipes shall be perpendicular to their longitudinal axes.

9-05.3(1)B Basis for Acceptance

The basis for acceptance of plain concrete culvert or drain pipe shall be on the results of three edge bearing tests performed at the manufacturer's plant within the 90 day period immediately preceding shipment of the pipe.

9-05.3(1)C Age at Shipment

Plain concrete culvert pipe may be shipped when it meets all test requirements. Unless it is tested and accepted at an earlier age, it shall not be considered ready for shipment sooner than 28 days after manufacture when made with Type II portland cement or blended hydraulic cement, nor sooner than 7 days when made with Type III portland cement.

9-05.3(2) Reinforced Concrete Culvert Pipe

Reinforced concrete culvert pipe shall be round and conform to the requirements of AASHTO M 170 except as herein provided.

The wall thickness and steel area for all classes of pipe which are of a diameter not set forth in AASHTO M 170, but within the maximum and minimum diameter limits set forth therein, shall be determined by interpolation from data given in the tables for pipes of diameters next smaller and next larger, respectively.

For all classes of pipe, except Class I, which are of a diameter less than the minimum for the particular class set forth in AASHTO M 170, the minimum wall thickness shall be 1¼ inch and the steel area shall not be less than 0.06 square inch per linear foot of pipe barrel length.

9-05.3(2)A End Design and Joints

Section 9-05.3(1)A will apply to reinforced concrete culvert pipe.

9-05.3(2)B Basis for Acceptance

The basis for acceptance of reinforced concrete pipe 60 inches in diameter and smaller shall be determined by the results of the three-edge bearing test for the load to produce a 0.01-inch crack, and testing to the ultimate load will ordinarily not be required, except as necessary to obtain samples for making the absorption test. In lieu of broken pieces of pipe obtained as above provided, 4-inch diameter cores from pipe sections selected by the Engineer may be furnished for performing the absorption test. Sections of pipe which have been tested to the actual 0.01-inch crack will ordinarily not be further load tested; and such sections which meet or exceed the required strength and quality standards may be accepted for use on the project.

Acceptance of reinforced concrete pipe larger than 60 inches in diameter shall be based on inspection of the size and placement of the reinforcing steel, and, at the option of the Engineer, on compressive strength tests of 4-inch diameter cores cut from the pipe, or on compressive strength of representative test cylinders cast with and cured with the pipe.

9-05.3(2)C Age at Shipment

Reinforced concrete culvert pipe may be shipped when it meets the requirements of Section 9-05.3(1)C.

9-05.3(2)D Elliptical Reinforcement

In lieu of marking circular pipe with elliptical reinforcement in accordance with AASHTO M 170, the location of the top of the pipe shall be indicated by 3-inch, waterproof, painted stripes on the inside and outside of the pipe for a distance of 2 feet from each end of the section. At the option of the Contractor, a lift hole or lift holes may be provided at the top of the pipe in lieu of the painted stripes. If one lift hole is provided, it shall be at the balance point of the pipe; and if two lift holes are provided, they shall be spaced equidistant each side of the balance point. Such holes shall not interfere with the reinforcement. After placing, open lift holes shall be filled with mortar conforming to Section 9-20.4(3) or concrete plugs before backfilling.

In addition to the requirements as set forth in AASHTO M 170, it will be required on all pipe 30 inches and over in diameter with elliptical steel reinforcement that the manufacturer expose the reinforcement in not less than one of three lengths of pipe manufactured. A hole exposing the steel shall be cut on the inside of the pipe at top or bottom and a second hole on the outside, 90 degrees from the top or bottom position. After placing, holes exposing the reinforcement shall be filled with mortar conforming to Section 9-20.4(3) or concrete plugs before backfilling.

9-05.3(3) Mitered Concrete End Sections

Mitered concrete end sections shall be plain concrete conforming to AASHTO M 86 or reinforced concrete conforming to the applicable sections of AASHTO M 170 with the design requirements as listed in Table 2, Wall B, Circular Reinforcement in circular pipe, and the [Standard Plans](#).

9-05.4 Steel Culvert Pipe and Pipe Arch

Steel culvert pipe and pipe arch shall meet the fabrication requirements of AASHTO M 36, Type I and Type II. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M 274 (ASTM A929).

9-05.4(1) Elliptical Fabrication

When elongated pipes are specified, circular pipes shall be fabricated 5 percent out of round to form an elliptical section. The vertical or longer axis of the elliptical section shall be clearly marked before shipping.

9-05.4(2) Mitered Ends

The ends of steel culvert pipe or pipe arch shall not be mitered unless called for in the Plans. If mitered ends are specified, the ends of culvert pipe over 30 inches in diameter shall be mitered to conform to the slope of the embankment in which the culvert is to be placed whether the culvert is constructed normal to or at an angle with the centerline of the roadway.

Mitered steel pipe end sections 12 inches through 30 inches in diameter shall be of the same material and thickness and have the same protective coating as the pipe to which they are attached. Mitered pipe ends of these dimensions shall be constructed in conformance with the [Standard Plans](#).

9-05.4(3) Vacant**9-05.4(4) Vacant**

9-05.4(5) Polymer Protective Coating

Polymer coated steel pipe and pipe-arch shall meet the fabrication requirements of AASHTO M 36 (ASTM A760). Polymer protective coatings shall meet the material requirements of AASHTO M 246 (ASTM A742). Polymer coating shall be mill applied to galvanized steel coils before fabrication and shall measure 10 mils thick on each side.

9-05.4(6) Vacant**9-05.4(7) Coupling Bands**

Coupling bands for steel pipe shall be as shown in the [Standard Plans](#) and shall be fabricated of the same material as the pipe. Bands may be up to three nominal thicknesses thinner than used for the pipe, but not thinner than 0.064 inches or thicker than 0.109 inches. Bands shall be coated with the same metallic protective treatment as the pipe but shall not be coated with an asphalt protective treatment. Bands shall be made by the same manufacturer as the steel pipe selected for installation.

Corrugations on the bands shall be the same size and shape as those on the pipes to be connected. Steel bolts and nuts for coupling bands shall meet the requirements of ASTM A307 and shall be galvanized in accordance with AASHTO M 232. Steel angles, when required for coupling bands, shall meet the requirements of AASHTO M 36. When annular corrugated bands are used to connect helically corrugated lock-seam pipe, the seam shall be welded at the pipe ends prior to recorrugating to prevent unraveling of the seam. All welds shall develop the full strength of the parent metal.

Bands shall conform to the corrugations of the pipe and shall meet all applicable requirements of AASHTO M 36, with the following exceptions:

Coupling bands for all sizes of steel pipe arch with 3 by 1-inch corrugations shall be 24 inches wide.

Type K coupling bands shall only be used on circular culvert pipe when extending an existing culvert. Rubber gaskets shall be used and shall conform to the requirements of Section 9-04.4(3), match the width of the band, and have a minimum thickness of 1 inch.

Type K coupling bands are allowed for use on all sizes of steel pipe arch with 3 by 1-inch corrugations. Type K bands for this application shall be 24 inches wide. Rubber gaskets shall be used and shall conform to the requirements of Section 9-04.4(3), match the width of the band, and have a minimum thickness of 1 inch. When Type K bands are used, pipe arch ends are not required to be recorrugated.

Gaskets are required for all culvert installations and shall meet the requirements of Section 9-05.10(1).

9-05.4(8) Steel Nestable Pipe

Steel nestable pipe shall meet the requirements for steel pipe of these Specifications except in the method of fabrication. Circular pipe shall be fabricated in two semicircles.

Nestable pipe may be either the stitch-type as hereinafter described or the flange-type in accordance with Military Designation MIL-P-236. One longitudinal edge of each half of the stitch-type nestable circular pipe shall be notched to provide interlocking seams which will form the two segments into the full section when it is erected in the field. Hook and eye bolts, or other approved means, shall be provided to hold the segments firmly together.

Individual plates shall be a minimum of 2 feet in length except for short or half sections required to complete the end section of the culvert.

When protective treatment is specified in the Plans, nestable pipe shall be coated with one of the treatments as provided in Section 9-05.4(3).

9-05.4(9) Steel End Sections

The applicable provisions of AASHTO M 36 shall apply to the construction of steel end sections, except that the end sections shall be fabricated of the same material with the same metallic protective treatment as the pipe.

Asphalt coating shall not be used on steel end sections.

9-05.4(9)A Fabrication

The shape, thickness, dimensions, and number of pieces shall conform to the [Standard Plans](#) for the size and shape of pipe shown in the Plans. They shall be manufactured as integral units or so formed that they can be readily assembled and erected in place. When bolts are used for assembly, they shall be $\frac{3}{8}$ -inch diameter or larger and shall be galvanized. No field welding or riveting will be permitted.

9-05.4(9)B Galvanized Hardware

Bolts, nuts, and miscellaneous hardware shall be galvanized in accordance with the provisions of AASHTO M 232.

9-05.4(9)C Toe Plate Extensions

Toe plate extensions shall be furnished only when so designated in the Plans. When required, the toe plate extensions shall be punched with holes to match those in the lip of the skirt and fastened with $\frac{3}{8}$ inch or larger galvanized nuts and bolts. Toe plate extensions shall be the same material and thickness as the end section and shall be fabricated of the same material with the same metallic protective treatment as the end section.

9-05.5 Aluminum Culvert Pipe

Aluminum culvert pipe shall conform to the applicable requirements of AASHTO M 196.

9-05.5(1) Elliptical Fabrication

Section 9-05.4(1) shall apply to aluminum pipes.

9-05.5(2) Mitered Ends

Section 9-05.4(2) shall apply to aluminum pipes.

9-05.5(3) Vacant**9-05.5(4) Vacant****9-05.5(5) Coupling Bands**

Bands shall be fabricated of the same material as the pipe and shall meet all applicable requirements of AASHTO M 196, except the band thickness shall not be more than 0.105 inches or less than 0.060 inches. All other requirements of Section 9-05.4(7) shall apply.

9-05.5(6) Aluminum End Sections

The applicable provisions of AASHTO M 196 shall apply to the construction of end sections and toe plate extensions for aluminum pipes. In addition, they shall conform to the requirements of Section 9-05.4(9).

Asphalt coating shall not be used on aluminum end sections.

9-05.6 Structural Plate Pipes, Arches and Boxes**9-05.6(1) Steel Structural Plate Structures**

Plates, metal bearings, flanges, members for structural reinforcement and fasteners for constructing steel structural plate pipes, arches and boxes shall conform to the requirements of AASHTO M 167 (ASTM A761) or ASTM A1113.

9-05.6(2) Aluminum Structural Plate Structures

Plates, extrusions and fasteners for constructing aluminum structural plate pipes, arches and boxes shall conform to the requirements of AASHTO M 219 (ASTM B746).

9-05.7 Concrete Storm Sewer Pipe**9-05.7(1) Plain Concrete Storm Sewer Pipe**

Plain concrete storm sewer pipe shall conform to the requirements of AASHTO M 86, Class 2.

9-05.7(1)A Basis for Acceptance

The basis for acceptance of plain concrete storm sewer pipe shall be the same as specified in Section 9-05.3(1)B.

9-05.7(2) Reinforced Concrete Storm Sewer Pipe

Reinforced concrete storm sewer pipe shall conform to the requirements of AASHTO M 170 and shall be of the class noted in the Plans or in the Special Provisions. Section 7.3.1 of AASHTO M 170 shall be amended to require that both bells and spigots shall be reinforced in pipe 30 inches in diameter and greater.

The identification of the minor axis of elliptical reinforcement shall be in accordance with Section 9-05.3(2)D.

9-05.7(2)A Basis for Acceptance

The basis for acceptance of reinforced concrete storm sewer pipe shall be the same as specified in Section 9-05.3(2)B.

9-05.7(3) Concrete Storm Sewer Pipe Joints

All concrete storm sewer pipe shall be joined with rubber gaskets. The joints and gasket material shall meet the requirements of ASTM C990. Gasket material shall be handled and stored in accordance with Section 9-04.4(5).

9-05.7(4) Testing Concrete Storm Sewer Pipe Joints

When a particular type of pipe joint design, material or joining method has not previously been tested and approved, the following test shall be made on one test length of the assembled storm sewer pipe to qualify the design, material or method of joining the pipe. At the option of the Engineer, additional testing may be requested if subsequent field testing of installed pipe indicates difficulty in obtaining properly joined pipe. The tests will be conducted at the manufacturer's yard, and the manufacturer will be required to make such space and facilities available as required to conduct the tests.

9-05.7(4)A Hydrostatic Pressure on Pipes in Straight Alignment

Hydrostatic pressure tests on pipes in straight alignment shall be made in accordance with the procedure outlined in Section 10 of ASTM C990, except that they shall be performed on an assembly consisting of not less than three nor more than five pipe sections selected from stock by the Engineer and assembled in accordance with standard installation instructions issued by the manufacturer. The end sections shall be bulkheaded and restrained against internal pressure.

9-05.7(4)B Hydrostatic Pressure Tests on Pipes in Maximum Deflected Position

Upon completion of the test for pipe in straight alignment, the test section shall be deflected until at least two of the joints have been deflected to the maximum amount shown in the manufacturer's standard installation instructions. When thus deflected, there shall be no leakage at the joints from an applied internal hydrostatic pressure of 5 psi.

9-05.7(4)C Hydrostatic Pressure Test on 15-Inch Diameter and Larger Pipe Under Differential Load

The test sections shall be suitably supported so that one of the pipes of the test assembly is suspended freely between adjacent pipes, bearing only on the joints. The suspended pipe shall then be loaded, at its midpoint, in addition to the mass of the pipe, in accordance with the following schedule:

Diameter	Load
15 inches	7,400 lbs.
18 inches	8,800 lbs.
21 inches	10,000 lbs.
24 inches and over	11,000 lbs.

While under this load, the stressed joints shall show no leakage when subjected to an internal hydrostatic pressure of 5 psi. At the option of the manufacturer, $\frac{1}{2}$ of the load may be applied on the bell end of the suspended pipe in lieu of the full load on the center of the suspended pipe.

9-05.8 Vitrified Clay Sewer Pipe

This material shall not be used in Washington State Department of Transportation projects unless specified in the Special Provisions.

Vitrified clay sewer pipe shall conform to ASTM C700, and all joints shall be factory manufactured in accordance with ASTM C425.

9-05.9 Steel Spiral Rib Storm Sewer Pipe

Steel spiral rib storm sewer pipe shall meet the fabrication requirements of AASHTO M 36 and these Specifications. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M 274 (ASTM A929). The size, coating, metal, and protective treatment, if any, shall be as shown in the Plans or in the Specifications.

The manufacturer of spiral rib storm sewer pipe shall furnish the Engineer a Manufacturer's Certificate of Compliance stating that the materials furnished comply in all respects with these Specifications. The Engineer may require additional information or tests to be performed by the Contractor at no expense to the Contracting Agency.

Unless otherwise specified, spiral rib storm sewer pipe shall be furnished with pipe ends cut perpendicular to the longitudinal axis of the pipe. Pipe ends shall be cut evenly. Spiral rib pipe shall be fabricated by using a continuous helical lock seam.

Spiral rib storm sewer pipe shall have helical ribs that project outwardly, be formed from a single thickness of material, and conform to one of the following configurations:

1. $\frac{3}{4}$ -inch-wide by $\frac{3}{4}$ -inch-deep ribs at $7\frac{1}{2}$ inches on center.
2. $\frac{3}{4}$ -inch-wide by 1-inch-deep ribs at $11\frac{1}{2}$ inches on center.
3. $\frac{3}{4}$ -inch-wide by $\frac{5}{8}$ -inch-deep ribs at 12 inches on center.

Pipe shall be fabricated with ends that can be effectively jointed with coupling bands. When it is required, spiral rib pipe shall be furnished with bituminous or polymer protective treatment 1 or 2 treated or paved. The bituminous treatment for spiral rib pipe shall conform to the requirements of Sections 9-05.4(3) and 9-05.4(4). Polymer coating shall conform to Section 9-05.4(5).

9-05.9(1) Continuous Lock Seam Pipe

Pipes fabricated with a continuous helical seam parallel to the rib may be used for full circle pipe. The seam shall be formed in the flat between ribs and shall conform to Sections 7.5.1 through 7.5.3 of AASHTO M 36.

9-05.9(1)A Basis for Acceptance

The basis for acceptance will be a qualification test, conducted by the State Materials Laboratory, for each manufacturer of spiral rib lock seam steel pipe. Only those specific pipe sizes and gasket materials, if any, approved under the qualification test will be accepted.

Continuous lock seam pipe shall be sampled and tested in accordance with AASHTO T 249.

9-05.9(2) Vacant**9-05.9(3) Coupling Bands**

Coupling bands shall be of the same material as the pipe. Coupling bands and gaskets shall conform to Section 9-05.10(1).

9-05.10 Steel Storm Sewer Pipe

Steel storm sewer pipe shall conform to the requirements of Section 9-05.4 for steel culvert pipe, except that protective coating shall be Treatment 1 or 5, and be constructed of helically corrugated lock seam pipe. When gasketed helically corrugated lock seam steel pipe is called for, and the pipe is properly sized to meet hydraulic requirements, Treatment 5 is not required.

9-05.10(1) Coupling Bands

Coupling bands shall be as shown in the [Standard Plans](#). Bands shall be fabricated of the same material as the pipe and shall meet all applicable requirements of AASHTO M 36. Bands may be up to three nominal thicknesses thinner than used for the pipe, but not thinner than 0.064 inches or thicker than 0.109 inches. Bands shall be coated with the same metallic protective treatment as the pipe but shall not be coated with an asphalt treatment. Bands shall be made by the same manufacturer as the steel pipe selected for installation.

Corrugations on the bands shall be the same size and shape as those on the pipe to be connected. Steel bolts and nuts for coupling bands shall meet the requirements of ASTM A307 and shall be galvanized in accordance with AASHTO M 232. Steel angles, when required for coupling bands, shall meet the requirements of AASHTO M 36. When annular corrugated bands are used to connect helically corrugated lock-seam pipe, the seam shall be welded at the pipe ends prior to recorrugating to prevent unraveling of the seam. All welds shall develop the full strength of the parent metal.

Gaskets are required for all storm sewer installations. Gasket material for coupling bands shall meet the requirements of Section 9-04.4(3). Gaskets for Type D bands shall match the width of the band and have a minimum thickness of $\frac{3}{8}$ inch. O-ring gaskets for Type F bands shall have a cross-sectional diameter of $\frac{13}{16}$ inch for pipe diameters of 36 inches or smaller and $\frac{7}{8}$ inch for larger pipe diameters.

Type K coupling bands are not allowed for storm sewer applications.

9-05.10(2) Basis for Acceptance

The basis for acceptance of steel storm sewer pipe will be the same as specified in Section 9-05.4, except when gasketed helically corrugated lock seam steel pipe is called for. A qualification test conducted by the State Materials Laboratory will be required for each manufacturer of gasketed helically corrugated lock seam steel pipe. Only those specific pipe sizes and gasket materials approved under the qualification test will be accepted.

9-05.11 Aluminum Storm Sewer Pipe

Aluminum storm sewer pipe shall conform to the requirements of Section 9-05.5 for aluminum culvert pipe, and the pipe shall be constructed of helically corrugated lock seam aluminum pipe.

9-05.11(1) Coupling Bands

Coupling bands for aluminum pipe shall be as shown in the [Standard Plans](#). Bands shall be fabricated of the same material as the pipe and shall meet all applicable requirements of AASHTO M 196, except the band thickness shall not be more than 0.105 inches or less than 0.060 inches. All other requirements of Section 9-05.10(1) shall apply.

9-05.11(2) Basis for Acceptance

The basis for acceptance of aluminum storm sewer pipe will be the same as specified in Section 9-05.0, except when gasketed helically corrugated lock seam aluminum pipe is called for. A qualification test, conducted by the State Materials Laboratory, will be required for each manufacturer of gasketed helically corrugated lock seam aluminum pipe. Only those specific pipe sizes and gasket materials approved under the qualification test will be accepted.

9-05.12 Polyvinyl Chloride (PVC) Pipe**9-05.12(1) Solid Wall PVC Culvert Pipe, Solid Wall PVC Storm Sewer Pipe, and Solid Wall PVC Sanitary Sewer Pipe**

Solid wall PVC culvert pipe, solid wall PVC storm sewer pipe, and solid wall PVC sanitary sewer pipe and fittings shall be solid wall construction and shall conform to the following requirements:

For pipe sizes up to 15 inches: ASTM D3034 SDR 35

For pipe sizes from 18 to 48 inches: ASTM F679 using a minimum pipe stiffness of 46 psi in accordance with Table 1.

Joints for solid wall PVC pipe shall conform to ASTM D3212 using elastomeric gaskets conforming to ASTM F477.

Fittings for solid wall PVC pipe shall be injection molded, factory welded, or factory solvent cemented.

9-05.12(2) Profile Wall PVC Culvert Pipe, Profile Wall PVC Storm Sewer Pipe, and Profile Wall PVC Sanitary Sewer Pipe

Profile wall PVC culvert pipe and profile wall PVC storm sewer pipe shall meet the requirements of ASTM F794 Series 46, or ASTM F1803. Profile wall PVC sanitary sewer pipe shall meet the requirements of ASTM F794 Series 46, or ASTM F1803. The maximum pipe diameter shall be as specified in the Qualified Products List.

Joints for profile wall PVC culvert pipe shall conform to ASTM D3212 using elastomeric gaskets conforming to ASTM F477, or as approved through the State Materials Laboratory.

Qualified manufacturers are identified in the Qualified Products List. Qualification for each manufacturer requires joint system conformation to ASTM D3212 using elastomeric gaskets conforming to ASTM F477 and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

Fittings for profile wall PVC pipe shall meet the requirements of ASTM F794 Series 46, or ASTM F1803.

9-05.13 Ductile Iron Sewer Pipe

Ductile iron pipe shall conform to ANSI A 21.51 or AWWA C151 and shall be cement mortar lined and have a 1-mil seal coat per AWWA C104 or a ceramic-filled, amine-cured Novalac Epoxy lining as indicated on the Plans or in the Special Provisions. The ductile iron pipe shall be Special Thickness Class 50, Minimum Pressure Class 350, or the Class indicated on the Plans or in the Special Provisions.

Nonrestrained joints shall be rubber gasket type, push on type, or mechanical type, and shall meet the requirements of AWWA C111.

Cast iron fittings may be used with ductile iron pipe. Saddles fastened to pipe with external bands are not acceptable on new systems. Normally, all fittings shall be the same material as the pipe being connected, except that fittings using other materials or constructed with more than one material may be used subject to the approval of the Engineer. Fittings shall have sufficient strength to withstand handling and load stresses normally encountered.

9-05.14 ABS Composite Sewer Pipe

This material shall not be used in Washington Department of Transportation projects unless specified in the Special Provisions.

ABS composite pipe shall meet the requirements of AASHTO M 264.

ABS composite pipe shall be provided with Type OR (flexible gasketed) joints. Rubber gasketed joints shall conform to applicable provisions of ASTM C443.

Fittings for ABS composite pipe shall be specifically designed for connection to ABS composite pipe with solvent cement. Normally, all fittings shall be the same material as the pipe being connected, except that fittings using other materials or constructed with more than one material may be used subject to the approval of the Engineer. Fittings shall have sufficient strength to withstand handling and load stresses normally encountered.

9-05.15 Metal Castings

For all metal castings the producing foundry shall provide certification stating the country of origin, the material meets the required ASTM or AASHTO Specification noted in the Subsections below. The producing foundry shall detail all test results from physical testing to determine compliance to the Specifications. The test reports shall include physical properties of the material from each heat and shall include tensile, yield, and elongation as specified in the appropriate ASTM or AASHTO Specification. For AASHTO 1 M 306, Section 8, Certification is deleted and replaced with the above certification and testing requirements.

Metal castings for drainage structures shall not be dipped, painted, welded, plugged, or repaired. Porosity in metal castings for drainage structures shall be considered defective and subject to rejection by the Engineer. Metal castings made from gray iron or ductile iron shall conform to the requirements of AASHTO M 306, and metal castings made from cast steel shall conform to the requirements of Section 9-06.8. All metal castings shall meet the proof load testing requirements of AASHTO M 306.

9-05.15(1) Manhole Ring and Cover

Castings for manhole rings shall be gray iron or ductile iron and covers shall be ductile iron.

All covers shall be interchangeable within the dimensions shown in the [Standard Plans](#). All mating surfaces shall be machine finished to ensure a nonrocking fit.

The inside vertical recessed face of the ring and the vertical outside edge of the cover shall be machined or manufactured to the following tolerances:

Ring	$\pm \frac{3}{32}$ inch
Cover	$\pm \frac{3}{32}$ inch

All manhole rings and covers shall be identified by the name or symbol of the producing foundry and country of casting origin. This identification shall be in a plainly visible location when the ring and cover are installed. Ductile iron shall be identified by the following, "DUC" or "DI". The producing foundry and material identification shall be adjacent to each other and shall be minimum $\frac{1}{2}$ -inch to maximum 1-inch high letters, recessed to be flush with the adjacent surfaces.

9-05.15(2) Metal Frame, Grate, and Solid Metal Cover for Catch Basins or Inlets

Castings for metal frames for catch basins and inlets shall be cast steel, gray iron, or ductile iron, and as shown in the [Standard Plans](#).

Castings for grates and solid metal covers for catch basins and inlets shall be cast steel or ductile iron and as shown in the [Standard Plans](#). Additionally, leveling pads are allowed on grates and solid metal covers with a height not to exceed $\frac{1}{8}$ inch. The producing foundry's name and material designation shall be embossed on the top of the grate. The material shall be identified by the following: "CS" for cast steel or "DUC" or "DI" for ductile iron and shall be located near the producing foundry's name.

Grates and covers shall be seated properly to prevent rocking, including the replacement of existing covers with solid metal covers. After seating, the frame and grate or frame and cover shall be maintained as a unit. Alternate designs are acceptable provided they conform to the manufacturer's shop drawings approved prior to Award of the Contract.

9-05.15(3) Cast Metal Inlets

The castings for cast metal inlets shall be cast steel or ductile iron, and as shown in the [Standard Plans](#). Alternate plans are acceptable provided they conform to the fabricator's shop drawings approved prior to Award of Contract.

9-05.16 Grate Inlets and Drop Inlets

Steel in grates, angles, and anchors for grate inlets shall conform to ASTM A36, except structural tube shall conform to ASTM A500, Grade B, and structural shapes may conform to ASTM A992. After fabrication, the steel shall be galvanized in accordance with AASHTO M 111, or galvanized with a hot-sprayed (plasma flame applied) 6 mil minimum thickness plasma coating.

Steel grating shall be fabricated by weld connections. Welds, welding procedures, and welding materials shall conform with the AWS D1.1/D1.1M, latest edition, Structural Welding Code.

Alternate grate designs will be permitted, with the approval of the Engineer, providing the hydraulic capacity is not decreased, the overall dimensions are the same allowing the grate to be interchangeable, and the strength is essentially equal to the grate shown in the [Standard Plans](#) or the Plans.

The Contractor has the option of furnishing either cast-in-place or precast inlets unless otherwise shown in the Plans. Alternate designs are acceptable provided they conform to the fabricator's shop drawings approved prior to Award of the Contract.

9-05.17 Aluminum Spiral Rib Storm Sewer Pipe

Aluminum spiral storm sewer pipe shall meet the fabrication requirements of AASHTO M 196 and these Specifications. Aluminum alloy shall meet the material requirements of AASHTO M 97 (ASTM B744). The size and corrugation shall be as shown in the Plans or in the Specifications. The size, metal, and protective treatment shall be as shown in the Plans or in the Specifications.

The manufacturer of spiral rib storm sewer pipe shall furnish to the Engineer a Manufacturer's Certificate of Compliance stating that the materials furnished comply in all respects with these Specifications. The Engineer may require additional information or tests to be performed by the Contractor at no expense to the Contracting Agency.

Unless otherwise specified, spiral rib storm sewer pipe shall be furnished with pipe ends cut perpendicular to the longitudinal axis of the pipe. Pipe ends shall be cut evenly. Spiral rib pipe shall be fabricated by using a continuous helical lock seam.

Spiral rib storm sewer pipe shall have helical ribs that project outwardly, be formed from a single thickness of material, and conform to one of the following configurations:

1. $\frac{3}{4}$ -inch-wide by $\frac{3}{4}$ -inch-deep ribs at $7\frac{1}{2}$ inches on center.
2. $\frac{3}{4}$ -inch-wide by 1-inch-deep ribs at $11\frac{1}{2}$ inches on center.
3. $\frac{3}{4}$ -inch-wide by $\frac{5}{8}$ -inch-deep ribs at 12 inches on center.

9-05.17(1) Continuous Lock Seam Pipe

Pipes fabricated with a continuous helical lock seam parallel to the rib may be used for full circle pipe. The lock seam shall be formed in the flat between ribs and shall conform to Sections 13.2.1 through 13.2.5 of AASHTO M 196.

9-05.17(1)A Basis for Acceptance

The basis for acceptance will be a qualification test, conducted by the State Materials Laboratory, for each manufacturer of spiral rib lock seam pipe. Only those specific pipe sizes and gasket materials, if any, approved under the qualification test, will be accepted.

Continuous lock seam pipe shall be sampled and tested in accordance with AASHTO T 249.

9-05.17(2) Coupling Bands

Coupling bands shall be of the same material as the pipe. Coupling bands and gaskets shall conform to Section 9-05.10(1).

9-05.18 Safety Bars for Culvert Pipe

Steel pipe used as safety bars and steel pipe used as sockets shall conform to ASTM A53, Grade B. Steel tubing used as safety bars shall conform to ASTM A500, Grade B. Steel plate shall conform to ASTM A36. All parts shall be galvanized after fabrication in accordance with AASHTO M 111.

9-05.19 Corrugated Polyethylene Culvert Pipe, Couplings, and Fittings

Corrugated polyethylene culvert pipe, couplings, and fittings shall meet the requirements of AASHTO M 294 Type S or D for pipe 12- to 60-inch diameter with silt-tight joints.

Corrugated polyethylene culvert pipe manufacturers shall participate in the National Transportation Product Evaluation Program (NTPEP) work plan for HDPE (High Density Polyethylene) Thermoplastic Pipe and be listed on the NTPEP audit website displaying they are NTPEP compliant.

Joints for corrugated polyethylene culvert pipe shall be made with either a bell/bell or bell and spigot coupling and shall incorporate the use of a gasket conforming to the requirements of ASTM D1056 Type 2 Class B Grade 3 or ASTM F477. All gaskets shall be factory installed on the coupling or on the pipe by the qualified manufacturer.

Qualification for each manufacturer of corrugated polyethylene culvert pipe requires an approved joint system and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

9-05.20 Corrugated Polyethylene Storm Sewer Pipe, Couplings, and Fittings

Corrugated polyethylene storm sewer pipe, couplings, and fittings shall meet the requirements of AASHTO M 294 Type S or D. The maximum pipe diameter for corrugated polyethylene storm sewer pipe shall be the diameter for which a manufacturer has submitted. Fittings shall be blow molded, rotational molded, or factory welded.

Corrugated polyethylene storm sewer pipe manufacturers shall participate in the National Transportation Product Evaluation Program (NTPEP) work plan for HDPE (High Density Polyethylene) Thermoplastic Pipe and be listed on the NTPEP audit website displaying they are NTPEP compliant.

All joints for corrugated polyethylene storm sewer pipe shall be made with a bell/bell or bell and spigot coupling and shall conform to ASTM D3212 using elastomeric gaskets conforming to ASTM F477. All gaskets shall be factory installed on the pipe in accordance with the manufacturer's recommendations.

Qualification for each manufacturer or corrugated polyethylene storm sewer pipe requires joint system conformance to ASTM D3212 using elastomeric gaskets conforming to ASTM F477 and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

9-05.21 Steel Rib Reinforced Polyethylene Culvert Pipe

Steel rib reinforced polyethylene culvert pipe shall meet the requirements of ASTM F2562 Class 1 for steel reinforced thermoplastic ribbed pipe and fittings for pipe 24 to 60 inches in diameter with silt-tight joints.

Silt-tight joints for steel reinforced polyethylene culvert pipe shall be made with a bell/bell or bell and spigot coupling and shall incorporate the use of a gasket conforming to the requirements of ASTM F477. All gaskets shall be installed on the pipe by the manufacturer.

Qualification for each manufacturer of steel reinforced polyethylene culvert pipe requires an approved joint system and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

9-05.22 Steel Rib Reinforced Polyethylene Storm Sewer Pipe

Steel rib reinforced polyethylene storm sewer pipe shall meet the requirements of ASTM F2562 Class 1 for steel reinforced thermoplastic ribbed pipe and fittings. The maximum diameter for steel reinforced polyethylene storm sewer pipe shall be the diameter for which a manufacturer has submitted a qualified joint. Qualified manufacturers and approved joints are listed in the Qualified Products List. Fittings shall be rotationally molded, injection molded, or factory welded.

All joints for steel reinforced polyethylene storm sewer pipe shall be made with a bell and spigot coupling and shall conform to ASTM D3212 using elastomeric gaskets conforming to ASTM F477. All gaskets shall be installed on the pipe by the manufacturer.

Qualification for each manufacturer of steel reinforced polyethylene storm sewer pipe requires joint system conformance to ASTM D3212 using elastomeric gaskets conforming to ASTM F477 and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties it deems appropriate.

9-05.23 High-Density Polyethylene (HDPE) Pipe

HDPE pipe shall be manufactured from resins meeting the requirements of ASTM D3350 with a minimum cell classification of 345464C and a Plastic Pipe Institute (PPI) designation of PE 4710.

The pipes shall have a minimum standard dimension ratio (SDR) of 32.5.

HDPE pipe shall be joined into a continuous length by an approved joining method.

The joints shall not create an increase in the outside diameter of the pipe. The joints shall be fused, snap together, or threaded. The joints shall be watertight, rubber gasketed if applicable, and pressure testable to the requirements of ASTM D3212.

Joints to be welded by butt fusion shall meet the requirements of ASTM F2620 and the manufacturer's recommendations. Fusion equipment used in the joining procedure shall be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, fusion temperature, alignment, and fusion pressure. All field welds shall be made with fusion equipment equipped with a Data Logger. Temperature, fusion pressure, and a graphic representation of the fusion cycle shall be part of the Quality Control records. Electro fusion may be used for field closures, as necessary. Joint strength shall be equal to or greater than the tensile strength of the pipe.

Fittings shall be manufactured from the same resins and cell classification as the pipe unless specified otherwise in the Plans or Specifications. Butt fusion fittings and Flanged or Mechanical joint adapters shall have a manufacturing standard of ASTM D3261. Electro fusion fittings shall have a manufacturing standard of ASTM F1055.

HDPE pipe to be used as liner pipe shall meet the requirements of AASHTO M 326 and this specification.

The supplier shall furnish a Manufacturer's Certification of Compliance stating that the materials meet the requirements of ASTM D3350 with the correct cell classification with the physical properties listed above. The supplier shall certify that the dimensions meet the requirements of ASTM F714 or as indicated in this Specification or the Plans.

At the time of manufacture, each lot of pipes, liners, and fittings shall be inspected for defects and tested for Elevated Temperature Sustained Pressure in accordance with ASTM F714. The Contractor shall not install pipes that are older than 2 years from the date of manufacture.

At the time of delivery, the pipe shall be homogeneous throughout, uniform in color, and free of cracks, holes, foreign materials, blisters, or deleterious faults.

Pipe shall be marked at 5-foot intervals or less with a coded number that identifies the manufacturer, SDR, size, material, machine, and date on which the pipe was manufactured.

9-05.24 Polypropylene Culvert Pipe, Polypropylene Storm Sewer Pipe, and Polypropylene Sanitary Sewer Pipe

All joints for polypropylene pipe shall be made with a bell/bell or bell and spigot coupling and shall conform to ASTM D3212 using elastomeric gaskets conforming to ASTM F477. All gaskets shall be factory installed on the pipe in accordance with the manufacturer's recommendations.

Qualification for each manufacturer of polypropylene storm sewer pipe requires joint system conformance to ASTM D3212 using elastomeric gaskets conforming to ASTM F477 and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties it deems appropriate.

9-05.24(1) Polypropylene Culvert Pipe and Storm Sewer Pipe

Polypropylene culvert and storm sewer pipe shall conform to the following requirements:

1. For dual wall pipe sizes up to 60 inches: ASTM F2881 or AASHTO M 330, Type S or Type D.
2. For double or triple wall pipe sizes up to 60 inches: ASTM F2764.
3. Fittings shall be factory welded, injection molded or PVC.

9-05.24(2) Polypropylene Sanitary Sewer Pipe

Polypropylene sanitary sewer pipe shall conform to the following requirements:

1. For pipe sizes up to 60 inches: ASTM F2764.
2. Fittings shall be factory welded, injection molded or PVC.

9-05.30 Vacant

9-05.40 Vacant

9-05.50 Precast Concrete Drainage Structures

9-05.50(1) Fabrication Tolerances and Requirements

All precast concrete items shall meet the requirements of AASHTO M 199, fabricated as shown on the Plans, and shall meet the tolerances and revisions as listed below.

1. The following information shall be legibly marked on each precast product (excluding rectangular and round adjustment sections). Marking shall be indented into the concrete, painted thereon with waterproof paint, or contained within a bar-coded sticker firmly attached to the product:
 - a. fabricator name or trademark.
 - b. date of manufacture.
2. Catch Basins (to include Type 1, Type 1L, and Type 1P), and Concrete Inlets:
 - a. knock-out wall thickness, measured at thinnest point, 1½ to 2½ inches.
 - b. knock-out diameter, 5 percent plus/minus allowance.
 - c. base thickness, measured at thinnest point, 4 inches with ½-inch minus tolerance.
 - d. all other dimensions as shown on Plans, 5 percent plus/minus allowance.
3. Catch Basin Type 2 and Manhole Type 1, 2, 3:
 - a. knock-out diameter, 5 percent plus/minus allowance.
4. Flat Slab Tops:
 - a. round or rectangular opening, 5 percent plus/minus allowance.
5. Rectangular or Circular Adjustment Sections:
 - a. opening size or diameter, 5 percent plus/minus allowance.
6. Conical Sections:
 - a. top opening diameter, 5 percent plus/minus allowance.

7. Grate Inlets:
 - a. knock-out wall thickness, measured at thinnest point, 1½ to 2½ inches.
 - b. knock-out diameter, 5 percent plus/minus allowance.
 - c. opening size, 2½ percent plus/minus allowance.
8. Drop Inlets:
 - a. knock-out diameter, 1 inch plus/minus allowance.

9-05.50(2) Manholes

Precast concrete manholes shall meet the requirements of AASHTO M 199.

The joints may be the tongue and groove type or the shiplap type, sufficiently deep to prevent lateral displacement.

When secondary synthetic fiber reinforcement is used in 48-inch diameter by 3-foot-high eccentric or concentric cone sections, the synthetic fiber shall meet the requirements of Section 9-05.50(9). A minimum of two hoops of W2 wire shall be placed in the 48-inch end of each cone. No steel is required in the remainder of the cone.

Precast manhole sections 48-inch diameter, with no knockouts, may be produced using no steel reinforcement. As an alternate to conventional steel reinforcement, manufacturers shall use synthetic structural fibers meeting the requirements of Section 9-05.50(10).

9-05.50(3) Precast Concrete Catch Basins

Precast concrete catch basins shall conform to the requirements of Section 9-05.50(1), except that the dimensions shall be as set forth in the Plans.

When secondary synthetic fiber reinforcement is used to produce Type 1, Type 1L, and Type 1P Catch Basins, the synthetic fiber shall meet the requirements of Section 9-05.50(9). A minimum amount of steel reinforcement shall be used to reinforce the area around the knockouts. Steel reinforcing shall consist of a No. 3 horizontal hoop reinforcing bar located above the knockouts and a No. 3 vertical reinforcing bar in each corner, extending a minimum of 18 inches below the top surface of the catch basin.

Catch Basin Type 1 may be produced using structural synthetic fibers meeting the requirements of Section 9-05.50(10). Catch Basin Type 1 shall contain one hoop of No. 3 reinforcing bar around the top perimeter.

Knockouts or cutouts may be placed on all four sides and may be round or D-shaped.

9-05.50(4) Precast Concrete Inlets

Precast concrete inlets shall conform to the requirements of Section 9-05.50(1), except that the dimensions shall be as set forth in the Plans.

9-05.50(5) Precast Concrete Drywells

Precast concrete drywells shall meet the requirements of Section 9-05.50(1). Seepage port size and shape may vary per manufacturer. Each seepage port shall provide a minimum of 1 square inch and a maximum of 7 square inches for round openings and 15 square inches for rectangular openings. The ports shall be uniformly spaced with at least one port per 8 inches of drywell height and 15 inches of drywell circumference.

Precast Drywells may be produced using no steel reinforcement. As an alternate to conventional steel reinforcement, manufacturers shall use synthetic structural fibers meeting the requirements of Section 9-05.50(10).

9-05.50(6) Vacant

9-05.50(7) Vacant

9-05.50(8) Vacant

9-05.50(9) Synthetic Micro Fibers for Precast Units

The synthetic fiber, either nylon multifilament fibers or polypropylene fibrillated fibers, shall meet the requirements of ASTM C1116, Section 4.1.3. Synthetic fibers shall be added at a minimum dosage rate of 1.0 pound of nylon multifilament fibers per cubic yard of concrete or 1.5 pounds of polypropylene fibrillated fibers per cubic yard of concrete and shall be thoroughly mixed with the concrete before placement in the forms. The synthetic fibers shall be a minimum of 0.75 inches and a maximum of 2 inches in length.

9-05.50(10) Synthetic Macro Fibers for Precast Units

Synthetic fibers shall be monofilament or monofilament/fibrillated blend made of polyolefin, polypropylene, or polypropylene/polyethylene blend, meeting the requirements of ASTM C1116, Section 4.1.3, and ICC Acceptance Criteria 38. Additionally, the vendor or manufacturer must furnish an Engineering Report that provides test data in accordance with ASTM C1609 and/or ASTM C1399 from an ICC-qualified commercial laboratory relating to the specification requirements. The vendor or manufacturer shall provide a letter of certification stating compliance with specifications and/or standard codes.

The fibers shall be a minimum of 2 inches in length and have an aspect ratio (length divided by the equivalent diameter of the fiber) between 70 and 100 when the fibers are in their final phase.

The fibers shall have a minimum tensile strength of 50 ksi and a minimum modulus of elasticity of 600 ksi, when tested in accordance with ASTM D7508.

Precast drainage units shall have a minimum dosage rate of 4.0-lbs/cu yd. or more in order to obtain a residual strength of 175 psi when tested in accordance with ASTM C1609 and/or ASTM C1399. The fiber supplier shall submit independent laboratory data to support the residual strength results.

9-05.51 Adjustment Sections**9-05.51(1) Precast Concrete**

Precast concrete shall meet the requirements of Sections 9-05.50(2), 9-05.50(3), 9-05.50(4) or 9-05.50(5).

9-05.51(2) Metal Castings

Metal castings shall meet the requirements of Section 9-05.15.

9-05.51(3) Concrete Block

Concrete blocks shall conform to the requirements of Section 9-12.1.

9-05.51(4) Concrete Brick

Concrete brick shall conform to the requirements of Section 9-12.2.

9-05.51(5) Expanded Polypropylene Foam

Expanded Polypropylene material shall conform to ASTM D3575 and have a traffic rating compliant with AASTHO M-306 HS-25. Grade adjustments installed on sanitary manholes shall have a tongue and groove fit. The grade adjustment installed directly under the casting shall be a finish adjustment with a smooth upper surface. No shims of any type or material are allowed. A slope required to match the specified grade and terrain shall be achieved utilizing angled Expanded Polypropylene (EPP) grade adjustments conforming to the same specifications listed above.

9-06 Structural Steel and Related Materials**9-06.1 Structural Carbon Steel**

Structural carbon steel shall conform to AASHTO M270 (ASTM A709), Grade 36, except as otherwise noted.

9-06.2 Structural Low Alloy Steel

Structural low alloy steel shall conform to ASTM A709, Grades 50, 50W, 50S, quenched and self-tempered (QST) 50, QST 50S, HPS 50W, or 50CR as specified in the Plans or Special Provisions, except as otherwise noted.

9-06.3 Structural High-Strength Steel

Structural high-strength steel shall be high yield strength, strength structural steel conforming to AASHTO M 270 (ASTM A709), Grades quenched and self-tempered (QST) 65, QST 70, HPS 70W, or HPS 100W as specified in the Plans or Special Provisions, except as otherwise noted.

9-06.4 Resin Bonded Anchor System

The resin bonded anchor system shall conform to the following requirements:

1. Threaded Anchor Rod and Nuts

Threaded anchor rods shall conform to ASTM A193 Grade B7, ASTM F1554 GR105, or ASTM A449, except as otherwise noted and be fully threaded. Threaded anchor rods for stainless steel resin bonded anchor systems shall conform to ASTM F593 Type A or better and shall be Type 304 unless otherwise specified.

Nuts shall conform to ASTM A563, or ASTM A194, Grade DH, except as otherwise noted. Nuts for stainless steel resin bonded anchor systems shall conform to ASTM F594 and shall be Type 304 unless otherwise specified.

Washers shall conform to ASTM F436 and shall meet the same requirements as the supplied anchor rod, except as otherwise noted. Washers for stainless steel resin bonded anchor systems shall conform to ASTM A240 and the geometric requirements of ASME B18.21.1 and shall be Type 304 Stainless Steel unless otherwise specified.

Nuts and threaded anchor rods, except those manufactured of stainless steel, shall be galvanized in accordance with ASTM F2329. Galvanized threaded anchor rods shall be tested for embrittlement after galvanizing, in accordance with Section 9-29.6(5).

Threaded anchor rods used with resin capsules shall have the tip of the rod chiseled in accordance with the resin capsule manufacturer's recommendations. Galvanized threaded rods shall have the tip chiseled prior to galvanizing.

2. Resin Bonding Material

Resin bonding material shall be a two-component epoxy resin conforming with ASTM C881 Type IV.

3. Ultimate Anchor Tensile Capacity

Resin bonded anchors shall be tested in accordance with ASTM E488 to have the following minimum ultimate tensile load capacity when installed in concrete having a maximum compressive strength of 6000 pounds per square inch (psi) at the embedment specified below:

Anchor Diameter (inch)	Tensile Capacity (lbs.)	Embedment (Inches)
$\frac{3}{8}$	7,800	3- $\frac{3}{8}$
$\frac{1}{2}$	12,400	4- $\frac{1}{2}$
$\frac{5}{8}$	19,000	5- $\frac{5}{8}$
$\frac{3}{4}$	27,200	6- $\frac{3}{4}$
$\frac{7}{8}$	32,000	7- $\frac{7}{8}$
1	41,000	9
1- $\frac{1}{4}$	70,000	11- $\frac{1}{4}$

Submittal and construction requirements are specified in Section 6-02.3(18)A.

9-06.5 Bolts and Rods

9-06.5(1) Unfinished Bolts

Unfinished bolts (ordinary machine bolts) shall conform to the Specification requirements of ASTM A307 Grade A or B. Nuts shall comply with ASTM A563 Grade A requirements. Washers, unless otherwise specified, shall meet ASTM F844 Specifications.

The Contractor shall submit a Manufacturer's Certificate of Compliance for the bolts, nuts, and washers prior to installing any of them.

9-06.5(2) Vacant

9-06.5(3) High-Strength Bolts

High-strength bolts for structural steel joints shall conform to either ASTM F3125 Grade A325 Type 1 or 3 or ASTM F3125 Grade A490 Type 1 or 3, as specified in the Plans or Special Provisions. Tension control bolt assemblies, meeting all requirements of ASTM F3125 Grade F1852 may be substituted where Grade A325 high-strength bolts and associated hardware are specified.

Bolts conforming to ASTM F3125 Grade A490 shall not be galvanized.

Bolts for unpainted and nongalvanized structures shall conform to ASTM F3125 Grade A325 Type 3, ASTM F3125 Grade A490 Type 3, ASTM F3125 Grade F1852 Type 3, or ASTM F3125 Grade F2280 Type 3 as specified in the Plans or Special Provisions.

Nuts for high-strength bolts shall meet the following requirements:

ASTM F3125 Grade A325 Bolts

Type 1 (black)	ASTM A563 Grade C, C3, D, DH, and DH3 AASHTO M 292 (ASTM A194) Grade 2H
Type 3 (black weathering)	ASTM A563 Grade C3 and DH3
Type 1 (hot-dip galvanized)	ASTM A563 Grade DH AASHTO M 292 (ASTM A194) Grade 2H

ASTM F3125 Grade A490 Bolts

Type 1 (black)	ASTM A563 Grade DH and DH3 AASHTO M 292 (ASTM A194) Grade 2H
Type 3 (black weathering)	ASTM A563 Grade DH3

Nuts that are to be galvanized shall be tapped oversized the minimum required for proper assembly. The amount of overlap shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the mechanical requirements of ASTM A563 and the rotational capacity test specified in ASTM F3125.

Galvanized nuts shall be lubricated in accordance with ASTM A563 including supplementary requirement S2. Documentation shall include the name, method of application, and dilution of the lubricant applied to the nuts.

Washers for ASTM F3125 Grade A325 and Grade A490 bolts shall meet the requirements of ASTM F436 and may be circular, beveled, or extra thick, as required. The surface condition and weathering characteristics of the washers shall be the same as for the bolts being specified.

Direct Tension Indicators shall conform to the requirements of ASTM F959 and may be used with either ASTM F3125 Grade A325 or Grade A490 bolts. The matching type of direct tension indicator washer shall be used with the bolt grade and type specified. Direct tension indicators shall be galvanized by mechanical deposition in accordance with ASTM B695 class 55. Hot-dip galvanizing will not be allowed.

All bolts, nuts, and direct tension indicators shall be marked and identified as required in the pertinent Specifications.

Lock-pin and collar fasteners which meet the materials, manufacturing, and chemical composition requirements of ASTM F3125 Grade A325 or Grade A490, and which meet the mechanical property requirements of the same Specification in full size tests, and which have a body diameter and bearing areas under lock-pin head and collar not less than those provided by a bolt and nut of the same nominal size may be used. The Contractor shall submit a detailed installation procedure to the Engineer for approval. Approval from the Engineer to use a lock-pin and collar fasteners shall be received by the Contractor prior to use.

The Contractor shall provide Manufacturer's Certificate of Compliance for all bolts, nuts, washers, and load indicators. The Manufacturer's Certificate of Compliance shall include certified mill test reports and test reports performed on the finished bolt confirming that all of the materials provided meet the requirements of the applicable AASHTO or ASTM Specification. The documentation shall also include the name and address of the test laboratory, the date of testing, the lot identification of the bolts and nuts, and coating thickness for galvanized bolts and nuts. Shipping containers (not lids) shall be marked with the lot identification of the item contained therein.

Bolts shall be sampled prior to incorporating into a structure. For the purposes of selecting samples, a lot of bolts shall be the quantity of bolts of the same nominal diameter and same nominal length in a consignment shipped to the project site. The minimum number of samples from each lot shall be as follows:

Lot Size	Sample Size ¹
0 to 50	*
51 to 150	4
151 to 1,200	6
1,201 to 10,000	10
10,001 to 35,000	16
35,001 and over	24

*Manufacturer's Certificate of Compliance – samples not required.

¹Nuts, washers, and load indicator devices, and tension control bolt assemblies or devices shall be sampled at the same frequency as the bolts.

All testing of bolts, nuts, washers, and load indicating devices shall be performed on specimens as they are to be installed.

All samples shall include a Manufacturer's Certificate of Compliance for each lot of bolts provided as defined in Section 1-06.3.

9-06.5(4) Anchor Bolts and Anchor Rods

Anchor bolts and anchor rods shall meet the requirements of ASTM F1554 and, unless otherwise specified, shall be Grade 105 and shall conform to Supplemental Requirements S2, S3, and S4.

Nuts for ASTM F1554 Grade 105 black anchor bolts and anchor rods shall conform to ASTM A563, Grade D or DH. Nuts for ASTM F1554 Grade 105 galvanized anchor bolts and anchor rods shall conform to either ASTM A563, Grade DH, or AASHTO M 292 (ASTM A194), Grade 2H, and shall conform to the overtapping, lubrication, and rotational testing requirements in Section 9-06.5(3). Nuts for ASTM F1554 Grade 36 or 55 black or galvanized anchor bolts and anchor rods shall conform to ASTM A563, Grade A or DH. Washers shall conform to ASTM F436.

The bolts and rods shall be tested by the manufacturer in accordance with the requirements of the pertinent Specification and as specified in these Specifications. Anchor bolts, anchor rods, nuts, and washers shall be inspected prior to shipping to the project site. The Contractor shall submit to the Engineer for acceptance a Manufacturer's Certificate of Compliance for the anchor bolts, anchor rods, nuts, and washers, as defined in Section 1-06.3. If the Engineer deems it appropriate, the Contractor shall provide a sample of the anchor bolt, anchor rod, nut, and washer for testing.

All bolts, rods, nuts, and washers shall be marked and identified as required in the pertinent Specification.

9-06.6 Vacant

9-06.7 Vacant

9-06.8 Steel Castings

Steel castings shall conform to the requirements of AASHTO M 103, Mild to Medium Strength Carbon Steel Castings for General Application, grade 70-36, unless otherwise designated in the Plans or in the Special Provisions.

9-06.9 Gray Iron Castings

Gray iron castings shall conform to the requirements of AASHTO M 306. The class of castings to be furnished shall be that designated in the Plans or in the Special Provisions.

9-06.10 Malleable Iron Castings

Malleable iron castings shall conform to the requirements of ASTM A47.

9-06.11 Steel Forgings and Steel Shafting

Steel forgings shall conform to the requirements of AASHTO M 102. The classes of forgings to be furnished shall be those specified in the Plans or in the Special Provisions.

Steel shafting shall conform to the requirements of AASHTO M 169, Grade Designation 1016 to 1030 inclusive, unless otherwise specified.

9-06.12 Bronze Castings

Bronze castings shall conform to the requirements of ASTM B22, Bronze Castings for Bridges and Turntables.

9-06.13 Vacant**9-06.14 Ductile Iron Castings**

Ductile iron castings shall conform to the requirements of ASTM A536, Grade 80-55-06, unless otherwise specified in the Plans or in the Special Provisions.

9-06.15 Welded Shear Connectors

Welded shear studs shall be made from cold drawn bar stock conforming to the requirements of AASHTO M 169. Grades 1010 through 1020, inclusive, either semi-killed or killed deoxidation.

The material shall conform to the following mechanical properties:

Tensile Strength	60,000 psi min.
Yield Strength	50,000 psi min.
Elongation	20 percent min.
Reduction of Area	50 percent min.

Mechanical properties shall be determined in accordance with AASHTO T 244.

At the manufacturer's option, mechanical properties of the studs shall be determined by testing either the steel after cold finishing, or the full diameter finished studs.

9-06.16 Roadside Sign Structures

All bolts, nuts, washers, cap screws, and coupling bolts shall conform to ASTM F3125 Grade A325 and Section 9-06.5(3), except as noted otherwise. All connecting hardware shall be galvanized after fabrication in accordance with AASHTO M 232.

Posts for single-post sign structures shall meet the requirements of ASTM A500 Grade B or ASTM A53 Grade B, Type E or S.

Posts for perforated square steel posts shall meet the requirements of ASTM A653 Grade 50. Perforated square steel posts shall be finished in accordance with ASTM A653 G90 Structural Quality Grade 50 or ASTM A653 G140.

Slip bases (SB1, SB2, and SB3) for perforated square steel posts shall conform to the following:

Plates	ASTM A572
Castings (SB3)	ASTM A536 Grade 65-45-12 and ASTM A153
Tubing	ASTM A500 Grade B
Angle Iron (SB1)	ASTM A36

Except as noted otherwise, the slip bases (SB1, SB2, and SB3) for perforated square steel posts shall be hot-dipped galvanized.

The heavy-duty anchor (lower sign post support) used for perforated square steel posts (ST-4) shall meet the requirements of ASTM A500 Grade B and shall be hot-dipped galvanized.

The bolts for connecting square steel posts to the upper slip plate SB-1, SB-2, or SB-3 shall be corner bolts and conform to ASTM F568 Class 4.6, zinc coated, shoulder flange bolts and conform to ASTM A29, zinc coated; or commercial bolts stock and conform to ASTM A307, zinc coated.

The bolts connecting perforated square steel posts to the lower sign post support (ST-2 or ST-4) shall conform to ASTM A307, Grade A and galvanized. The bolts connecting the lower slip plate (SB-1, SB-2, or SB-3) to the heavy-duty anchor (lower sign post support ST-4) shall conform to ASTM A307 and galvanized. The bolt stop for ST-2 and ST-4 shall conform to ASTM A307, Grade A and galvanized.

Wide flange steel or solid square steel posts for multiple-post sign structures shall conform to either ASTM A36 or ASTM A992. Posts conforming to either ASTM A588 or ASTM A572 Grade 50 may be used as an acceptable alternate to the ASTM A36 and ASTM A992 posts. All steel not otherwise specified shall conform to either ASTM A36 or ASTM A992.

Except as noted otherwise, all steel, including posts, base plates, and base stiffeners, shall be galvanized after fabrication in accordance with AASHTO M 111.

Base connectors for multiple directional steel breakaway posts shall conform to the following:

Brackets	Aluminum Alloy 6061 T-6
Bosses for Type TPB Brackets	ASTM A582
Anchor Ferrules	Type 304 stainless steel for threaded portion. AISI 1045 steel rod and AISI 1008 coil for cage portion

Anchor couplings for multiple directional steel breakaway posts shall conform to AMS 6378D with a tensile breaking strength range as follows:

Type TPA	17,000 to 21,000 lb
Type TPB	47,000 to 57,000 lb

For multi-directional breakaway base connectors, shims shall conform to ASTM A653, SS Grade 33, Coating Designation G 165.

9-06.17 Noise Barrier Wall Access Door

Access door frames shall be formed of 14-gauge steel to the size and dimensions shown in the Plans. The access door frame head and jamb members shall be mitered, securely welded, and ground smooth. Each head shall have two anchors and each jamb shall have three anchors. The hinges shall be reinforced with ¼-inch by 12-inch plate, width equal to the full inside width of the frame.

Access doors shall be full flush 1-¾-inch thick seamless doors with a polystyrene core. Door faces shall be constructed with smooth seamless 14-gauge roller-levered, cold-rolled steel sheet conforming to ASTM A 792 Type SS, Grade 33 minimum, Coating Designation AZ55 minimum. The vertical edges shall be neat interlocked hemmed edge seam. The top and bottom of the door shall be enclosed with 14-gauge channels. Mortise and reinforcement for locks and hinges shall be 10-gauge steel. Welded top cap shall be ground and filled for exterior applications. The bottom channel shall have weep holes.

Each access door shall have three hinges. Access door hinges shall be ASTM A 276 Type 316 stainless steel, 4-½-inches square, with stainless steel ball bearing and non-removable pins.

Each access door shall have two pull plates. The pull plates shall be ASTM A 240 Type 316 stainless steel, with a grip handle of one-inch diameter and 8 to 10-inches in length.

The door assembly shall be fabricated and assembled as a complete unit including all hardware specified prior to shipment.

9-06.18 Metal Bridge Railing

Metal bridge railing shall conform to the type and material Specifications set forth in the Plans and Special Provisions. Steel used for metal railings, when galvanized after fabrication in accordance with AASHTO M 111, shall have a controlled silicon content of either 0.00 to 0.06 percent or 0.15 to 0.25 percent. Mill test certificates verifying the silicon content of the steel shall be submitted to both the galvanizer and the Engineer prior to beginning galvanizing operations.

Section 8, part (b) of the Aluminum Association Standard Specifications for Aluminum Railing Posts Alloy A 344-T4 is hereby revised to provide that no X-ray inspection will be required after a foundry technique has been established for each mold which will ensure production of castings which are free from harmful defects. Inspection for approval of castings will be made by the Engineer after the finished castings have been anodized as noted in the Plans.

Welding of aluminum shall be in accordance with Section 9-28.14(3).

9-06.19 Strip Seal and Modular Expansion Joint System Components

9-06.19(1) Strip Seal Expansion Joint System Components

Metal components shall conform to ASTM A36, ASTM A992, ASTM A572 or ASTM A588.

Elastomeric joint seals shall conform to the following:

Property	Test Method	Range of Values
Hardness Durometer A	ASTM D2240	50 - 70
Tensile Strength	ASTM D412	2000 psi minimum
Elongation at break	ASTM D412	250% minimum
Compression set	ASTM D395	40% max at 70 hr at 212F
Oven Aging 70 hours	ASTM D573	
Tensile loss		20% maximum
Elongation loss		20% maximum
Change in hardness		10-points maximum
Oil Swell weight change	ASTM D471	45% max at 70 hr at 212F
Ozone Resistance	ASTM D1149	No cracks at 70 hr at 104F
Low Temperature Stiffening	ASTM D2240	0 to +15 points at 7 days at 14F

9-06.19(2) Modular Expansion Joint System Components

Structural steel shall conform to ASTM A36, ASTM A572 Grade 50, or ASTM A588. Aluminum components shall not be used.

Stainless steel shall conform to ASTM A240 Type 304.

Bolts and other hardware shall conform to the requirements of ASTM F3125 Grade A325 Type 1 or 2 and shall be galvanized in accordance with ASTM F2329 and Section 9-06.5(3).

PTFE shall conform to Section 9-31.8(2).

Expansion joint seals shall conform to the following:

Property	Test Method	Range of Values
Hardness Durometer A	ASTM D2240	50 - 70
Tensile Strength	ASTM D412	2000 psi minimum
Elongation at break	ASTM D412	250% minimum
Compression set	ASTM D395	40% max at 70 hr at 212F
Oven Aging 70 hours	ASTM D573	
Tensile loss		20% maximum
Elongation loss		20% maximum
Change in hardness		10-points maximum
Oil Swell weight change	ASTM D471	45% max at 70 hr at 212F
Ozone Resistance	ASTM D1149	No cracks at 70 hr at 104F
Low Temperature Stiffening	ASTM D2240	0 to +15 points at 7 days at 14F

The maximum size of each expansion joint strip seal shall be 3 inches. Box-type seals or seals utilizing double webs will not be acceptable. Seals shall be continuous without splices.

9-06.20 **Vacant**

9-06.21 **Vacant**

9-06.22 **Bolts, Washers, and Other Hardware**

Ordinary machine bolts and flat head bolts shall be made from commercial bolt stock meeting the Specifications of ASTM A307, and shall be grade A. Drift bolts and dowels may be either wrought iron or medium steel. Washers may be cast iron or malleable iron or may be cut from medium steel or wrought iron plate.

All bolts and other hardware which are to be galvanized and which require bending or shaping shall be hot forged to the required shape before galvanizing. Cold bending of such material will not be permitted because of the tendency toward embrittlement during the galvanizing process. Galvanizing shall be in accordance with AASHTO M 232.

Split rings for log cribbing of 4 inches inside diameter shall be manufactured from hot rolled, low carbon steel conforming to ASTM A711 AISI, Grade 1015. Each ring shall form a true circle with the principle axis of the cross section of the ring metal parallel to the geometric axis of the ring. The thickness of the metal section shall be 0.195 inch plus or minus 0.010 inch and the section shall be beveled from the central portion toward the edges to a thickness of 0.145 inch plus or minus 0.010 inch. It shall be cut through in one place in its circumference to form a tongue and slot. Split ring connectors shall be galvanized in accordance with AASHTO M 232.

Spike-grid timber connectors shall be manufactured according to ASTM A47 for malleable iron castings. They shall consist of four rows of opposing spikes forming a 4½-inch square grid with 16 teeth which are held in place by fillets which are diamond shaped in cross section.

Nails shall be round wire of standard form. Spikes shall be wire spikes or boat spikes, as specified in the Plans. Bolts, dowels, washers, and other hardware, including nails, shall be black or galvanized as specified in the Plans, but if not so specified shall be galvanized when used in treated timber structures.

9-07 Reinforcing Steel**9-07.1 General****9-07.1(1) Acceptance by Manufacturer's Certification**

Reinforcing steel may be accepted by the Engineer based on the Manufacturer's Certificate of Compliance.

9-07.1(1)A Acceptance of Materials

Reinforcing steel rebar manufacturers shall comply with the National Transportation Product Evaluation Program (NTPEP) Work Plan for Reinforcing Steel (rebar) Manufacturers. Reinforcing steel rebar manufacturers shall participate in the NTPEP Audit Program for Reinforcing Steel (rebar) Manufacturers and be listed on the NTPEP audit program website displaying that they are NTPEP compliant.

Steel reinforcing bar manufacturers use either English or a Metric size designation while stamping rebar. The actual size of the bar, whether stamped with an English or a Metric size designation is acceptable. The Contract Plans and the [Standard Plans](#) will continue to use an English size designation. The table below shows the comparable reinforcing steel bar size designations in both units of measure:

English Designation	Bar Diameter	Metric Designation
#3	(0.375 inches)	#10
#4	(0.500 inches)	#13
#5	(0.625 inches)	#16
#6	(0.750 inches)	#19
#7	(0.875 inches)	#22
#8	(1.000 inches)	#25
#9	(1.128 inches)	#29
#10	(1.270 inches)	#32
#11	(1.410 inches)	#36
#14	(1.690 inches)	#43
#18	(2.260 inches)	#57

9-07.1(2) Bending

Steel reinforcing bars shall be cut and bent cold to the shapes shown on the Plans. Fabrication tolerances shall be in accordance with ACI 315. The dimensions shown in the Plans are out-to-out unless shown otherwise. Hooks and bends of steel reinforcing bars shall be bent to the following inside diameters unless shown otherwise in the Plans:

Bar Size	Stirrups and Ties (in)	All Other Bars
No. 3	1½	6 bar diameters
No. 4	2	6 bar diameters
No. 5	2½	6 bar diameters
No. 6	4½	6 bar diameters
No. 7	5¼	6 bar diameters
No. 8	6	6 bar diameters
No. 9 through No. 11		8 bar diameters
No. 14 through No. 18		10 bar diameters

The supplementary requirements of AASHTO M31 for bend tests shall apply to size No. 14 and No. 18 steel reinforcing bars which have hooks or bends.

Hooked ends of steel reinforcing bars shall be standard hooks unless shown otherwise in the Plans. Standard hooks shall consist of a 90-, 135-, or 180-degree bend as shown in the Plans plus a minimum bar extension at the free end of the bar shown in the table below. Seismic hooks shall consist of a 135-degree bend plus a minimum bar extension at the free end of the bar shown in the table below.

Minimum Bar Extensions for Standard and Seismic Hooks					
Bar Size	180° Hook	135° Hook		90° Hook	
	All Bars	Seismic Hook	All Other Bars	Stirrups and Ties	All Other Bars
No. 3	2 ½"	3"	2¼"	2¼"	4½"
No. 4	2 ½"	3"	3"	3"	6"
No. 5	2 ½"	3¾"	3¾"	3¾"	7½"
No. 6	3"	4½"	4½"	9"	9"
No. 7	3½"	5¼"	5¼"	10½"	10½"
No. 8	4"	6"	6"	12"	12"
No. 9	4¾"				13¾"
No. 10	5¼"				15¼"
No. 11	5¼"				17"
No. 14	7"				20½"
No. 18	9¼"				27¼"

9-07.1(3) Lengths

Net length is the length of bar along the bar centerline from end to end. Net lengths of bent bars shown in the "LENGTH" column of the bar list in the Plans are rounded to the nearest inch.

9-07.1(4) Vacant

9-07.2 Deformed Steel Bars

Deformed steel bars for concrete reinforcement shall conform to either AASHTO M 31 Grade 60 or ASTM A706 Grade 60, except as otherwise noted in this section or as shown in the Plans. Steel reinforcing bars for the cast-in-place components of bridge structures, and for precast substructure components of bridge structures, shall conform to ASTM A706 Grade 60 only.

Deformed steel bars are referred to in the Plans and Specifications by number: for example, No. 3, No. 4, No. 5, etc.

9-07.2(1) Headed Steel Reinforcing Bar

Headed steel reinforcing bars shall conform to Section 9-07.2 and ASTM A970, including Annex A1 requirements for Class HA head dimensions. Headed steel reinforcing bars shall be cold-swaged headed bars, forged headed bars or threaded headed bars.

9-07.3 Epoxy-Coated Steel Reinforcing Bars

Epoxy-coated rebar shall be coated according to ASTM A775 with the additional following modifications:

1. The list of steel reinforcing bars acceptable for coating shall include ASTM A706.
2. The Contractor shall furnish a written certification that properly identifies the material, the number of each batch of coating material used, quantity represented, date of manufacture, name and address of manufacturer, and a statement that the supplied coating material meets the requirements of ASTM A775.

3. Prior to coating the bars, the Contractor shall submit to the Engineer for review, the coating material manufacturer's recommendation on the proper use and application requirements of the coating material. For Pre-approved Epoxy Coating Facilities, this information will be available to the Fabrication Inspector upon request.
4. A certification stating that all bars have been coated in accordance with the coating material manufacturer's recommendations and these Specifications shall be furnished with each shipment. This certification shall include for each bar size the preheat temperatures, cure times, thickness checks, holidays detected, and test results. Two copies of these certifications shall be furnished to the Engineer.
5. The Contractor shall give advance notice to the Engineer of the coating schedule in the coating plant so that Contracting Agency inspection may be provided. The Engineer may inspect the coated bars at the coating plant for approval.
6. The patching material, compatible with the coating material and inert in concrete, shall be supplied with each shipment.
7. For projects where epoxy-coated steel reinforcing bars are used in the top mat of bridge decks only, the maximum amount of damage to the coating shall not exceed 0.25 percent of the surface area of each bar.
8. The thickness of epoxy coating shall be 10 mils plus or minus 2 mils.
9. Samples, when required, shall be shipped to the Washington State Department of Transportation, Materials Laboratory, 1655 South 2nd Avenue, Tumwater, WA 98504.

9-07.4 Plain Steel Bars

Where plain steel bars are specified, they shall conform to the chemical and physical properties of AASHTO M 31, Grade 60, unless specifically noted otherwise. Plain steel bars are indicated in the Plans and Specifications by fractions of an inch; for example, $\frac{3}{8}$ inch \emptyset , $\frac{1}{2}$ inch \emptyset , $\frac{5}{8}$ inch \emptyset , etc.

9-07.5 Dowel Bars (for Cement Concrete Pavement)

9-07.5(1) Dowel Bars for Cement Concrete Pavement Rehabilitation

Dowel bars for Cement Concrete Pavement Rehabilitation shall be $1\frac{1}{2}$ inch outside diameter plain round steel bars or tubular bars 18 inches in length and meet the requirements of one of the following: dowel bar types:

1. Epoxy-coated dowel bars shall be round plain steel bars of the dimensions shown in the *Standard Plans*. They shall conform to AASHTO M 31, Grade 60 or ASTM A615, Grade 60 and shall be coated in accordance with ASTM A1078 Type 2 coating, except that the bars may be cut to length after being coated. Cut ends shall be coated in accordance with ASTM A1078 with a patching material that is compatible with the coating, inert in concrete and recommended by the coating manufacturer. The thickness of the epoxy coating shall be 10 mils plus or minus 2 mils. The Contractor shall furnish a written certification that properly identifies the coating material, the number of each batch of coating material used, quantity represented, date of manufacture, name and address of manufacturer, and a statement that the supplied coating material meets the requirements of ASTM A1078 Type 2 coating. Patching material, compatible with the coating material and inert in concrete and recommended by the manufacturer shall be supplied with each shipment for field repairs by the Contractor.
2. ASTM A513 steel tubes made from Grade 60 Carbon Steel Tube with a 1.625 inch outside diameter and a 0.120-inch wall thickness. Both the inside and outside of the tube shall be zinc coated with G40 galvanizing in accordance with ASTM A653. Following zinc coating the tubes shall be coated in accordance with Section 9-07.5(1) item 1. The ends of the tube shall be capped to prevent intrusion of concrete or other materials.

9-07.5(2) Corrosion Resistant Dowel Bars (for Cement Concrete Pavement and Cement Concrete Pavement Rehabilitation)

Corrosion resistant dowel bars shall be 1½ inch outside diameter plain round steel bars or tubular bars 18 inches in length and meet the requirements of one of the following:

1. Stainless Steel-Clad dowel bars shall have a minimum 0.06 inches clad to a plain steel inner bar meeting the chemical and physical properties of AASHTO M31, Grade 60, or AASHTO M255, Grade 60. Stainless Steel Clad shall meet the chemical properties of ASTM A276, Type 316L.
2. Stainless Steel Tube dowel bars shall have a minimum 0.06-inch-thick tube press-fitted onto a plain steel inner bar meeting the chemical and physical properties of AASHTO M 31, Grade 60, or AASHTO M255, Grade 60. A lubricant/adhesive shall be used between the tube and the plain steel bar to fill any voids. Stainless Steel Tube material shall meet the chemical properties of ASTM A276, Type 316L.
3. Stainless Steel Solid dowel bars shall be ASTM A276, Type 316L.
4. Corrosion-resistant, low-carbon, chromium plain steel bars for concrete reinforcement meeting all the requirements of ASTM A1035 Alloy Type CS Grade 100 or Alloy Type CS Grade 120.
5. Zinc Clad dowel bars shall be 1½ inch solid bars meeting the chemical and physical properties of AASHTO M 31, Grade 60 or AASHTO M 255, Grade 60 or ASTM A513 steel tubes made from Grade 60 carbon steel tube with a 1.625 inch outside diameter by 0.120-inch wall thickness. The bars shall have a minimum 0.035 inches A710 Zinc alloy clad to the plain steel inner bar or tube. A710 Zinc shall be composed of zinc: 99.5 percent, by weight, minimum; copper: 0.1 – 0.25 percent, by weight; and iron: 0.0020 percent, by weight, maximum. Each end of tubular bars shall be plugged using a snug-fitting insert to prohibit any intrusion of concrete or other materials.
6. Multicoated fusion bonded epoxy bars shall consist of an ASTM A615 bar with alternating layers of ASTM A934 coating and an abrasion resistant overcoat (ARO). The ASTM A934 coating shall form the base and there shall be two layers of each coating material. The minimum thickness of the combined layers of the ASTM A934 coating and ARO coating shall be 20 mils. The ARO shall meet the following requirements:

Test	Method	Specification
Gouge Resistance	NACE TM0215, 30 kg wt., LS-1 bit @ 25°C	< 0.22 mm
Gouge Resistance	NACE TM0215, 50 kg wt., LS-1 bit @ 25°C	< 0.44 mm

7. ASTM A513 steel tubes made from Grade 60 Carbon Steel Tube with a 1.625 inch outside diameter and a 0.120-inch wall thickness. Both the inside and outside of the tube shall be zinc coated with G90 galvanizing in accordance with ASTM A653. Following zinc coating the tubes shall be coated in accordance with Section 9-07.5(1) item 1. The ends of the tube shall be capped to prevent intrusion of concrete or other materials.

The surface of the finished cut-to-length corrosion-resistant, low-carbon, chromium plain steel bars for concrete reinforcement meeting all the requirements of ASTM A1035 dowels shall be provided with a hot-rolled, as-rolled finish, including mill scale. The surface of all other finished cut-to-length dowels shall be provided with a smooth “ground” or “cold drawn” finish.

Stainless Steel Clad and Stainless Steel Tube Dowel bar ends shall be sealed with a patching material (primer and finish coat) used for patching epoxy-coated reinforcing steel as required in Section 9-07.3, item 6.

9-07.6 Tie Bars (for Cement Concrete Pavement)

Tie bars shall conform to the requirements of the *Standard Specifications* for Deformed Billet Steel Bars for Concrete Reinforcement, AASHTO M 31, Grade 60 and shall be coated in accordance with ASTM A775 or corrosion-resistant, uncoated, low-carbon, chromium deformed steel bars for concrete reinforcement meeting all the requirements of ASTM A1035.

The form of the deformed bar shall be subject to approval by the Engineer.

Tie bars shall be free from dirt, grease, or other defects affecting the strength or bond with the concrete.

9-07.7 Welded Wire Reinforcement

Welded wire for concrete reinforcement shall meet the requirements of ASTM A1064, Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete. Welded wire reinforcement manufacturers shall participate in the NTPEP Audit Program for Reinforcing Steel (rebar) Manufacturers and shall be listed on the NTPEP audit program website displaying that they are NTPEP compliant.

9-07.8 Deformed Wire

Deformed wire shall conform to the requirements of AASHTO M 336, Deformed Steel Wire for Concrete Reinforcement.

Deformed wire is noted in the Plans and Specifications by the letter D, followed by a number indicating the cross sectional area of the wire; for example, D2, D5, D20, etc.

9-07.9 Cold Drawn Wire

Cold drawn wire shall conform to the requirements of AASHTO M336, Cold Drawn Steel Wire for Concrete Reinforcement.

Cold drawn wire is noted in the Plans and Specifications by the letter W followed by a number indicating the cross-sectional area of the wire; for example, W2, W5, W20, etc.

9-07.10 Prestressing Reinforcement Strand

Prestressing reinforcement shall be ½-inch diameter for precast-prestressed concrete piles and ½- or 0.6-inch diameter for pretensioned concrete girders, post-tensioned segmental precast concrete girders, or cast-in-place prestressed concrete.

Prestressing reinforcement shall be mill bright high tensile strength seven wire low relaxation strand conforming to the requirements of AASHTO M 203 (ASTM A416), Grade 270.

Each reel of prestressing reinforcement shall be accompanied by a Manufacturer's Certificate of Compliance, a mill certificate, and a test report. The mill certificate and test report shall include the yield and ultimate strengths, elongation at rupture, modulus of elasticity, and the stress strain curve for the actual prestress reinforcing intended for use. All values certified shall be based on test values and actual sectional areas of the material being certified.

For every five reels furnished, one sample, not less than 5½ feet long, shall be sent to the Engineer for testing. Samples of the furnished reels with Manufacturer's Certificate of Compliance, a mill certificate, and test report may be shipped directly by the manufacturer to the Engineer. An independent inspector, approved by the Contracting Agency, shall be present during sampling and shall provide a written certification to the Engineer.

9-07.11 Prestressing Reinforcement Bar

High-strength steel bars shall conform to AASHTO M 275, Type II.

Nuts shall conform to either ASTM A29 Grade C1045, or ASTM A536 Grade 100-70-03, and shall be capable of developing the larger of either 100 percent of the minimum ultimate tensile strength (MUTS), or 95 percent of the actual ultimate tensile strength (AUTS), of the bar. The anchor nuts shall conform to the specified strength requirement while permitting a maximum 5-degree misalignment between the nut and the bearing plate. A minimum of three tests, each from a different heat, are required.

Couplers, if required, shall be AASHTO M 169 Grade 1144, or equivalent steel, developing the larger of either 100 percent of the MUTS, or 95 percent of the AUTS, of the bar. The test shall be performed with the coupler having a one-inch unengaged segment between the two coupled bars. A minimum of three tests, each from a different heat, are required.

For unbonded bars under dynamic loading, the connections shall withstand at least 500,000 cycles from 60 percent to 66 percent MUTS followed by at least 50 cycles between 40 percent MUTS and 80 percent MUTS. A minimum of three tests, each from a different heat, are required.

The Contractor shall supply a Manufacturer's Certificate of Compliance in accordance with Section 1-06.3 for each bar. The Contractor shall supply a Manufacturer's Certificate of Compliance in accordance with Section 1-06.3 for all nuts and couplers, confirming compliance with the specified strength requirement.

For each heat of steel for high-strength steel bar, the Contractor shall submit two samples, each not less than 5½ feet long, to the Engineer for testing.

9-08 Paints and Related Materials**9-08.1 Paint****9-08.1(1) Description**

Paints used for highway and bridge structure applications shall be made from materials meeting the requirements of the applicable Federal and State Paint Specifications, Department of Defense (DOD), American Society on Testing of Materials (ASTM), and The Society for Protective Coatings specifications in effect at the time of manufacture. The colors, where designated, shall conform to Section 9-08.1(8).

9-08.1(2) Paint Types**9-08.1(2)A Vinyl Pretreatment**

Vinyl pretreatment shall be a two-component basic zinc chromate-vinyl butyral wash primer conforming to DOD-P-15328 (Formula 117 for Metals) and SSPC Paint 27. Zinc chromate shall be the insoluble type. The paint shall be supplied as two components that are mixed together just prior to use.

9-08.1(2)B Galvanizing Repair Paint, High Zinc Dust Content

Galvanizing repair paint shall conform to Federal Specification MIL-P-21035B.

9-08.1(2)C Inorganic Zinc-Rich Primer, Shop Applied

Inorganic zinc-rich primer shall be a two-component, self-curing, inorganic zinc-rich paint, conforming to either AASHTO M300 or SSPC Paint 20 Type I.

9-08.1(2)D Vacant**9-08.1(2)E Epoxy Polyamide**

Epoxy polyamide primer shall be a two-component system conforming to MIL-DTL-24441 or SSPC Coating Standard No. 42.

9-08.1(2)F Primer, Zinc-Rich, Single-Component, Moisture-Cured Polyurethane, Field Applied

Zinc-rich primer shall meet the following requirements:

Vehicle Type:	Moisture-cured polyurethane.
Pigment Content:	80 percent minimum zinc by weight in dry film.
Volume Solids:	60 percent minimum.
Minimum wt./gal.	22.0 pounds.

9-08.1(2)G Intermediate and Stripe Coat, Single Component, Moisture-Cured Polyurethane

Vehicle Type: Moisture-cured polyurethane.

Pigment: A minimum of 3.0 lbs. of micaceous iron oxide per gallon.

Intermediate and any stripe coat shall meet the following requirements:

Minimum volume solids 50 percent.

A minimum of 3.0 lbs/gal. of micaceous iron oxide.

The intermediate coating shall be certified by the manufacturer to be able to be recoated by the top coat in a minimum of 4 days.

9-08.1(2)H Top Coat, Single-Component, Moisture-Cured Polyurethane

Vehicle Type: Moisture-cured aliphatic polyurethane.

Color and Gloss: Meet the SAE AMS Standard 595 Color as specified in the table below.

The Top Coat shall meet the following requirements

The resin shall be an aliphatic urethane.

Minimum-volume solids 50 percent.

The top coat shall be a gloss or semi-gloss.

Color	Semi-Gloss
Washington Gray	26357
Mt. Baker Gray	26134
Mt. St. Helens Gray	26306
Cascade Green	24158

9-08.1(2)I Rust-Penetrating Sealer

Rust-penetrating sealer shall be a two-component, chemically cured, 100 percent solids epoxy.

9-08.1(2)J Black Enamel

The enamel shall conform to Federal Specification MIL PRF 24635E Type II Class 2.

9-08.1(2)K Orange Equipment Enamel

The enamel shall be an alkyd gloss enamel conforming to Federal Specification MIL-PRF-24635E Type II Class 1. The color, when dry, shall match that of SAE AMS Standard 595, color number 12246.

For factory application to individual items of new equipment, samples and testing of the enamel shall not be required; however, the equipment manufacturer shall match the color specified and shall certify the quality of enamel used.

9-08.1(2)L Exterior Acrylic Latex Paint-White

This paint shall conform to Federal Specification MIL-PRF-24635E Type II Class 1, 2 or 3.

This paint may be used self-primed in multiple coats over salts-treated wood and on interior and exterior masonry surfaces.

9-08.1(2)M NEPCOAT Qualified Products List A

Qualified products used shall be part of a NEPCOAT system supplied by the same manufacturer.

9-08.1(2)N NEPCOAT Qualified Products List B

Qualified products used shall be part of a NEPCOAT system supplied by the same manufacturer.

9-08.1(3) Working Properties

The paint shall contain no caked material that cannot be broken up readily by stirring. When applied to a clean vertical surface, the paint shall dry without running, streaking, or sagging.

9-08.1(4) Storage Properties

Paints manufactured under these Specifications shall show no skin over the surface after 48 hours in a partially filled container, when tested as outlined in Federal Test Method Standard No. 141. A slight amount of skin or gel formation where the surface of the paint

meets the side of the container may be disregarded. Variable percentages of anti-skinning agents are shown in those formulas set forth above that are susceptible to undesirable skin formation. The manufacturer will be allowed to vary the amount of anti-skinning agent given in the formulas provided the above results are accomplished and provided the paint does not dry to a nonuniform or nonelastic film.

9-08.1(5) Fineness of Grinding

The paint shall be ground so that all particles of pigment will be dispersed and be coated with vehicle, and the residue on a 325 sieve will not exceed 1 percent by weight of the pigment. Paint shall be homogeneous, free of contaminant, and of a consistency suitable for use under intended application. Finished paint shall be well ground, and the pigment shall be properly dispersed in the vehicle, conforming to the requirements of the paint. Dispersion in the vehicle shall be such that the pigment does not settle excessively, does not cake or thicken in the container, and does not become granular or curdled.

9-08.1(6) Test Methods

Except as otherwise specified, all paints shall be sampled and tested in the ready-mixed form. The test methods shall be as specified in the WSDOT [Materials Manual](#) M 46-01 or the corresponding test method covered by Federal Test Method Standard No. 141 or as specified under AASHTO R 31.

9-08.1(7) Acceptance

For projects with moisture-cured polyurethane quantities less than 20 gallons, acceptance will be by the Manufacturer's Certificate of Compliance.

For projects with moisture-cured polyurethane quantities greater than 20 gallons, the product shall be listed in the current WSDOT Qualified Products List (QPL). If the lot number is listed on the QPL, it may be accepted without additional testing. If the lot number is not listed on the QPL, a 1-quart sample shall be submitted to the State Materials Laboratory for testing and acceptance.

For all other paint types, acceptance will be based on visual inspection.

9-08.1(8) Standard Colors

When paint is required to match a SAE AMS Standard 595 color, the paint manufacturer or the Contractor may obtain a sample of the required color through the following internet link: www.sae.org/standardsdev/colorchips

Unless otherwise specified, all top or finish coats shall be semi-gloss, with the paint falling within the range of 35 to 70 on the 60-degree gloss meter.

9-08.2 Powder Coating Materials for Coating Galvanized Surfaces

The powder coating system shall consist of two components: an epoxy primer coat and a polyester finish coat. The epoxy primer coat and the polyester finish coat materials shall be from the same manufacturer.

The epoxy primer coat shall be an epoxy powder primer conforming to the following requirements:

Property	Specification	Performance Requirement
Adhesion	ASTM D3359 Method B	5B (no failure)
Flexibility	ASTM D522 Method B	Pass 3/8" mandrel bend
Pencil Hardness	ASTM D3363	H Plus
Specific Gravity	ASTM D5965	1.25 minimum

The polyester finish coat shall conform to American Architectural Manufacturers Association (AAMA) Specification 2604.

Degassing additives may be added as necessary to prevent pin holes in the finish coat. The degassing additives shall be added in accordance with manufacturer's recommendations.

The color of the powder coating system polyester finish coat shall be as specified in the Plans or Special Provisions.

Repair materials shall be as recommended by the powder coating manufacturer and as specified in the Contractor's powder coating plan as accepted by the Engineer.

9-08.3 Concrete Surface Treatments

9-08.3(1) Pigmented Sealer Materials

The pigmented sealer shall be a semi-opaque, colored toner containing only methyl methacrylate-ethyl acrylate copolymer resins, toning pigments suspended in solution at all times by a chemical suspension agent, and solvent. Toning pigments shall be laminar silicates, titanium dioxide, and inorganic oxides only. There shall be no settling or color variation. Tinting shall occur at the factory at the time of manufacture and placement in containers, prior to initial shipment. Use of vegetable or marine oils, paraffin materials, stearates, or organic pigments in any part of coating formulation will not be permitted. The color of pigmented sealer shall be as specified by the Contracting Agency. The Contractor shall submit a 1-quart wet sample, a drawdown color sample, and spectrophotometer or colorimeter readings taken in accordance with ASTM D2244, for each batch and corresponding standard color card. The calculated Delta E shall not exceed 1.5 deviation from the Commission Internationale de l'Eclairage (CIELAB) when measured at 10 degrees Standard Observer and Illuminant D 65.

The 1-quart wet sample shall be submitted in the manufacturer's labeled container with product number, batch number, and size of batch. The companion drawdown color sample shall be labeled with the product number, batch number, and size of batch. The Contractor shall submit the specified samples and readings to the Engineer at least 14 calendar days prior to the scheduled application of the sealer. The Contractor shall not begin applying pigmented sealer until receiving the Engineer's written approval of the pigmented sealer color samples.

9-08.3(2) Exposed Aggregate Concrete Coatings and Sealers

9-08.3(2)A Retardant Coating

Retardant coating shall exhibit the following properties:

1. Retards the set of the surface mortar of the concrete without preventing the concrete to reach the specified 28-day compressive strength.
2. Leaves the aggregate with its original color and luster, and firmly embedded in the concrete matrix.
3. Allows the removal of the surface mortar in accordance with the methods specified in Section 6-02.3(14)E without the use of acidic washing compounds.
4. Allows for uniform removal of the surface mortar.

If the Contractor proposes use of a retardant coating that is not listed in the current WSDOT QPL, the Contractor shall submit a Type 2 Working Drawing consisting of a one-quart product sample from a current lot along with supporting product information, Safety Data Sheet, and a Manufacturer's Certificate of Compliance stating that the product conforms to the above performance requirements.

9-08.3(2)B Clear Sealer

The sealer for concrete surfaces with exposed aggregate finish shall be a clear, non-gloss, penetrating sealer of either a silane, siloxane, or silicone based formulation.

9-08.3(3) Permeon Treatment

Permeon treatment shall be a product of known consistent performance in producing the SAE AMS Standard 595 Color No. 30219 target color hue established by WSDOT, either selected from the WSDOT Qualified Products List (QPL), or an equivalent product accepted by the Engineer. For acceptance of products not listed in the current WSDOT QPL, the Contractor shall submit Type 3 Working Drawings consisting of a one-quart product sample from a current lot, supporting product information and a Safety Data Sheet.

9-08.4 Abrasive Blast Materials**9-08.4(1) Abrasive Blast Media**

Material used for field abrasive blasting shall conform to Military Specification MIL-A-22262B(SH) as listed on QPL-22262-28 as maintained by the Department of the Navy. The Contractor shall provide the Engineer with certified test results from the abrasive blast media manufacturer showing that the abrasive blast material meets the Military Specification. The Contractor shall select the type and size of abrasive blast media to produce a roughened, sharp, angular surface profile conforming to the surface requirements specified by the manufacturer of the selected paint system.

9-08.4(2) Lead Abatement Additive

Lead abatement additive shall be a granular chemical abrasive additive consisting of a complex calcium silicate designed to stabilize lead through multiple mechanisms, including, but not limited to, pH adjustment, chemical reactions, and encapsulation. The additive shall be specifically designed and manufactured for lead paint abatement.

9-08.5 Surface Cleaning Materials**9-08.5(1) Bird Guano Treatment**

Bird guano treatment shall consist of a 5.25 percent sodium hypochlorite solution.

9-08.5(2) Fungicide Treatment

Fungicide treatment shall consist of a 5.25 percent sodium hypochlorite solution.

9-08.5(3) Water

Water used for water jetting steel surface cleaning operations shall be clean, fresh water only, without any detergents, bleach, or any other cleaning agents or additives. Recycling of rinse water for water jetting operations is not allowed.

9-08.6 Filter Fabric

Filter fabric for water jetting operations shall be a polypropylene, nonwoven, needle-punched geosynthetic or equivalent material conforming to the following requirements:

Property	Specification	Performance Requirement
Grab Tensile Strength	ASTM D4632	100 pounds minimum
Apparent Opening Size	ASTM D4751	#70 sieve
Permittivity	ASTM D4491	1.0 sec-1 or better

9-08.7 Single-Component Polyurethane Sealant

Single-component polyurethane sealant shall conform to ASTM C920 Grade NS Class 25 or higher.

9-08.8 Foam Backer Rod

Foam backer rod shall be closed cell expanded polyethylene or polyurethane foam.

9-09 Timber and Lumber**9-09.1 General Requirements**

All timber and lumber shall be sized as indicated in the Plans.

All timber and lumber to be painted shall be surfaced on all sides. All timber and lumber to be painted shall be thoroughly air or kiln dried to an equilibrium moisture content and shall be stored in such a manner as to remain in a thoroughly dry condition until placed into the Work.

9-09.2 Grade Requirements

Timber and lumber shall conform to the grades and usage listed below.

Timber and lumber shall be marked with a certified lumber grade stamp provided by one of the following agencies:

West Coast Lumber Inspection Bureau (WCLIB),

Western Wood Products Association (WWPA),

Pacific Lumber Inspection Bureau (PLIB), or

Any lumber grading bureau certified by the American Lumber Standards Committee.

For structures, all material delivered to the project shall bear a grade stamp and have a grading certificate. The grade stamp and grading certificate shall not constitute final acceptance of the material. The Engineer may reject any or all of the timber or lumber that does not comply with the Specifications or has been damaged during shipping or upon delivery. The grading certificate shall be issued by either the grading bureau whose stamp is shown on the material, or by the lumber mill, which shall be under the supervision of one of the grading bureaus listed above. The certificate shall include the following:

Name of the mill performing the grading;

The grading rules being used;

Name of the person doing the grading, with current certification;

Signature of a responsible mill official;

Date the lumber was graded at the mill; and,

Grade, dimensions, and quantity of the timber or lumber

For Guardrail Posts and Blocks, Signposts, Mileposts, Sawed Fence Posts, and Mailbox Posts, the material delivered to the project shall either bear a grade stamp on each piece or have a grading certificate as defined above. The grade stamp or grading certificate shall not constitute final acceptance of the material. The Engineer may reject any or all of the timber or lumber that does not comply with the specifications or has been damaged during shipping or upon delivery.

9-09.2(1) Structures

All timber and lumber for structures shall be Douglas Fir-Larch unless specified otherwise in the contract, and shall conform to the following:

Materials 2" to 4" nominal thick, 5" nominal and wider (Structural Joists and Planks)	No. 1 and better, grade (Section 123-b of WCLIB) or (Section 62.11 of WWPA)
Materials 5" nominal and thicker (Beams and Stringers)	No. 1 and better, grade (Section 130-b of WCLIB) or (Section 70.11 of WWPA)

Timber lagging for soldier pile walls shall be Douglas Fir-Larch, grade No. 2 or better, or Hem-Fir No. 1.

When the material is delivered to the project, the Engineer will check the order for the appropriate grade stamp. The invoice and grading certificate accompanying the order must be accurate and complete with the information listed above. The grading certificate and grade markings shall not constitute final acceptance of the material. The Engineer may reject any or all of the timber or lumber that does not comply with the Specifications or has been damaged during shipping or upon delivery.

9-09.2(2) Guardrail Posts and Blocks.

Timber and lumber for guardrail posts and blocks (classified as Posts and Timbers) shall conform to the species and grades listed below:

Douglas Fir	No. 1 and better, grade (Section 131-b WCLIB) or (Section 80.11 WWPA)
Hem Fir	Select Structural, grade (Section 131-a WCLIB) or (Section 80.10 WWPA)
Southern Yellow Pine	No. 1 and better, grade (Southern Pine Inspection Bureau)

When the material is delivered to the project, the Engineer will check the order for the appropriate grade stamp. The grade markings shall not constitute final acceptance of the material. The Engineer may reject any or all of the timber or lumber that does not comply with the Specifications or has been damaged during shipping or upon delivery.

Posts shall be inspected by an American Lumber Standards Committee (ALSC) accredited agency, and bear a quality mark that certifies preservative penetration and retention levels that meet the required AWP standard U1–Use Category in Section 9-09.3(1).

9-09.2(3) Signposts, Mileposts, Sawed Fence Posts, and Mailbox Posts

The allowable species of timber and lumber for signposts and mileposts shall be Douglas Fir-Larch or Hem Fir. Timber and lumber for sawed fence posts and mailbox posts shall be Western Red Cedar, Douglas Fir-Larch, or Hem Fir.

Signposts, mileposts, sawed fence posts, and mailbox posts shall conform to the grades shown below:

4" × 4"	Construction grade (Light Framing, Section 122-b WCLIB) or (Section 40.11 WWPA)
4" × 6"	No. 1 and better, grade (Structural Joists and Planks, Section 123-b WCLIB) or (Section 62.11 WWPA)
6" × 6", 6" × 8", 8" × 10"	No. 1 and better, grade (Posts and Timbers, Section 131-b WCLIB) or (Section 80.11 WWPA)
6" × 10", 6" × 12"	No. 1 and better, grade (Beams and Stringers, Section 130-b WCLIB) or (Section 70.11 WWPA)

9-09.3 Preservative Treatment

9-09.3(1) General Requirements

All timber and lumber requiring preservative treatment shall be treated in accordance with AASHTO M133. As specified by AASHTO M133, the American Wood Protection Association (AWPA) standards shall govern the Specifications. These Specifications include: storing and curing the timber and lumber, the wood preservatives, the preservative treatment process, documenting the results of the treatment, inspection, testing, and the identification of properly treated timber.

For guardrail posts, the AWPA Standard U1–Use Category referred to in AASHTO M133 Section 6.1 is hereby superseded as follows: guardrail posts shall be treated according to AWPA Standard U1–Use Category UC4B, except that those installed in Eastern Washington (East of the Cascade Mountain Crest) may be treated according to Use Category UC4A.

Unless otherwise specified in the Contract, all timber and lumber shall be treated in accordance with Sections U1 and T1 of the latest edition of the AWPA standards.

All cutting, boring, chamfering, routing, surfacing, and trimming shall be done prior to treating. Any field drilling or cutoffs shall be treated by two liberal applications of a compatible preservative. The applications shall be in accordance with the requirements of AWPA Standard M-4 entitled, "Standard for the Care of Pressured Treated Wood Products".

All charges shall consist of pieces of the same species that are similar in form, size, moisture content, and receptivity to treatment. The pieces in the charge shall be separated to ensure contact of treating medium with all surfaces. The method of determining the retention of the preservatives shall be by assay.

All orders of treated timber and lumber shall be accompanied by a Certificate of Treatment showing conformance to this specification and AWPA standards record. The Certificate of Treatment shall include the following information:

- Name and location of the wood preserving company,
- Customer identification,
- Date of treatment and charge number,
- Type of chemical used and amount of retention,
- Treating process and identification of the Specification used,
- Boring records verifying treatment penetration for timber and lumber with a nominal dimension of 6" by 6" or larger,
- Description of material that was treated, and
- Signature of a responsible plant official.

All timber and lumber to be used in aquatic environments, unless specified otherwise in the Contract, shall be chemically treated using Western Wood Preservers Institute Best Management Practices (BMPs). The producer of the chemically treated products shall supply a written certification that the BMPs were utilized, including a description and appropriate documentation of the BMPs used. This information may be included on the Certificate of Treatment record.

9-10 Piling**9-10.1 Timber Piling**

Timber piling shall be untreated or treated with the preservatives specified in the Plans and completely described in Section 9-09.3.

Timber piles shall have the following limiting diameters:

Length in Feet	Min. Butt Dia. 3 feet Above Butt in inches	Max. Butt Dia. 3 feet Above Butt in inches	Min. Tip Dia. in inches
Under 40	12	20	7
40 to 54	12	20	7
55 to 74	13	20	7
Over 74	14	20	7

Timber piles shall be strapped with at least three straps: one approximately 18 inches from the butt, one approximately 24 inches from the butt, and one approximately 12 inches from the tip. Additional straps shall be provided at approximately 15-foot centers between the butt and tip. Strapping shall encircle the pile once and be tensioned as tightly as possible. Straps shall be 1¼ inches wide, 0.31 inch thick, cold rolled, fully heat treated, high tensile strapping, painted, and waxed, with an ultimate tensile strength of 5,100 pounds. The seal shall be 2¼ inches long, 20 gage, crimped with a notch type sealer to furnish a joint yielding 80 percent of the strap tensile strength. Treated timber piles shall be strapped after treatment.

9-10.1(1) Untreated Piling

Except where specifically provided otherwise, untreated timber piling shall be Douglas Fir, Western Red Cedar, or Larch. Piling for foundations shall be Douglas Fir. Piling shall be cut from sound, live trees and shall contain no unsound knots. Sound knots will be permitted, provided the diameter of the knot does not exceed 4 inches, or ½ of the small diameter of the pile at the point where they occur, whichever is smaller. Any defect or combination of defects which will impair the strength of the pile more than the maximum allowable knot will not be permitted.

Piling shall be cut above the butt swell and shall have a uniform taper from butt to tip. A line drawn from the center of the tip to the center of the butt shall not fall outside the center of the pile at any point more than 1 percent of the length of the pile. A spiral grain or twist in excess of ¼ turn in 10 feet of length will be cause for rejection.

Untreated timber trestle piling shall have an average of at least five annual rings per inch measured radially over a distance of 3 inches at the butt, beginning at a point 3½ inches from the heart. At least 9 inches of heartwood shall show at the butt.

Ring count requirements for untreated timber foundation piling and detour trestle piling will be waived.

9-10.1(2) Creosote Treated Piling

For creosote treated piling, Douglas Fir timber shall be used. All other requirements shall be the same as for untreated piling, except that the ring count requirement will be waived.

9-10.1(3) Timber Composite Piling

Timber composite piling shall consist of a pile made up of two timber sections. The lower section shall be untreated, and the upper section shall be creosote treated.

The treated and untreated sections of timber composite pile shall meet the respective requirements specified above for full length of treated and untreated timber piling.

9-10.1(4) Peeling

Untreated and creosote treated piles shall be peeled by removing all of the rough bark and at least 80 percent of the inner bark. No strip of inner bark remaining on the pile shall be over $\frac{3}{4}$ inch wide or over 8 inches long, and there shall be at least 1 inch of clean wood surface between any two such strips. Not less than 80 percent of the surface on any circumference shall be clean wood. All knots shall be trimmed close to the body of the pile.

9-10.2 Concrete Piling**9-10.2(1) Concrete**

The concrete for prestressed piles shall have a minimum compressive strength of 6,000 psi at the age of 28 days. The minimum compressive strength of concrete at the transfer of prestress shall be 3,300 psi.

The concrete for other precast piles shall be Class 4000. Mixing, transporting, and placing concrete shall be in accordance with the provisions of Section 6-02.3.

The Contractor shall mold and test a sufficient number of concrete test cylinders to determine the strength of the concrete as required by the Specifications. Under the surveillance of the Engineer, the test cylinders shall be molded, cured, and tested in accordance with the procedures established by the State Materials Laboratory.

In the event that a sufficient number of concrete test cylinders are not molded to satisfy all testing required on any one pile, cores measuring 4 inches in diameter by 5 inches in height shall be taken and tested by the Contractor. If the strength of the core meets the required compressive strength of the concrete, the pile may be accepted. The coring and testing of the core shall be done under the surveillance of the Engineer.

9-10.2(2) Reinforcement

Reinforcement shall meet the requirements of Section 9-07.

9-10.3 Cast-In-Place Concrete Piling

Reinforcement for cast-in-place concrete piles shall conform to Section 9-07.2.

9-10.4 Steel Pile Tips and Shoes

Steel pile tips and shoes shall be fabricated of cast steel conforming to ASTM A148 Grade 90-60 [620-415] or ASTM A27 Grade 65-35 [450-240] and be free from any obvious defects. Pile tips shall be accompanied by a mill test report stating the chemical and physical properties (tensile and yield) of the steel.

9-10.5 Steel Piling

The material for rolled steel piling H-piling and pile splices shall conform to ASTM A36, ASTM A572 or ASTM A992. The material for steel pipe piling and splices shall conform to one of the following requirements except as specifically noted in the plans:

1. API 5L Grade X42 or X52 material may be used for longitudinal seam welded or helical (spiral) seam submerged-arc welded pipe piles of any diameter.
2. ASTM A252, Grade 2 or 3 material may be used for longitudinal seam welded or helical (spiral) seam submerged-arc welded pipe piles of any diameter. For the purposes of welding and prequalification of base metal, steel pipe pile designated as ASTM A252 may be treated as prequalified provided the chemical composition conforms to a prequalified base metal classification listed in Table 3.1 of the AWS D1.1/D1.1M, latest edition, Structural Welding Code, the grade of pipe piling meets or exceeds the grade specified in the Plans, and the carbon equivalent (CE) is a maximum of 0.45-percent.
3. ASTM A709 or ASTM A588 material may be used for longitudinal seam welded piles of any diameter.

The base metal, coil or plate, used for fabrication of all steel pipe piling shall meet the ASTM A709 non-fracture critical tension component impact test (CVN) requirements for Zone 2.

For helical (spiral) seam submerged-arc welded pipe piles, the maximum radial offset of strip/plate edges shall be $\frac{1}{8}$ inch. The offset shall be transitioned with a taper weld and the slope shall not be less than a 1 in 2.5 taper. The weld reinforcement shall not be greater than $\frac{3}{16}$ inches and misalignment of weld beads shall not exceed $\frac{1}{8}$ inch.

Steel soldier piles, and associated steel bars and plates, shall conform to ASTM A36, ASTM A572 or ASTM A992, except as otherwise noted in the Plans.

9-11 Waterproof Membrane**9-11.1 Asphalt for Waterproofing**

Waterproof membrane shall be a sheet membrane conforming to ASTM D 6153 Type III, the puncture capacity specified below, and either the thin polymer sheet tensile stress or the geotextile and fabric grab tensile strength specified below:

Performance Properties	Test Method	Specification Requirements
Tensile Stress (for Thin Polymer Sheets)	ASTM D 882	75 pounds per inch min.
Grab Tensile Strength (for Geotextiles and Fabrics)	ASTM D 4632 (Woven or Nonwoven)	200 pounds min.
Puncture Capacity (For Thin Polymer Sheets, Geotextiles and Fabrics)	ASTM E 154	200 pounds min.

Waterproofing membrane will be accepted based on a Manufacturer's Certificate of Compliance with each lot of waterproof membrane.

9-11.2 Primer for Waterproof Membrane

The primer for the waterproof membrane shall be appropriate for bonding the sheet membrane to the bridge deck surface and shall be compatible with the membrane in accordance with the waterproof membrane manufacturer's recommendations.

9-12 Masonry Units**9-12.1 Concrete Blocks**

Concrete blocks for building construction shall conform to the requirements of ASTM C90.

9-12.2 Concrete Brick

Concrete brick shall conform to the requirements of ASTM C55.

9-13 Riprap, Quarry Spalls, Slope Protection, and Rock for Erosion and Scour Protection and Rock Walls

9-13.1 Riprap and Quarry Spalls

9-13.1(1) General

Riprap and quarry spalls shall consist of broken stone or broken concrete rubble and shall be free of rock fines, soil, or other extraneous material. Concrete rubble shall not be contaminated by foreign materials such as fibers, wood, steel, asphalt, sealant, soil, plastic and other contaminants or deleterious material. Concrete rubble that is imported to the job site will require testing and certification for toxicity characteristics in accordance with Section 9-03.21(1).

The grading of the riprap shall be determined by the Engineer by visual inspection of the load before it is dumped into place, or, if so ordered by the Engineer, by dumping individual loads on a flat surface and sorting and measuring the individual rocks contained in the load. Should the riprap contain insufficient spalls, as defined in Section 9-13.1(5), the Contractor shall furnish and place supplementary spall material.

Riprap and quarry spalls shall be free from segregation, seams, cracks, and other defects tending to destroy its resistance to weather and shall meet the following test requirements:

Aggregate Property	Test method	Requirement
Degradation Factor	WSDOT Test Method T 113	15 minimum
Los Angeles Wear, 500 Rev.	AASHTO T 96	50% maximum
Specific Gravity, SSD	AASHTO T 85	2.55 minimum

9-13.1(2) Heavy Loose Riprap

Heavy loose riprap shall meet the following requirements for grading:

	Minimum Size	Maximum Size
30% to 90%	1 ton (½ cu. yd.)	N/A
60% to 90%	300 lbs. (2 cu. ft.)	1 ton (½ cu. yd.)
10% to 30%	3 inch	50 lbs. (spalls)

9-13.1(3) Light Loose Riprap

Light loose riprap shall meet the following requirements for grading:

	Size Range	Maximum Size
20% to 90%	300 lbs. to 1 ton (2 cu. ft. to ½ cu. yd.)	N/A
15% to 80%	50 lbs. to 1 ton (½ cu. ft. to ½ cu. yd.)	300 lbs. to 1 ton (2 cu. ft. to ½ cu. yd.)
10% to 20%	3 inch	50 lbs. (spalls)

9-13.1(4) Hand Placed Riprap

Hand placed riprap shall be as nearly rectangular as possible, 60 percent shall have a volume of not less than 1 cubic foot. No stone shall be used that is less than 6 inches thick, nor which does not extend through the wall.

9-13.1(5) Quarry Spalls

Quarry spalls shall meet the following requirements for grading:

Sieve Size	Percent Passing
8"	100
3"	40 max.
3/4"	10 max.

9-13.2 Vacant

9-13.3 Vacant

9-13.4 Rock for Erosion and Scour Protection

Rock for Erosion and Scour Protection shall be hard, sound, and durable material, free from seams, cracks, and other defects that tend to destroy its resistance to weather, and it shall consist of broken and/or processed rock. Rock for Erosion and Scour Protection shall meet the quality requirements in Section 9-13 and the grading requirements in Section 9-13.4(2). The use of recycled materials and concrete rubble is not permitted for this application.

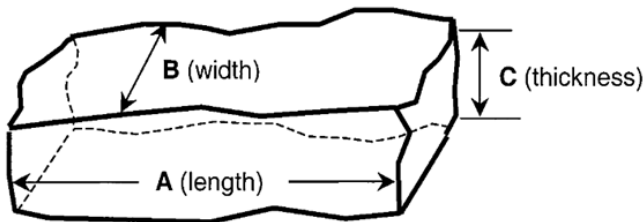
Rock for erosion and scour protection shall meet the grading requirements in Section 9-13.4(2) and the following test requirements for quality:

Aggregate Property	Test Method	Requirement
Bulk Specific Gravity	AASHTO T 85	2.55 minimum
Los Angeles Wear, 500 Rev.	AASHTO T 96	50% maximum
Degradation Factor	WSDOT Test Method T 113	15 minimum
Absorption	AASHTO T 85	3% maximum

Field tests can be performed at the quarry or on the job site by testers that are certified/qualified in the above specified test procedures, or representative samples can be obtained for laboratory testing, by an AASHTO accredited lab, to ensure that the physical and mechanical properties meet the requirements. The AASHTO lab accreditation shall state the lab is accredited for the above specified test procedures.

9-13.4(1) Suitable Shape of Rock for Erosion and Scour Protection

The Suitable Shape of these rocks shall be "Angular" (having sharply defined edges) to "Subangular" (having a shape in between Rounded and Angular) for a higher degree of interlocking to provide stability to the protected area. The use of round, thin, flat, or long and needle-like shapes is not allowed.



Suitable Shape can be determined by the ratio of the Length/Thickness, where the Length is the longest axis, Width is the second longest axis, and Thickness is the shortest. The Suitable Shape shall be the maximum of 3.0 using the following calculation:

$$\frac{A(\text{Length})}{C(\text{Thickness})} \leq 3.0$$

9-13.4(2) Grading Requirements of Rock for Erosion and Scour Protection

Rock for Erosion and Scour Protection will be classified as Class A, Class B, and Class C, and it shall have a "Well-Graded" structure that meets the requirements for Suitable Shape and conforms to one or more of the following gradings as shown in the Plans.

Class A	
Approximate Size (in.) ¹	Percent Passing (Smaller)
18	100
16	80-95
12	50-80
8	15-50
4	15 max.

Class C	
Approximate Size (in.) ¹	Percent Passing (Smaller)
42	100
36	80-95
28	50-80
22	15-50
14	15 max.

Class B	
Approximate Size (in.) ¹	Percent Passing (Smaller)
30	100
28	80-95
22	50-80
16	15-50
10	15 max.

Class D	
Approximate Size (in.) ¹	Percent Passing (Smaller)
54	100
48	80-95
40	50-80
30	15-50
20	15 max.

¹Approximate Size can be determined by taking the average dimension of the three axes of the rock, Length, Width, and Thickness, by use of the following calculation:

$$\frac{\text{Length} + \text{Width} + \text{Thickness}}{3} = \text{Approximate Size}$$

9-13.4(3) Material Acceptance

Rock for Erosion and Scour Protection shall be visually accepted by the Engineer. The Engineer shall determine the Suitable Shape, Approximate Size, and Grading of the load before it is placed. If so ordered by the Engineer, the loads shall be dumped on a flat surface for sorting and measuring the individual rocks contained in the load. The Engineer reserves the right to reject rock at the quarry, at the job site or stockpile, and in-place in the structures throughout the duration of the Contract. Rock rejected at the job site shall be removed from the project site. Rock rejected at the quarry shall be prevented from mixing with satisfactory rock.

9-13.5 Concrete Slope Protection

Concrete slope protection shall consist of reinforced portland cement or blended hydraulic cement concrete poured or pneumatically placed upon the slope with a rustication joint pattern or semi-open concrete masonry units placed upon the slope closely adjoining each other.

9-13.5(1) Semi-Open Concrete Masonry Units Slope Protection

Precast cement concrete blocks shall conform to the requirements of ASTM C1319.

9-13.5(2) Poured Portland Cement or Blended Hydraulic Cement Concrete Slope Protection

Cement concrete for poured concrete slope protection shall be commercial concrete in conformance with Section 6-02.3(2)B.

9-13.5(3) Pneumatically Placed Portland Cement or Blended Hydraulic Cement Concrete Slope Protection

Cement – This material shall be portland cement or blended hydraulic cement as specified in Section 9-01.

Aggregate – This material shall meet the requirements for fine aggregate as specified in Section 9-03.1. The moisture content of the fine aggregate at the time of use shall be between 3 and 6 percent by weight.

Reinforcement – Wire mesh reinforcement shall conform to the provisions of Section 9-07.7.

Water – Water shall conform to the provisions of Section 9-25.1.

9-13.6 Vacant**9-13.7 Rock for Rock Wall****9-13.7(1) Rock for Rock Walls and Chinking Material**

Rock for rock walls and chinking material shall be hard, sound and durable material, free from seams, cracks, and other defects tending to destroy its resistance to weather, and shall meet the following test requirements:

Test	Test Method	Requirements
Specific Gravity, SSD	AASHTO T 85	2.55 min.
LA Wear	AASHTO T 96	50% max.
Degradation	WSDOT T 113	15 min.
Absorption	AASHTO T 85	3% max.

Rock for rock wall sizes are approximately as follows:

Rock Size	Rock Weight (lbs)	Average Dimension (in.)
Type One	50 to 200	12 to 18
Type Two	200 to 700	18 to 28
Type Three	700 to 2,000	28 to 36
Type Four	2,000 to 4,000	36 to 48
Type Five	4,000 to 6,000	48 to 54
Type Six	6,000 to 8,000	54 to 60

Chinking material shall be a minimum of 4 inches average dimension.

9-13.7(2) Backfill for Rock Wall

Backfill for rock walls shall be shot rock ranging in size from a minimum of 2 inches to a maximum of 6 inches.

Acceptance shall be based on visual inspection by the Engineer.

9-14 Erosion Control and Roadside Planting

9-14.1 Materials Submittals and Acceptance

Standard Specification Section	Material	For each material used the Contractor shall submit a materials certificate of compliance in accordance with Section 1-06.2 along with the following information to the Engineer
9-14.2(1)	Topsoil Type A	Compliance with the applicable section.
9-14.2(2)	Topsoil Type B	
9-14.2(3)	Topsoil Type C	
9-14.3	Seed	
9-14.4	Fertilizer	
9-14.5	Mulch and Amendments	
9-14.5(1)	Straw	
9-14.5(2)	Hydraulically Applied Erosion Control Products	
9-14.5(2)A	Long-Term Mulch in Section	Test results reported on WSDOT Form 220-042 documenting that the mulch meets the requirements in Section 9-14.5(2) Table 1 and Section 9-14.5(2)A, Table 2 of this section.
9-14.5(2)B	Moderate-Term Mulch	Test results reported on WSDOT Form 220-043 documenting that the mulch meets the requirements in Section 9-14.5(2) Table 1 and the applicable requirements of these sections.
9-14.5(2)C	Short-Term Mulch	
9-14.5(3)	Bark and Wood Chip Mulch	Compliance with the applicable section.
9-14.5(4)	Wood Strand Mulch	A satisfactory test report, performed in accordance with WSDOT T 125 and compliance with this section.
9-14.5(6)	Agriculture Grade Gypsum	Compliance with the applicable section.
9-14.5(7)	Tackifier	Test results that show the tackifier meets requirements of Section 9-14.5(2) Table 1 and compliance with this section.

Standard Specification Section	Material	For each material used the Contractor shall submit a materials certificate of compliance in accordance with Section 1-06.2 along with the following information to the Engineer
9-14.5(8)	Compost	<p>Cert & following information is required to be submitted 14 days prior to application.</p> <p>a) A copy of the Solid Waste Handling Permit issued to the manufacturer by the Jurisdictional Health Department in accordance with https://apps.leg.wa.gov/WAC/default.aspx?cite=173-350 (Minimum Functional Standards for Solid Waste Handling).</p> <p>b) Compost Test Data submitted on WSDOT Form 220-038 that show the compost complies with the processes, testing, and standards specified in WAC 173-350 and this section. An independent Seal of Testing Assurance (STA) Program certified laboratory shall perform the testing within 90 calendar days of application.</p> <p>c) A copy of the manufacturer's annual Seal of Testing Assurance STA certification as issued by the U.S. Composting Council.</p> <p>d) A sample of the compost approved for use.</p> <p>e) A list of feed stocks by volume for each compost type.</p> <p>f) Compliance with the applicable section.</p>
9-14.5(9)	Horticultural Grade Perlite	Test results reported on WSDOT Form 220-037 documenting that the horticultural grade perlite meets the requirements of this section.
9-14.6(2)	Biodegradable Erosion Control Blanket	Independent laboratory test results reported on WSDOT Form 220-039 documenting that the biodegradable erosion control blanket meets the requirements of Section 9-14.6(2)A, 9-14.6(2)B or 9-14.6(2)C.
9-14.6(5)	Wattles	Compliance with the applicable section.
9-14.6(6)	Compost Socks	
9-14.7	Plant Materials	If cuttings are taken from private property the contractor shall submit a copy of the written permission to the Engineer prior to cuttings being collected.

9-14.2 Topsoil

Topsoil shall not contain recycled materials, foreign materials, or Noxious and Nuisance weeds of any Class designated by authorized State or County officials. Aggregate shall not comprise more than 10 percent by volume of Topsoil and shall not be greater than two inches in diameter.

9-14.2(1) Topsoil Type A

Topsoil Type A shall be as specified in the Special Provisions.

9-14.2(2) Topsoil Type B

Topsoil Type B shall be native topsoil taken from within the project limits either from the area where roadway excavation is to be performed or from strippings from borrow, pit, or quarry sites, or from other designated sources. In the production of Topsoil Type B, all vegetative matter, less than 4 feet in height, shall become a part of the topsoil.

9-14.2(3) Topsoil Type C

Topsoil Type C shall be native topsoil meeting the requirements of Topsoil Type B but obtained from a source provided by the Contractor outside of the Contracting Agency owned right of way.

9-14.3 Seed

Within 30 calendar days of Execution of Contract, the Contractor shall provide written evidence to the Engineer that seed mix has been contracted or procured.

The Contractor shall furnish the following documentation to the Engineer:

1. The state or provincial seed dealer license and endorsements. All seed vendors must have a business license issued by supplier's state or provincial Department of Licensing with a "seed dealer" endorsement.
2. Copies of Washington State Department of Agriculture (WSDA) test results on each lot of seed. Test results shall be within six months prior to the date of application.
3. Certification of Compliance letter stating the seed species meets the contract requirements. The Certificate of Compliance letter is required with each blend of seed mix for the project. The Certificate of Compliance letter shall show the formula as found in the Special Provisions, include the information specified in Standard Specification, be certified in accordance with WAC 16-302 and accompanied by seed tags/labels for each species within the specified mix.

Native seed shall be identified under the Association of Official Seed Certifying Agents (AOSCA) certification. When Source Identified seed is specified, seed tags/label shall be identified by providing the AOSCA seed label. Source Identified seed shall be generation four or less and be designated by G0, G1, G2, G3, or G4. Non-Source seed shall meet or exceed Washington State Department of Agriculture (WSDA) Certified Seed Standards and be from within the appropriate genetic zones of the Ecoregion(s) as defined by the US Environmental Protection Agency (EPA).

Seed mixes shall be commercially prepared and supplied in sealed containers. The labels shall show:

1. Common and botanical names of seed,
2. Lot number,
3. Net weight,
4. Pounds of Pure live seed (PLS) in the mix,
5. Origin of seed.

9-14.4 Fertilizer

Fertilizer shall be a standard commercial grade of organic or inorganic fertilizer of the kind and quality specified. It may be separate or in a mixture containing the percentage of total nitrogen, available phosphoric acid, and water-soluble potash or sulfur in the amounts specified. All fertilizers shall be furnished in standard unopened containers with weight, name of plant nutrients, and manufacturer's guaranteed statement of analysis clearly marked, all in accordance with State and Federal laws.

Fertilizer shall be supplied in one of the following forms:

1. A dry free-flowing granular fertilizer, suitable for application by agricultural fertilizer spreader.
2. A soluble form that will permit complete suspension of insoluble particles in water, suitable for application by power sprayer.
3. A homogeneous pellet, suitable for application through a ferti-blast gun.
4. A tablet or other form of controlled release with a minimum of a 6 month release period.
5. A liquid suitable for application by a power sprayer or hydroseeder.

9-14.5 Mulch and Amendments

All amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's guaranteed chemical analysis and name. In lieu of containers, amendments may be furnished in bulk. A Manufacturer's Certificate of Compliance shall accompany each delivery. Compost and other organic amendments shall be accompanied with all applicable health certificates and permits.

9-14.5(1) Straw

Straw shall be in an air-dried condition, free of noxious weeds, seeds, and other materials detrimental to plant life. Hay is not acceptable.

All straw material shall be Certified Weed-Free Straw using North American Weed Management Association (NAWMA) standards or the Washington Wilderness Hay and Mulch (WWHAM) program run by the Washington State Noxious Weed Control Board. Information can be found at www.nwcb.wa.gov.

In lieu of Certified Weed-Free Straw, the Contractor shall submit documentation that the material is steam or heat treated to kill seeds, or shall submit U.S., Washington State, or other states' Department of Agriculture laboratory test reports, dated within 90 days prior to the date of application, showing that there are no viable seeds in the straw.

9-14.5(2) Hydraulically Applied Erosion Control Products (HECPs)

All HECPs shall be made of natural plant fibers unaltered by synthetic materials, and in a dry condition, free of noxious weeds, seeds, chemical printing ink, germination inhibitors, herbicide residue, chlorine bleach, rock, metal, plastic, and other materials detrimental to plant life.

The HECP shall be suitable for spreading with a hydroseeder.

All HECPs shall be furnished premixed by the manufacturer with Organic or Synthetic Tackifier as specified in Section 9-14.5(7). The product shall be hydrated in accordance with the manufacturer's recommendations.

The Contractor shall submit test results, dated within 3 years prior to the date of application, from an independent, accredited laboratory, as approved by the Engineer, showing that the product meets the following requirements:

Table 1 HECR Requirements
 These test requirements apply to the fully mixed product, including tackifiers, dyes, or other additives that may be included in the HECR final product in its sprayable form.

Properties	Test Method	Requirements
Acute Toxicity	EPA-821-R-02-012 Methods for Measuring Acute Toxicity of Effluents. Test leachate from recommended application rate receiving 2 inches of rainfall per hour using static test for No-Observed-Adverse-Effect-Concentration (NOEC).	Four replicates are required with no statistically significant reduction in survival in 100 percent leachate for a Daphnid at 48 hours and Oncorhynchus mykiss (rainbow trout) at 96 hours.
Solvents	EPA 8260 (SW846)	Benzene – < 0.03 mg/kg Methylene chloride – < 0.02 mg/kg Naphthalene – < 5 mg/kg Tetrachloroethylene – < 0.05 mg/kg Toluene – < 7 mg/kg Trichloroethylene – < 0.03 mg/kg Xylenes – < 9 mg/kg
Heavy Metals	EPA 6010 or 6020 (SW856)	Antimony – < 4 mg/kg Arsenic – < 6 mg/kg Barium – < 80 mg/kg Boron – < 160 mg/kg Cadmium – < 2 mg/kg Total Chromium – < 4 mg/kg Copper – < 10 mg/kg Lead – < 5 mg/kg Nickel – < 2 mg/kg Selenium – < 10 mg/kg Strontium – < 40 mg/kg Zinc – < 30 mg/kg
Heavy Metals	EPA 6010 or 6020 (SW856) or EPA 7470 or 7471 (SW856)	Mercury – < 2 mg/kg

If the HECP contains cotton or straw, the Contractor shall submit documentation that the material has been steam or heat treated to kill seeds, or shall submit U.S., Washington State, or other states' Department of Agriculture laboratory test reports, dated within 90 days prior to the date of application, showing that there are no viable seeds in the mulch.

The HECP shall be manufactured in such a manner that, when agitated in slurry tanks with water, the fibers will become uniformly suspended, without clumping, to form a homogeneous slurry. When hydraulically applied, the material shall form a strong moisture-holding mat that allows the continuous absorption and infiltration of water.

If the HECP contains a dye to facilitate placement and inspection of the material, it shall be nontoxic to plants, animals, and aquatic life and shall not stain concrete or painted surfaces.

The HECP shall not be harmful to plants, animals, and aquatic life.

9-14.5(2)A Long-Term Mulch

Long-Term Mulch shall adhere to the soil, create a blanket-like mass and bond with the soil surface to create a continuous, porous, absorbent, and flexible erosion-resistant blanket that allows for seed germination and plant growth. Long-Term Mulch shall meet the requirements in Table 2, Long-Term Mulch Test Requirements. Products containing cellulose fiber produced from paper or paper components will not be approved or accepted. With the exception of seed and water, field mixing of additives or components is not acceptable.

Table 2 Long-Term Mulch Test Requirements

The Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP) on 5-year intervals generated on or after November 1, 2015 showing that the product meets the Cover-Factor (C Factor) in accordance with ASTM D6459.		
Properties	Test Method	Requirements
Performance in Protecting Slopes from Rainfall-Induced Erosion	ASTM D6459. Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle.	C Factor = 0.01 maximum using Revised Universal Soil Loss Equation (RUSLE)
The Contractor shall submit test results from an independent, accredited laboratory, on 5-year intervals generated on or after July 15 of 2017 showing that the product meets the following requirements.		
Properties	Test Method	Requirements
Water Holding Capacity	ASTM D7367	800 percent minimum
Organic Matter Content	AASHTO T 267	90 percent minimum
Seed Germination Enhancement	ASTM D7322	Long Term 420 percent minimum

9-14.5(2)B Moderate-Term Mulch

Within 48 hours of application, the Moderate-Term Mulch shall bond with the soil surface to create a continuous, absorbent, flexible, erosion-resistant blanket. Moderate-Term Mulch shall effectively perform the intended erosion control function in accordance with Section 8-01.3(1) for a minimum of 3 months, or until temporary vegetation has been established, whichever comes first.

9-14.5(2)C Short-Term Mulch

Short-Term Mulch shall effectively perform the intended erosion control function in accordance with Section 8-01.3(1) for a minimum of 2 months, or until temporary vegetation has been established, whichever comes first. Short-Term Mulch shall not be used in conjunction with permanent seeding.

9-14.5(3) Bark or Wood Chip Mulch

Bark or wood chip mulch shall be derived from fir, pine, or hemlock species. It shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant, aquatic, or animal life. Sawdust shall not be used as mulch. Mulch produced from finished wood products or construction debris will not be allowed.

Bark or wood chips shall be tested within 90 days of delivery to the project site and in accordance with WSDOT [T 123](#) and shall meet the following loose volume gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
2"	95	100
No. 4	0	30

9-14.5(4) Wood Strand Mulch

Wood strand mulch shall be a blend of angular, loose, long, thin wood pieces that are frayed, with a high length-to-width ratio, and it shall be derived from native conifer or deciduous trees. A minimum of 95 percent of the wood strand shall have lengths between 2 and 10 inches. At least 50 percent of the length of each strand shall have a width and thickness between $\frac{1}{16}$ and $\frac{1}{2}$ inch. No single strand shall have a width or thickness greater than $\frac{1}{2}$ inch.

The mulch shall not contain salt, preservatives, glue, resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust or wood chips or shavings will not be acceptable.

This product shall not be harmful to plants, animals, and aquatic life.

9-14.5(5) Agricultural Grade Dolomite Lime

Agricultural grade dolomite lime shall be in a pelletized or granular form, meeting the grading requirements of ASTM C602 for Class E.

9-14.5(6) Agricultural Grade Gypsum

Agricultural grade gypsum shall consist of Calcium Sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) in a pelletized or granular form and shall meet the following grading requirements;

Sieve Size	Percent Passing
$\frac{1}{4}$ "	99 - 100
No. 20	20 max

All percentages are by weight.

9-14.5(7) Tackifier

Tackifiers are used as a tie-down for soil, compost, seed, and/or mulch. Tackifiers shall contain no growth or germination-inhibiting materials and shall not reduce infiltration rates. Tackifiers shall hydrate in water and readily blend with other slurry materials. Tackifiers shall include a mulch tracer added to visible aid uniform application, and shall not be harmful to plants, animals, or aquatic life.

9-14.5(7)A Organic Tackifier

Organic tackifiers shall be derived from natural plant sources and shall not be harmful to plants, animals, and aquatic life.

9-14.5(7)B Synthetic Tackifier

Synthetic tackifiers shall not be harmful to plants, animals, and aquatic life.

9-14.5(8) Compost

Compost products shall be the result of the biological degradation and transformation of organic materials under controlled conditions designed to promote aerobic decomposition. Compost shall be stable with regard to oxygen consumption and carbon dioxide generation. Compost shall be mature with regard to its suitability for serving as a soil amendment or an erosion control BMP as defined below. The compost shall have a moisture content that has no visible free water or dust produced when handling the material.

Compost production and quality shall comply with [WAC 173-350](#).

Compost products shall meet the following physical criteria:

1. Compost material shall be tested in accordance with U.S. Composting Council Testing Methods for the Examination of Compost and Composting (TMECC) 02.02-B, "Sample Sieving for Aggregate Size Classification".

Fine compost shall meet the following gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
1"	100	
5/8"	90	100
1/4"	75	100

Note: Maximum particle length of 4 inches. Fine compost shall have a carbon to nitrogen ratio (C:N) less than 25:1. The carbon to nitrogen ratio shall be calculated using the dry weight of "Organic Carbon" using TMECC 04.01A divided by the dry weight of "Total N" using TMECC 04.02D.

Medium compost shall meet the following gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
1"	100	
5/8"	85	100
1/4"	70	85

Note: Maximum particle length of 4 inches. Medium compost shall have a carbon to nitrogen ratio (C:N) between 18:1 and 35:1. The carbon to nitrogen ratio shall be calculated using the dry weight of "Organic Carbon" using TMECC 04.01A divided by the dry weight of "Total N" using TMECC 04.02D.

Coarse compost shall meet the following gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
2"	100	
1"	90	100
¾"	70	100
¼"	40	60

Note: Maximum particle length of 6 inches. Coarse compost shall have a carbon to nitrogen ratio (C:N) between 25:1 and 35:1. The carbon to nitrogen ratio shall be calculated using the dry weight of "Organic Carbon" using TMECC 04.01A divided by the dry weight of "Total N" using TMECC 04.02D.

- The pH shall be between 6.0 and 8.5 when tested in accordance with U.S. Composting Council TMECC 04.11-A, "1:5 Slurry pH".
- Physical contaminants, defined in [WAC 173-350](#) (e.g. plastic, concrete, ceramics, metal) shall be less than 0.5 percent by weight as determined by U.S. Composting Council TMECC 03.08-A "Classification of Inerts by Sieve Size".
- Minimum organic matter shall be 40 percent by dry weight basis as determined by U.S. Composting Council TMECC 05.07A "Loss-On-Ignition Organic Matter Method (LOI)".
- Soluble salt contents shall be less than 4.0 mmhos/cm when tested in accordance with U.S. Composting Council TMECC 04.10 "Electrical Conductivity".
- Maturity shall be greater than 80 percent in accordance with U.S. Composting Council TMECC 05.05-A, "Germination and Root Elongation".
- Stability shall be 7-mg CO₂-C/g OM/day or below in accordance with U.S. Composting Council TMECC 05.08-B "Carbon Dioxide Evolution Rate".
- The compost product shall originate from organic feedstocks as defined in [WAC 173-350](#) as "Wood waste", "Yard debris", "Post-consumer food waste", "Preconsumer animal-based wastes", and/or "Preconsumer vegetative waste". The Contractor shall provide a list of feedstock sources by percentage in the final compost product.
- The Engineer may also evaluate compost for maturity using U.S. Composting Council TMECC 05.08-E "Solvita® Maturity Index". Fine compost shall score a number 6 or above on the Solvita® Compost Maturity Test. Medium and Coarse compost shall score a 5 or above on the Solvita® Compost Maturity Test.

9-14.5(9) Horticultural Grade Perlite

Horticultural grade perlite shall be in a pelletized or granular form.

Horticultural grade perlite shall meet the following requirements for quality and grading:

Quality Requirements		
Property	Test Method ¹	Requirement
pH (of water slurry)	PI 202	6.5 – 8.0
Bulk Density, lb/ft ³	PI 200	2 – 10

¹PI, abbreviation for the Perlite Institute

Gradation Requirements	
Sieve Size	Percent Passing
No. 4	99 - 100
No. 18	30 max
No. 30	10 max

All percentages are by weight.

9-14.6 Erosion Control Devices

9-14.6(1) Polyacrylamide (PAM)

PAM is used as a tie-down for soil, compost, or seed, and is also used as a flocculent. PAM products shall meet ANSI/NSF Standard 60 for drinking water treatment with an AMD content not to exceed 0.05 percent. PAM shall be anionic and shall be linear, and not cross-linked. The minimum average molecular weight shall be greater than 5-mg/mole. The charge density shall be no less than 15 percent and no greater than 30 percent. The product shall contain at least 80 percent active ingredients and have a moisture content not exceeding 10 percent by weight. PAM shall be delivered in a dry granular or powder form.

9-14.6(2) Biodegradable Erosion Control Blanket

Biodegradable erosion control blankets, including netting if present, shall be made of natural plant fibers unaltered by synthetic materials. All blanket material shall be kept in place until permanent vegetation has been established, or for a minimum of 6 months, whichever comes first.

9-14.6(2)A Biodegradable Erosion Control Blanket for Slopes Steeper than 3:1 (H:V)

Table 6

Properties	ASTM Test Method	Requirements for Slopes Steeper than 3:1
Protecting Slopes from Rainfall-Induced Erosion	ASTM D6459 Soil tested shall be sandy loam as defined by the NRCS** Soil Texture Triangle	C factor = 0.04 maximum for cumulative R-Factor < 231
Mass Per Unit Area	ASTM D6475	7.6 oz./sq. yd. minimum
Light Penetration	ASTM D6567	44% maximum
Tensile Strength MD × XD*	ASTM D6818	10.0 × 6.0 pounds/inch minimum
Tensile Elongation MD × XD*	ASTM D6818	38% × 33% maximum

*MD is Machine Design and XD is Cross Direction

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9-14.6(2)B Biodegradable Erosion Control Blanket for Slopes Flatter than 3:1 (H:V)

Table 7

Properties	ASTM Test Method	Slope Flatter than 3:1 Requirements
Protecting Slopes from Rainfall-Induced Erosion	ASTM D6459 Soil tested shall be sandy loam as defined by the NRCS** Soil Texture Triangle	C factor = 0.15 maximum for cumulative R-Factor < 231
Mass Per Unit Area	ASTM D6475	7.6 oz./sq. yd. minimum
Light Penetration	ASTM D6567	40% maximum
Tensile Strength MD × XD*	ASTM D6818	6.5 × 2.3 pounds/inch minimum
Tensile Elongation MD × XD*	ASTM D6818	38% × 33% maximum

*MD is Machine Design and XD is Cross Direction

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9-14.6(2)C Biodegradable Erosion Control Blanket for Ditches

Table 8

Properties	Test Method	Requirements
Performance in Protecting Earthen Channels from Stormwater-Induced Erosion	ASTM D6460 Soil tested shall be sandy loam as defined by the NRCS** Soil Texture Triangle	Limiting Shear (T_{Limit}) = 2.0 psf minimum. Limiting Velocity (V_{Limit}) = 7.5 ft/sec flow minimum.
Mass per Unit Area	ASTM D6475	7.4 oz./ sq. yd. minimum
Light Penetration	ASTM D6567	65% maximum
Tensile Strength MD × XD*	ASTM D6818	9.6 × 3.2 lbs/inch minimum
Tensile Elongation MD × XD*	ASTM D6818	38% × 33% maximum

*MD is Machine Design and XD is Cross Direction

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9-14.6(3) Plastic Covering

Plastic covering shall meet the requirements of ASTM D4397 for polyethylene sheeting.

9-14.6(4) Check Dams

All materials used for check dams shall be non-toxic and not pose a threat to wildlife when installed.

9-14.6(4)A Biodegradable Check Dams

Biodegradable check dams shall meet the following requirements:

Compost Sock	Section 9-14.6(6)
Coir Log	Section 9-14.6(7)

The Contractor may substitute a different biodegradable check dam as long as it complies with the following and is accepted by the Engineer:

1. Made of natural plant fiber unaltered by synthetic material.
2. Netting if present shall be made of natural plant fibers unaltered by synthetic materials. Materials shall effectively perform the intended erosion control function until permanent vegetation has been established or for a minimum of 6 months, whichever comes first.
3. Straw bales shall not be used as check dams.
4. Wattles shall not be used as check dams.

9-14.6(4)B Non-biodegradable Check Dams

Non-biodegradable check dams shall meet the following requirements:

1. Geotextile materials shall conform to Section 9-33 for silt fence.
2. Other such devices that meet the requirements of Section 9-14.6(4) and shall be approved by the Engineer prior to installation.

9-14.6(5) Wattles

Wattles shall consist of cylinders of plant material such as weed-free straw, coir, wood chips, excelsior, or wood fiber or shavings encased within netting made of natural plant fibers unaltered by synthetic materials. Wattles shall be a minimum of 8 inches in diameter. Netting material shall be clean, evenly woven, and free of encrusted concrete or other contaminating materials such as preservatives. Netting material shall be free from cuts, tears, or weak places and shall effectively perform the intended erosion control function until permanent vegetation has been established or for a minimum of 6 months, whichever comes first.

If wood chip filler is used, it shall meet the material requirements as specified in Section 9-14.5(3). If straw filler is used, it shall meet the material requirements as specified in Section 9-14.5(1). If wood shavings are used, 80 percent of the fibers shall have a minimum length of 6 inches between 0.030 and 0.50 inches wide and between 0.017 and 0.13 inches thick.

Stakes for wattles shall be made of wood from untreated Douglas fir, hemlock, or pine species.

9-14.6(6) Compost Socks

Compost socks shall consist of fabric made of natural plant fibers unaltered by synthetic materials. The compost sock shall be filled with Medium Compost as specified in Section 9-14.5(8). Compost socks shall be at least 8 inches in diameter. The sock shall be clean, evenly woven; free of encrusted concrete or other contaminating materials; free from cuts, tears, broken or missing yarns; free of thin, open, or weak areas; and free of any type of preservative. Sock fabric shall effectively perform the intended erosion control function until permanent vegetation has been established or for a minimum of 6 months, whichever comes first.

Stakes for compost socks shall be made of wood from untreated Douglas fir, hemlock, cedar, or pine species.

9-14.6(7) Coir Log

Coir logs shall be made of 100 percent durable coconut (coir) fiber uniformly compacted within woven netting made of bristle coir twine with a minimum tensile strength of 80 lbs. The netting shall have nominal 2 by 2-inch openings. Log segments shall have a maximum length of 20 feet, with a minimum diameter as shown in the Plans. Logs shall have a minimum density of 7 lbs/cf.

Stakes shall be untreated Douglas fir, hemlock, cedar, or pine species. Wood stakes shall have a notch to secure the rope ties. Rope ties shall be made of ¼-inch diameter commercially available hemp rope.

9-14.6(8) High Visibility Fencing

High visibility fence shall be UV stabilized, orange, high-density polyethylene or polypropylene mesh.

Support posts shall be wood or steel in accordance with [Standard Plan I-10.10](#). The posts shall have sufficient strength and durability to support the fence through the life of the project.

9-14.6(9) High Visibility Silt Fence

High visibility silt fence shall be a minimum of 5 feet in height, high visibility orange, UV stabilized and shall meet the geotextile requirements in Section 9-33 Table 6. Support posts shall be in accordance with the [Standard Plans](#). The posts shall have sufficient strength and durability to support the fence through the life of the project.

9-14.7 Plant Materials**9-14.7(1) Description**

Bareroot plants are grown in the ground and harvested without soil or growing medium around their roots.

Container plants are grown in pots or flats that prevent root growth beyond the sides and bottom of the container.

Balled and burlapped plants are grown in the ground and harvested with soil around a core of undisturbed roots. This rootball is wrapped in burlap and tied or placed in a wire basket or other supportive structure.

Cuttings are live plant material without a previously developed root system. Source plants for cuttings shall be dormant when cuttings are taken and all cuts shall be made with a sharp instrument. Cuttings may be collected. If cuttings are collected, the requirement to be nursery grown or held in nursery conditions does not apply. Written permission shall be obtained from property owners and provided to the Engineer before cuttings are collected. The Contractor shall collect cuttings in accordance with applicable sensitive area ordinances. Cuttings shall meet the following requirements:

1. Live branch cuttings shall have flexible top growth with terminal buds and may have side branches. Live branch cuttings shall be cut from one- to two-year-old wood. The rooting end shall be cut at an approximate 45-degree angle. Live branch cuttings shall be ¾ inch to 1½ inch in diameter.
2. Live stake cuttings shall have a straight top cut immediately above a bud. The lower, rooting end shall be cut at an approximate 45-degree angle. Live stakes shall be cut from one to two year old wood. Live stake cuttings shall be cut and installed with the bark intact with no branches or stems attached, and be ¾ inch to 1½ inch in diameter.
3. Live pole cuttings shall have a diameter between 2 inches and 3.5 inches. Live poles shall have no more than three branches that must be located at the top end of the pole and those branches shall be pruned back to the first bud from the main stem.

Rhizomes shall be a prostrate or subterranean stem, usually rooting at the nodes and becoming erect at the apex. Rhizomes shall have a minimum of two growth points. Tubers shall be a thickened and short subterranean branch having numerous buds or eyes.

9-14.7(2) Quality

At the time of delivery, all plant material furnished shall meet the grades established by the latest edition of the American Standard for Nursery Stock, (ASNS) ANSI Z60.1 and shall conform to the size and acceptable conditions as listed in the Contract, and shall be free of all foreign plant material.

All plant material shall comply with State and Federal laws with respect to inspection for plant diseases and insect infestation. Plants must meet Washington State Department of Agriculture plant quarantines and have a certificate of inspection. Plants originating in Canada must be accompanied by a phytosanitary certificate stating the plants meet USDA health requirements.

All plant material shall be purchased from a nursery licensed to sell plants in their state or province.

Live woody or herbaceous plant material, except cuttings, rhizomes, and tubers, shall be vigorous, well formed, with well developed fibrous root systems, free from dead branches, and from damage caused by an absence or an excess of heat or moisture, insects, disease, mechanical or other causes detrimental to good plant development. Evergreen plants shall be well foliated and of good color. Deciduous trees that have solitary leaders shall have only the lateral branches thinned by pruning. All conifer trees shall have only one leader (growing apex) and one terminal bud, and shall not be sheared or shaped. Trees having a damaged or missing leader, multiple leaders, or Y-crotches shall be rejected.

Root balls of plant materials shall be solidly held together by a fibrous root system and shall be composed only of the soil in which the plant has been actually growing. Balled and burlapped rootballs shall be securely wrapped with jute burlap or other packing material not injurious to the plant life. Root balls shall be free of weed or foreign plant growth.

Plant materials shall be nursery grown stock. Plant material, with the exception of cuttings, gathered from native stands shall be held under nursery conditions for a minimum of one full growing season, shall be free of all foreign plant material, and meet all of the requirements of these Specifications, the Plans, and the Special Provisions.

Container grown plants shall be plants transplanted into a container and grown in that container sufficiently long for new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container, without having roots that circle the pot. Plant material which is root bound, as determined by the Engineer, shall be rejected. Container plants shall be free of weed or foreign plant growth.

Container sizes for plant material of a larger grade than provided for in the container grown Specifications of the ASNS shall be determined by the volume of the root ball specified in the ASNS for the same size plant material.

All bare root plant materials shall have a heavy fibrous root system and be dormant at the time of planting.

Average height to spread proportions and branching shall be in accordance with the applicable sections, illustrations, and accompanying notes of the ASNS.

Plants specified or identified as "Street Tree Grade" shall be trees with straight trunks, full and symmetrical branching, central leader, and be developed, grown, and propagated with a full branching crown. A "Street Tree Grade" designation requires the highest grade of nursery shade or ornamental tree production which shall be supplied.

Street trees with improperly pruned, broken, or damaged branches, trunk, or root structure shall be rejected. In all cases, whether supplied balled and burlapped or in a container, the root crown (top of root structure) of the tree shall be at the top of the finish soil level. Trees supplied and delivered in a nursery fabric bag will not be accepted.

Plants that have been determined by the Engineer to have suffered damage for the following reasons will be rejected:

1. Girdling of the roots, stem, or a major branch.
2. Deformities of the stem or major branches.
3. Lack of symmetry.
4. Dead or defoliated tops or branches.
5. Defects, injury, and condition that render the plant unsuitable for its intended use.

Plants that are grafted shall have roots of the same genus as the specified plant.

9-14.7(3) Handling and Shipping

Handling and shipping shall be done in a manner that is not detrimental to the plants.

The nursery shall furnish a notice of shipment in triplicate at the time of shipment of each truck load or other lot of plant material. The original copy shall be delivered to the Engineer, the duplicate to the consignee and the triplicate shall accompany the shipment to be furnished to the Inspector at the job site. The notice shall contain the following information:

1. Name of shipper.
2. Date of shipment.
3. Name of commodity (including all names as specified in the Contract).
4. Consignee and delivery point.
5. State Contract number.
6. Point from which shipped.
7. Quantity contained.
8. Size (height, runner length, caliper, etc., as required).
9. Signature of shipper by authorized representative.

To acclimate plant materials to Northwest conditions, all plant materials used on a project shall be grown continuously outdoors north of the 42nd Latitude (Oregon-California border) from not later than August 1 of the year prior to the time of planting.

All container grown plants shall be handled by the container.

All balled and burlapped plants shall be handled by the ball.

Plant material shall be packed for shipment in accordance with prevailing practice for the type of plant being shipped, and shall be protected at all times against drying, sun, wind, heat, freezing, and similar detrimental conditions both during shipment and during related handling. Where necessary, plant material shall be temporarily heeled in. When transported in closed vehicles, plants shall receive adequate ventilation to prevent sweating. When transported in open vehicles, plants shall be protected by tarpaulins or other suitable cover material.

9-14.7(4) Sod

The sod shall be field grown one calendar year or older, have a well developed root structure, and be free of all weeds, disease, and insect damage.

Prior to cutting, the sod shall be green, in an active and vigorous state of growth, and mowed to a height not exceeding 1 inch.

The sod shall be cut with a minimum of 1 inch of soil adhering.

9-14.8 Stakes, Guys, and Wrapping

The minimum size of wire used for guying shall be 12-gauge, soft drawn.

Hose for guying shall be nylon, rubber, or reinforced plastic and shall have an inside diameter of at least 1 inch.

Tree wrap shall be a crinkled waterproof paper weighing not less than 4 pounds per 100 square feet and shall be made up of two sheets cemented together with asphalt.

9-15 Irrigation System

All materials and equipment incorporated in the system shall be new, undamaged, of standard quality, and shall be subject to testing as specified. When the water supply for the irrigation system is from a nonpotable source, irrigation components shall have lavender indicators supplied by the equipment manufacturer.

9-15.1 Pipe and Fittings

Pipe shall be copper, galvanized iron, PVC, or polyethylene, as specified in the Plans or in the Special Provisions.

9-15.1(1) Galvanized Pipe and Fittings

Pipe shall be standard weight, hot-dip galvanized iron or steel pipe, threaded and coupled. Pipe shall meet the requirements of ASTM A53.

All pipe fittings shall be standard threaded galvanized malleable iron fittings.

9-15.1(2) Polyvinyl Chloride Pipe and Fittings

PVC pipe and fittings shall be of PVC compound Type 1, Grade 1, conforming to ASTM D1785 Specifications. The pipe and fittings shall be approved and certified by the National Sanitation Foundation. The Engineer may require dimensional and quick burst tests of pipe and fittings after arrival at the job site. Acceptance of the materials shall be subject to passing the designated tests per ASTM Standards.

PVC solvent weld pipe shall be of PVC 1120 material and shall have 200 psi minimum pressure rating with SDR 21 walls which conform to ASTM D2241. PVC pipe with walls heavier than SDR 21 shall be installed when noted in the Plans and specified in the Special Provisions. PVC threaded pipe shall be of PVC 1120 material and shall be schedule 80 which conforms to ASTM D1785.

PVC pipe fittings shall conform to ASTM D2466, Type I, Grades 1 or 2. Pipe may be belled on one end with the dimensions of the tapered bell conforming to ASTM D2672.

Each length of PVC pipe is to be marked with an identifying extrusion "run" number and the manufacturer's name or trade name plus the pipe size and schedule.

Acceptance of the materials shall be subject to approval by conforming to the designated tests in accordance with ASTM Standards following the table below.

Type	Minimum Requirements
PVC pipe – Schedule 40, 80 and 120	ASTM D1785; Compounds following ASTM D1784, PVC 12454 or 143333
PVC pipe – SDR 21 (Class 200)	ASTM D2241; Compounds following ASTM D1784, PVC 12454, 14333
PVC Fittings – Schedule 40	ASTM D2466; Compounds following ASTM D1784, PVC 12454, 13354, 11443 or 14333
PVC Fittings – Schedule 80	ASTM D2467, ASTM D2464; Compounds following PVC 12454, 11443, 14333

9-15.1(3) Polyethylene Pipe

Polyethylene pipe shall be SDR 15, medium density polyethylene, meet the following requirements of ASTM D2239, PE1404, PE2708, PE3608, PE4608, or PE4710, and be National Sanitation Foundation (NSF) certified.

Thick walled polyethylene (poly) pipe shall be used in conjunction with fittings recommended by the manufacturer of the poly pipe to produce a flexible swing joint assembly between the lateral line and the irrigation sprinkler. The pipe shall be manufactured from high quality, low density virgin polyethylene material and have a

minimum wall thickness of 0.10 inch and a minimum inside diameter of 0.49 inch. The pipe shall be capable of withstanding 80 psi operating water pressure at 110°F. The length of thick walled poly pipe at each flexible swing joint assembly shall be 18 inches minimum to 36 inches maximum.

9-15.2 Drip Tubing

Drip tubing shall be manufactured from specially formulated, chemical resistant, low to medium density virgin polyethylene or polybutylene selected for excellent weatherability and stress cracking resistance and designed specifically for use in drip irrigation systems. Drip tubing shall have a minimum wall thickness of 0.045 inch.

9-15.3 Automatic Controllers

Automatic controllers shall be an electronic timing device for automatically opening and closing control valves for predetermined periods of time. The automatic controller shall be enclosed in a weatherproof painted metal housing fabricated from 16 gauge sheet aluminum alloy 6061-T6 or 16-gauge sheet steel or unpainted, nonrusting industrial grade stainless steel or as specified in the Plans. The pedestal shall have a completely removable locking faceplate to allow easy access to wiring.

The automatic controller housing shall have a locking device. All locks or locking devices shall be master keyed. The controller shall be compatible with and capable of operating the irrigation system as designed and constructed and shall include the following operating features:

1. Each controller station shall be adjustable for any desired period of time, from less than 1 minute to at least 99 minutes.
2. The controller shall be able to adjust so that any number of days may be omitted and whereby any one or more positions on the controller can be skipped. When adjustments are made, they shall continue automatically within a 14-day cycle until the Engineer desires to make new adjustments.
3. Controls shall allow any position to be operated manually, both on or off, whenever desired, without disrupting the operating cycle.
4. Controls shall provide for resetting the start of the irrigation cycle at any time and advancing from one position to another.
5. Controllers shall contain a power on-off switch and fuse assembly.
6. Controllers shall be 24-volt AC with battery back-up for memory retention of the operating cycle.
7. Each controller shall have rain sensor compatibility.

9-15.4 Irrigation Heads

Irrigation heads shall be of the type, pattern, and coverage shown in the Plans at rated operating pressure specified.

Sprinkler heads shall be designed so that spray adjustments can be made by either an adjustment screw or interchangeable nozzles. Watering cores shall be easily removed without removing the housing from the pipe.

All instructions, special wrenches, clamps, tools, and equipment supplied by the manufacturer necessary for the installation and maintenance of the irrigation heads shall be turned over to the Engineer upon completion and acceptance of the project.

9-15.5 Valve Boxes

Valve box sizes and types shall conform to the Plans and be extendable to obtain the depth required. All manual drain valves and manual control valves shall be installed in valve box with a vandal-resistant lid as shown in the Plans.

9-15.6 Gate Valves

Gate Valves shall be of the same size as the pipes on which they are placed and shall have union or flange connections. Service rating (for nonshock cold water) shall be 150 psi. Gate Valves shall be of the double disk, taper seat type, with rising stem, union bonnet and hand wheel or suitable cross wheel for standard key operation. Manufacturer's name, type of valve, and size shall be imprinted or printed on the valve.

9-15.7 Control Valves

9-15.7(1) Manual Control Valves

Manual control valves shall be of the same size as the pipes connecting into them unless specified otherwise in the Plans. Service rating shall be not less than 150 psi nonshock cold water. When bronze is specified, the body shall follow ASTM B62. Brass body, ball and stem shall follow ASTM B16 or ASTM B124 (377). All plastic manual valves shall be pressure rated minimum of 125 psi and ASTM D1784. Socket dimensions shall follow ASTM D2467. Threaded dimensions shall follow ASTM D2464.

Manual control valves shall be designed for underground installation with suitable cross wheel for operation with a standard key and installed in a valve box. Manual control valves shall have removable bonnet and stem assemblies with adjustable packing glands and shall house long acme threaded stems to ensure full opening and closing.

9-15.7(2) Automatic Control Valves

Automatic remote control valves shall be globe pattern and glass filled nylon with flanged or screwed connections as required. The automatic control valve shall be constructed so as to allow all internal parts to be removable from the top of the valve without disturbing the valve installation.

Automatic control valves shall be of a normally-closed design and shall be operated by an electronic solenoid having a maximum rating of 6.5 watts utilizing 24-volt AC power with 50/60 Hz. Electronic solenoids shall have a stainless steel plunger and be directly attached to the valve bonnets or body with all control parts fully encapsulated. Automatic control valves shall be 20-200 psi. The opening and closing speed of the valve shall be a minimum of five seconds for closure and a minimum of three seconds for opening with a constant rate of opening and closing. A manual control bleed cock shall be included on the valve to operate the valve without the requirement of electrical current. A manual shutoff stem with cross handle for wrench operation is required for manual adjustment from fully closed to wide open. Once the manual adjustment is set, the valve shall operate automatically in the adjusted position. Water flow shall be completely stopped when the control valve is closed either manually or automatically. Automatic control valves and automatic controllers need not be from the same manufacturer.

9-15.7(3) Automatic Control Valves with Pressure Regulator

Automatic control valves with pressure regulators shall be similar to the automatic control valves described in Section 9-15.7(2) and shall reduce the inlet pressure to a constant pressure regardless of supply fluctuations. The regulator shall be fully adjustable.

9-15.8 Quick Coupling Valves

Quick coupler valves shall have an operating range between 5 to 125 psi. The body of the valves shall be of cast Copper Alloy No. C84400 Leaded Semi-Red Brass conforming to ASTM B584. The base of the valve shall have standard female pipe threads. The design of the valve shall be such that it will open only upon inserting a coupler key and will close as the coupler key is removed from the valve. Leakage of water between the coupler and valve body when in operation shall not be accepted. The valve body receiving the coupler key shall be designed with double worm slots to allow smooth action in opening and closing of the valve with a minimum of effort. Slots shall be notched at the base to hold

the coupler key firmly in the open position. Couplers shall be of the same material as the valve body with stainless steel double guide lugs to fit the worm slots. Couplers shall be of one-piece construction with steel reinforced side handles attached. All couplers shall have standard male pipe threads at the top. Couplers shall be furnished with all quick coupler valves unless otherwise specified.

9-15.9 Drain Valves

Drain valves shall be a ½- or ¾-inch PVC or metal gate valve manufactured for irrigation systems. Drain valves shall be designed for underground installation with suitable cross wheel for operation with a standard key, shall have a service rating of not less than 150 psi nonshock cold water, and shall be installed in a valve box.

Drain valves on potable water systems shall only be allowed on the downstream side of approved cross-connection control devices.

9-15.10 Hose Bibs

Hose bibs shall be angle type, constructed of bronze or brass, threaded to accommodate a ¾-inch hose connection, and shall be key operated. Design shall be such as to prevent operation by wrench or pliers.

9-15.11 Cross Connection Control Devices

Atmospheric vacuum breaker assemblies (AVBAs), pressure vacuum breaker assemblies (PVBAs), double check valve assemblies (DCVAs), and reduced pressure backflow devices (RPBDs) shall be of a manufacturer and product model approved for use by the Washington State Department of Health, Olympia, Washington, or a Department of Health-certified agency.

9-15.12 Check Valves

Adjustable spring check valves shall be PVC and shall be pressure rated at 200 psi. Valves shall be adjustable from 5 to 15 pounds spring tension but shall not cause pressure loss in excess of 5 psi for flows up to 30 gpm. Valves shall have angled seats, Buna-N seals, and threaded connections, and shall be installed in 8 inch round plastic valve boxes with vandal-resistant lids.

9-15.13 Pressure Regulating Valves

Pressure regulating valves shall have a minimum of 150 psi working pressure with an adjustable outlet range of 20 to 70 psi. The valves shall be factory set as shown in the Plans. Pressure regulating valves shall be rated for safe operation at 175 psi nonshock cold water.

9-15.14 Three-Way Valves

Three-way valves shall be tight closing, three port, ball or plug type, constructed to permit straight through and 90-degree flow only. The valve shall be of bronze or approved corrosion resistant body materials and shall have a minimum of 150 psi working pressure. The head of the valve, or handle when applicable, shall be permanently marked to indicate port position.

9-15.15 Flow Control Valves

Valve body materials shall be plastic or metal. Internal parts shall be stainless steel. Valves shall be factory set to the flows as shown in the Plans. Valves shall have no external adjustment and be tamper-proof when installed. Control valves ¼ inch or smaller shall have a minimum pressure absorption range of 2 to 32 psi. Larger flow control valves ½ inch or larger shall have a minimum pressure absorption range of 3 to 50 psi.

Flow shall be controlled to 5 percent of Plan volumes.

9-15.16 Air Relief Valve

The air relief valve shall automatically relieve air and break a vacuum in the serviced pipe. Body materials shall be installed exactly at all high points.

9-15.17 Electrical Wire and Splices

Electrical wire used between the automatic controller and automatic control valves shall be solid or stranded copper, minimum size AWG 14. Insulation shall be Type USE Chemically Cross Linked Polyethylene or Type UF, and shall be listed by a Nationally Recognized Testing Laboratory. Each conductor shall be color coded and marked at each end and at all splices with zone or station number identification.

Low voltage splices shall be made with a direct bury splice kit using a twist-on wire connector and inserted in a waterproof polypropylene tube filled with a silicone electrical insulating gel or heat-shrinkable insulation tubing. Heat-shrinkable insulation tubing shall consist of a mastic-lined heavy-wall polyolefin cable sleeve.

9-15.18 Detectable Marking Tape

Detectable marking tape shall consist of inert polyethylene plastic that is impervious to all known alkalis, acids, chemical reagents, and solvents likely to be encountered within the soil, with a metallic foil core to provide for the most positive detection and pipeline location.

The tape shall be color coded and shall be imprinted continuously over its entire length in permanent black ink indicating the type of line buried below and shall also have the word "Caution" prominently shown. Color coding of the tape shall be as follows:

Utility	Tape Color
Water	Blue
Sewer	Green
Electrical	Red
Gas/Oil	Yellow
Telephone/CATV	Orange
Non-Potable Water	Purple

The width of the tape shall be as recommended by the manufacture based on depth of installation.

9-15.19 Wye Strainers

Wye strainers shall be bronze or brass with screwed end connections, 20 mesh Monel or stainless steel screen, and standard tapped bronze retainer cap and closure plug. Service rating shall be not less than 150 psi nonshock cold water.

9-16 Fence, Guardrail and Glare Screen**9-16.1 Chain Link Fence and Gates****9-16.1(1) General**

All material used in the construction of chain link fence and gates shall be new. Iron or steel material shall be galvanized unless specified otherwise. Material upon which serious abrasions of galvanizing occur shall not be acceptable.

9-16.1(1)A Post Material for Chain Link Fence

Except as noted otherwise, post material shall conform to the requirements of AASHTO M 181, Type I (zinc-coated steel), Grade 1 or 2, and shall include all round and roll-formed material (line posts, brace posts, end posts, corner posts, and pull posts).

Round Post Material

Round post material shall be Grade 1 or 2.

Roll Form Material

Roll-formed post material shall be Grade 1.

Roll-formed end, corner, and pull posts shall have integral fastening loops to connect to the fabric for the full length of each post.

Grade 1 post material shall conform to the weight per linear foot, minimum wall thickness and detail requirements of ASTM F1043. Grade 1 post material that exceeds the maximum wall thickness requirement of ASTM F1043 may be accepted, provided it does not interfere with the proper construction of the fence.

Grade 2 post material shall meet the organic exterior coatings requirements of AASHTO M 181 (Section 33) and the additional requirement that the interior coated surface shall be capable of resisting 300 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in accordance with ASTM B117.

9-16.1(1)B Chain Link Fence Fabric

Chain link fabric shall consist of 11-gauge wire for chain link fence Types 3, 4, and 6, and 9-gauge wire for chain link fence Type 1. The fabric shall be zinc-coated steel wire conforming to AASHTO M 181, Class C. Zinc 5 percent Aluminum-Mischmetal alloy meeting the requirements of ASTM B750 may be substituted for zinc coating (hot-dipped) at the application rate specified by AASHTO M 181 for hot-dip zinc coating. Coating for chain link fence fabric shall meet the requirements of ASTM A817 with minimum weight of coating of uncoated wire surface 1.0 oz/sq ft (305 g/m²). The wire shall be woven into approximately 2-inch diamond mesh. The width and top and bottom finish of the fabric shall be as specified in AASHTO M 181.

9-16.1(1)C Tension Wire

Tension wire shall meet the requirements of AASHTO M 181. Tension wire galvanizing shall be Class 1.

9-16.1(1)D Fittings and Hardware

Except where indicated, fittings shall be malleable cast iron or pressed steel and shall conform to the requirements of ASTM F626 or AASHTO M 232, whichever is applicable.

Tension truss rods shall be $\frac{3}{8}$ -inch round galvanized rods with drop forged turnbuckles or other approved type of adjustment. Couplings for tubular sections shall be outside sleeve type and shall be at least 6 inches long.

Eye bolts for attaching tension wire shall be $\frac{3}{8}$ -inch diameter and of sufficient length to fasten to the type of post being used.

Tension bars shall be $\frac{3}{16}$ by $\frac{3}{4}$ -inch nominal and cross sectional area shall be $0.141 \text{ in}^2 \pm 5$ percent.

Hog rings shall be 12-gauge galvanized steel wire. Tie wire shall be 9-gauge galvanized steel wire or 9-gauge aluminum wire meeting the requirements of ASTM F626.

Fabric bands and stretcher bars shall meet the requirements of Section 9-16.6(9).

9-16.1(1)E Chain Link Gates

Gate frames shall be constructed of not less than 1½-inch (I.D.) galvanized pipe conforming to AASHTO M 181 Type I, Grade 1 or 2, as specified in Section 9-16.1(1)A. The corners of the gate frame shall be fastened together and reinforced with a malleable iron or pressed steel fitting designed for the purpose, or they may be welded. Welding shall conform to the requirements of Section 6-03.3(25). All welds shall be ground smooth coated with paint conforming to Section 9-08.1(2)B. The paint shall be applied in one or more coats to provide a minimum dry film thickness of 3.5 mils.

Chain link fence fabric for filling the gate frame shall meet the requirements of Section 9-16.1(1)B for the fence type being furnished.

Cross trussing shall be $\frac{5}{16}$ -inch steel adjustable rods galvanized in accordance with Section 9-16.1(1)D.

Each gate shall be furnished complete with necessary hinges, latch, and drop bar locking device designed for the type of gate posts and gate used on the project. Gates shall have positive type latching devices with provisions for padlocking. Hinges, latches, and locking devices shall be galvanized in accordance with Section 9-16.1(1)D.

Gate frames constructed of steel sections, other than pipe, that are fabricated in such a manner as to form a gate of equal or better rigidity may be used provided they are approved by the Engineer.

9-16.1(1)F Concrete

All concrete for chain link fence shall be as specified in Section 6-02.3(2)B.

9-16.2 Wire Fence and Gates

9-16.2(1) General

All materials used in the construction of the wire fence shall be new. All iron or steel material shall be galvanized. Material upon which serious abrasions of galvanizing occur will not be acceptable.

9-16.2(1)A Steel Post Material

Round Post Material

Round post material shall conform to AASHTO M 181, Type I, Grade 1.

Angle Post Material (Channel, T, U, Y, or Other Approved Style)

All angle post material shall be galvanized in accordance with the requirements of AASHTO M 111, except the anchor plate on fence post material shall be Grade 55. Angle post used for end, corner, gate, and pull post and brace shall have a minimum weight of 3.1 lb/ft.

Posts shall not be less than 7 feet in length. A tolerance of -5 percent on the weight of individual posts, braces or anchor plates will be permitted. One type of line post shall be used throughout the project. Line posts shall be studded, slotted, or properly adapted for attaching either wire or mesh in a manner that will not damage the galvanizing of posts, wire or mesh during the fastening. Line posts shall have a minimum weight of 1.33 lbs/ft and shall be provided with a tapered galvanized steel anchor plate. The anchor plate shall be securely attached and have a surface area of $20 \pm 2 \text{ in}^2$, and a minimum weight of 0.67 pounds.

9-16.2(1)B Wood Fence Posts and Braces

Douglas fir, Western red cedar, hemlock, or larch shall be used in the construction of wood fence posts and braces. The material shall be of good quality and approved by the Engineer before use. Peeler cores shall not be used for round posts. Wood fencing materials shall have sufficient sapwood in the outer periphery to obtain the specified penetration of preservative. Western red cedar will not require preservative treatment. Fencing materials shall be cut to the correct length before pressure treatment.

Line posts shall be 3-inch minimum diameter round posts or nominal 3 by 3-inch square sawed posts. If the posts are to be pointed for driving, they shall be pointed before treatment. Line posts shall be at least 7 feet in length.

Pull posts and brace posts shall be 6-inch diameter round posts or nominal 6 by 6-inch material not less than 7 feet in length.

End, gate, and corner posts, and posts at an intersecting fence shall be 6-inch diameter round posts or nominal 6 by 6-inch material not less than 7' 10" in length.

All sawed posts and timbers shall meet the requirements in the table under Section 9-09.2.

The preservatives used to pressure treat wood fencing materials shall meet the requirements of Section 9-09.3.

The retention and penetration of the preservative shall be as follows:

Minimum Retention in Pounds Per Cubic Foot		
Preservative	Sawed Posts	Round Posts
Creosote	10.00	8.00
Pentachlorophenol	0.50	0.40
ACZA	0.40	0.40
CCA	0.40	0.40

Minimum Penetration

for material 5 inches or less – 0.40 inches penetration and 90 percent of sapwood

for material 5 inches or greater – 0.50 inches penetration and 90 percent of sapwood

9-16.2(1)C Brace Wire

Brace wire shall be 9-gauge wire galvanized to meet the requirements of AASHTO M 279, Type Z, Class 1.

9-16.2(1)D Staples and Wire Clamps

The staples used to attach the wire fencing to wood posts shall be 9-gauge wire, 1½ inches long, galvanized to meet the requirements of AASHTO M 279, Type Z, Class 1.

The wire clamps used to attach the wire fencing to steel posts shall be 11-gauge wire, galvanized to meet the requirements of AASHTO M 279, Type Z, Class 1.

9-16.2(1)E Barbed Wire

Barbed wire shall conform to the requirements of AASHTO M 280, Type Z and shall consist of two strands of 12½-gauge wire, twisted with four point 14-gauge barbs with barbs spaced 5 inches apart (Design 12-4-5-14R). Galvanizing shall be Class 3.

9-16.2(1)F Wire Mesh

Wire mesh shall conform to the requirements of AASHTO M 279, Type Z and shall consist of eight horizontal wires with vertical stays spaced 6 inches apart. The top and bottom wires shall be 10-gauge, and the intermediate wires and vertical stays shall be 12½-gauge. The mesh shall have a total width of 32 inches (Design 832-6-12½). Galvanizing shall be Class 3.

The zinc coated wire as represented by the test specimens shall be capable of being wrapped in a close helix at a rate not exceeding 15 turns/minute around a cylindrical steel mandrel having a diameter the same as the specimen being tested, without cracking or flaking the zinc coating to such an extent that any zinc can be removed by rubbing with the bare fingers.

9-16.2(1)G Vertical Cinch Stays

Vertical cinch stays shall be 10-gauge galvanized wire meeting the requirements of AASHTO M 279, Type Z, Class 1.

9-16.2(1)H Miscellaneous Hardware

Bolts, nuts, hinges, latches and other miscellaneous hardware shall be galvanized in accordance with AASHTO M 232.

9-16.2(1)I Wire Gates

Gate frames shall be constructed of galvanized pipe with a nominal diameter of not less than 1 inch. The pipe shall conform to the requirements of AASHTO M 181 Type I, Grade 1. Wire gates shall be not less than 48 inches in height and shall be designed to fit openings of the width called for in the Plans or as indicated by the Bid items. Each gate shall be provided with two upright braces of the same material as the frame, spaced at ½ points in the gate. All gates shall be provided with adjustable ⅝-inch diameter galvanized diagonal truss rods from corner to corner. Galvanizing shall be in accordance with Section 9-16.2(1)H.

The gate frame shall be provided with wire mesh conforming to the requirements specified in Section 9-16.2(1)F, except that it shall consist of 10 horizontal wires and have a total width of 47 inches.

Each gate shall be furnished complete with necessary galvanized hinges and latch designed for use with the type of gate posts used on the project. The hinges shall be so designed as to be securely attached to the gate post and to enable the gate to be swing back against the fence. Double gates shall be hinged in the same manner as single gates and shall be provided with an approved galvanized drop bar locking device. Galvanizing for hinges, latches, and locking devices shall be in accordance with Section 9-16.2(1)H.

9-16.2(1)J Concrete

All concrete for wire fence shall be as specified in Section 6-02.3(2)B.

9-16.3 Beam Guardrail**9-16.3(1) Rail Element**

The W-beam or thrie beams rail elements, backup plates, reducer sections, and end sections shall conform to *A Guide to Standardized Highway Barrier Hardware* published by AASHTO, AGC, and ARTBA. All rail elements shall be formed from 12-gauge steel except for thrie beam reducer sections, reduced length thrie beam rail elements, thrie beams used for bridge rail retrofits, and Design F end sections, which shall be formed from 10-gauge steel.

The rail splices shall have a minimum total ultimate strength of 80,000 pounds at each joint.

The 6-inch channel rails and splice plates shall conform to ASTM A36, except that the channel rails may conform to ASTM A992. All fabrication shall be complete before galvanizing.

The holes in the plate shall be slotted to facilitate erection and to permit expansion and contraction. The edges of the rail shall be rolled or rounded so they will present no sharp edges. Where the rail is on a curve, the plates at the splice shall make contact throughout the area of splice. When the radius of curvature is less than 150 feet, the rail shall be shaped in the shop.

9-16.3(2) Posts and Blocks

Posts and blocks may be of creosote, pentachlorophenol, waterborne chromate copper arsenate (CCA), or ammoniacal copper zinc arsenate (ACZA), treated timber, or galvanized steel (galvanized steel posts only – no blocks). Blocks made from alternate materials that meet Manual for Assessing Safety Hardware (MASH) criteria may be used in accordance with the manufacturer's recommendations. Wood posts and blocks may be surface four sides (S4S) or rough sawn.

Posts and blocks shall be of the size, length, and type as shown in the Plans and shall meet the requirements of the below Specifications.

Timber posts and blocks shall conform to the grade specified in Section 9-09.2. Timber posts and blocks shall be fabricated as specified in the Plans before being treated. Timber posts and blocks shall be treated by the empty cell process to provide a minimum retention, depending on the treatment used, according to the following:

Treatment	AWPA UC4A	AWPA UC4B
Creosote oil	10.0 lbs. pcf.	10.0 lbs. pcf.
Pentachlorophenol	0.40 lbs. pcf.	0.50 lbs. pcf.
ACZA	0.40 lbs. pcf.	0.60 lbs. pcf.
CCA	0.40 lbs. pcf.	0.60 lbs. pcf.

Treatment shall be in accordance with Section 9-09.3.

Galvanized steel posts, and base plates, where used, shall conform to either ASTM A36 or ASTM A992, and shall be galvanized in accordance with AASHTO M 111. Welding shall conform to Section 6-03.3(25). All fabrication shall be completed prior to galvanizing.

9-16.3(3) Galvanizing

W-beam or thrie beam rail elements and terminal sections shall be galvanized in accordance with AASHTO M 180, Class A, Type II. Channel rails, splice plates, WF steel posts, and base plates shall be galvanized in accordance with ASTM A123. Anchor cables shall be galvanized in accordance with Federal Specification RR-W-410, Table II, galvanized at finished size. Bolts, nuts, washers, plates, rods, and other hardware shall be galvanized in accordance with ASTM A153.

9-16.3(4) Hardware

Unfinished bolts (ordinary machine bolts), nuts, and washers for unfinished bolts, shall conform to Section 9-06.5(1). High-strength bolts, nuts, and washers for high-strength bolts shall conform to Section 9-06.5(3).

Unfinished bolts shall be accepted by field verification and documentation that bolt heads are stamped 307A. The Contractor shall submit a manufacturer's certificate of compliance per Section 1-06.3 for high-strength bolts, nuts, and washers prior to installation of the hardware.

9-16.3(5) Anchors

Welding shall conform to Section 6-03.3(25).

All welding shall be equal in strength to the parent metal.

All fabrication shall be complete and ready for assembly before galvanizing. No punching, drilling, cutting, or welding will be permitted after galvanizing unless authorized by the Engineer.

Foundation tubes shall be fabricated from steel conforming to the requirements of ASTM A500, Grade B or ASTM A501.

The anchor plate assembly shall develop a minimum tensile strength of 40,000 pounds.

The anchor plate, W8 × 18, and metal plates shall be fabricated of steel conforming to the Specifications of ASTM A36, except that the W8 × 18 may conform to ASTM A992.

The strut and yoke assembly shall be fabricated of 10-gauge steel conforming to the Specifications of ASTM A36. The bearing plate shall be fabricated of steel conforming to the Specifications of ASTM A36. The breakaway terminal post sleeve shall be fabricated of steel conforming to the Specifications of ASTM A53, Grade B, Schedule 40.

Anchor cable shall be ¾ inch preformed, 6 by 19 wire strand core or independent wire rope core (IWRC), galvanized, right regular lay manufactured of improved plow steel with a minimum breaking strength of 42,800 pounds. Two certified copies of mill test reports of the cable used shall be furnished to the Engineer.

Swaged cable fittings shall develop 100 percent of the specified breaking strength of the cable. One swaged fitting attached to 3 feet of cable shall be furnished to the Engineer for testing.

The swaged fitting and stud assembly shall be of steel conforming to the requirements of American Iron and Steel Institute C-1035 and shall be annealed and galvanized suitable for cold swaging.

All metal components of the anchor and cable assembly and not less than the top 14 inches of the W8 × 18 for the Type 2 anchor shall be galvanized in accordance with Section 9-16.3(3).

Cement concrete shall conform to the requirements of Section 6-02.3(2)B.

Cement grout shall conform to Section 9-20.3(4) and consist of one part portland cement or blended hydraulic cement and two parts sand.

9-16.3(6) Inspection and Acceptance

The Contractor shall give notice to the Engineer before the rail elements are fabricated in order that inspections may be provided. The Contractor shall arrange for all facilities necessary for the inspection of material and quality of construction at the point of fabrication of the rail element, and inspectors shall be allowed free access to necessary parts of the premises.

The Inspector shall have the authority to reject materials or work that do not fulfill the requirements of these Specifications. In cases of dispute, the Contractor may appeal to the Engineer, whose decision will be final.

The Inspector may accept a mill test report certifying that the steel used in fabricating the rail element meets the requirements of the Specifications. The Contracting Agency reserves the right, however, to require the Contractor to furnish samples of the steel proposed for use and to determine to its satisfaction that the steel meets the Specification requirements. Steel rail elements, fittings, end section hardware, and bolts may be accepted by the Engineer based on the Manufacturer's Certification of Compliance.

9-16.4 Wire Mesh Slope Protection**9-16.4(1) General**

All metal material used in the construction of wire mesh slope protection shall be new and galvanized. Imperfectly galvanized material or material upon which serious abrasion of galvanizing occurs will not be acceptable.

9-16.4(2) Wire Mesh

The galvanized wire mesh shall be a Style 1 double-twisted hexagonal mesh conforming to ASTM A975 with 8 by 10 opening, except when a colorized, polyvinyl chloride coating is required then the Style shall be a Style 3.

The longitudinal edges of the wire mesh fabric shall have knuckled selvedges with continuous selvedge wire as specified in ASTM A975.

9-16.4(3) Wire Rope

Wire rope shall be ¾-inch-diameter, independent wire rope class (IWRC) 6x19, extra improved plow steel (EIP) wire rope galvanized in accordance with ASTM A1023. Each lot of wire rope shall be accompanied by a Manufacturer's Certificate of Compliance, a mill certificate, and a test report showing the wire rope meets the minimum breaking force requirements of ASTM A1023.

9-16.4(4) Hardware

Weldless steel rings shall be drop-forged steel and heat treated after forging; have a single pull, working load limit of at least 10,000 lbs; and meet performance requirements of Federal Specification RR-C-271D Type VI.

Thimbles required for all wire rope loops shall be standard weight, galvanized, and meet performance requirements of Federal Specification FF-T-276b Type II.

Wire rope clips shall have drop-forged steel bases, be galvanized, and meet performance requirements of Federal Specification FF-C-450 Type I Class 1.

9-16.4(5) Fasteners and Lacing Wire

Fasteners shall consist of 11 gauge high tensile steel. Lacing wire shall consist of 9 gauge, zinc-coated steel wire conforming to ASTM A641.

9-16.4(6) Ground Anchors

Threaded bar ground anchors shall be deformed, continuously threaded, steel reinforcement bars conforming to either Section 9-07.2 or Section 9-07.11. Threaded bar ground anchors shall be either epoxy-coated in accordance with Sections 6-02.3(24)H and 9-07.3 or galvanized after fabrication in accordance with ASTM A767 Class I.

Hollow-core anchor bars shall have continuous threads/deformations and be fabricated from steel tubing conforming to ASTM A519. Couplers and nuts shall provide 100 percent of the guaranteed minimum tensile strength of the hollow core anchor bars.

Bearing plates shall conform to ASTM A572 Grade 50 and shall be galvanized after fabrication in accordance with AASHTO M 111. Nuts shall conform to either AASHTO M 291 Grade B, hexagonal, or Section 9-07.11. Nuts shall be galvanized after fabrication in accordance with AASHTO M 111 for plate washers and AASHTO M 232 for all other hardware.

Grout for ground anchors shall be Grout Type 2 for Nonshrink Applications, conforming to Section 9-20.3(2).

Concrete for gravity anchors shall be either commercial concrete conforming to 8 Section 6-02.3(2)B or Class 3000 conforming to Section 6-02.

Steel reinforcing bars for gravity anchors shall conform to Section 9-07.2, and shall be epoxy-coated in accordance with Sections 6-02.3(24)H and 9-07.3.

9-16.5 Vacant**9-16.6 Glare Screen****9-16.6(1) General**

All material used in the construction of the fence shall be new. Iron or steel material shall be galvanized or aluminum coated as specified. Imperfectly galvanized or aluminum coated material, or material upon which serious abrasions of galvanizing or aluminum coating occur, will not be acceptable.

9-16.6(2) Glare Screen Fabric

Glare screen fabric shall consist of diamond woven wire mesh. The fabric wire may be 0.148-inch diameter aluminum alloy complying with the Aluminum Association requirements for alloy 6061T94, or it may be 0.148-inch diameter (9-gauge) iron or steel wire complying with the requirements of ASTM A392 galvanized or ASTM A491 for aluminum coated, except that galvanizing of Type 2 glare screen fabric shall be not less than 0.8 ounce per square foot and shall be done before weaving. Aluminum coating shall be Class II.

Type 1 glare screen mesh size shall be approximately a 1 inch diamond. Type 2 glare screen mesh size shall be a maximum of 3½ inch vertical and 5½ inch horizontal. The design shall permit the slats to be installed in a vertical position as shown in the Plans without distortion of the slats.

9-16.6(3) Posts

Line posts for Types 1 and 2 glare screens shall be 2 inch inside diameter galvanized steel pipe with a nominal weight of 3.65 pounds per linear foot. End, corner, brace, and pull posts for Type 1 Design A and B and Type 2 shall be 2½ inch inside diameter galvanized steel pipe with a nominal weight of 5.79 pounds per linear foot. Intermediate pull posts (braced line posts) shall be as specified for line posts.

The base material for the manufacture of steel pipes used for posts shall conform to the requirements of ASTM A53, except the weight tolerance on tubular posts shall be applied as provided below.

Posts provided for glare screen will have an acceptance tolerance on the weight per linear foot, as specified, equal to plus or minus 5 percent. This tolerance will apply to each individual post.

All posts shall be galvanized in accordance with AASHTO M 181, Section 32. The minimum average zinc coating is per square foot of surface area. This area is defined as the total area inside and outside. A sample for computing the average of mass of coating is defined as a 12-inch piece cut from each end of the galvanized member.

9-16.6(4) Tension Wire

Top and bottom tension wire shall be 7-gauge coil spring steel wire of good commercial quality and shall have a zinc coating averaging 0.8 ounces per square foot of surface area.

9-16.6(5) Vacant

9-16.6(6) Tension Wire Attachments

All tension wire attachments shall be galvanized steel conforming to the requirements of AASHTO M 232 unless otherwise specified. Eye bolts shall have either a shoulder or a back-up nut on the eye end and be provided with an eye nut where needed or standard hex nut and lock washer $\frac{3}{8}$ -inch diameter for tension wire and of sufficient length to fasten to the type of posts used. Turnbuckles shall be of the shackle end type, $\frac{1}{2}$ -inch diameter, with standard take-up of 6 inches and provided with $\frac{3}{8}$ -inch diameter pins.

9-16.6(7) Slats**9-16.6(7)A Wood Slats**

Wood slats shall be $\frac{3}{8}$ by $2\frac{3}{8}$ inch by the height designation of the fence. Material shall be finished and treated cedar or redwood and shall be free from loose knots, cracks, and other imperfections. A dimensional tolerance of plus or minus $\frac{1}{16}$ inch in width or thickness is allowed provided that the maximum space between slats does not exceed $\frac{3}{8}$ inch.

9-16.6(7)B Plastic Slats

Plastic slats shall be $\frac{3}{8}$ by $2\frac{3}{8}$ inch by the height designation of the fence. They shall be manufactured from tubular polyethylene color pigmented material consisting of high-density virgin polyethylene and color pigments, designed to retard ultraviolet penetration. The material shall have a minimum wall thickness of 0.0030 inch plus or minus 0.0003 inch and shall remain flexible without distortion and without becoming brittle through a temperature range of -70°F to $+250^{\circ}\text{F}$. Tensile strength shall be at least 3,600 psi and the melt index shall not exceed 0.25.

Plastic slats shall be retained in place by means of U-shaped retainer members at the bottom and top of the fence. Retainer members shall be of the same material as the slats.

The color for plastic slats will be approved by the Engineer from samples submitted by the Contractor or supplier.

9-16.6(8) Fittings

Fittings shall be malleable cast iron or pressed steel and galvanized in accordance with the requirements of AASHTO M 232.

Fittings shall be those furnished by the manufacturer of the fence.

9-16.6(9) Fabric Bands and Stretcher Bars

Fabric bands shall be $\frac{1}{8}$ inch by 1-inch nominal. Stretcher bars shall be $\frac{3}{16}$ inch by $\frac{3}{8}$ inch nominal or $\frac{5}{16}$ inch diameter round bar nominal $\frac{3}{16}$ inch diameter round stretcher bar shall be used with Type 1. Nominal shall be construed to be the area of the cross section of the shape obtained by multiplying the specified width by thickness. A variation of minus 5-percent from this theoretical area shall be construed as "nominal" size. All shall be galvanized to meet the requirements of ASTM F626.

9-16.6(10) Tie Wire and Hog Rings

Tie wire shall be 9-gauge aluminum wire complying with the ASTM B211 for alloy 1100 H14 or 9-gauge galvanized wire meeting the requirements of AASHTO M 279. Galvanizing shall be Class 1.

Hog rings shall be 12-gauge galvanized steel wire.

9-16.7 Cable Fence

Steel pipe shall conform to ASTM A 53, Grade B, Type E or S.

Steel bars, plates, and shapes shall conform to ASTM A 36.

Steel components shall be galvanized after fabrication in accordance with AASHTO M 111.

Resin bonded anchors shall conform to Section 9-06.4.

Proof coil chain shall conform to ASTM A413 Grade 30.

Spelter sockets and turnbuckles shall conform to the size and breaking strength requirements specific in the Plans, shall be compatible with the wire rope selected by the Contractor, and shall be galvanized after fabrication in accordance with AASHTO M 232.

Wire rope shall conform to one of the following:

1. ASTM A 603 with Class A weight zinc-coated wires throughout.
2. ASTM A 1023 with drawn galvanized wires throughout in accordance with ASTM A 1007. Acceptance of ASTM A 1023 wire rope is contingent upon the Contractor furnishing a Type 1 Working Drawing certifying that the lot of supplied wire rope has a minimum modulus of elasticity of 15,000 ksi when tested in accordance with ASTM A 931 Section 3.2.17.

9-17 Flexible Guide Posts

9-17.1 General

Flexible guide posts shall be made of a flexible, nonwarping, nonmetallic, durable plastic material; shall be resistant to damage due to impact, ultraviolet light, ozone, hydrocarbons, and other effects of atmospheric weathering; shall resist stiffening with age; and shall be free of burns, discoloration, contamination and other objectionable marks or defects that affect appearance or serviceability. The portion of ground mounted guide post installed below ground may be the same material as the portion above ground or other durable material suitable for firmly anchoring the post in the ground. When iron or steel are used for the in ground portion, galvanize in accordance with AASHTO M111. The top of tubular posts shall be closed to prevent moisture or debris from entering. Surface mounted guide posts shall be mounted on a base made of a rigid high impact resistant material and be resistant to ultraviolet light, ozone, and hydrocarbons. The post shall mount directly into or onto the base in a tamper proof manner and shall allow for easy replacement. Guardrail mounted guide posts shall be the same as ground mounted guide posts except the length shall be adjusted to meet the mounting height requirements in the [Standard Plans](#). Appropriate holes shall be provided for fastening the guide post to the guard rail post.

The material composition of flexible guide posts subsequently furnished shall not vary from that of the samples upon which the State Materials Laboratory pre-approval is based. If analysis by the Materials Laboratory determines there is a change in material composition, such change shall constitute grounds for rejection and/or removal from the Qualified Products List.

The post system shall be designed for permanent installation to resist overturning, twisting, and displacement from wind and impact forces.

Each flexible guide post shall be permanently identified with the manufacturer's name, and the month and year of fabrication. Ground mounted guide posts shall have a permanent a mark indicating the recommended burial depth. The letters shall be solvent resistant, a minimum of ¼ inch in height, and permanently affixed to the post.

Unless otherwise specified, the color of the guide post shall be white or brown as indicated in the Plans.

The reflective panel on a flat or elliptical guide post shall have a minimum width of 3 inches facing traffic. The reflective sheeting shall have a minimum area of 24 square inches (3 by 8 inches). The reflective panel on a round guide post shall have an 8-inch minimum band of reflective sheeting visible for 360 degrees.

9-17.1(1) Dimensions

1. **Flat Type** – The post has a minimum width of 3 inches of continuous flat surface with no curvature for the entire length of the post. This will allow for ridges on the outer edges and back of post intended for structural support.
2. **Tubular Type** – The post is tubular or round/circular in shape. This allows for a tubular post with a minimum diameter of 3 inches or a tubular post with a minimum diameter of 2 inches with a flat or flattened oval surface at least 3 inches wide and 12 inches long measured from the top for mounting reflective sheeting.
3. **Non-flat and Non-Tubular Type** – This includes all post that do not fit into the two types indicated above. This would include convex, w-shape, oval, and other post designs. The post shall be wide enough to accept a 3-inch wide reflective sheeting. Any curvature or rounding shall not significantly reduce the brightness value of the reflective sheeting.

4. **Surface Mount Guide Post Base** – The base for surface mount guide posts shall be approximately 8 inches in diameter with a maximum height of 2 inches.
5. Guide posts shall be of such length to provide the required mounting height above the pavement surface in accordance with the [Standard Plans](#).

9-17.1(2) Reflective Sheeting

Reflective sheeting for guide posts shall be in accordance with Section 9-28.12. The reflective panel on a flat or elliptical guidepost shall have a minimum width of 3 inches facing traffic. The reflective sheeting shall have a minimum area of 24 square inches (3 by 8 inches). The reflective panel on a round guidepost shall have an 8-inch minimum band of reflective sheeting visible for 360 degrees. Mount the reflective sheeting on the guide post as detailed in the [Standard Plans](#). Sheeting shall remain in place during the life of the post.

9-17.2 Ultraviolet Resistance Test Procedure (Laboratory Test)

Two posts will be tested initially for tensile strength and elongation according to ASTM D638 and again after 1,000 hours QUV weatherometer exposure (ASTM G53).

Six bow tie specimens shall be prepared from the delineator post samples submitted for the purpose of ultraviolet (UV) exposure. The specimens shall be cycled at 1,000 hours in a weatherometer in accordance with ASTM G53 (3 hr. 60C UV, 3 hr. 50C CON). Three of each type shall be used for control purposes. The remaining three shall be subjected to 1,000 hours of UV exposure in the QUV weatherometer. Specimen dimensions conform to those outlined below.

The laboratory test data shall summarize the tensile strength of each, and the average tensile strength for both control and weathered samples. The data shall also summarize the elongation of each, and the average elongation for both control and weathered samples. The average values shall be used to show the percent change in tensile and elongation.

9-17.2(1) Acceptance

The specimens shall show no signs of delamination, distress, or discoloration. Physical properties of tensile strength and rigidity shall be maintained within 80 percent of the unconditioned values.

9-17.3 Field Impact Test Procedure

Sample size of eight units will be tested the following way:

Flexible Ground Mounted Posts

Eight flexible ground mounted posts installed by the manufacturer (four installed manually and four installed mechanically). The delineators will be hit ten times (four posts for glancing bumper hits and four posts for wheel hits). A standard sedan with a bumper height of approximately 18 inches while traveling at a speed of 55 ± 2 mph will be used for impact testing. Five of the impacts will be at an ambient temperature of $32 \pm 5^\circ\text{F}$ and the remaining five impacts at an ambient temperature of $85 \pm 5^\circ\text{F}$. The test vehicle shall impact four of the posts at an angle perpendicular to the front of the post and shall impact the remaining posts at an angle of 25 degrees clockwise from the angle perpendicular to the front of the posts. The same test samples will be used for the ten hits. Two flexible posts will be used for weatherometer testing. A glancing hit is defined as one on the bumper near the vehicle headlight. The delineators shall be installed a minimum of eight hours prior to being hit.

Flexible Surface Mounted Posts

Eight flexible surface mounted posts installed by the manufacturer will be hit ten times (four posts for glancing bumper hits and four posts for wheel hits). A standard sedan with a bumper height of approximately 18 inches while traveling at a speed of 55 ± 2 mph will be used for impact testing. Five of the impacts will be at an ambient temperature of $32 \pm 5^\circ\text{F}$ and the remaining five impacts at an ambient temperature of $85 \pm 5^\circ\text{F}$. The test vehicle shall impact four of the posts at an angle perpendicular to the front of the post and shall impact the remaining posts at an angle of 25 degrees clockwise from the angle perpendicular to the front of the posts. The same test samples will be used for the ten hits. Two flexible posts will be used for weatherometer testing. A glancing hit is defined as one on the bumper near the vehicle headlight. The delineators shall be installed a minimum of eight hours prior to being hit.

9-17.3(1) Test Observations

Inspect each post after each impact and document the following:

1. Any splits, cracks, breaks, or other forms of deformation or distress;
2. The percent list to vertical 2 minutes after each impact;
3. The approximate percentage of the reflective area that is damaged after each impact to an extent it no longer performs as intended;
4. Any problems or comments associated with the installation and removal of the posts and bases. The testing agent will document any special equipment or techniques required for installing or removing the posts and bases.
5. Any problems or comments associated with the performance of each ground mounted flexible delineator post that would be of interest to the states;
6. Type of soil and impact surface.

9-17.3(2) Acceptance

A failure is defined as any of the following:

1. A minimum of 50 percent of the reflective sheeting shall be retained undamaged. An area of damage greater than 50 percent is considered a failure.
2. If the guide post leans more than 10 degrees from vertical it is considered a failure.
3. Any cracking, other than surface cracking evident on only one face of the post, is considered a failure.
4. Pullout in excess of 3 inches is considered a failure.

At least six of the guide posts must pass each criteria in the 55 ± 2 mph series of impacts to be acceptable.

9-17.4 Pre-approval

In order for a particular model of flexible guide post to become preapproved, the following conditions must be met:

1. The manufacturer must submit a written request for pre-approval along with samples for each model to be tested to: State Materials Engineer, Department of Transportation Materials Laboratory, PO Box 47365, Olympia, WA 98504-7365. Requests shall identify the model for which approval is being requested. Samples shall be complete with reflective panel attached and shall be accompanied by the manufacturer's written installation procedures.
2. The guide posts will be field impact tested by the State Materials Laboratory to verify compliance with these Specifications.

3. In lieu of State Materials Laboratory testing, the Lab will accept the results of preapproved testing performed by the National Transportation Product Evaluation Program (NTPEP), the manufacturer, or other agencies under the following conditions:
 - a. The State Materials Laboratory is informed of the preapproval testing sufficiently in advance in order to attend and observe. Attendance will be at the discretion of the Materials Laboratory.
 - b. The results of the testing shall be reported in sufficient detail to enable the State Materials Laboratory to evaluate compliance with these Specifications.
4. The manufacturer must submit a certified test report, including test data developed by an approved testing laboratory, which demonstrates that the guide post complies with the requirements of these Specifications. Certified test data supplied by the manufacturer shall be subject to verification by appropriate tests conducted by the State Materials Laboratory.

Frequency of field testing, evaluation, and pre-approval updating shall be at the sole discretion of the State Materials Laboratory.

9-18 Barrier Delineator

Barrier delineators shall consist of a flat plastic reflector lens or reflective sheeting attached to a housing or bracket to facilitate the mounting of the delineator on concrete traffic barrier. The reflective surface shall be a minimum area of 9 square inches for reflectors and 12 square inches for reflective sheeting. The housing or bracket can be flexible or rigid, molded from a durable plastic material approved by the Engineer. Barrier delineators shall be one-sided for single direction or two sided for bi-directional.

Reflectors shall be acrylic or polycarbonate conforming to AASHTO M 290. Reflectors shall equal or exceed the following minimum values of specific intensity:

Observation Angle (Degrees)	Entrance Angle (Degrees)	Specific Intensity cd/ft-c	
		White	Yellow
0.1	0	126	75
0.1	20	50	30

Reflective sheeting for barrier delineators shall be in accordance with Section 9-28.12.

9-19 Detectable Warning Surface**9-19.1 Surface Applied Detectable Warning Surface****9-19.1(1) General Requirements**

The detectable warning surface area shall be yellow and shall match SAE AMS Standard 595, color number 33538. When painting a detectable warning surface is required, such as on a steel detectable warning surface, the yellow paint shall conform to Section 9-08.1(8) and shall match SAE AMS Standard 595, color number 33538.

Units shall be composed of steel, iron, plastics, polymeric materials, resins, pigments. The units shall be uniform in color and texture, be free of cracks or other defects, and have clean-cut and well-defined edges.

The detectable warning surface shall meet the following physical properties:

Standard	Property	Results
ASTM C501	Wear Resistance	Wear Index: >15
ASTM C1028	Slip Resistance	Dry Coefficient of friction 0.8 minimum Wet Coefficient of friction 0.5 minimum
ASTM E96	Water Vapor Transmission	10 grams/square foot/24 hours
Various	Adhesion/Bonding Strength	See Note*

*Note: Due to various types of materials available, the Manufacturer shall certify, through independent laboratory testing, that the type of material used for detectable warnings will adhere to prepared surface.

9-19.2 Cast-in-Place Detectable Warning Surface**9-19.2(1) General Requirements**

The detectable warning surface area shall be yellow and shall match SAE AMS Standard 595, color number 33538. When painting a detectable warning surface is required, such as on a steel detectable warning surface, the yellow paint shall conform to Section 9-08.1(8) and shall match SAE AMS Standard 595, color number 33538.

Units shall be composed of steel, iron, plastics, polymeric materials, resins, pigments. The units shall be uniform in color and texture, be free of cracks or other defects, and have clean-cut and well-defined edges.

They shall be weather resistant and durable to normal pedestrian wear and maintenance activities, and show no appreciable fading, lifting, or shrinkage.

The detectable warning units shall meet the following physical properties:

Standard	Property	Results
ASTM C501	Wear Resistance	Wear Index: >15
ASTM C1028	Slip Resistance	Dry Coefficient of friction 0.8 minimum Wet Coefficient of friction 0.5 minimum
ASTM E96	Water Vapor Transmission	10 grams/square foot/24 hours

9-20 Concrete Patching Material, Grout, and Mortar**9-20.1 Patching Material for Cement Concrete Pavement**

Concrete patching material will be prepackaged mortar extended with aggregate. The amount of aggregate for extension shall conform to the manufacturer's recommendation.

Patching mortar and patching mortar extended with aggregate shall contain cementitious material and conform to Sections 9-20.1(1) and 9-20.1(2). The Manufacturer shall use the services of a laboratory that has an equipment calibration verification system and a technician training and evaluation process in accordance with AASHTO R 18 to perform all tests specified in Section 9-20.1.

9-20.1(1) Patching Mortar

Patching mortar shall conform to the following requirements:

Compressive Strength	ASTM Test Method	Specification
at 3 hours	C 39	Minimum 3,000 psi
at 24 hours	C 39	Minimum 5,000 psi
Length Change		
at 28 days	C 157	0.15 percent maximum
Total Chloride Ion Content	C 1218	1 lb/yd ³ maximum
Bond Strength		
at 24 hours	C 882 (As modified by C 928, Section 9.5)	Minimum 1,000 psi
Scaling Resistance (at 25 cycles of freezing and thawing)	C 672 (As modified by C 928, Section 9.4)	1 lb/ft ² maximum

9-20.1(2) Patching Mortar Extended With Aggregate

Patching mortar extended with aggregate shall meet the following requirements:

Compressive Strength	ASTM Test Method	Specification
at 3 hours	C 39	Minimum 3,000 psi
at 24 hours	C 39	Minimum 5,000 psi
Length Change		
at 28 days	C 157	0.15 percent maximum
Bond Strength		
at 24 hours	C 882 (As modified by ASTM C928, Section 9.5)	Minimum 1,000 psi
Scaling Resistance (at 25 cycles of freezing and thawing)	C 672	2 Maximum Visual Rating
Freeze thaw	C 666	Maximum expansion 0.10% Minimum durability 90.0%

9-20.1(3) Aggregate

Aggregate used to extend the patching mortar shall meet the requirements of Section 9-03.1(4) and be AASHTO Grading No. 8. A Manufacturer's Certificate of Compliance shall be required showing the aggregate source and the gradation. Mitigation for Alkali Silica Reaction (ASR) will not be required for the extender aggregate used for concrete patching material.

9-20.1(4) Water

Water shall meet the requirements of Section 9-25.1. The quantity of water shall be within the limits recommended by the manufacturer.

9-20.2 Patching Material for Concrete Structure Repair

Concrete patching material shall be a prepackaged mixture of portland or blended hydraulic cement, aggregate, and admixtures. Fly ash, ground granulated blast furnace slag and microsilica fume may be used. The concrete patching material may be shrinkage compensated. The concrete patching material shall also meet the following requirements:

- Compressive strength of 6000 psi or higher at 28 days in accordance with AASHTO T 22 (ASTM C 39), unless noted otherwise
- Bond strength of 250 psi or higher at 28 days or less in accordance with ASTM C 1583 or ICRI 210.3R
- Shrinkage shall be 0.05 percent (500 microstrain) or lower at 28 days in accordance with AASHTO T 160 (ASTM C 157) as modified by ICRI 320.3R
- Permeability shall be 2,000 coulombs or lower at 28 days in accordance with AASHTO T 277 (ASTM C 1202)
- Freeze-thaw resistance shall have a durability factor of 90 percent or higher after a minimum of 300 cycles in accordance with AASHTO T 161 Procedure A (ASTM C 666)
- Soluble chloride ion limits in Section 6-02.3(2) shall be satisfied

9-20.3 Grout

Grout is a mixture of Portland or blended hydraulic cement and water with or without aggregates and with or without admixtures. Grout may also contain fly ash and/or concrete admixtures. Grout may be a Contractor's submitted mix design or a Manufacturer's prepackaged grout product.

All prepackaged grouts shall be used in accordance with the manufacturer's recommendations, including but not limited to, shelf life, mixing, surface preparation, and curing.

Where required, all 2-inch cube specimens fabricated in the field shall be made in accordance with WSDOT T 813. All 2-inch cube specimens fabricated in a laboratory shall be made in accordance with FOP for AASHTO T 106. All 2-inch cube specimens shall be tested in accordance with FOP for AASHTO T 106.

When coarse aggregate is used, specimens shall be fabricated in accordance with FOP for AASHTO R 100 and tested in accordance with AASHTO T 22.

9-20.3(1) Grout Type 1 for Post-Tensioning Applications

Grout Type 1 shall be a Class C prepackaged material conforming to the requirements of the latest edition of PTI M55.1 Specification for Grouting of Post-Tensioned Structures.

9-20.3(2) Grout Type 2 for Nonshrink Applications

Grout Type 2 shall be a nonshrink, prepackaged material meeting the requirements of ASTM C1107. The minimum compressive strength shall be 4,000 psi at 7 days.

9-20.3(3) Grout Type 3 for Unconfined Applications

Grout Type 3 shall be a prepackaged material that does not include expansive admixtures meeting the following requirements:

- Compressive strength shall be 4000 psi or higher at 28 days in accordance with AASHTO T 22 (ASTM C 39) for grout extended with coarse aggregate or AASHTO T 106 (ASTM C109) otherwise.

- Bond strength shall meet one of the following:
 - 250 psi or higher at 28 days or less in accordance with ASTM C1583.
 - 2000 psi or higher at 28 days or less in accordance with ASTM C882. The following modification to ASTM C882 is acceptable: use Type 3 Grout in lieu of epoxy resin base bonding system and freshly mixed portland-cement mortar in the procedure for testing Type II and V systems.
- Drying shrinkage shall be 0.08 percent (800 microstrain) or lower at 28 days in accordance with AASHTO T 160 (ASTM C157). The following modification to AASHTO T 160 is acceptable: use a standard specimen size of 3 x 3 x 11-¼ inches.

9-20.3(4) Grout Type 4 for Multipurpose Applications

Grout Type 4 shall be a multipurpose grout material for structural and nonstructural applications. The grout shall be produced using portland cement Type I/II. The water to cementitious material ratio shall not exceed 0.45 and water-reducing admixtures may be used. Multipurpose grout may be extended up to three parts fine aggregate to one part cement. The minimum compressive strength shall be 4,000 psi at 7 days. Substitution of fly ash for cement is allowed up to 20 percent.

9-20.4 Mortar

Mortar shall be material made from Portland or blended hydraulic cement, water, and fine aggregate.

9-20.4(1) Fine Aggregate for Mortar

Fine Aggregate for mortar shall conform to the requirements of Section 9-03.2.

9-20.4(2) Mortar Type 1 for Concrete Surface Finish

Mortar Type 1 for concrete surface finishing shall be either prepackaged or a Contractor-recommended blend of portland cement Type I/II and fine aggregate conforming to Section 9-20.4(1). If the Class 1 concrete surface finishing mortar is a Contractor-recommended blend, it shall conform to the sand-to-cement ratios specified in Section 6-02.3(14)A.

9-20.4(3) Mortar Type 2 for Masonry Applications

Mortar Type 2 for masonry shall be either prepackaged or a Contractor-recommended blend of portland cement Type I/II and fine aggregate conforming to Section 9-20.4(1).

9-20.4(4) Mortar Type 3 for Concrete Repair

Mortar Type 3 shall be a prepackaged material that does not include expansive admixtures. Aggregate extension and mixing procedures shall be in accordance with the manufacturer's recommendation. The minimum compressive strength shall be 4,000 psi at 7 days.

9-20.5 Bridge Deck Repair Material

Bridge deck repair material shall be either an ultra-low viscosity, two-part liquid, polyurethane-hybrid polymer concrete, or a pre-packaged cement based repair mortar, conforming to the following requirements:

1. Minimum compressive strength of 2,500 psi, in accordance with ASTM C 109.
2. Total soluble chloride ion content by mass of product shall conform to the limits specified in Section 6-02.3(2) for reinforced concrete.
3. Permeability of less than 2,000 coulombs at 28-days or more in accordance with AASHTO T 277.

If pre-packaged deck repair material does not include coarse aggregate, the Contractor shall extend the mix with coarse aggregate as recommended by the manufacturer.

9-21 Raised Pavement Markers (RPM)**9-21.1 Raised Pavement Markers Type 1****9-21.1(1) Physical and Chemical Properties**

The markers shall be of uniform composition and free from surface irregularities, cracks, checks, chipping, peeling, spalling, crazing, and other physical damage interfering with appearance, application, or durability.

The markers shall be precast in the form of a single based spheroidal segment terminating in a rounded or squared shoulder. Markers shall be white or yellow.

The markers shall meet the following requirements:

Property	Unit	Thermoplastic Markers	Plastic Markers
Mass	grams	N/A	125 min.
Height	inches	0.65-0.78	0.65-0.78
Diameter/Width	inches	3.85-4.05	3.85-4.05
Shoulder height	inches	0.08-0.22	0.08-0.22
Planeness of base:			
Concavity	inches	0.05 max.	0.05 max.
Convexity	inches	0.05 max.	0.05 max.
Reflectance (white only)	%MgO	80 min.	80 min.
Impact resistance	inch-pound	15 min.	15 min.
Titanium Dioxide (white only)	% by weight	N/A	21 min.

The markers passing laboratory tests will be field tested for approval. The field tests will include installation with control markers to determine relative adhesion and durability characteristics.

9-21.2 Raised Pavement Markers Type 2**9-21.2(1) Standard Raised Pavement Markers Type 2**

The marker housing shall contain reflective faces as shown in the Plans to reflect incident light from either a single or opposite directions and meet the requirements of ASTM D 4280 including Flexural strength requirements.

9-21.2(2) Abrasion Resistant Raised Pavement Markers Type 2

Abrasion Resistant Raised Markers Type 2 shall comply with Section 9-21.2(1) and meet the requirements of ASTM D 4280 with the following additional requirement: The coefficient of luminous intensity of the markers shall be measured after subjecting the entire lens surface to the test described in ASTM D 4280 Section 9.5 using a sand drop apparatus. After the exposure described above, retroreflected values shall not be less than 0.5 times a nominal unblemished sample.

9-21.3 Raised Pavement Markers Type 3

Raised pavement markers Type 3 shall be extruded from high impact thermoplastic material which has been ultra-violet radiation stabilized and shall meet the following requirements:

Impact resistance	15 inch-lbs, min.
Reflectance (White Only)	80 percent min.
Concavity & Convexity	
Transverse	1/16 inch, max.
Longitudinal	1/8 inch, max
Base Width	4"
Length	6", 8", 10" or 12"
Height	0.60-0.75"
Shoulder height	0.08-0.20

The ends shall be beveled from the top of the shoulder edge at a slope of 1:1 nominal.

9-22 Monument Cases**9-22.1 Monument Cases, Covers, and Risers**

Castings for monument cases, covers, and risers shall be gray iron castings conforming to the requirements of AASHTO M306, Class 35B. The cover and seat shall be machined so as to have perfect contact around the entire circumference and full width of bearing surface. Dipping, painting, welding, plugging, or repairing defects will not be permitted.

9-23 Concrete Curing Materials, Bonding Agents, and Admixtures**9-23.1 Sheet Materials for Curing Concrete**

Sheet materials for curing concrete shall meet the requirements of ASTM C171, Sheet Materials for Curing Concrete, except that only white reflective type shall be used.

9-23.2 Liquid Membrane-Forming Concrete Curing Compounds

Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309 Type 1 or 2, Class A or B, except that the water retention when tested in accordance with WSDOT T 814 shall be 2.50 grams for all applications.

Each lot of liquid membrane-forming curing compound shall be sampled at the project site and tested for acceptance. Liquid membrane-forming curing compound shall not be used in the absence of satisfactory test results.

9-23.3 Water Repellent Compound

The water repellent compound shall be a clear, penetrating type, silicone resin base compound containing no filler or other material which will leave a film on the surface of the masonry after it is applied. It shall be of such consistency that it can be applied readily by brush or spray to the masonry at atmospheric temperature down to -20°F.

The average absorption of three test specimens treated with the water repellent compound, when tested in accordance with ASTM D6532, shall not exceed 2 percent after being partially immersed in water for 72 hours immediately after curing.

Water Repellent Compounds shall be a product listed in the WSDOT Qualified Products List (QPL).

Acceptance of each lot of the Water Repellent Compound for use on the project shall be based on a Manufacturer's Certificate of Compliance.

9-23.4 Sodium Metasilicate

Sodium metasilicate shall comply with ASTM D537.

9-23.5 Burlap Cloth

Burlap cloth shall meet the requirements of AASHTO M182, Class 4.

9-23.6 Chemical Admixtures for Concrete

Acceptance of chemical admixtures will be based on Manufacturer's Certificate of Compliance. If required by the Engineer, admixtures shall be sampled and tested before they are used. A 1-pint (500-milliliter) sample of the admixture shall be submitted to the WSDOT Headquarters Materials Laboratory for testing 10 days prior to use. Chemical Admixtures shall contain less than 1 percent chloride ion (Cl⁻) by weight of admixture.

9-23.6(1) Air-Entraining Admixtures

Air-Entraining admixtures shall meet the requirements of AASHTO M154 or ASTM C260.

9-23.6(2) Type A Water-Reducing Admixtures

Type A Water-Reducing admixtures shall conform to the requirements of AASHTO M194 Type A or ASTM C494 Type A.

9-23.6(3) Type B Retarding Admixtures

Type B Retarding admixtures shall conform to the requirements of AASHTO M194 Type B or ASTM C494 Type B.

9-23.6(4) Type C Accelerating Admixtures

Type C Accelerating admixtures shall conform to the requirements of AASHTO M194 Type C or ASTM C494 Type C, and only nonchloride accelerating admixtures shall be used.

9-23.6(5) Type D Water-Reducing and Retarding Admixtures

Type D Water-Reducing and Retarding admixtures shall conform to the requirements of AASHTO M194 Type D or ASTM C494 Type D.

9-23.6(6) Type E Water-Reducing and Accelerating Admixtures

Type E Water-Reducing and Accelerating admixtures shall conform to the requirements of AASHTO M194 Type E or ASTM C494 Type E, and only nonchloride accelerating admixtures shall be used.

9-23.6(7) Type F Water-Reducing, High Range Admixtures

Type F Water-Reducing, High Range admixtures shall conform to the requirements of AASHTO M194 Type F or ASTM C494 Type F.

9-23.6(8) Type G Water-Reducing, High Range, and Retarding Admixtures

Type G Water-Reducing, High Range, and Retarding admixtures shall conform to the requirements of AASHTO M194 Type G or ASTM C494 Type G.

9-23.6(9) Type S Specific Performance Admixtures

Type S Specific Performance admixtures are limited to ASR-mitigating, viscosity modifying, shrinkage reducing, rheology-controlling, and workability-retaining admixtures. They shall conform to the requirements of ASTM C494 Type S. When a Type S admixture is used, a report on the performance characteristics of the Type S admixture shall be submitted along with the WSDOT concrete mix design (WSDOT Form 350-040). The report shall describe the performance characteristics and provide data substantiating the specific characteristics of the Type S admixture in accordance with ASTM C494.

9-23.7 Vacant**9-23.8 Waterproofing**

Concrete made with waterproofing admixtures shall have a percent absorption after immersion and boiling of less than 5.0 percent at 7 days and a volume of permeable voids less than 11 percent at 7 days per ASTM C642. The Contractor shall submit evidence in the form of test results showing compliance with these specifications, when they submit their concrete mix design.

If the concrete requires air entrainment, the Contractor shall also submit evidence to the Engineer that the admixture will not adversely effect the air void system of the hardened concrete. Test results complying with ASTM C457 shall be provided as evidence to satisfy this requirement.

9-23.9 Fly Ash

Fly ash shall conform to the requirements of AASHTO M295 Class C or F including supplementary optional chemical requirements as set forth in Table 2.

Fly ash that exceeds the available alkali limits set in AASHTO M295 Table 2 may be used if they meet the tests requirements of Section 9-03.1(1). The supplementary optional chemical limits in AASHTO M295 Table 2 do not apply to fly ash used in Controlled Density Fill.

9-23.9(1) Tests and Acceptance

Fly ash may be accepted by the Engineer based on the Manufacturer's Mill Test Report Number indicating full conformance to the Specifications. All shipments of the fly ash to the Contractor or concrete supplier shall identify the applicable Mill Test Report Number. The concrete supplier or Contractor shall provide mill test identification on all concrete deliveries.

Fly ash producers, importers/distributors, and suppliers that certify fly ash shall participate in the fly ash acceptance program as described in WSDOT QC 4.

Each mixing facility or plant utilizing fly ash shall be equipped with a suitable means or device for obtaining a representative sample of the fly ash. The device shall enable the sample to be readily taken in proximity to the fly ash weigh hopper and from a container or conveyor holding only fly ash.

Fly ash may be tested using samples taken at the job site by the Engineer for submission to the State Materials Laboratory for testing.

9-23.10 Ground Granulated Blast Furnace Slag

Ground granulated blast furnace slag shall meet the requirements of AASHTO M 302, Grade 100 or Grade 120. The grade of the ground granulated blast furnace slag, the source, and type of manufacturing facility shall be certified on the cement mill test certificate.

9-23.10(1) Tests and Acceptance

Ground granulated blast furnace slag may be accepted by the Engineer based on the Manufacturer's Mill Test Report Number indicating full conformance to the Specifications. All shipments of the ground granulated blast furnace slag to the Contractor or concrete supplier shall identify the applicable Mill Test Report Number. The concrete supplier or Contractor shall provide mill test identification on all concrete deliveries.

Ground granulated blast furnace slag producers, importers/distributors, and suppliers that certify ground granulated blast furnace slag shall participate in the ground granulated blast furnace slag acceptance program as described in WSDOT QC 5.

Each mixing facility or plant utilizing ground granulated blast furnace slag shall be equipped with a suitable means or device for obtaining a representative sample of the ground granulated blast furnace slag. The device shall enable the sample to be readily taken in proximity to the ground granulated blast furnace slag weigh hopper and from a container or conveyor holding only ground granulated blast furnace slag.

Ground granulated blast furnace slag may be tested using samples taken at the job site by the Engineer for submission to the State Materials Laboratory for testing.

9-23.11 Microsilica Fume

Microsilica Fume shall conform to the requirements of AASHTO M307. The optional physical requirement for Reactivity with Cement Alkalies set forth in Table 3 will be required when Microsilica Fume is being used as an ASR mitigation measure.

9-23.12 Natural Pozzolan

Natural Pozzolans shall be ground Pumice and shall conform to the requirements of AASHTO M295 Class N, including supplementary optional chemical requirements as set forth in Table 2.

9-23.13 Blended Supplementary Cementitious Material

Blended Supplementary Cementitious Material (SCM) shall meet the requirements of ASTM C1697. Blended SCMs shall be limited to binary or ternary blends of fly ash, ground granulated blast furnace slag, and microsilica fume. Fly ash shall meet the requirements of Section 9-23.9. Ground granulated blast furnace slag shall meet the requirements of Section 9-23.10. Microsilica fume shall meet the requirements of Section 9-23.11. The individual SCMs composing the blended SCM shall be individually listed on the WSDOT Qualified Products List.

9-24 Plastic Waterstop**9-24.1 Material**

The waterstops shall be fabricated from a plastic compound, the basic resin of which shall be polyvinyl chloride. The compound shall contain any additional resins, plasticizers, inhibitors, or other material such that when the material is compounded, it shall meet the performance requirements given in these Specifications.

Single-pass reworked material of the same composition generated from the fabricator's waterstop production may be used. No reclaimed polyvinyl chloride shall be used.

All waterstops shall be molded or extruded in such a manner that any cross section will be dense, homogeneous, and free from porosity and other imperfections.

The waterstops shall be symmetrical in shape, nominal 4 inches in width, by $\frac{3}{16}$ inch thick, and a minimum of four ribs on each side of the bulb. The bulb thickness and diameter shall be as noted in the Plans.

9-24.1(1) Tests of Material

The waterstops shall meet all of the physical and other test requirements of this material as defined in the Corps of Engineers Specifications for Polyvinyl Chloride Water Stop CRD-C572, except that the tear resistance of the material shall be not less than 160 pounds per inch. The Contractor shall furnish such sample material as required by the Engineer for the purpose of making tests.

9-25 Water**9-25.1 Water for Concrete**

Water for concrete, grout, and mortar shall be clear, apparently clean, and suitable for human consumption (potable). If the water contains substances that cause discoloration, unusual smell or taste, or other suspicious content, the Engineer may require the Contractor to provide test results documenting that the water meets the physical test requirements and chemical limits described in ASTM C1602 for nonpotable water.

Water from mixer washout operations may be used in concrete provided it meets or exceeds the above criteria as well as the following additional requirements:

1. Concrete with water from mixer washout operations shall not be used in bridge roadway deck slabs, flat slab bridge superstructures, modified concrete overlays, or prestressed concrete.
2. Specific Gravity shall not exceed 1.07.
3. Alkalies, expressed as $[\text{Na}_2\text{O}+0.658 \text{K}_2\text{O}]$, shall not exceed 600 ppm.
4. Shall be free of coloring agents.
5. If the wash water contains admixtures from different manufacturers, the Contractor shall provide evidence that the combination of admixtures are compatible and do not adversely affect the air void system of the hardened concrete as per Section 6-02.3(3).
6. All tests to verify that the physical and chemical requirements are met, shall be conducted on the following schedule:
 - a. The physical requirements shall be tested on weekly intervals for four weeks and thereafter on monthly intervals.
 - b. The chemical requirements shall be tested on monthly intervals.
 - c. The specific gravity shall be determined daily in accordance with ASTM D1429, Test Method D.

The Contractor shall use the services of a Laboratory that has a equipment calibration/ verification system, and a technician training and evaluation process per AASHTO R 18 to conduct all tests. The laboratory shall use testing equipment that has been calibrated/ verified at least once within the past 12 months to meet the requirements of each test procedure in accordance with the appropriate section of AASHTO R 18. Documentation of tester qualifications and equipment verification records shall be maintained and available for review by the Contracting Agency upon request. Agency reviews of the laboratory facility, testing equipment, personnel, and all qualification, calibration, and verification records will be conducted at the Contracting Agency's discretion.

9-25.2 Water for Plants

Water for plants shall not contain dissolved or suspended matter which will be harmful to the plant material on which it is to be used.

9-26 Epoxy Resins**9-26.1 Epoxy Bonding Agents****9-26.1(1) General**

Epoxy bonding agents shall be two-component epoxy resin-base systems that meet the requirements of ASTM C881, shall be furnished in the type, grade, and class specified, and shall meet the requirements below. For pre-packaged cartridge kits, the epoxy bonding agent shall meet the requirements of ASTM C881 when mixed according to the manufacturer's instructions, utilizing the manufacturer's mixing nozzle. When not specified, an appropriate grade and class shall be selected for the particular application. Epoxy bonding agents for patching external concrete shall be concrete-gray in color.

9-26.1(1)A Type I and Type IV

Epoxy bonding agents used for bonding hardened concrete to hardened concrete and other materials shall be Type I for non-load bearing applications and Type IV for load bearing applications.

9-26.1(1)B Type II and Type V

Epoxy bonding agents used for bonding freshly mixed concrete to hardened concrete shall be Type II for non-load bearing applications and Type V for load bearing applications.

9-26.1(1)C Type III

Epoxy bonding agents used for bonding skid-resistant materials to hardened concrete and as a binder in epoxy mortars and epoxy concretes used on traffic bearing surfaces shall be Type III.

9-26.1(2) Packaging and Marking

The components of the epoxy system furnished under these Specifications shall be supplied in separate containers or pre-packaged cartridge kits that are non-reactive with the materials contained. The contents of each container shall be such that when the container contents are combined, a properly proportioned final mixture results.

Separate containers shall be marked by permanent marking that identify the formulator, "Component A" (Contains the Epoxy Resin) and "Component B" (Contains the Curing Agent), type, grade, class, lot or batch number, mixing instructions and the quantity contained in pounds or gallons as defined by these Specifications.

Pre-packaged cartridge kits shall be marked by permanent marking that identify the formulator, type, grade, class, lot or batch number, mixing instructions and the quantity contained in ounces or milliliters as defined by these Specifications.

Potential hazards shall be so stated on the package in accordance with the Federal Hazardous Products Labeling Act and State of Washington, Department of Labor and Industries Regulations for Shipment of Hazardous Products.

9-26.1(3) Certification

If requested by the Contracting Agency, the manufacturer of the epoxy system shall certify that components A and B meet the requirements of this Specification before a sample will be accepted for testing by the Contracting Agency. The Manufacturer's Certificate of Compliance shall be furnished in accordance with Section 1-06.3.

9-26.1(4) Rejection

Except as noted otherwise, the entire lot of both components may be rejected if samples submitted for test fail to meet any requirements of this Specification.

9-26.1(5) Acceptance

Acceptance of the Epoxy Bonding Agents for use on the project shall be based on a passing test report from the State Materials Laboratory.

9-26.2 Epoxy Adhesive for Lane Markers**9-26.2(1) General**

Epoxy adhesives for lane markers shall meet the requirements of AASHTO M237 for Type II – Standard Setting, High Viscosity, Epoxy Adhesive. In lieu of the square base test specimen molds for the Slant Shear Strength test specified in AASHTO M237, cylindrical molds in accordance with ASTM C882 may be used.

9-26.2(2) Packaging and Marking

Packaging and Marking of Epoxy Adhesive for Lane Markers shall meet the requirements of Section 9-26.1(2).

9-26.2(3) Certification

Certification of Epoxy Adhesive for Lane Markers shall meet the requirements of Section 9-26.1(3).

9-26.2(4) Rejection

Rejection of Epoxy Adhesive for Lane Markers shall meet the requirements of Section 9-26.1(4).

9-26.2(5) Acceptance

Acceptance of each lot of the Epoxy Adhesive for Lane Markers for use on the project shall be based on a Manufacturer's Certificate of Compliance.

9-26.3 Epoxy Grout/Mortar/Concrete**9-26.3(1) General**

This Specification shall apply to epoxy grout, epoxy mortar and epoxy concrete for traffic and non-traffic bearing applications. Epoxy grout/mortar/concrete shall consist of an epoxy bonding agent and an aggregate component.

Prepackaged epoxy grout/mortar/concrete shall be prepared from a ready-to-mix epoxy bonding agent/aggregate system supplied by a manufacturer in kit form.

Non-prepackaged epoxy grout/mortar/concrete shall be prepared from an epoxy bonding agent and an aggregate component that is clean, surface dry and inert and that is of a quality and gradation suitable for portland cement mortar or concrete. Aggregate meeting the requirements of Section 9-03.1(2) will be satisfactory. Epoxy grout/mortar/concrete for patching external concrete shall be concrete-gray in color.

9-26.3(1)A Traffic Bearing Applications

Epoxy grout/mortar/concrete for traffic bearing applications shall have a 7-day compressive strength of not less than 4,000 psi when tested in accordance with ASTM C579. Epoxy bonding agent shall be Type III as described in Section 9-26.1(1)C.

9-26.3(1)B Non-Traffic Bearing Applications

Epoxy grout/mortar/concrete for non-traffic bearing applications shall have a 7-day compressive strength of not less than 4,000 psi when tested in accordance with ASTM C579. Epoxy bonding agent shall be Type I, II, IV, or V as appropriate for intended use as described in Sections 9-26.1(1)A and 9-26.1(1)B.

9-26.3(2) Packaging and Marking

Packaging and Marking of the epoxy bonding agent component of epoxy grout/mortar/concrete shall meet the requirements of Section 9-26.1(2).

9-26.3(3) Certification

Certification of the epoxy bonding agent component of epoxy grout/mortar/concrete shall meet the requirements of Section 9-26.1(3).

9-26.3(4) Rejection

Rejection of the epoxy bonding agent component of epoxy grout/mortar/concrete shall meet the requirements of Section 9-26.1(4).

9-26.3(5) Acceptance

Acceptance of the epoxy grout/mortar/concrete material for use on the project shall be based on a passing test report from the State Materials Laboratory.

9-27 Cribbing**9-27.1 Vacant****9-27.2 Vacant****9-27.3 Gabion Cribbing****9-27.3(1) Gabion Fabric**

Gabions may be fabricated from either hexagonal twisted wire or from welded wire. Only one type of wire and protective coating shall be used throughout a structure.

Baskets shall be furnished in the required dimensions with a dimensional tolerance of plus or minus 5 percent.

Wire for construction of gabions shall be either galvanized steel wire conforming to ASTM A641, Class 3, Soft Temper, or aluminized steel wire conforming to ASTM A809, Soft Temper. The wire shall have a minimum tensile strength of 60,000 psi when tested in accordance with ASTM A370.

9-27.3(2) Gabion Baskets

Gabion baskets 1 foot or greater in the vertical dimension shall have openings with nominal dimensions not to exceed 4½ inches and the maximum area of any opening shall not exceed 10 square inches.

1. Hexagonal Twisted Wire

- a. Wire for galvanized or aluminized hexagonal twisted welded wire shall be nominal sized 0.120 inch galvanized steel wire or aluminized steel wire.
- b. Hexagonal twisted wire shall be formed from galvanized or aluminized wire in a uniform hexagonal pattern with nonraveling double twist. The perimeter edges of each panel shall be tied to a selvage wire of the same composition as the panel body and have a minimum diameter of 0.150 inch so that the selvage is at least the same strength as the body of the panel.

2. Welded Wire

- a. Welded wire shall be fabricated from galvanized steel wire having a diameter of 0.106 inch. Wire shall be galvanized prior to fabrication.
- b. Welded wire shall be formed in a uniform square pattern with openings 3 by 3 inches with a resistance weld at each connection in accordance with ASTM A1064.
- c. If required, a PVC coating shall be fusion bonded onto the welded wire mesh to provide a nominal coating thickness of 0.0216 inch per side with a minimum of 0.0150 inch.

3. PVC Coating (For Welded Wire Only)

Acceptance of PVC coating material shall be by certified test reports of an independent laboratory. The initial properties of PVC coating material shall have a demonstrated ability to conform to the following requirements:

- a. **Specific Gravity** – In the range of 1.2 to 1.4, when tested according to ASTM D792.
- b. **Tensile Strength** – Not less than 2,275 psi, when tested according to ASTM D638.
- c. **Modulus of Elasticity** – Not less than 1,980 psi at 100 Strain, when testing according to ASTM D638.
- d. **Hardness** – Shore “A” not less than 75 when tested according to ASTM D2240.

- e. **Brittleness Temperature** – Not higher than 15°F when tested according to ASTM D746.
- f. **Resistance to Abrasion** – The percentage of the mass loss shall be less than 12 percent when tested according to ASTM D1242, Method B at 200 cycles, CSI-A Abrader Tape, 80 Grit.
- g. **Salt Spray Exposure and Ultraviolet Light Exposure** – The PVC shall show no effect after 3,000 hours of salt spray exposure according to ASTM B117. The PVC shall show no effect of exposure to ultraviolet light with test exposure of 3,000 hours using apparatus Type E and 63°C, when tested according to Practice D1499 and Practice G 23. After the salt spray test and exposure to ultraviolet light as specified above, the PVC coating shall not show cracks, blister, split, nor show a noticeable change of color. In addition, the specific gravity, tensile strength, modulus of elasticity, and resistance to abrasion shall not change more than 6, 25, 25, and 10 percent respectively from their initial values.

9-27.3(3) Gabion Mattresses

Gabion baskets less than 1 foot in the vertical dimension shall have openings with nominal dimensions not to exceed 3.3 inches, and the maximum area of any opening shall not exceed 6 square inches.

1. Hexagonal Twisted Wire

- a. Wire for galvanized or aluminized hexagonal twisted wire shall be nominal sized 0.086 inch galvanized steel wire or aluminized steel wire.
- b. Hexagonal twisted wire shall be formed from galvanized or aluminized wire in a uniform hexagonal pattern with nonraveling double twisted. The perimeter edges of each panel shall be tied to a selvage wire of the same composition as the panel body and have a minimum diameter of 0.1062 inch so that the selvage is at least the same strength as the body of the panel.

2. Welded Wire

- a. Welded wire shall be fabricated from galvanized steel wire having a diameter of 0.080 inch. Wire shall be galvanized prior to fabrication.
- b. Welded wire shall be formed in a uniform rectangular pattern with openings 1½ by 3 inches with a resistance weld at each connection in accordance with ASTM A1064.
- c. If required, a PVC coating shall be fusion bonded onto the welded wire to provide a nominal coating thickness of 0.0216 inch per side with a minimum of 0.0150 inch. The PVC coating shall be in conformance with Section 9-27.3(2).

9-27.3(4) Fasteners for Basket Assembly

The lacing wire shall be a nominal sized 0.0866 inch galvanized steel wire or aluminized steel wire. Lacing wire shall have the same coating as the basket.

Spiral binders, if used for joining welded wire panels shall be formed from 0.106 inch nominal diameter steel wire with a 3-inch pitch having the same Specifications and coating as the welded wire. Lacing wire may be used in lieu of spiral binders.

Alternate fasteners for basket assembly shall remain closed when subjected to a 600 pound tensile force when confining the maximum number of wires to be confined. Installation procedures and test results for alternate fasteners shall be submitted for approval.

Internal connecting wires shall be the same as required for lacing wire. Alternate stiffeners acceptable to the gabion manufacturer may be used.

9-27.3(5) Nonraveling Construction

The gabion wire shall be fabricated in a manner to be nonraveling. This is defined as the ability to resist pulling apart at any of the connections forming the panel when a single strand in a section of panel is cut.

9-27.3(6) Stone

Stone for filling gabions shall have a Degradation Factor of at least 30. The stone shall be dense enough to pass the unit weight test described in Section 8-24.3(3)F. Stone shall meet the following requirements for gradation:

Sieve Size	Percent Passing
8"	100
6"	75-90
4"	0-10
% Fracture	75 min.

All percentages are by weight.

9-28 Signing Materials and Fabrication

9-28.1 General

Unless noted otherwise in the Plans, permanent signs shall be constructed of sheet aluminum. Permanent signs which measure 36 inches or less on a side and are to be mounted on a single post may be constructed of single 0.135-inch fiberglass reinforced plastic panels. Sign overlay panels may be either 0.050-inch aluminum or 0.075-inch fiberglass reinforced plastic panels. All signs, except internally illuminated signs, shall be reflectorized.

See ASTM D4956 for reflective sheeting type designations. Standard control signs and guide sign borders, letters, numerals, symbols, shields, and arrows shall be in accordance with the WSDOT [Sign Fabrication Manual](#) M 55-05.

All STOP, YIELD, DO NOT ENTER, WRONG WAY, FREEWAY ENTRANCE, and HIGHWAY ENTRANCE signs shall be constructed entirely of Type IV reflective sheeting. All S series signs shall be constructed entirely of Type XI reflective sheeting unless otherwise specified. Overhead mounted warning signs with a yellow background shall use Type XI background reflective sheeting. Yellow overhead exit only panels shall use Type IV or XI reflective as shown in the Plans. Background reflective sheeting for all other signs shall be Type IV reflective sheeting or as noted in the Plans. Sign legends for all overhead signs shall be Type XI reflective sheeting, while legends on all other signs shall be constructed of Type IV reflective sheeting unless otherwise specified. Sign legends include: borders, letters, numerals, symbols, shields, and arrows. Reflective legend sheeting types shall not be mixed on individual signs.

9-28.2 Manufacturer's Identification and Date

All signs shall show the manufacturer's name and date of manufacture on the back. In addition, the width and height dimension, in inches, the Contract number, and the number of the sign as it appears in the Plans shall be placed using 3-inch series C black letters on the back of destination, distance, and large special signs. Hand painted numbers are not permitted.

9-28.3 Corner Radius

All regulatory and warning signs shall have rounded corners with the exception of stop signs. Information and guide signs may have square cut corners. Borders for signs having square cut corners shall have a corner radius approximately $\frac{1}{8}$ of the lesser side dimension of the sign up to a maximum radius of 12 inches. For signs with rounded corners, the borders shall be concentric with the rounded corners.

9-28.4 Extruded Windbeams and "Z" Bar

All multiple post and multiple panel signs shall be constructed and installed with horizontal extruded windbeams and "Z" bar, when required, as shown in the Plans or the [Standard Plans](#). All bolt and rivet heads visible on the sign face shall be anodized or painted to match the sign color area immediately surrounding the bolt or rivet head with the exception that rivet heads in the white colored sign areas shall be coated to match the white color or be uncoated rivet heads. Extruded windbeams and "Z" bar shall be accepted on the basis of a certificate of compliance from the manufacturer. Materials shall be as designated in Section 9-28.11.

9-28.5 Letter and Spacing Formula

Letter and arrow sizes shall be as specified in the Plans. Spacing formulas shall be those furnished by the manufacturer of the letters.

9-28.6 Destination Sign Messages

Destination sign messages, borders, shields, and symbols shall be direct applied unless otherwise noted in the sign plans. All message components shall be one piece construction unless the least dimension exceeds available sheeting widths. All components shall have smooth, sharp cut edges. Components which are torn, wrinkled, or exhibit poor construction, will not be permitted.

9-28.7 Process Colors

Transparent and opaque process colors used in silk screening sign messages shall be as recommended by the manufacturer. When properly applied, process colors shall perform satisfactorily for the expected life of the sheeting. Applied colors shall present a smooth surface, free from foreign material, and all messages and borders shall be clear and sharp. Sheeting shall conform to the retroreflective minimum values and color limits established for its type and color without regard to whether the color is integral to the sheeting or achieved by applying transparent colors to silver/white sheeting. There shall be no variations in color, and overlapping of colors will not be permitted.

Properly applied and cured process colors shall exhibit no blistering, bubbling, or loss of color or transparency when cleaned with a mild non-abrasive detergent solution. Minor loss of color may be detected when solvents such as kerosene, mineral spirits, heptane, or VM&P Naphtha are used to clean severely contaminated signs; e.g., paint vandalism. However, the colors shall not blister, bubble, peel, or be easily removed.

9-28.8 Sheet Aluminum Signs

Sheet aluminum signs shall be constructed of material conforming to ASTM B209 alloy 6061-T6 or alloy 5052-H36 or H38. Alloy 5005-H34 may be used for sign overlays. The Contractor shall provide a mill test certificate from the aluminum manufacturer attesting to the correct alloy and temper of the metal supplied, when requested by the Engineer.

After the sheeting has been fabricated, the surface of each panel shall be protected from corrosion. The corrosion protection shall meet the requirements of ASTM B449 Class II Specification for Chromates on Aluminum. Aluminum signs over 12 feet wide by 5 feet high shall be comprised of vertical panels in increments of 2, 3, or 4 feet wide. No more than one 2-foot and/or 3-foot panel may be used per sign. The Contractor shall use the widest panels possible. All parts necessary for assembly shall be constructed of aluminum, galvanized steel, or stainless steel in accordance with the Plans. Sheet thickness shall be as follows:

Maximum Horizontal Dimension	Sheet Aluminum Thickness
Overlay panels	0.050 inch
Up to 20 inches	0.063 inch
20 to 36 inches, inclusive	0.080 inch
Over 36 inches (Permanent Signs)	0.125 inch

The side dimension for a diamond shaped warning sign is considered to be the maximum horizontal dimension.

Before placing aluminum in contact with untreated steel, the steel surfaces shall be protected by proper cleaning and painting with one coat of paint conforming to Section 9-08.1(2)B and two coats of aluminum paint.

Metal shall be handled by device or clean canvas gloves between all cleaning and etching operations and the application of reflective sheeting.

9-28.9 Fiberglass Reinforced Plastic Signs

Fiberglass reinforced plastic signs and overlay panels shall be constructed of a fiberglass reinforced thermoset polyester laminate. The sign panel shall be acrylic modified and UV stabilized for outdoor weathering ability.

The sign panel shall be stabilized to prevent the release of migrating constituents (such as solvents, monomers, etc.) over the expected life of the sign. The sign panel shall contain no residue release agents on the surface of the laminate so neither migrating constituents or release agents will be present in amounts which will interfere with any subsequent bonding operations.

The sign panel shall not contain visible cracks, pinholes, foreign inclusions, or surface wrinkles that would affect implied performance, alter the specific dimensions of the panel, or otherwise affect its serviceability.

The sign panel surface shall be wiped clean with a slightly water dampened cloth before applying reflective sheeting.

9-28.9(1) Mechanical Properties

All mechanical properties are stated as minimum requirements. The mechanical properties are measured in both the line direction of the panel and at 90 degrees to the line as noted in the appropriate ASTM test referenced.

Mechanical Property	Ave. Min. Requirement	ASTM Test
Tensile Strength	10.0 psi × 10 ³	D638
Tensile Modulus	1.2 psi × 10 ⁶	D638
Flexural Strength	20.0 psi × 10 ³	D790
Flexural Modulus	1.2 psi × 10 ⁶	D790
Compression Strength	32.0 psi × 10 ³	D695
Compression Modulus	1.4 psi × 10 ⁶	D695
Punch Shear	12.0 psi × 10 ³	D732

9-28.9(2) Physical Properties

Sign Panels are to be 0.135 inch thick. Overlay panels are to be 0.075 inch thick. Panel thickness tolerance shall be plus or minus 0.005 inch. Panel tolerance on nominal length and width shall be plus or minus ⅛ inch for dimensions of 12 feet or less and shall be within ⅛ inch of square per 12 feet of length when measured in accordance with ASTM D3841.

Panels shall be manufactured with smooth surfaces on both top and bottom of the panel.

Panel flatness of a 30 by 30-inch panel shall be measured by hanging the panel diagonally in suspension. The maximum deflection measured diagonally, parallel and perpendicular to the panel by lines drawn through the center of the panel, shall not exceed ½ inch. The panel shall then be hung diagonally in suspension in an oven for 48 hours at 180°F. The maximum deflection shall again be measured as previously noted and shall not exceed ½ inch. All measurements shall be made when panels are at ambient temperature.

Panels shall be pigmented to a visually uniform gray color within the MunsellR range of N.7.5/to N.8.5/.

Panels shall have a maximum coefficient of lineal thermal expansion of 1.8×10^{-5} in/in/°F. when tested in accordance with ASTM D696.

Panels shall be classified as to a minimum Grade II (weather resistant) panel as specified in ASTM D3841 following 3,000 plus or minus 100 hour weatherometer test.

Panels shall contain additives designed to be less responsive to fire ignition and flame propagation. As such, the extent of burning shall not exceed 1.0 inch when tested in accordance with ASTM D635.

Panels shall resist the impact energy of 20 foot-pounds applied with a hemispherical tipped object 1 inch in diameter.

The panels thermal stability for strength and impact resistance qualities shall not be appreciably affected over a temperature range of -65°F to 212°F.

Fiberglass reinforced plastic panels for signs shall be accepted on the basis of a certificate of compliance from the manufacturer as outlined in Section 1-06.3.

9-28.10 Digital Printing

Transparent and opaque durable inks used in digital printed sign messages shall be as recommended by the manufacturer. When properly applied, digital printed colors shall have a warranty life of the base retroreflective sign sheeting. Digital applied colors shall present a smooth surface, free from foreign material, and all messages and borders shall be clear and sharp. Digital printed signs shall conform to 70% of the retroreflective minimum values established for its type and color. Digitally printed signs shall meet the daytime color and luminance, and nighttime color requirements of ASTM D 4956. No variations in color or overlapping of colors will be permitted. Digital printed permanent traffic signs shall have an integrated engineered match component clear protective overlay recommended by the sheeting manufacturer applied to the entire face of the sign. On Temporary construction/maintenance signs printed with black ink only, the protective overlay film is optional, as long as the finished sign has a warranty of a minimum of three years from sign sheeting manufacturer.

All digital printed traffic control signs shall be an integrated engineered match component system. The integrated engineered match component system shall consist of retroreflective sheeting, durable ink(s), and clear overlay film all from the same manufacturer applied to aluminum substrate conforming to Section 9-28.8.

The sign fabricator shall use an approved integrated engineered match component system as listed on the Qualified Products List (QPL). Each approved digital printer shall only use the compatible retroreflective sign sheeting manufacturer's engineered match component system products.

Each retroreflective sign sheeting manufacturer/integrated engineered match component system listed on the QPL shall certify a Contracting Agency approved sign fabricator is approved to operate their compatible digital printer. The sign fabricator shall re-certify annually with the retroreflective sign manufacturer to ensure their digital printer is still meeting manufacturer's specifications for traffic control signs. Documentation of each re-certification shall be submitted to the QPL Engineer annually.

9-28.11 Hardware

Bolts, nuts, locknuts, and washers shall be of the same material for each attachment. Bolts, nuts, locknuts, and washers for signs mounted on overhead sign structures (i.e., sign bridges, cantilevers sign structures, and bridge mounted sign brackets) shall be stainless steel only.

Hardware	Specification
Bolts	ASTM F468 2024-T4 Aluminum ASTM A307 Steel ASTM F593 Group 1, Condition A Stainless Steel, or ASTM A193, Grade B8, Class 1 Stainless Steel
U-bolts	ASTM A276 Type 304 Stainless Steel
Washers	ASTM B209 2024-T4 Aluminum ASTM F844 Steel ANSI B18.22.1 Stainless Steel Alloy 304
Nuts	ASTM F467 2024-T4 Aluminum ASTM A563 Grade A Steel ASTM F594 Group 1 Stainless Steel, or ASTM A194 Grade 8 or 8A Stainless Steel
Locknuts (with nylon insert unless otherwise in the Plans)	ASTM F467 2024-T4 Aluminum ASTM A563 Grade A Steel ASTM F594 Group 1 Stainless Steel, or noted ASTM A194 Grade 8 or 8A Stainless Steel
Rivets	ASTM B316 5052 Aluminum Alloy ASTM B316 5056 Aluminum Alloy
Post Clips	ASTM B179 356-T6 Aluminum
Windbeams	ASTM B221 6061-T6 Aluminum
Angle and "Z" Bar	ASTM B221 6061-T6 Aluminum ASTM A36 or ASTM A992 Steel
Strap and Mounting Bracket	ASTM A666, Type 201 Stainless Steel

All steel parts shall be galvanized in accordance with AASHTO M111. Steel bolts and related connecting hardware shall be galvanized in accordance with ASTM F 2329.

9-28.12 Reflective Sheeting

Reflective sheeting material shall conform to ASTM D4956 - *Standard Specification for Retroreflective Sheeting for Traffic Control*. The following standard reflective sheeting types have been modified to reflect Contracting Agency requirements:

Device Type	Use	Sheeting Color	Sheeting Types
Permanent Signing			
Permanent Signing	All	All	IV ¹
Object Markers	All	All	IV
Temporary Construction Signing			
Warning Signs	All	Fluorescent Orange	VIII, IX, X ² , XI
Regulatory Signs	All	White	IV

Device Type	Use	Sheeting Color	Sheeting Types
Regulatory Signs	Rural	White	II ³ , IV
Regulatory Signs	Urban/Rural	White	II ³ , IV
Regulatory Signs	All	Red	III, IV
Regulatory Signs	All	Green	II, IV
Regulatory Letters, Border or Symbols	-	Green	III ³ , IV
Temporary Construction Signs	All	All Other Background Colors	III ³ , IV
Other Devices			
Barricades	All	White or Orange	III ³ , IV
Barrier Delineators	All	White or Yellow	III, IV, V, XI
Bollards	All	All	IV
Flexible Guidepost	All	All	III, IV, V
Pedestrian Channelization Devices	All	White or Orange	III ³ , IV
Signal Backplates	Portable Signals		IV
Signal Backplates	Permanent Signals		See Section 9-29.16
Tall Channelization Devices - 42-inch	All	Fluorescent Orange/White	III ⁴ , IV ⁴ , VIII, IX, XI
Traffic Cones 28-inch and 36-inch	All	White or Higher White	III ³ , IV
Traffic Safety Drums	All	Fluorescent Orange/White	III ⁴ , IV ⁴ , VIII, IX, XI ⁴
Transportable Attenuators	All	Yellow and Black Chevron	III ³ , IV
Transportable Attenuators	All	White and Red Chevron	IV
Tubular Markers (portable or pavement mounted)	All	White or Yellow	III ³ , IV
Utilities Attached to Bridges			I, See Section 6-01.10

1. Except S Series signs with fluorescent yellow green sheetings shall use Type XI and Overhead Warning Signs and Overhead Exit Only panels with fluorescent yellow shall use Type IV or XI.
2. Former Type X, not shown in ASTM 04956, however meets requirements of Types VII, IX, and XI.
3. Only devices in inventory may be used, new fabrication shall use Type IV.
4. Type III and Type IV orange and white sheeting may be still used through December 31, 2026.

9-28.12(1) Application

The reflective sheeting shall be applied in the manner specified by the sheeting manufacturer. The applied sign face shall not have bubbles, wrinkles, or foreign material beneath the reflective sheeting.

9-28.12(2) Edge Treatment

All edges and splices of reflective sheeting signs shall be coated with an edge sealer when recommended by the manufacturer of the reflectorized sheeting.

9-28.12(3) Splices and Color Matching

Splicing of reflective sheeting shall not be permitted on signs or panels with dimensions up to and including 48 inches in height or width unless the reflective sheeting specified does not come in this width, then the widest width material shall be used. When sheeting joints are required, they shall be lap-jointed with the top sheet overlapping the bottom sheet by no less than $\frac{3}{16}$ inch. The fabricator shall endeavor to use the least number of seams possible with the horizontal lap preferable. Roller applied or reverse screened sheeting may be butt-jointed with joint gap not to exceed $\frac{1}{32}$ inch. Color matching of adjacent sheets of reflective sheeting comprising a sign shall be accomplished without a noticeable difference in color. No borders shall be spliced other than the splice of the tangent border to the corner radius.

9-28.13 Demountable Prismatic Reflectorized Message and Borders

The letters, digits, and alphabet accessories shall consist of embossed 0.040-inch thick sheet aluminum frames conforming to ASTM B209 grade 3003-H14 in which prismatic reflectors are installed to prevent their displacement in handling or service. Letters in which reflectors are assembled by means of tape are unacceptable. The plastic reflectors face shall be colorless and be entirely smooth to present a water repellent and dirt resistant surface. The area indicating the letter shape that is not reflectorized shall be white for maximum daytime contrast with the sign background. All letters shall be free of any imperfections and shall present a high quality appearance. Demountable prismatic border shall be comprised of a minimum length of 2 feet with allowance of one shorter section between each corner radius.

Letters shall be fastened to the sign with aluminum screws or blind rivets conforming to ASTM B209 grade 2024-T4.

The coefficient of retroreflection of each reflex reflector intended for use in cutout letters, symbols, and accessories shall be equal to or exceed the following minimum values with measurements made with reflectors spinning.

Observation Angle (Degrees)	Entrance Angle (Degrees)	Coefficient of Retroreflection Candle Power/Square inch/Foot Candle
0.1	0	14.0
0.1	20	5.6

Failure to meet the specific minimum values shall constitute failure of the reflector being used. Upon failure of more than two of the 50 samples tested, a resample of 100 reflectors shall be tested. Failure of more than four of these samples shall be cause for rejection of the lot.

9-28.14 Sign Support Structures

All sign support structures shall be constructed as shown in the Plans.

9-28.14(1) Timber Sign Posts

At the Contractor's options, timber sign posts and mileposts shall be treated Douglas Fir or treated Hem-Fir meeting the grades specified in Section 9-09.2. Douglas Fir and Hem-Fir posts shall be given a treatment in accordance with Section 9-09.3(1). Preservative and retention shall be as shown in Section 9-16.2 for sawn posts.

9-28.14(2) Steel Structures and Posts

Truss chords, struts, and diagonals, end posts, and end post struts and diagonals for sign bridge structures and cantilever sign structures shall conform to either ASTM A36 or ASTM A53 Grade B Type E or S. The nominal pipe diameter and the pipe wall thickness shall be as shown in the Plans or *Standard Plans*. All other structural steel for sign bridge structures and cantilever sign structures shall conform to either ASTM A36 or ASTM A992. Truss member connection hardware shall conform to Section 9-06.5(3).

Pipe members for bridge mounted sign brackets shall conform to ASTM A53 Grade B Type E or S, and shall be Schedule 40 unless otherwise specified. All other structural steel for bridge mounted sign brackets shall conform to either ASTM A36 or ASTM A992. U bolts, and associated nuts and washers, shall be stainless steel conforming to Section 9-28.11, and shall be fabricated hot.

Anchor rods for sign bridge and cantilever sign structure foundations shall conform to Section 9-06.5(4), including Supplemental Requirement S4 tested at -20°F. Nuts and washers for sign bridge and cantilever sign structure foundations shall conform to ASTM A563 Grade DH and ASTM F436, respectively.

Steel sign structures and posts shall be galvanized after fabrication in accordance with AASHTO M111, unless noted otherwise in the Plans. All bolts, nuts, and washers shall be galvanized after fabrication in accordance with ASTM F2329. Unless otherwise specified in the Plans or Special Provisions, metal surfaces shall not be painted.

Except as otherwise noted, steel used for sign structures and posts shall have a controlled silicon content of either 0.00 to 0.06 percent or 0.15 to 0.25 percent. Steel used for slip bases (SB-1, SB-2, SB-3) and heavy-duty anchors shall have a controlled silicon maximum of 0.40 percent. If the Plans or Special Provisions specify painting of the galvanized steel surfaces, then the controlled silicon content requirement does not apply for those steel members. Mill test certificates verifying the silicon content of the steel shall be submitted to both the galvanizer and the Engineer prior to beginning galvanizing operations.

Minor fabricating and modifications necessary for galvanizing will be allowed if not detrimental to the end product as determined by the Engineer. If such modifications are contemplated, the Contractor shall submit a Type 2 Working Drawing of the proposed modifications.

9-28.14(2)A Monotube Sign Bridge and Cantilever Sign Structures

Structural steel, except for cover plates, anchor rod templates and as otherwise shown in the Plans, shall conform to either ASTM A572 Grade 50, or ASTM A588. Cover plates shall conform to ASTM A36.

Handhole cover screws shall conform to ASTM F593, Grade 1.

Sign bracket bolts, nuts, and washers shall conform to Section 9-06.5(1).

Monotube splice bolts, mounting beam bolts, and associated nuts and washers, shall conform to ASTM F3125 Grade A325, and shall be galvanized after fabrication in accordance with ASTM F2329. Tension control bolts conforming to ASTM F 3125 Grade F1852 may be used as monotube splice bolts, and if used shall be galvanized after fabrication in accordance with ASTM B695 Class 55 Type I. Monotube sign bracket rods shall conform to Section 9-06.5(1) and shall be galvanized after fabrication in accordance with ASTM F2329.

Anchor rods and associated nuts and washers shall conform to Section 9-06.5(4) with supplemental requirement S4 tested at -20°F. Anchor rods shall be galvanized a minimum of 1'-0" at the exposed end in accordance with ASTM F2329. Nuts and washers shall be galvanized in accordance with ASTM F2329.

9-28.14(3) Aluminum Structures

Welding of aluminum shall be in accordance with AWS D1.2/D1.2M, latest edition, Structural Welding Code – Aluminum.

Aluminum alloy filler metals utilized on anodized structures shall result in color matching to base metals.

9-28.15 Vacant

9-29 Illumination, Signal, Electrical**9-29.1 Conduit, Innerduct, and Outerduct**

Conduit shall be free from defects, including out of round and foreign inclusions. Conduit shall be uniform in color, density, and physical properties. The inside shall be smooth and free from burrs, which could damage cable during installation. Conduit ends shall be cut square to the inside diameter and supplied with thread protectors. All conduit, conduit fittings, and associated hardware/appurtenances shall be listed by a Nationally Recognized Testing Laboratory.

9-29.1(1) Rigid Metal Conduit, Galvanized Steel Outerduct, and Fittings

Rigid metal conduit (RMC) shall be straight and be rigid galvanized steel or stainless steel, as required, and bear the mark of a Nationally Recognized Testing Laboratory. Exterior and interior surfaces of the galvanized steel conduit, except threaded ends, shall be uniformly and adequately zinc coated by a hot-dip galvanizing process. The average of the zinc coating shall comply with Federal Specification WW-C-581d.

9-29.1(2) Rigid Metal Conduit Fittings and Appurtenances

Couplings for RMC may be either hot-dip or electroplated galvanized.

Conduit bodies and fittings for RMC systems shall be listed by a Nationally Recognized Testing Laboratory listed for wet locations and shall be hot-dip galvanized malleable iron or bronze. Conduit bodies shall have tapered threads and include a bolt on cover with stainless steel screws and a neoprene gasket seal.

Grounding end bushings shall be bronze or galvanized malleable iron with copper, tinned copper, stainless steel, or integral lug with stainless steel clamping screw, mounting screw, and set screw.

Conduit clamps and straps shall be Type 304 or Type 316 stainless steel or hot-dip galvanized. Two-hole-type straps shall span the entire width of the support channel and attach to the supports on both sides of the conduit with bolts and associated hardware. Two-piece conduit clamps shall interlock with the support channel with a single bolt.

Conduit supports for surface-mounted conduit shall be hot-dip galvanized or Type 304 or Type 316 stainless steel channel using Type 304 or Type 316 stainless steel bolts and spring nuts.

9-29.1(2)A Expansion Fittings, Deflection Fittings, and Combination Expansion/Deflection Fittings

Expansion fittings for RMC shall be weather tight, with hot-dip galvanized malleable or ductile iron end couplings and body and shall allow for 4 inches of movement minimum (2 inches in each direction). Expansion fittings for RMC shall have an external tinned copper bonding jumper or an internal tinned copper bonding jumper. The internal tinned copper bonding jumper shall not reduce the conduit conductor capacity.

Deflection fittings for RMC shall be weather tight, with hot-dip galvanized ductile iron or bronze end couplings, with molded neoprene sleeve, stainless steel bands, and internal tinned copper bonding jumper. Deflection fittings shall provide for conduit movement of $\frac{3}{4}$ inch in all directions and angular movement of 30 degrees in any direction.

A combination of a deflection and an expansion fitting for RMC shall be assembled from a deflection fitting and an expansion fitting as defined above.

The bonding jumper used for expansion fittings and combination expansion deflection fittings shall be a tinned copper braid attached to the conduit with a galvanized "U" bolt-type connection designed for the application.

9-29.1(3) Flexible Metal Conduit

Liquidtight flexible metal conduit (LFMC) shall consist of a single strip of continuous flexible interlocked steel galvanized inside and out, forming a smooth internal wiring channel with a liquid tight covering of sunlight-resistant flexible PVC conforming to NEC Article 350.

9-29.1(3)A Flexible Metal Conduit Appurtenances

Liquidtight connectors shall be the insulated throat type, conforming to NEC Article 350, and listed for wet locations.

9-29.1(4) Non-Metallic Conduit**9-29.1(4)A Rigid PVC Conduit**

Rigid PVC conduit shall conform to NEMA TC 2 and UL 651. Fittings shall conform to NEMA TC-3, and be UL 514C and UL 651.

PVC solvent cement shall meet ASTM D2564, including note 8 (label to show pipe sizes for which the cement is recommended).

9-29.1(4)B Expansion Fittings

Expansion fittings for use with PVC shall allow for 4 inches of movement minimum (2 inches in each direction). Expansion fittings for PVC conduit shall be PVC and have a threaded terminal adaptor or coupling end, and shall meet the requirements listed in Section 9-29.1(4)A.

9-29.1(4)C HDPE Conduit

HDPE conduit shall be listed by a Nationally Recognized Testing Laboratory recognized by the United States Department of Labor, Occupational Safety and Health Administration's Nationally Recognized Testing Laboratory (NRTL) Program. Couplings for HDPE shall be mechanical and listed for use with HDPE.

Aluminum mechanical couplings are prohibited.

9-29.1(4)D Deflection Fittings

Deflection Fittings for use with rigid PVC conduit shall be as described in Section 9-29.1(2)A.

9-29.1(5) Innerduct and Outerduct

The innerduct system shall be factory-installed and shall be designed so that expansion and contraction of the innerducts takes place in the coupling body to eliminate compatibility problems. The conduit coupling body shall have a factory-assembled gasket that is multistage and antireversing, sealing both the outerduct and innerducts. A secondary midbody O-ring gasket shall be seated into the coupling body and shall hold the coupling body firmly in the outerduct.

All fittings, adapters, and bends (sweeps) shall be provided and shall be manufactured from the same materials and manufacturing process as the conduit, except as specified otherwise. The conduit system shall be a complete system with the following accessories:

Manhole Terminator Kits	Conduit and Innerduct Plugs
Deflection Fittings	Pull string
Offset Fittings	Pull rope
Expansion/Contraction Fittings	Conduit spacers
Repair Kits	Split Plugs

9-29.1(5)A Rigid Galvanized Steel Outerduct With PVC or PE Innerduct

Each section of steel outerduct shall be supplied with one reversing spin coupling that allows straight sections and fittings to be joined without spinning the conduit. The reversing coupling shall be galvanized and have three setscrews or a lock nut ring to lock the coupling in place. Setscrews or lock nut ring shall be galvanized or stainless steel and ensure continuous electrical ground. The couplings shall be galvanized steel with the same material properties as the conduit.

The conduit system shall be designed so that assembly of components can be accomplished in the following steps:

1. Loosen setscrews or lock nut ring on coupling and spin back to allow for insertion.
2. Spin coupling mating sections forward to bottom.
3. Tighten setscrews on lock nut ring.

9-29.1(5)B Rigid PVC Outerduct With PVC or PE Innerduct

Protective outerduct for Schedule 40 PVC and Schedule 80 PVC conduit outerduct shall be 4 inch with a minimum 5-inch extended integral "bell end" and shall be gray in color. The outerduct minimum wall thickness shall be 0.23 inch for Schedule 40 PVC and 0.32 inch for Schedule 80 PVC.

Conduit and fittings for PVC outerduct shall be manufactured with an ultraviolet inhibitor.

The coupling body for PVC outerduct shall include a factory-assembled, multistage gasket that is antireversing, sealing both the outer and innerducts. A secondary midbody gasket shall be seated at the shoulder of the bell to ensure air and water integrity of the system. The bell end and the coupling body assembly shall accept a minimum of 5 inches of the spigot end.

The conduit system shall be designed so that straight sections and fittings will assemble without the need for lubricants or cement.

PVC outerduct shall have a longitudinal print-line that denotes "Install This Side Up" for proper innerduct alignment. PVC outerducts shall have a circumferential ring on the spigot end of the duct to provide a reference point for ensuring the proper insertion depth when connecting conduit ends. The line shall be a minimum of 5 inches from the end of the conduit.

9-29.1(5)C Innerduct for Straight Sections of Galvanized Steel Outerduct or PVC Outerduct

The innerducts shall have a minimum outside diameter of 1.25 inch and a minimum inside diameter of 1.2 inch. Larger diameter innerducts may be provided if the wall thickness and diameter tolerances are met. The tolerance for inside and outside diameters shall be 0.005 inch. The innerducts shall have a minimum wall thickness of 0.060 inch. Innerduct shall be color coded and shall index a minimum of one innerduct with a different color. Alternate color codes are permitted as long as the color codes are contiguous between adjacent junction boxes. The innerducts shall be factory installed in the outerduct.

Dynamic coefficient of friction of innerducts shall be tested in accordance with Telcordia GR-356-CORE procedure. The coefficient of friction shall be less than 0.30 between medium-density polyethylene jacketed fiber optic cable and the prelubricated innerduct. The coefficient of friction shall be less than 0.10 between the ¼-inch diameter polypropylene rope (suitable for fiber optic cable pulling) and the prelubricated innerduct. Pull rope used for testing (meeting the 0.10 coefficient of friction requirement) shall be the same type as the pull rope used for cable installation. The Contractor shall provide as part of the conduit submittals a certificate of compliance with these coefficient of friction requirements.

The innerduct shall have a smooth, nonribbed interior surface, with a factory prelubricated coating. The coating shall provide the required dynamic coefficient of friction.

Innerduct shall be extruded polyvinyl chloride (PVC) or polyethylene (PE).

The coupling body for the innerduct shall be factory assembled in the bell end of the outerduct and shall be manufactured from a high-impact engineered thermoplastic. The coupling body face shall be supplied with lead-ins to facilitate assembly.

All outerduct shall be marked with data traceable to plant location.

9-29.1(5)D Conduit With Innerducts Fittings and Appurtenances

Duct plugs shall be polypropylene and be equipped with a neoprene or polyurethane gasket. Plugs shall be equipped with an attachment to secure the pull rope in the innerduct. The plug shall withstand 5 psi.

9-29.1(5)D1 Bends for 4-Inch PVC Conduit With Innerducts or Galvanized Steel Conduit With Innerducts

All bend radii shall be 36 inches or greater. The conduit system shall provide a complete line of fixed and flexible sweeps with system-compatible bell and spigot or threaded ends. The bends shall contain high-temperature burn-through-resistant innerducts manufactured from PVC, PE, or Nylon-66. The innerducts shall meet all other requirements for innerduct in Sections 9-29.1(1) and 9-29.1(5)A.

9-29.1(5)D2 Prefabricated Fixed and Flexible Bends (for Innerducts)

The prefabricated standard fixed PVC bends shall have a radius between 4 and 9 feet and sweep angles of 11.25, 22.5, 45, or 90 degrees.

Flexible bends shall be prefabricated. These conduits may be field bent to a uniform radius no less than 4 feet. The field bend shall be no greater than 90 degrees. Grounding shall be continuous in flexible bends. Outerduct for flexible ends shall be manufactured from reinforced PVC. Expansion and deflection fittings for rigid galvanized steel conduit with innerduct shall be provided in accordance with Section 9-29.1(2)A.

9-29.1(6) Detectable Underground Warning Tape

Detectable Underground Warning tape shall be Orange imprinted in black lettering with the message "FIBER OPTIC CABLE BURIED BELOW" or equal. The warning tape shall be polyethylene with a metallic backing. The polyethylene shall be a minimum 4 mils thick and 3 inches wide.

9-29.1(7) Steel Casings

Steel casing material shall conform to ASTM A252 Grade 2 or 3 or casing as approved by the Engineer. The Contractor shall furnish pipe of adequate thickness to withstand the forces exerted by the boring operation as well as those forces exerted by the earth during installation and shall be a minimum of $\frac{3}{8}$ inch thick. All joints shall be welded by a welder qualified in accordance with AWS D1.1 structural welding code, Section 3.

9-29.1(8) Drilling Fluid

Drilling fluid used for directional boring shall be an inert mixture of water and bentonite clay, conforming to the drilling equipment manufacturer's recommendations.

9-29.1(9) Repair

Manufacturer repair kits shall be used for field repair of existing conduit, innerduct and outerduct. The conduit repair kit shall be manufactured specifically for the repair of existing damaged conduit, inner duct and outer duct. The repair kit shall be prepackaged and include the split conduit and split couplings necessary to restore the damaged conduit to the original inside dimensions including a water and airtight seal.

9-29.1(10) Pull Tape

Pull tape shall be pre-lubricated polyester pulling tape. The pull tape shall have a minimum width of ½-inch and a minimum tensile strength of 500 pounds. Pull tape may have measurement marks.

9-29.1(11) Foam Conduit Sealant

Foam conduit sealant shall be self-expanding waterproof foam designed to prevent both water and pest intrusion. The foam shall be designed for use in and around electrical equipment, including both insulated and bare conductors.

9-29.2 Junction Boxes, Cable Vaults, and Pull Boxes

The Contractor shall perform quality control inspection. The Contracting Agency intends to perform Quality Assurance Inspection. By its inspection, the Contracting Agency intends only to verify the quality of that Work. This inspection shall not relieve the Contractor of responsibility for identifying and replacing defective material and workmanship. Prior to the start of production of the precast concrete units, the Contractor shall advise the Engineer of the production schedule. The Contractor shall give the Inspector safe and free access to the Work. If the Inspector observes non-specification Work or unacceptable quality control practices, the Inspector will advise the plant manager. If the corrective action is not acceptable to the Engineer, the unit(s) will be rejected.

9-29.2(1) Junction Boxes

For the purposes of this Specification concrete is defined as portland cement or blended hydraulic cement concrete and non-concrete is all others.

The Contractor shall provide shop drawings for all components, hardware lid, frame, reinforcement, and box dimensions. The shop drawings shall be prepared by (or under the supervision of) a Professional Engineer, licensed under Title 18 RCW, State of Washington, in the branch of Civil or Structural. Each sheet shall carry the following:

1. Professional Engineer's original signature, date of signature, original seal, and registration number. If a complete assembly drawing is included which references additional drawing numbers, including revision numbers for those drawings, then only the complete assembly drawing is required to be stamped.
2. The initials and dates of all participating design professionals.
3. Clear notation of all revisions including identification of who authorized the revision, who made the revision, and the date of the revision.

Design calculations shall carry on the cover page, the Professional Engineer's original signature, date of signature, original seal, and registration number.

For each type of junction box, or whenever there is a change to the junction box design, a proof test, as defined in this Specification, shall be performed and new shop drawings submitted.

9-29.2(1)A Standard Duty Junction Boxes

Standard Duty Junction Boxes are defined as Type 1, 2 and 8 junction boxes and shall have a minimum load rating of 22,500 pounds and be tested in accordance with Section 9-29.2(5). A complete Type 8 Junction Box includes the spread footing shown in the [Standard Plans](#). All Standard Duty Junction Boxes placed in sidewalks, walkways, and shared use paths shall have slip resistant surfaces. Non-slip lids and frames shall be hot dip galvanized in accordance with AASHTO M111.

9-29.2(1)A1 Concrete Junction Boxes

The Standard Duty Concrete Junction Box steel frame, lid support, and lid shall be painted with a black paint containing rust inhibitors or painted with a shop applied, inorganic zinc primer in accordance with Section 6-07.3, or hot-dip galvanized in accordance with AASHTO M 111.

Concrete used in Standard Duty Junction Boxes shall have a minimum compressive strength of 6,000 psi when reinforced with a welded wire hoop, or 4,000 psi when reinforced with welded wire fabric or fiber reinforcement. The frame shall be anchored to the box by welding headed studs $\frac{3}{8}$ by 3 inches long, as specified in Section 9-06.15, to the frame. The wire fabric shall be attached to the studs and frame with standard tie practices. The box shall contain ten studs located near the centerline of the frame and box wall. The studs shall be placed one anchor in each corner, one at the middle of each width and two equally spaced on each length of the box.

Materials for Type 1, 2, and 8 Concrete Junction Boxes shall conform to the following:

Materials	Requirement
Concrete	Section 6-02
Reinforcing Steel	Section 9-07
Fiber Reinforcing	ASTM C1116, Type III
Lid	ASTM A786 diamond plate steel
Slip Resistant Lid	ASTM A36 steel
Frame	ASTM A786 diamond plate steel or ASTM A36 steel
Slip Resistant Frame	ASTM A36 steel
Lid Support	ASTM A36 steel, or ASTM A1011 SS Grade 36 (or higher)
Handle & Handle support	ASTM A36 steel, or ASTM A1011 CS (All Grades) or SS (All Grades)
Anchors (studs)	Section 9-06.15
Bolts, Studs, Nuts, Washers	ASTM F593 or A193, Type 304 or 316, or Stainless Steel grade 302, 304, or 316 steel in accordance with approved shop drawings
Locking and Latching Mechanism Hardware and Bolts	In accordance with approved shop drawings

9-29.2(1)A2 Non-Concrete Junction Boxes

Material for the non-concrete junction boxes shall be of a quality that will provide for a similar life expectancy as portland cement or blended hydraulic cement concrete in a direct burial application.

Type 1, 2, and 8 non-concrete junction boxes shall have a Design Load of 22,500 pounds and shall be tested in accordance with Section 9-29.2(5). Non-concrete junction boxes shall be gray in color and have an open bottom design with approximately the same inside dimensions, and present a load to the bearing surface that is less than or equal to the loading presented by the concrete junction boxes shown in the [Standard Plans](#). Non-concrete junction box lids shall be steel and shall include a pull slot and shall be secured with two stainless steel Penta-head auger bolts recessed into the cover. The tapped holes for the securing bolts shall extend completely through the box to prevent accumulation of debris. Bolts shall conform to ASTM F593, stainless steel.

9-29.2(1)B Heavy-Duty Junction Boxes

Heavy-Duty Junction Boxes are defined as Type 4, 5 and 6 junction boxes and shall be concrete and have a minimum vertical load rating of 46,000 pounds without permanent deformation and 60,000 pounds without failure when tested in accordance with Section 9-29.2(5).

The Heavy-Duty Junction Box steel frame, lid support and lid fabricated from steel plate and shapes shall be painted with a shop applied, inorganic zinc primer in accordance with Section 6-07.3. Ductile iron and gray iron castings shall not be painted.

The concrete used in Heavy-Duty Junction Boxes shall have a minimum compressive strength of 4,000 psi.

Materials for Type 4, 5, and 6 Concrete Junction Boxes shall conform to the following:

Materials	Requirement
Concrete	Section 6-02
Reinforcing Steel	Section 9-07
Lid	ASTM A786 diamond plate steel, rolled from plate complying with ASTM A572, grade 50 or ASTM A588, and having a min. CVN toughness of 20 ft-lb at 40 degrees F Or Ductile iron casting meeting Section 9-05.15
Frame and stiffener plates	ASTM A572 grade 50 or ASTM A588, both with min. CVN toughness of 20 ft-lb at 40 degrees F Or Gray iron casting meeting Section 9-05.15
Handle	ASTM A36 steel or ASTM A1011 Grade CS or SS
Anchors (studs)	Section 9-06.15
Threaded Anchors for Gray Iron Frame	ASTM F1554 grade 55 Headed Anchor Requirements
Bolts, Studs, Nuts, Washers	ASTM F593 or A193, Type 304 or 316, or Stainless steel grade 302, 304, or 316 in accordance with approved shop drawing
Hinges and Locking and Latching Mechanism and associated Hardware and Bolts	In accordance with approved shop drawings
Safety Bars	In accordance with approved shop drawings

The bearing seat and lid perimeter shall be free from burrs, dirt, and other foreign debris that would prevent solid seating. Bolts and nuts shall be liberally coated with anti-seize compound. Bolts shall be installed snug tight. The bearing seat and lid perimeter shall be machined to allow a minimum of 75 percent of the bearing areas to be seated with a tolerance of 0.0 to 0.005 inches measured with a feeler gage. The bearing area percentage will be measured for each side of the lid as it bears on the frame.

9-29.2(2) Cable Vaults and Pull Boxes

Cable Vaults and Pull Boxes shall be constructed as a concrete box and as a concrete lid. The lids for the Cable Vaults and Pull Boxes shall be interchangeable and both shall fit the same box as shown in the [Standard Plans](#).

The Contractor shall provide shop drawings for all components, including concrete box, Cast Iron Ring, Ductile Iron Lid, Steel Rings, and Lid. In addition, the shop drawings shall show placement of reinforcing steel, knock outs, and all other appurtenances. The shop drawing shall be prepared by or under the direct supervision of a Professional Engineer,

licensed under Title 18 RCW, State of Washington, in the branch of Civil or Structural. Each sheet shall carry the following:

1. Professional Engineer's original signature, date of signature, original seal, and registration number. If a complete assembly drawing is included which references additional drawing numbers, including revision numbers for those drawings, then only the complete assembly drawing is required to be stamped.
2. The initials and dates of all participating design professionals.
3. Clear notation of all revisions including identification of who authorized the revision, who made the revision, and the date of the revision.

Design calculations shall carry on the cover page, the Professional Engineer's original signature, date of signature, original seal, and registration number.

For each type of box or whenever there is a change to the Cable Vault or Pull Box design, a proof test, as defined in this Specification, shall be performed and new shop drawings submitted.

9-29.2(2)A Standard Duty Cable Vaults and Pull Boxes

Standard Duty Cable Vaults and Pull Boxes shall be concrete and have a minimum load rating of 22,500 pounds and be tested in accordance with Section 9-29.2(5). For the purposes of this Section, Small Cable Vaults are considered a type of Standard Duty Cable Vault.

Concrete for Standard Duty Cable Vaults and Pull Boxes shall have a minimum compressive strength of 4,000 psi. The lid frame shall be anchored to the vault/box concrete lid by welding headed studs $\frac{3}{8}$ by 3 inches long, as specified in Section 9-06.15, to the frame. The wire fabric shall be attached to the studs and frame with standard tie practices. The vault/box concrete lid shall contain ten studs located near the centerline of the frame and wall. Studs shall be placed one anchor in each corner, one at the middle of each width and two equally spaced on each length of the vault/box. The steel frame, lid support, and lid shall be painted with a black paint containing rust inhibitors or painted with a shop applied, inorganic zinc primer in accordance with Section 6-07.3 or hot-dip galvanized in accordance with AASHTO M111.

All Standard Duty Cable Vaults and Pull Boxes placed in sidewalks, walkways, and shared-use paths shall have slip-resistant surfaces. The steel frame, lid support, and lid for the Standard Duty Cable Vaults and Pull Boxes shall be hot-dip galvanized.

Materials for Standard Duty Cable Vaults and Pull Boxes shall conform to the following:

Materials	Requirement
Concrete	Section 6-02
Reinforcing Steel	Section 9-07
Lid	ASTM A786 diamond plate steel
Slip Resistant Lid	ASTM A36 steel
Frame	ASTM A36 steel
Slip Resistant Frame	ASTM A36 steel
Lid Support	ASTM A36 Steel, or ASTM A1011 Grade SS
Handle & Handle Support	ASTM A36 steel or ASTM A1011 Grade CS or SS
Anchors (studs)	Section 9-06.15
Bolts, Studs, Nuts, Washers	ASTM F593 or A193, type 304 or 316, or Stainless steel grade 302, 304, 316 in accordance with approved shop drawing
Hinges and Locking Mechanism Hardware and Bolts	In accordance with approved shop drawings

9-29.2(2)B Heavy-Duty Cable Vaults and Pull Boxes

Heavy-Duty Cable Vaults and Pull Boxes shall be constructed of concrete having a minimum compressive strength of 4,000 psi, and have a minimum vertical load rating of 46,000 pounds without permanent deformation and 60,000 pounds without failure when tested in accordance with Section 9-29.2(5).

Materials for Heavy Duty Cable Vaults and Pull boxes shall conform to the following:

Materials	Requirement
Concrete	Section 6-02
Reinforcing Steel	Section 9-07
Cover	Section 9-05.15(1)
Ring	Section 9-05.15(1)
Anchors (studs)	Section 9-06.15
Bolts, Nuts, Washers	ASTM F593 or A193, Type 304 or 316, or Stainless steel grade 302, 304, 316 in accordance with approved shop drawing

9-29.2(3) Structure Mounted Junction Box

Surface mounted junction boxes and concrete embedded junction boxes installed in cast-in-place structures shall be stainless steel NEMA 4X.

Concrete embedded junction boxes installed in structures constructed by slip forming shall be stainless steel NEMA 3R and shall be adjustable for depth, with depth adjustment bolts, which are accessible from the front face of the junction box with the lid installed.

NEMA junction boxes and cover screws shall be type 304 stainless steel. Junction boxes installed on exterior of structures shall have an external hinge. Junction boxes shall be labeled with the appropriate designation.

Polyethylene drain tubes for junction boxes mounted in structures shall be 3/8-inch diameter with a wall thickness of 0.062 inches and shall be rated for a 110 psi working pressure at 73°F.

The size of NEMA 4X junction boxes and NEMA 3R junction boxes shall be as shown in the Plans.

9-29.2(4) Cover Markings

Junction boxes, cable vaults, and pull boxes with metallic lids shall be marked with the appropriate legend in accordance with the bead weld details in the [Standard Plans](#). Non-metallic lids shall be embossed with the appropriate legend and a non-skid surface. Legends for metallic lids and non-metallic lids shall be 1-inch nominal height.

Junction boxes, cable vaults and pull boxes shall be marked or embossed for use in accordance with the Plans and following schedule:

System Type	Legend	System Type	Legend
Traffic Signal Interconnect	COMM	Power, Service to Signal or ITS Cabinet	LT
Fiber Optic Trunk Lines	ITS	Power, Service to Transformer	LT
Fiber Optic Laterals	ITS	Power, Lighting Circuits	LT
ITS Cabinet (any type) to Field Equipment (CCTV, Detection, VMS, etc.)	ITS	Power, Metering point (pedestal, pole, etc.) to Service Cabinet	PWR
Telephone (POTS or DSL) Service Drop	TEL	Signal Cabinet to Field Equipment (Displays, Detection, etc.)	TS
Weigh-in-Motion (WIM) cabinet to Field Equipment (in-pavement sensors, detection, signs, etc.)	WIM		

Spare junction boxes connected to a labeled system shall use the same system label. Spare junction boxes that are not connected to a labeled system may be left unlabeled (blank).

9-29.2(5) Testing Requirements

Testing is required for all junction boxes, cable vaults and pull boxes. Junction boxes, cable vaults and pull boxes shall be tested by an independent materials testing facility, and a test report issued documenting the results of the tests performed. Junction boxes, cable vaults, and pull boxes listed on the QPL have a testing report on file and do not require a testing report to be submitted by the Contractor.

For each junction box, vault and pull box type, the independent testing laboratory shall meet the requirements of AASHTO R 18 for Qualified Tester and Verified Test Equipment. The test shall be conducted in the presence of a Professional Engineer, licensed under Title 18 RCW, State of Washington, in the branch of Civil or Structural, and each test sheet shall have the Professional Engineer's original signature, date of signature, original seal, and registration number. One copy of the test report shall be furnished to the Contracting Agency certifying that the box and cover meet or exceed the loading requirements for that box type, and shall include the following information:

1. Product identification.
2. Date of testing.
3. Description of testing apparatus and procedure.
4. All load deflection and failure data.
5. Weight of box and cover tested.
6. Upon completion of the required test(s) the box shall be loaded to failure or to the maximum load possible on the testing machine (70,000 pounds minimum).
7. A brief description of type and location of failure or statement that the testing machine reached maximum load without failure of the box.

9-29.2(5)A Standard Duty Boxes and Vaults

Standard Duty Concrete Junction Boxes, Cable Vaults, and Pull Boxes shall be load tested to 22,500 pounds. The test load shall be applied uniformly through a 10 by 10 by 1-inch steel plate centered on the lid. The test load shall be applied and released ten times, and the deflection at the test load and released state shall be recorded for each interval. At each interval the junction box shall be inspected for lid deformation, failure of the lid/frame welds, vertical and horizontal displacement of the lid/frame, cracks, and concrete spalling.

Concrete junction boxes will be considered to have withstood the test if none of the following conditions are exhibited:

1. Permanent deformation of the lid or impairment to the function of the lid. Permanent deformation is defined as greater than 0.125 inches.
2. Vertical or horizontal displacement of the lid frame.
3. Cracks wider than 0.012 inches that extend 12 inches or more.
4. Fracture or cracks passing through the entire thickness of the concrete.
5. Spalling of the concrete.

9-29.2(5)B Retrofit Security Lids for Standard Duty Concrete Junction Boxes

Security lids used to retrofit existing Standard Duty Concrete Junction Boxes shall be tested as follows:

1. The security lid shall be installed on an appropriately sized box that is currently approved on the Qualified Products List.
2. The security lid and box assembly shall be load tested in accordance with Section 9-29.2(5)A. After the ten load cycles but before loading to failure, the security lid shall be fully opened and removed to verify operability.
3. The locking mechanism(s) shall be tested as follows:
 - a. The locking mechanism shall be cycled 250 times (locked, then unlocked again) at room temperature (60-80°F). If there is more than one identical locking mechanism, only one needs to be cycled in this manner.
 - b. Temperature changes should be limited to no more than 60°F per hour.
 - c. The security lid shall be cooled to and held at -30°F for 15 minutes. The locking mechanism shall then be cycled once to verify operation at this temperature.
 - d. The security lid shall be heated to and held at 120-122°F for 15 minutes. The locking mechanism shall then be cycled once to verify operation at this temperature.
 - e. The security lid shall be temperature adjusted to and held at 110°F and 95 percent humidity for 15 minutes. The locking mechanism shall then be cycled once to verify operation at this temperature and humidity.

9-29.2(5)C Standard Duty Non-Concrete Junction Boxes

Non-concrete Junction Boxes shall be tested in the same manner as for Standard Duty Boxes and Vaults described in Section 9-29.2(5)A. In addition, the Contractor shall provide a Manufacturer Certificate of Compliance for each non-concrete junction box installed.

9-29.2(5)D Heavy-Duty Boxes and Vaults

Heavy-Duty Junction Boxes, Cable Vaults, and Pull Boxes shall be load tested to 46,000 pounds. The test load shall be applied vertically through a 10 by 20 by 1-inch steel plate centered on the lid with an orientation both on the long axis and the short axis of the junction box. The test load shall be applied and released ten times on each axis. The deflection at the test load and released state shall be recorded for each interval. At each interval the test box shall be inspected for lid deformation, failure of the lid or frame welds, vertical and horizontal displacement of the lid frame, cracks, and concrete spalling. After the twentieth loading interval the test shall be terminated with a 60,000 pound load being applied vertically through the steel plate centered on the lid and with the long edge of steel plate orientated parallel to the long axis of the box.

Heavy-Duty Junction Boxes will be considered to have withstood the 46,000 pound test if none of the following conditions are exhibited:

1. Permanent deformation of the lid or impairment to the function of the lid. Permanent deformation is defined as greater than 0.125 inches.
2. Vertical or horizontal displacement of the lid frame.
3. Cracks wider than 0.012 inches that extend 12 inches or more.
4. Fracture or cracks passing through the entire thickness of the concrete.
5. Spalling of the concrete.

Heavy-Duty Junction Boxes will be considered to have withstood the 60,000 pound test if all of the following conditions are exhibited:

1. The lid is operational.
2. The lid is securely fastened.
3. The welds have not failed.
4. Permanent dishing or deformation of the lid is $\frac{1}{4}$ inch or less.
5. No buckling or collapse of the box.

9-29.3 Fiber Optic Cable, Electrical Conductors, and Cable

9-29.3(1) Fiber Optic Cable

All fiber optic cables shall be single mode fiber optic cables unless otherwise specified in the Contract. All fiber optic cables shall meet the following requirements:

1. Compliance with the current version of ANSI/ICEA S-87-640. A product data specification sheet clearly identifying compliance or a separate letter from manufacturer to state compliance shall be provided.
2. Cables shall be gel free, loose tube, low water peak, and all dielectric with no metallic component.
3. Cables shall not be armored unless specified in the Contract.
4. Cables shall be approved for mid-span entries and be rated by the manufacturer for outside plant (OSP) use, placement in underground ducts, and aerial installations.
5. Fiber counts shall be as specified in the Contract.
6. Fibers and buffer tubes shall be color coded in accordance with the current version of EIA/TIA-598.
7. Fibers shall not have factory splices.
8. Outer Jacket shall be Type M (Medium Density Polyethylene). Outer jacket shall be free from holes, splits, blisters, or other imperfections and must be smooth and concentric as is consistent with the best commercial practice.
9. A minimum of one (1) rip cord is required for each cable.
10. Cable markings shall meet the following additional requirements:
 - a. Color shall be white or silver.
 - b. Markings shall be approximately 3 millimeters (118 mils) in height, and dimensioned and spaced to produce good legibility.
 - c. Markings shall include the manufacturer's name, year of manufacture, the number of fibers, the words "OPTICAL CABLE", and sequential length marks.
 - d. Sequential length markings shall be in meters or feet, spaced at intervals not more than 1 meter or 2 feet apart, respectively.

- e. The actual cable length shall not be shorter than the cable length marking. The actual cable length may be up to 1 percent longer than the cable length marking.
 - f. Cables with initial markings that do not meet these requirements will not be accepted and may not be re-marked.
11. Short term tensile strength shall be a minimum of 600 pounds (lbs). Long term tensile strength shall be a minimum of 180 pounds (lbs). Tensile strength shall be achieved using a fiberglass reinforced plastic (FRP) central member and / or aramid yarns.
 12. All cables shall be new and free of material or manufacturing defects and dimensional non-uniformity that would:
 - a. Interfere with the cable installation using accepted cable installation practices;
 - b. Degrade the transmission performance or environmental resistance after installation;
 - c. Inhibit proper connection to interfacing elements;
 - d. Otherwise yield an inferior product.
 13. The fiber optic cables shall be shipped on reels with a drum diameter at least 20 times the diameter of the cable, in order to prevent damage to the cable. The reels shall be substantial and constructed so as to prevent damage during shipment and handling. Reels shall be labeled with the same information required for the cable markings, with the exception that the total length of cable shall be marked instead of incremental length marks. Reels shall also be labeled with the type of cable.

9-29.3(1)A Singlemode Fiber Optic Cable

Single-Mode optical fibers shall be EIA/TIA 492-CAAB or ISO/IEC 11801 Type OS2, low water peak zero dispersion fibers, meeting the requirements of ITU-T G.652.D.

9-29.3(1)B Multimode Optical Fibers

Where multimode fiber optic cables are specified in the Contract, the optical fibers shall be one of the following types, as specified in the Contract:

1. Type OM1, meeting the requirements of EIA/TIA 492-AAAA-A or ISO/IEC 11801. The fiber core diameter shall be 62.5 μm .
2. Type OM2, meeting the requirements of EIA/TIA 492-AAAB-A or ISO/IEC 11801. The fiber core diameter shall be 50 μm .

All multimode optical fibers shall have a maximum attenuation of 3.0 dB/km at 850nm and 1.0 dB/km at 1300nm. Completed cable assemblies shall be rated for 1000BaseLX Ethernet communications.

9-29.3(2) Electrical Conductors and Cable

9-29.3(2)A Single Conductor

9-29.3(2)A1 Single Conductor Current Carrying

All current carrying single conductors shall be stranded copper unless otherwise specified in the Contract. Copper wire shall conform to ASTM B3 and B8. Insulation shall be XLP (cross-linked polyethylene) or EPR (Ethylene Propylene Rubber), rated Type USE or USE-2, and rated for 600-volts or higher.

Aluminum wire shall be stranded aluminum conforming to ASTM B800 and B801 and listed under UL 854. Insulation shall be rated Type USE or USE-2 and for 600-volts or higher.

9-29.3(2)A2 Grounding Electrode Conductor

Grounding electrode conductor between the grounding electrode and the associated service or transformer cabinet shall be bare or insulated stranded copper. When insulated, the insulation shall be green or green with a yellow tracer.

9-29.3(2)A3 Equipment Grounding and Bonding Conductors

Equipment grounding and bonding jumper conductors shall be green insulated, stranded copper with insulation rated USE or USE-2 and 600-volts, with the exception that the equipment grounding and bonding jumper conductors installed between junction box, pull box, or cable vault frame and lids shall be tinned, braided copper.

9-29.3(2)A4 Location Wire

Location wire shall be steel core copper clad minimum size AWG 14 insulated conductor. The insulation shall be orange High Molecular Weight High Density Polyethylene (HMHDPE), Type USE, or Type USE-2.

9-29.3(2)B Multi-Conductor Cable

Two-conductor through 10-conductor unshielded signal control cable shall have stranded copper conductors and shall conform to International Municipal Signal Association (IMSA) signal cable 20-1.

9-29.3(2)C Aluminum Cable Steel Reinforced

Triplex or Quadraplex Type ACSR neutral self-supporting aerial conductors of the appropriate size for aluminum conductors shall be used where required in the Contract. The neutral conductor shall be the same size as the insulated conductor. All conductors shall be stranded.

9-29.3(2)D Pole and Bracket

Pole and bracket cable shall be a two-conductor cable rated for 600-volts. The individual conductors shall be one red and one black 19-strand No. 10 AWG copper, assembled parallel. The conductor insulation shall be 45-mil polyvinyl chloride or a 600-volt-rated cross-linked polyethylene. The Jacketing shall be polyethylene or polyvinyl chloride not less than 45 mils thick. If luminaires with remote ballasts are specified in the Contract, this same cable shall be used between luminaire and ballast for both timber and ornamental pole construction. If the luminaire requires fixture wire temperatures greater than 75°C, the outer jacket shall be stripped for that portion of the cable inside the luminaire. The single conductors shall then be sheathed with braided fiberglass sleeving of the temperature rating recommended by the luminaire manufacturer.

9-29.3(2)E Two-Conductor Shielded

Two-conductor shielded (2CS) cable shall have stranded 14 AWG (minimum) conductors and shall conform to IMSA Specification No. 50-2.

9-29.3(2)F Detector Loop Wire

Detector loop wire may be 12 or 14 AWG stranded copper wire, IMSA 51-3.

9-29.3(2)G Four-Conductor Shielded Cable

Four-conductor shielded cable (4CS) shall consist of a cable with four stranded 18 AWG conductors with polypropylene insulation, an aluminized polyester shield, water-blocking material in the cable interstices, and a 26-mil minimum outer jacket of polyethylene. The four-conductor assembly shall be twisted six turns per foot. Each conductor shall have a different insulation color. Overall cable diameter shall be 0.25 inch maximum. Capacitance between adjacent pairs shall be 18 pf per foot and 15 pf per foot between diagonal pairs. The capacitances shall not vary more than 10 percent after a 10-day immersion test with ends exposed in a saturated brine solution.

9-29.3(2)H Three-Conductor Shielded Cable

Three-conductor shielded cable (3CS) for the detector circuit for optical fire preemption receivers shall consist of three 20 AWG conductors with aluminized mylar shield and one No. 20 drain wire, all enclosed with an outer jacket. All wires shall be 7 by 28 stranded tinned copper material. Conductor insulation shall be rated 75°C, 600 volt. The drain wire shall be uninsulated. Conductor color coding shall be yellow, blue, and orange. DC resistance of conductors or drain wires shall not exceed 11 ohms per 1,000 feet. Capacitance from one conductor to the other two conductors and shield shall not exceed 48 pf per foot. The jacket shall be rated 80°C, 600 volt, with a minimum average wall thickness of 0.045 inch. The finished outside diameter of the cable shall be 0.3 inch maximum.

9-29.3(2)I Twisted Pair Communications Cable

Twisted Pair Communications Cable shall meet RUS Specification 1755.390 and shall be AWG22 conductor. The cable shall have a petroleum compound completely filling the inside of the cable and rated for OSP (Outside Plant) applications.

9-29.3(2)J Ethernet Cable

Ethernet cable installed outside of buildings shall be Category 5E (Cat 5e), Category 6 (Cat 6), or Category 6A (Cat 6a) as appropriate or specified in the Plans. Locations outside of buildings include, but are not limited to, roadside cabinets (e.g., service cabinets, traffic signal cabinets, ITS cabinets), exterior or underground conduit and on, or in, poles (e.g., light poles, signal poles, camera poles).

All Ethernet cables shall meet the following requirements:

1. Compliance with the requirements of ANSI/TIA-568-C.2.
2. Compliance with the appropriate ISO/IEC 11801 Class:
 - a. Cat 5e: ISO/IEC 11801 Class D.
 - b. Cat 6: ISO/IEC 11801 Class E.
 - c. Cat 6a: ISO/IEC 11801 Class EA.
3. Type F/UTP shielding.
4. Rated for outside plant (OSP) and/or direct burial installation. Cable rated for Engineered Burial is acceptable only when installed in conduit (may not be direct buried).
5. Minimum 300V (RMS) UL insulation rating.

Patch cables within a cabinet do not need to be rated for OSP or direct burial but shall have some level of outdoor rating for protection from moisture. All cables shall include protective boots over the connectors.

Unless otherwise specified in the Contract, the following minimum cable types are required for the transmission speed listed:

1. 2.5GBASE-T (or slower): Cat 5e.
2. 5GBASE-T: Cat 6.
3. 10GBASE-T: Cat 6a.

Ethernet Cables used for Power over Ethernet (PoE) shall have an IEEE 802.3 rating that meets or exceeds the power use of the connected device. Ratings and wattage limits are as follows:

1. Up to 15W: 802.3at Type 1
2. Up to 30W: 802.3at Type 2
3. Up to 60W: 802.3bt Type 3
4. Up to 100W: 802.3bt Type 4

9-29.3(3) Wire Marking Sleeves

Wire marking sleeves shall be full-circle in design, non-adhesive, printable using an indelible ink and shall fit snugly on the wire or cable. Marking sleeves shall be made from a PVC or polyolefin, and provide permanent identification for wires and cables.

9-29.4 Messenger Cable, Fittings

Messenger cable shall be $\frac{3}{8}$ -inch, 7-wire strand messenger cables conforming to ASTM A475, extra-high-strength grade, 15,400-pound minimum breaking strength, Class A galvanized.

Strain insulators shall be wet process porcelain, conforming to EEI-NEMA Class 54-2 standards for 12,000-pound ultimate strength.

Down guy assembly shall consist of an eight-way steel expanding anchor, having a minimum area of 300 square inches, made of pressed steel, coated with asphalt or similar preservative, and fitted with a $\frac{3}{4}$ -inch minimum guy eye anchor rod 8 feet long. As an alternate to expanding anchors, screw-type anchors with two 8-inch helix, $3\frac{1}{2}$ -inch pitch, 1-inch by 7-foot guy anchor rod, and rated for 7,000-pound maximum torque may be installed.

All pole hardware, bolts, plate rods, hangers, clips, wire guards, and pole bands shall be hot-dip galvanized in conformance with the requirements of AASHTO M232.

9-29.5 Vacant**9-29.6 Light and Signal Standards**

Light standards (including light standards with Type 1 or Type 2 luminaire arms) and signal standards (including Types I, II, III, IV, V, PPB, PS, RM, FB, and CCTV) shall be in accordance with the details shown in the Plans, as specified in the Special Provisions and as outlined herein, provided that only one luminaire arm type shall be used throughout the project.

Fabrication of light and signal standards shall conform to the applicable requirements of Section 6-03.3(14).

Light standard, signal standards, slip base hardware and foundation hardware shall be hot-dip galvanized in accordance with AASHTO M111, AASHTO M 232, or ASTM F 2329 as applicable. Where colored standards are required, standards shall be powder-coated after galvanizing in accordance with Section 6-07.3(11). The standard color shall be as specified in the Contract.

Materials for steel light and signal standards, and associated anchorage and fastening hardware, shall conform to Sections 9-29.6(1), 9-29.6(2), and 9-29.6(5) unless otherwise specified in one of the following documents:

1. The steel light and signal standard fabricator's preapproved plan as approved by the Washington State Department of Transportation and as identified in the Special Provisions.
2. The steel light and signal standard fabricator's shop drawing submittal, including supporting design calculations submitted as a Type 2E Working Drawing in accordance with Section 8-20.2(1) and the Special Provisions.

Frangible bolts for use on small signal standards (Type PS, RM, I, and FB) shall be pre-approved by WSDOT.

9-29.6(1) Steel Light and Signal Standards

Steel plates and shapes for light and signal standards shall conform to ASTM A36, except that structural shapes may conform to ASTM A992. Shafts for light and signal standards, except Type PPB signal standards, shall conform to ASTM A572 Grade 50. Shafts and caps for Type PPB signal standards, slipfitters for type PS I, FB, and RM signal standards, and all pipes shall conform to ASTM A53 Grade B. Base plates for light standards shall conform to ASTM A572, Grade 50, except as otherwise noted in the [Standard Plans](#) for fixed base light standards. Base plates for signal standards shall conform to ASTM A36. Connecting bolts shall conform to ASTM F3125 Grade A325. Fasteners for handhole covers, bands on lighting brackets, and connector attachment brackets shall conform to ASTM F593.

Steel used for light and signal standards shall have a controlled silicon content of either 0.00 to 0.06 percent or 0.15 to 0.25 percent. Mill test certificates verifying the silicon content of the steel shall be submitted to both the galvanizer and the Engineer prior to beginning galvanizing operations.

9-29.6(2) Slip Base Hardware

Slip plates and anchor plates for light standards and for Type FB and RM signal standards shall conform to the requirements of ASTM A572 Grade 50. The keeper plate shall be either 28 or 26 gage, and shall conform to ASTM A653 coating designation G 90. Clamping bolts for slip base assemblies and slip base adapters shall conform to ASTM F3125 Grade A325. Studs and bolts for slip base adapters shall conform to ASTM F3125 Grade A325. Nuts shall conform to ASTM A563 Grade DH. Hardened washers shall conform to ASTM F436. Plate washers shall conform to ASTM A36, and also shall conform to the flatness tolerances specified in ASTM F436 for circular washers.

Galvanized bolts shall meet Section 9-06.5(4).

9-29.6(3) Timber Light Standards, Timber Strain Poles, Timber Service Supports

All timber poles used in illumination or traffic signal systems shall be Douglas fir, machine shaved, roof sawed, conforming to the latest ANSI Specifications and Dimensions for Wood Poles.

All timber poles shall be gained according to industry standards. A dated nail or metallic date plate shall be set in the gain evidencing the year of treatment of the timber pole. The timber pole classes specified in the Contract are minimums – a timber pole of a stronger pole class may be used in place of the specified pole class.

All poles shall be treated with DCOI (DiCholoro-Octyl-Isothiazolin) in accordance with Section 9-09.3(1). Used poles for temporary installations may be treated with Pentachlorophenol (Penta) as an alternative to DCOI.

Tops shall be sawed before treatment. Where holes are bored in poles to accommodate hanging bolts for brackets, transformers, guy assemblies, or other accessories, such holes shall be painted with an appropriate preservative in accordance with Standard Specification 9-09.3(1) (Copper Naphthenate or Oxine Copper in accordance with AWWA Standard M4).

9-29.6(4) Welding

Welding of steel structures shall be in accordance with AWS D1.1/D1.1M, latest edition, Structural Welding Code, and Section 6-03.3(25).

9-29.6(5) Foundation Hardware

Anchor bolts for Type PPB, PS, I, FB, and RM signal standards shall conform to the requirements of ASTM F1554, grade 55. Nuts shall meet the requirements of ASTM A563, grade A. Washers shall meet the requirements of ASTM F844 or F436.

Anchor bolts, and associated nuts and washers, for Type CCTV, II, III, IV, and V signal standards and luminaire poles shall conform to Section 9-06.5(4). Anchor rods conforming to ASTM A449 may be substituted, provided that the galvanized ASTM A449 anchor rods having an ultimate tensile strength above 145 ksi shall be tested for embrittlement in accordance with either ASTM A143 (if the rod length is equal to or greater than five times the bolt diameter) or ASTM F606 Section 7 (if the rod length is less than five times the nominal bolt diameter).

9-29.7 Luminaire Fusing and Electrical Connections at Light Standard Bases, Cantilever Bases, and Sign Bridge Bases**9-29.7(1) Unfused Quick-Disconnect Connector Kits**

Unfused quick-disconnect connector kits shall conform to the following requirements:

1. The copper pin and copper receptacle shall be a crimped type of connection or a stainless steel set screw and lug connection to the cable. The receptacle shall establish contact pressure with the pin through the use of a tinned copper or copper beryllium sleeve spring and shall be equipped with a disposable mounting pin. The receptacle shall be fully annealed. Both the copper pin and receptacle shall have a centrally located recessed locking area adapted to be complementarily filled and retained by the rubber housing.
2. The plug and receptacle housing shall be made of water-resistant synthetic rubber that is able to be buried in the ground or installed in sunlight. Each housing shall provide a section to form a water-seal around the cable, have an interior arrangement to suitably and complementarily receive and retain the copper pin or receptacle, and a section to provide a water-seal between the two housings at the point of disconnection.
3. The kit shall provide waterproof in-line connector protection with three cutoff sections on both the line and load side to accommodate various wire sizes. All connections shall be as described in item "1" above. Upon disconnect, the connector shall remain in the load side of the kit.

9-29.7(2) Fused Quick-Disconnect Kits

Fused quick-disconnect kits shall provide waterproof in-line fuse protection. The kit shall provide three cutoff sections on both lines and load side to accommodate various wire sizes. All connections shall be as described in item "1" above. Upon disconnect, the fuse shall remain in the load side of the kit.

Fuses furnished for all lighting circuits shall be capable of handling the operating voltage of the circuit involved and shall have the following characteristics:

1. Fuses shall be capable of indefinitely supporting 110 percent of the rated load.
2. Fuses shall be capable of supporting 135 percent of the rated load for approximately 1 hour.
3. A load of 200 percent of rated load shall effectively cause instantaneous blowing of the fuse.
4. Fuses shall be rated as listed below and shall be sized to fit the fuse containers furnished on this project, according to the manufacturer's recommendations therefore.
5. Fuses shall be listed by a Nationally Recognized Testing Laboratory.

Luminaire Size	Service Voltage		
	480V	240V	120V
1,000W	10A	15A	30A
750W	5A	10A	20A
700W	5A	10A	20A
400W	5A	10A	15A
310W	5A	5A	10A
250W	5A	5A	10A
200W	4A	5A	10A
175W	4A	5A	10A
150W	3A	4A	5A
100W	2A	3A	4A
70W	2A	2A	2A
50W	2A	2A	2A
LED*	10A	10A	20A

*Applies to all LED luminaires, regardless of wattage. Fuses for LED luminaires shall be slow blow.

9-29.8 Vacant

9-29.9 Electrical, Ballasts and Transformers

Heat-generating components shall be mounted to use the portion of the luminaire upon which they are mounted as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the fixture temperature to 160°F.

Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors, except those in starting aids, shall be metal cased and hermetically sealed.

No capacitor, transformer, or other device shall employ the class of compounds identified as polychlorinated biphenyls (PCB) as dielectric, coolants, or for any other purpose.

9-29.9(1) Ballast

Each ballast shall have a name plate attached permanently to the case listing all electrical data.

A Manufacturer's Certificate of Compliance, in accordance with Section 1-06.3, meeting the manufacturer's and these Specifications' requirements, shall be submitted by the Contractor with each type of luminaire ballast.

Ballasts shall be designed for continuous operation at ambient air temperatures from 20°F without reduction in ballast life. Ballasts shall have a design life of not less than 100,000 hours. Ballasts shall be designed to operate for at least 180 cycles of 12 hours on and 12 hours off, with the lamp circuit in an open or short-circuited condition and without measurable reduction in the operating requirements. All ballasts shall be high power factor (90 percent).

Ballasts shall be tested in accordance with the requirements of current ANSI C 82.6, Methods of Measurement of High-Intensity-Discharge Lamp Ballasts. Starting aids for ballasts of a given lamp wattage shall be interchangeable between ballasts of the same wattage and manufacturer without adjustment.

Ballast assemblies shall consist of separate components, each of which shall be capable of being easily replaced. A starting aid will be considered as a single component. Each component shall be provided with screw terminals, NEMA tab connectors or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they connect.

Ballasts for high-pressure sodium lamps shall have a ballast characteristic curve which will intersect both of the lamp-voltage limit lines between the wattage limit lines and remain between the wattage limit lines throughout the full range of lamp voltage. This requirement shall be met not only at the rated input voltage of the ballast, but also the lowest and highest input voltage for which the ballast is rated. Throughout the lifetime of the lamp, the ballast curve shall fall within the specified limits of lamp voltage and wattage.

All luminaires ballasts shall be located within the luminaire housing. The only exception shall be ballasts to be mounted on lowering assemblies and shall be external to, and attached to the fixture assembly.

Ballast Characteristics for High Pressure Sodium (HPS) and Metal Halide (MH) Sources shall be:

Source	Line Volt.	Lamp Wattage	Ballast Type	Input Voltage Variation	Lamp Wattage Variation
HPS	all	70 400	Mag. Reg. Lag	10%	18%
HPS	all	750 1000	Auto Reg. Lead CWA	10%	30%
MH	all	175 400	Mag. Reg. Lag	10%	18%
MH	all	1000	Auto Reg. Lead CWA	10%	30%

9-29.9(2) Transformers

The transformers to be furnished shall be indoor/outdoor dry type transformers rated as shown in the Plans. The transformer coils, buss bar, and all connections shall be copper. Transformers, 7.5 KVA and larger shall be supplied with two full capacity taps, one at 5 percent and one at 10 percent below the normal full capacity.

9-29.10 Luminaires

All luminaires shall have their components secured to the luminaire frame with ANSI 300 series chrome-nickel grade stainless steel, zinc dichromate-coated steel, or ceramic-coated steel hardware. The luminaire slip-fitter bolts shall be stainless steel, hot-dip galvanized steel, zinc dichromate-coated steel, or ceramic-coated steel. All internal luminaire assemblies shall be assembled on or fabricated from either stainless steel or galvanized steel. The housing, complete with integral ballast (when applicable), shall be weathertight.

All roadway luminaires shall be rated for roadway use and meet 3G vibration requirements as described in ANSI C136.31.

The temperature rating of all wiring internal to the luminaire housing, excluding the pole and bracket cable, shall equal or exceed 200°F.

All LED luminaires shall have a Correlated Color Temperature (CCT) of 3000K nominal and a Color Rendering Index (CRI) of 70 or greater. LED output shall be a minimum of 85 percent at 75,000 hours at 25 degrees Celsius.

All luminaires shall be provided with markers for positive identification of light source type and wattage in accordance with ANSI C136.15-2011, with the exception that LED luminaires shall be labeled with the wattage of their conventional luminaire equivalents. Do not include the text "LED" for LED luminaire labels. Legends shall be sealed with transparent film resistant to dust, weather, and ultraviolet exposure.

Legends shall correspond to the following code:

Conventional Lamp Wattage	Conventional Wattage Legend	Equivalent LED Legend
70	7	7E
100	10	10E
150	15	15E
175	17	17E
200	20	20E
250	25	25E
310	31	31E
400	40	40E
700	70	70E
750	75	75E
1,000	X1	X1E

9-29.10(1) Conventional Roadway Luminaires

All luminaires shall have housings fabricated from aluminum. The housing shall be painted flat gray, SAE AMS Standard 595 color chip No. 26280, unless otherwise specified in the Contract. Painted housings shall withstand a 1,000 hour salt spray test as specified in ASTM B117.

Each housing shall include a four bolt slip-fitter mount capable of accepting a nominal 2" tenon and adjustable within +/- 5 degrees of the axis of the tenon. The clamping bracket(s) and the cap screws shall not bottom out on the housing bosses when adjusted within the +/- 5 degree range. No part of the slipfitter mounting brackets on the luminaires shall develop a permanent set in excess of 0.2 inch when the cap screws used for mounting are tightened to a torque of 32 foot-pounds. Each luminaire shall include leveling reference points for both transverse and longitudinal adjustment.

All luminaires with photocell sockets shall include shorting caps when shipped. The caps shall be removed and provided to the Contracting Agency when an alternate control device is required to be installed in the photocell socket. House side shields shall be included when required by the Contract. Order codes shall be modified to the minimum extent necessary to include the option for house side shields.

9-29.10(1)A High Pressure Sodium (HPS) Conventional Roadway Luminaires

HPS conventional roadway luminaires shall meet the following requirements:

1. General shape shall be "cobrahead" style, with flat glass lens and full cutoff optics.
2. Light pattern distribution shall be IES Type III.
3. The reflector of all luminaires shall be of a snap-in design or secured with screws. The reflector shall be polished aluminum or prismatic borosilicate glass.
4. Flat lenses shall be formed from heat resistant, high-impact, molded borosilicate or tempered glass.
5. The lens shall be mounted in a doorframe assembly, which shall be hinged to the luminaire and secured in the closed position to the luminaire by means of an automatic latch. The lens and doorframe assembly, when closed, shall exert pressure against a gasket seat. The lens shall not allow any light output above 90 degrees nadir. Gaskets shall be composed of material capable of withstanding the temperatures involved and shall be securely held in place.

6. The ballast shall be mounted on a separate exterior door, which shall be hinged to the luminaire and secured in the closed position to the luminaire housing by means of an automatic type of latch (a combination hex/slot stainless steel screw fastener may supplement the automatic-type latch).
7. Each luminaire shall be capable of accepting a 150, 200, 250, 310, or 400 watt lamp complete and associated ballast. Lamps shall mount horizontally.

9-29.10(1)B Light Emitting Diode (LED) Conventional Roadway luminaires

LED Conventional Roadway luminaires are divided into classes based on their equivalent High Pressure Sodium (HPS) luminaires. Current classes are 200W, 250W, 310W, and 400W. LED luminaires are required to be pre-approved in order to verify their photometric output. To be considered for pre-approval, LED luminaires must meet the requirements of this section.

LED luminaires shall include a removable access door, with tool-less entry, for access to electronic components and the terminal block. The access door shall be removable, but include positive retention such that it can hang freely without disconnecting from the luminaire housing. LED drivers may be mounted either to the interior of the luminaire housing or to the removable door itself.

LED drivers shall be removable for user replacement. All internal modular components shall be connected by means of mechanical plug and socket type quick disconnects. Wire nuts may not be used for any purpose. All external electrical connections to the luminaire shall be made through the terminal block.

LED luminaires shall not include a photocell receptacle.

LED luminaires shall be available for 120V, 240V, and 480V supply voltages. Voltages refer to the supply voltages to the luminaires present in the field. LED power usage shall not exceed the following maximum values for the applicable wattage class:

Class	Max. Wattage
200W	110W
250W	165W
310W	210W
400W	275W

Only one brand of LED conventional roadway luminaire may be used on a Contract. They do not necessarily have to be the same brand as any high-mast, underdeck, or wall-mount luminaires when those types of luminaires are specified in the Contract. LED luminaires shall include a standard 10 year manufacturer warranty.

The list of pre-approved LED Conventional Roadway luminaires is available at www.wsdot.wa.gov/Design/Traffic/ledluminaires.htm.

9-29.10(2) Vacant

9-29.10(3) Vacant

9-29.10(4) Underdeck and Wall Mount luminaires

Underdeck and wall-mount luminaires shall be LED and meet the general requirements of Section 9-29.10. Light distribution shall be as shown on the Contract. Luminaires shall have provisions for anchoring to concrete when required. Asymmetrical distribution luminaires shall be clearly labeled for proper orientation. The doorframe assembly shall be hinged, gasketed and secured to the body.

9-29.11 Control Equipment

Illumination circuits shall be controlled by a combination of photoelectric controls and lighting contactors as noted in the Contract.

9-29.11(1) Time Clock Controls

Time clocks, when specified in the Contract, shall be solid state and shall have a battery backup. The clock shall provide four functions and shall be enclosed within a dust tight mounting case. The unit shall be mounted on vibration dampened fittings.

The unit shall be pushbutton programmable with 15 events per week, selectable by day of week and time of day to the nearest minute.

The clock shall be accurate to plus or minus 15 seconds per month through a humidity variation of 0 to 95 percent and a temperature variation of 0°F to 150°F. The clock shall be within plus or minus 10 seconds after 10 hours of battery backup operation. The backup battery shall operate for 24 hours minimum.

Contacts shall be rated at 5 amps tungsten load for up to 100,000 cycles. Each clock function shall operate a 120 VAC normally open and normally closed set of contacts.

9-29.11(2) Photoelectric Controls

The photoelectric control shall be the twist-lock type and the light sensitive element shall be a solid-state photo diode. The control shall be designed to turn on at 3 foot-candles (32 lux) and turn off at 1.8 foot-candles (20 lux). The lighting control shall not drift by more than 1 percent over a 10-year period.

The output control relay shall have a 45-second time delay to prevent false turn-off caused by momentary brightness. This output relay shall be rated 1,000 watts incandescent or 15 amps inductive load. The contacts shall be normally closed. The unit shall be designed to not continuously pulse the output relay if the photo control bypass switch is energized.

The lighting control shall have a built in metal oxide varistor (MOV) rated 180 joules for lightning and transient protection. The control shall also have secondary zener diode and transient filter. The printed circuit board shall be coated to prevent corrosion. The normal operating voltage range will be 105 to 285 VAC.

9-29.12 Electrical Splice Materials

Circuit splicing materials shall meet the following specifications.

9-29.12(1) Illumination Circuit Splices

Illumination circuit splices shall be one of the following types:

1. Solderless crimped connections capable of securely joining the wires, both mechanically and electrically, as defined in Section 8-20.3(8).
2. Direct Burial (Submersible) Pedestal Splice / Connector, UL 486D listed for direct burial and submersible applications, and meeting ANSI C119.1 specifications. These do not require a separate or additional splice enclosure.
3. Split bolt vice-type connectors (aerial splices only).

9-29.12(2) Traffic Signal Splice Material

Induction loop splices and magnetometer splices shall use an uninsulated barrel-type crimped connector capable of being soldered.

9-29.12(3) Splice Enclosures**9-29.12(3)A Heat Shrink Splice Enclosure**

Heat shrink splice enclosures shall be medium or heavy wall cross-linked polyolefin, meeting the requirements of AMS-DTL-23053/15, with thermoplastic adhesive sealant. Heat shrink splices used for "wye" connections require rubber electrical mastic tape.

9-29.12(3)B Molded Splice Enclosure

Molded splice enclosures shall use epoxy resin in a clear rigid plastic mold. The material used shall be compatible with the insulation material of the insulated conductor or cable. The component materials of the resin insulation shall be packaged ready for convenient mixing without removing from the package.

9-29.12(4) Re-Enterable Splice Enclosure

Re-enterable splice enclosures shall use either dielectric grease or a flexible resin contained in a two-piece plastic mold. The mold shall either snap together or use stainless steel hose clamps.

9-29.12(5) Vinyl Electrical Tape for Splices

Vinyl electrical tape in splicing applications shall be at least 7-mils thick, listed under UL 510, and comply with IEC 60454-3-1 Classification Type 7.

9-29.12(6) Linerless Rubber Splicing Tape

Linerless rubber splicing tape shall be certified to ASTM D4388 Type II, Type III, or Type V.

9-29.13 Control Cabinet Assemblies

Control cabinet assemblies shall include all necessary equipment and auxiliary equipment for controlling the operation of traffic signals, programmable message signs, illumination systems, ramp meters, data stations, CCTV, and similar systems as required for the specific application. Traffic Signal Controller Cabinet Assemblies shall meet the requirements of the NEMA TS1 and TS2 specification or the California Department of Transportation "Transportation Electrical Equipment Specifications" (TEES) dated March 12, 2009 and applicable errata, as defined in this specification.

9-29.13(1) Environmental, Performance, and Test Standards for Solid-State Traffic Controller Assemblies

The scope of this Specification includes the controller of solid-state design installed in a weatherproof controller cabinet. The controller assembly includes the cabinet, controller unit, load switches, signal conflict monitoring circuitry, accessory logic circuitry, AC line filters, vehicle detectors, coordination equipment and interface, and preemption equipment. NEMA control assemblies shall meet or exceed current NEMA TS 1 Environmental Standards. Normal operation will be required while the control assembly is subjected to any combination of high and low environmental limits (such as low voltage at high temperature with high repetition noise transients). All other control equipment shall meet the environmental requirements of California Department of Transportation "Transportation Electrical Equipment Specifications" (TEES) dated March 12, 2009 and applicable errata.

The Contractor shall furnish to the Contracting Agency all guarantees and warranties furnished as a normal trade practice for all control equipment provided.

9-29.13(2) Traffic Signal Controller Assembly Testing

Each traffic signal controller assembly shall be tested as follows. The Contractor shall:

1. Prior to shipping, arrange appointment for testing at the WSDOT Materials Laboratory.

2. Assembly shall be defined as tightening all screws, nuts and bolts, verifying that all wiring is clear of moving parts and properly secured, installing all pluggables, connecting all cables and ensure that all Contract required documents are present, proper documentation is provided, and all equipment required by the Contract is installed.
3. The Contractor shall demonstrate that all of the functions required by the Contract perform as intended. Demonstration shall include energizing the cabinet and verifying that all 8 phases, 4 pedestrian movements and 4 overlaps (as required by the Contract Provisions) operate per Section 9-29.13. The Contractor shall place the controller in minimum recall with interval timing set at convenient value for testing purposes. Upon a satisfactory demonstration the controller assembly will then be accepted by WSDOT for testing.
4. If the assembly and acceptance for testing is not complete within 7 calendar days of delivery, the Engineer may authorize the return of the assembly to the Contractor, with collect freight charges to the Contractor.
5. WSDOT will test each traffic signal control assembly in accordance with the following test methods, WSDOT T 421, T 422, T 423, T 424, T 425, T 427, and T 428.
6. If the traffic signal control assembly passes all testing, the Contractor will be notified where the assembly is to be picked-up for delivery to the project. The Contractor shall pick-up the assembly within 7 calendar days of notification.
7. If the traffic signal control assembly fails testing, the Contractor has 7 calendar days to repair or replace any components that fail during the testing process at no cost to the Contracting Agency. All repairs shall be completed during normal business hours for the State Materials Lab. A failure shall be defined as a component that no longer functions as intended under the conditions required or does not meet the requirements of the Contract and is at the sole discretion of WSDOT. Once all repairs and replacement of components is complete WSDOT will retest the traffic controller as specified in step 6 and all costs for retesting will be deducted from monies due or that may become due the Contractor.

9-29.13(3) Traffic Signal Controller

The traffic signal controller shall conform to the Contract requirements and the applicable Specifications as listed below: All solid-state electronic traffic-actuated controllers and their supplemental devices shall employ digital timing methods.

1. NEMA control and all auxiliary equipment shall conform to current NEMA TS1 or TS2 Specification. Every pin of every connecting plug shall be utilized as described within the NEMA requirement, except that those pins identified as "spare" or "future" shall remain unused.
2. Type 2070 controllers shall be Type 2070 ATC and conform to the TEES and the Advanced Transportation Controller (ATC 5201) Standard. The standard 2070 ATC controller shall include the Board Support Package (ATC 5201, Paragraph 3.3.1) in electronic format, and shall consist of the following:
 - a. Type 2070LX Unit Chassis
 - b. 2070-1C CPU Module
 - c. 2070-2E+ Field I/O Module
 - d. 2070-3B or 2070-3D Front Panel. Newer front panels that are 2070-3B or 2070-3D compatible may be considered.
 - e. 2070-4 Power Supply

A spare blank cover (4X wide), designed to cover the slot for the 2070-2E module when it is removed, shall also be provided.

Type 2070 controllers shall support both serial bus (C12S) and parallel bus (C1S) operation.

Type 2070 controllers for ITS cabinets are required to be preapproved to ensure compatibility with ITS Operations Software. Type 2070 controllers preapproved for use in WSDOT ITS cabinets are listed in the QPL. Type 2070 controllers for traffic signal systems are specified in the contract.

9-29.13(4) Traffic-Signal Controller Software

All traffic signal controllers shall operate with software specified in the contract.

Traffic-actuated controllers shall be electronic devices which, when connected to traffic detectors or other means of actuation, or both, shall operate the electrical traffic signal system at one or more intersections.

If the complete traffic controller defined in the Special Provision requires NTCIP compliance the following are the minimum requirements for NTCIP operation.

Communication

The traffic controller hardware and software shall communicate with the central computer in a polled multi-drop operation. In the polled multi-drop operation, several traffic controllers shall share the same communication channel, with each controller assigned a unique ID number. Controller ID numbers shall conform to the NTCIP requirements for address numbers. A traffic controller shall only reply to messages labeled with its ID. In polled multi-drop mode, traffic controllers never initiate communication, but merely transmit their responses to messages from the central computer.

A laptop computer connected to the traffic controller's local communication port shall have the same control and diagnostic capabilities as the central computer. However, local laptop control capability shall be limited to that traffic controller.

NTCIP Requirements

The traffic controller software shall comply with the National Transportation Communications for ITS Protocol (NTCIP) documents and all related errata sheets published before July 1, 1999 and as referenced herein.

The traffic controller software shall support the following standards:

1. NTCIP 1101, Simple Transportation Management Framework (STMF), Conformance Level 1 (Simple Network Management Protocol (SNMP))
2. NTCIP 2001, Class B Profile. All serial ports on the device shall support communications according to these standards.
3. NTCIP 2101, SP-PMPP/RS232 Point-to-Multi-Point Protocol (PMPP)
4. NTCIP 2201, NTCIP TP-Null Transport Profile Null (TP-NULL)

The traffic controller software shall implement all mandatory objects of all mandatory conformance groups as defined in NTCIP 1201, Global Object Definitions, and NTCIP 1202, Object Definitions for Actuated Traffic Signal Controller Units. Software shall implement the following conformance groups:

NTCIP 1202, Object Definitions for ASC

Conformance Group	Reference
Configuration	1201 2.2
Time Management	
Time Base Event Schedule	
Report	2.5
Phase	1202 2.2
Rings	2.8
Detector	2.3
Unit	2.4
Preempt	2.7
Time Base	2.6
Coordination	2.5
Channel	2.9
Overlaps	2.10

The software shall implement the following optional objects:

Objects required by these specifications shall support all values within its standardized range. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's description field. The following list indicates the modified object requirements for these objects.

Object Name	Object ID	Required Values
Global Configuration	moduleType	Value 3
Database Management	dBCreateTransaction	All Values
Database Management	dBErrorType	All values
Time Management	globalsDaylightSavings	Values 2 and 3
Timebase Events Schedule	maxTimeBaseScheduleEntries	16
Timebase Events Schedule	MaxDayPlans	15
Timebase Events Schedule	MaxDayEvents	10
Report	maxEventLogCongifs	50
Report	MventConfigMode	Values 2 thru 5
Report	mventConfigAction	Values 2 and 3
Report	MaxEventLogSize	255
Report	MaxEventClasses	7
PMPP	maxGroupAddress	2
ASC Phase	maxPhases	8
ASC Phase	pPhaseStartp	Values 2 thru 6
ASC Phase	phaseOptions	All Values
ASC Phase	maxPhaseGroups	1
Rings	maxRings	2
Rings	maxSequences	16
Detector	maxVehicleDetectors	64
Detector	vehicleDetectorOptions	All Values
Detector	maxPedestrianDetector	8

Object Name	Object ID	Required Values
Unit	unitAutoPedestrianClear	All Values
Unit	unitControlStatus	All Values
Unit	unitFlashStatus	All Values
Unit	unitControl	All Values
Unit	maxAlarmGroups	1
Special Function	maxSpecialFunctionsOutputs	8
Coordination	coordCorrectionMode	Values 2 thru 4
Coordination	coordMaximumMode	Values 2 thru 4
Coordination	coordForceMode	Values 2 and 3
Coordination	maxPatterns	48
Coordination	patternTableType	Either 2,3 or 4
Coordination	maxSplits	16
Coordination	splitMode	Values 2 thru 7
Coordination	localFreeStatus	Values 2 thru 11
Time Base	maxTimebaseAscAction	48
Preempt	maxPreempts	4
Preempt	preemptControl	All Values
Preempt	preemptState	Values 2 thru 9
Overlaps	maxOverlaps	4
Overlaps	overlapType	Value 2 and 3
Overlaps	maxOverlapstatusGroup	1
Channels	maxChannels	16
Channels	channelControlGroup	Values 2 thru 4
Channels	channelFlash	Value 0,2,4,6,8,10,12 and 14
Channels	channelDim	Values 0 thru 15
Channels	maxChannelStatusGroup	2
TS 2 Port 1	maxPortAddresses	18
TS 2 Port 1	port1Table	Values 2 and 3

*Values in excess of the minimum requirement are considered to meet the specification.

Documentation

Software shall be supplied with all documentation on a USB Flash Drive. ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format shall be provided on a USB Flash Drive:

1. The official MIB Module referenced by the device functionality.
2. A manufacturer-specific version of the official MIB Module with the non-standardized range indicated in the SYNTAX field. The filename shall match the official MIB Module, with the extension "spc".
3. A MIB Module of all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and the supported ranges indicated in the SYNTAX field.

9-29.13(5) Flashing Operations

All traffic signals shall be equipped for flashing operation of signal displays. Controllers and cabinets shall be programmed for flashing red displays for all approaches. During flashing operation, all pedestrian circuits shall be de-energized.

Actuated traffic signal control mechanisms shall be capable of entry into flash operation and return to stop-and-go operation as follows:

1. Terminal Strip Input (Remote Flash). When called as a function of a terminal strip input, the controller shall provide both sequenced entry into flash and sequenced return to normal operation consistent with the requirements of the latest edition of the *Manual on Uniform Traffic Control Devices*.
2. Police Panel Switch. When the flash-automatic switch located behind the police panel door is turned to the flash position, the signals shall immediately revert to flash; and, the controller shall have a stop time input applied. When the switch is placed on automatic, the controller shall immediately time a 6 second all red period then resume stop-and-go operations at the beginning of major street green.
3. Controller Cabinet Switches. When the flash-automatic switch located inside the controller cabinet is placed in the flash position, the signals shall immediately revert to flash; however, the controller shall not have a stop time input applied. When the flash-automatic switch is placed in the automatic position, the controller shall immediately time a 6 second all red period, then resume stop-and-go operation at the beginning of the major green.
4. Power Interruption. On "NEMA" controllers, for any power interruption longer than 475 plus or minus 25 milliseconds, signals shall re-energize consistent with No. 2 above to ensure a 6-second flash period prior to the start of major street green. A power interruption of less than 475 plus or minus 25 milliseconds shall not cause resequencing of the controller and the signal displays shall re-energize without change. Type 2070 controllers shall re-energize consistent with No. 2 above after a power interruption of 1.75 plus or minus 0.25 seconds. The 6-second flash period will not be required. Any power interruption to a Type 2070 controller shall result in a 6 second flash period once power is restored.
5. Conflict Monitor. Upon detecting a fault condition, the conflict monitor shall immediately cause the signal to revert to flash and the controller to stop time. After the conflict monitor has been reset, the controller shall immediately take command of the signal displays at the beginning of major street green.

9-29.13(6) Emergency Preemption

Immediately after a valid call has been received, the preemption equipment shall cause the controller to terminate the appropriate phases as necessary with the required clearance intervals and enter any programmed subsequent preemption sequence. Preemption sequences shall be as noted in the Contract.

9-29.13(7) Drawings and Wiring Diagrams

Schematic wiring diagrams of the controllers, cabinets and auxiliary equipment shall be submitted when the assemblies are delivered. The diagram shall show in detail all circuits and parts. The parts shall be identified by name or number in a manner readily interpreted. Two hard copies and one PDF copy (on a USB flash drive) of each drawing, cabinet wiring diagram, and component wiring diagram shall be furnished with each cabinet and placed in the drawer shelf. The schematic drawing shall consist of a single sheet, detailing all circuits and parts, not to exceed 52-inches by 72-inches. The cabinet wiring diagram shall indicate and identify all wire terminations, all plug connectors, and the locations of all equipment in the cabinet. Included in the diagram shall be an intersection sketch identifying all heads, detectors, and pushbuttons and a phase diagram.

9-29.13(8) Generator Transfer Switch

A generator transfer switch shall be included on all Type 332, 332D, and 342LX cabinets. Generator transfer switches shall be included on other cabinet types when specified in the contract. The Generator Transfer Switch shall be capable of switching power from a utility power source to an external generator power source.

The Transfer Switch enclosure shall be of identical materials and dimensions and installation methods as the Police Panel type enclosure specified in the first paragraph of Section 9-29.13(10)D, with the exception that the enclosure door shall include a spring-loaded construction core lock capable of accepting a Best 6-pin or 7-pin CX series core. The core lock shall be provided with a construction core, of the same color as the cabinet doors, installed. Upon contract completion, two master keys for the construction core shall be delivered to the Engineer. The door shall be capable of being closed and locked while a generator cable is still plugged in, with the cable extending through a cable access notch with moveable cover. The plug shall not be removable when the door is closed and locked.

The enclosure shall include the following Transfer Switch equipment:

1. One NEMA L5-30P Flanged Inlet generator connector
2. One Utility power indicator light
3. One generator indicator light
4. A manual transfer switch that shall utilize an open transition (break before make) to ensure that utility power cannot be connected to the generator connection. The switch may be a rotary or similar switch, or may be composed of two circuit breakers. If two circuit breakers are used, they shall be 30 amp, 120 volt, single pole, single phase, circuit breakers. Switch positions shall be labeled as "Generator" and "Utility", with engraved phenolic name plates; where circuit breakers are used, the individual circuit breakers shall be labeled instead of the switch positions.
5. Where circuit breakers are used as the transfer switch, a mechanical lock out feature that prevents the Utility circuit breaker and the Generator circuit breaker from being in the ON position at the same time with the circuit breakers being capable of being independently switched. Alternatively, circuit breakers shall be installed with one inverted and both mechanically connected such that both operate in unison and one breaker opens before the other is closed.
6. The conductors from the Generator Transfer Switch enclosure to the cabinet circuit breaker shall be enclosed in nylon mesh sleeve.
7. The enclosure door shall be labeled with the letters "GTS".

9-29.13(9) Vacant**9-29.13(10) NEMA and Type 2070 Controllers and Cabinets****9-29.13(10)A Auxiliary Equipment for NEMA Controllers**

The following auxiliary equipment shall be furnished and installed in each cabinet for NEMA traffic-actuated controllers:

1. A solid-state Type 3 NEMA flasher with flash-transfer relay which will cut in the flasher and isolate the controller from light circuits. See Section 9-29.13(5) for operational requirements.
2. Modular solid state relay load switches of sufficient number to provide for each vehicle phase (including future phases if shown in the Plans), each pedestrian phase and preemption sequence indicated in the Contract. Type P & R cabinets shall include a fully wired 16-position back panel. Solid-state load switches shall conform to NEMA standards except only optically isolated load switches will be allowed. Load switches

shall include indicator lights on the input and output circuits. The controller cabinet shall have all cabinet wiring installed for eight vehicle phases, four pedestrian phases, four emergency pre-empts, four overlaps (OL A, B, C, D).

3. A power panel with:
 - a. A control-display breaker sized to provide 125 percent overload protection for all control equipment and signal displays, 20 amperes minimum.
 - b. A 15-ampere accessory breaker wired parallel to the control display breaker. The breaker will carry accessory loads, including, but not limited to, vent fans, cabinet lights, and plug receptacles.
 - c. A busbar isolated from ground and unfused for the neutral side of power supply.
 - d. A radio interference suppresser installed at the input power point. Interference suppressers shall be of a design which will minimize interference in both broadcast and aircraft frequencies and shall provide a minimum attenuation of 50 decibels over a frequency range of 200 kilohertz to 75 megahertz when used in connection with normal installations. The interference filters furnished shall be hermetically sealed in a substantial case filled with a suitable insulating compound. Terminals shall be nickel plated, 10-24 brass studs of sufficient external length to provide space to connect two 8 AWG wires and shall be so mounted that they cannot be turned in the case.

Ungrounded terminals shall be insulated from each other and shall maintain a surface leakage distance of not less than ½-inch between any exposed current conductor and any other metallic parts with an insulation factor of 100-200 megohms dependent on external circuit conditions.

Suppressers shall be designed for operations on 50 amperes, 125 volts, 60 cycles, single wire circuits, and shall meet standards of the Underwriters' Laboratories and the Radio Manufacturers Association.

- e. A Surge Protection Device connected to the controller power circuit for protection against voltage abnormalities of 1 cycle or less duration. The Surge Protection Device shall be a solid-state high-energy circuit containing no spark gap, gas tube, or crowbar component. The device shall provide transient protection between neutral and ground, line and ground, as well as line and neutral. If the protection circuits fail, they shall fail to an open circuit condition. The minimum interrupting capacity shall be 10,000 Amps. The Voltage Protection Rating shall be 600 volts or less when subjected to an impulse of 6,000 volts, 3,000-amp source impedance, 8.0/20 microsecond waveform as described in UL 1449. In addition, the device shall dissipate a 13,000 Amp or greater repeated single peak 8/20 microsecond current impulse, and withstand, without failure or permanent damage, one full cycle at 264 volts RMS. The device shall contain circuitry to prevent self-induced regenerative ringing. There shall be a failure warning indicator which shall illuminate a red light or extinguish a green light when the device has failed and is no longer operable.
 - f. Cabinet ground busbar independent (150K ohms minimum) of neutral.
4. A police panel located behind the police panel door with a flash automatic switch and a control-display power line on-off switch. See Section 9-29.13(5) for operational requirements.
5. An auxiliary control panel located inside the controller cabinet with a flash-automatic switch and a controller on-off switch. See Section 9-29.13(5) for operational requirements. A three wire 15 ampere plug receptacle with grounding contact and 15 ampere ground fault interrupter shall also be provided on the panel.

6. A conflict monitor conforming to NEMA standards. See Section 9-29.13(5) for operational requirements. The unit shall monitor conflicting signal indications at the field connection terminals. The unit shall be wired in a manner such that the signal will revert to flash if the conflict monitor is removed from service.

Supplemental loads not to exceed 10 watts per monitored circuit or other means, shall be provided to prevent conflict monitor actuation caused by dimming or lamp burn-out. Supplemental loads shall be installed on the control side of the field terminals. Conflict monitors shall include a minimum of one indicator light for each phase used. The monitoring capacity of the unit shall be compatible with the controller frame size. Conflict monitors shall include a program card.

7. A "Detector Panel", as specified in Section 9-29.13(10)B, shall be installed. The panel shall be mounted on the inside of the front cabinet door. The detector panel shall be constructed as a single unit. Detector switches with separate operate, test, and off positions shall be provided for each field detector input circuit. A high intensity light emitting diode (LED) shall be provided for each switch. The lamp shall energize upon vehicle, pedestrian, or test switch actuation. The test switch shall provide a spring-loaded momentary contact that will place a call into the controller. When in the OFF position, respective detector circuits will be disconnected. In the operate position, each respective detector circuit shall operate normally. Switches shall be provided on the panel with labels and functions as follows:
 - a. Display On – Detector indicator lights shall operate consistent with their respective switches.
 - b. Display Off – Detector indicator lights shall be de-energized.

A means of disconnecting all wiring entering the panel shall be provided. The disconnect shall include a means to jumper detection calls when the display panel is disconnected. All switches on the panel shall be marked with its associated Plan detector number. All markers shall be permanent.

8. Insulated terminal blocks of sufficient number to provide a termination for all field wiring. A minimum of 12 spare terminals shall be provided. Field wire connection terminal blocks shall be 600 volt, heavy duty, barrier type, except loop detector leads, which may be 300 volt. The 600 volt type terminal strips shall be provided with a field-side and a control-side connector separated by a marker strip. The 300 volt type shall have a marker strip, installed on the right side of vertical terminal strips or below horizontal terminal strips. The marker strip shall bear the circuit number indicated in the Plans and shall be engraved. Each connector shall be a screw type with No. 8 post capable of accepting no less than three 12 AWG wires fitted with spade tips.
9. A vent fan with adjustable thermostat. The minimum CFM rating of the fan shall exceed three times the cabinet volume.
10. All wiring within the cabinet, exclusive of wiring installed by the signal controller manufacturer, shall have insulation conforming to the requirements of Section 9-29.3. Cabinet wiring shall be trimmed to eliminate all slack and shall be laced or bound together with nylon wraps or equivalent. All terminals shall be numbered and permanently identified with PVC or polyolefin wire marking sleeve consistent with the cabinet wiring diagram provided by the signal controller manufacturer and the Contract. The cabinet will be completely wired so that the only requirement to make a field location completely operational is to attach field power and ground wiring. Internal cabinet wiring shall not utilize the field side connections of the terminal strip intended for termination of field wires.

11. Cabinet wiring diagram and component wiring diagrams meeting the requirements of Section 9-29.13(7) shall be furnished with each cabinet. Each cabinet shall be equipped with a shelf mounted roll out drawer mounted directly below the controller to house one or more cabinet wiring diagrams. The cabinet wiring diagram shall indicate and identify all wire terminations, all plug connectors, and the locations of all equipment in the cabinet. Included in the diagram shall be an intersection sketch identifying all heads, detectors, and pushbuttons; and a phase diagram.
12. Each vehicle detector amplifier, video detection output channel pedestrian call isolation unit, phase selector, discriminator, and load switch shall be identified with semi-permanent stick-on type label. The following information shall be included:
 - a. Vehicle Detector Amplifier Channel
 - i. Loop number
 - ii. Assigned phase(s)
 - b. Ped Call Isolation Unit
 - i. Pushbutton number
 - ii. Assigned phase(s)
 - c. Load Switches
 - i. Signal head number
 - ii. Assigned phase(s)
 - d. Phase Selectors
 - i. Circuit Letter
 - ii. Phase(s) called

The label shall be placed on the face of the unit. It shall not block any switch, light, or operational words on the unit. The lettering on this label shall be neat, legible, and easily read from a distance of approximately 6-feet.

9-29.13(10)B Auxiliary Equipment for Type 2070 Assemblies

The following requirements apply to required auxiliary equipment furnished with Type 2070 controllers:

1. Flashers, flash transfer relays, conflict monitor, AC isolators, DC isolators, discriminator modules, program modules, modem modules, breakers, buses, police panel switches, receptacles requirement, vent fans, and auxiliary control panel switches shall conform to the requirements noted in the TEES. DC isolators shall be capable of operating without 120 VAC available on the input file(s).
2. Flashing operation shall conform to Section 9-29.13(5), except the 6-second flash period described in Item 2 of that section will not be required. Emergency preemption shall conform to Section 9-29.13(6).
3. Input and output terminals shall be installed with a marking strip with field wire numbers noted in the Contract embossed on the strip. All cabinet and field conductor shall have a PVC or polyolefin wire marking sleeve installed, matching the input and output terminals above. Marking on sleeves shall be embossed or type written.
4. The input panel terminal blocks TB 2 through TB 9 and associated cable to the input files as described in the TEES shall be provided in all control assemblies.
5. Supplemental load resistor, not less than 2000 ohms and not greater than 5000 ohms not to exceed 10 watts per monitored circuit, shall be provided to prevent conflict monitor actuation caused by dimming or lamp burn-out.

Individual supplemental load resistors shall be installed within each output file on each of the following terminal circuits:

Output File #1LX

FT1-105 (SP 4P-Y)	FT2-114 (SP 2P-Y)
FT2-117 (SP 3-Y)	FT2-123 (SP 7-Y)
FT3-126 (SP 1-Y)	FT3-132 (SP 5-Y)
FT1-111 (SP 8P-Y)	FT2-120 (SP 6P-Y)
FT2-118 (SP 3-G)	FT2-124 (SP 7-G)
FT3-127 (SP 1-G)	FT3-133 (SP 5-G)

Output File #2LX

FT4-A102 (SP OLD-Y)	FT6-A122 (SP OLA-Y)
FT4-A103 (SP OLD-G)	FT6-A123 (SP OLA-G)
FT5-A115 (SP OLC-Y)	FT6-A125 (SP OLB-Y)
FT5-A116 (SP OLC-G)	FT6-A126 (SP OLB-G)

6. Load switches of sufficient quantity to fully populate the output files shall conform to TEES and shall have indicator lights for both input and output circuits.
7. A detector test panel, which shall be constructed as a single unit as shown in the [Standard Plans](#). Detector switches with separate operate (on), test, and off positions shall be provided for each field detector input circuit. A high intensity light emitting diode (LED) shall be provided for each switch. The lamp shall energize upon a detector call or test switch actuation. The test switch shall provide a spring-loaded momentary contact that will place a call into the controller. When in the OFF position, respective detector circuits will be disconnected. In the ON position, each respective detector circuit shall operate normally. A master display switch shall be provided on the panel with labels and functions as follows:
 - a. Display On – Detector indicator lights shall operate consistent with their respective switches.
 - b. Display Off – Detector indicator lights shall be de-energized.
 - c. Display Test (momentary contact) – All detector lights shall be energized, but does not put any calls in to the controller.

The detector test panel shall include a male (connector DT3P) and female (connector DT4S) Type DD50 D-Sub connectors as described in the [Standard Plans](#). Input and output cables to the detector test panel shall include the appropriate mating connector (DT3S and DT4P), such that the two cable ends can be connected and normal operations maintained if the detector test panel is removed.

All switches on the panel shall be marked with its associated Plan detector number. All markers shall be permanent.

8. A "Detector Termination and Interface Panel" shall be provided. When viewing the cabinet from the back, the panel shall be located on the upper left hand side of the cabinet. The panel shall be electrically located between the "Detector Test Panel" and the C-1 connector. The panel shall utilize touch safe insulated terminal blocks and each connector shall be a screw type with post.
9. Each switchpack socket shall have pin 11 common to Neutral.
10. The AC input Service Panel Assembly (SPA), with line voltage filter, transient surge protection and all neutral bus bars and equipment ground bus bars shall be on the right side of the cabinet, mounted no more than 18 inches from the bottom of the cabinet when viewed from the rear, as shown in the [Standard Plans](#), and meet the requirements described in TEES.

11. The PED yellow terminals on the CMU edge connector shall be extended with a 2 foot wire, coiled, heat shrink tipped and labeled for the correct corresponding terminal as CH-13Y/CMU-8, CH-14Y/CMU-11, CH-15Y/CMU-K, CH-16Y/CMU-N.
12. An "Absence of Red Programming Assembly" shall be provided, as shown in the [Standard Plans](#). There shall be provided on the back panel of the output file, 17 accessible jumper plug attachment areas, made up of three male pins per position (one, for each conflict monitor channel and one for red enable function). Each jumper plug shall be a two position connector, It shall be possible, by inserting and positioning one of the 16 connectors on the right two pins on the monitor board, to apply 120 VAC into a corresponding channel of the conflict monitor red channels. The connection between the red monitor board and the conflict monitor shall be accomplished via a 20 pin ribbon cable and the industry standard P-20 connector that attaches on the front panel of the monitor. It shall be possible, by inserting and positioning one of the 16 jumper plugs on the two left pins on the monitor board, to enable the corresponding channel to monitor for red fault by the conflict monitor. There shall be installed on the red monitor board a red fail monitor disable function that controls the 120 VAC red enable signal into the conflict monitor. During stop-and -go operation, 120VAC is sent via pin #20 on the P20 connector to enable red failure monitoring on the conflict monitor by having the connector moved to the side labeled "Red Enable". If this is disengaged by moving the connector to the side labeled "Red Relay", then 120VAC is removed from pin #20, and the conflict monitor will no longer monitor for red fail faults. The red enable function will also be wired such that if the traffic signal is in cabinet flash, then there will be no voltage on pin #20, and the conflict monitor will not monitor for red fail faults.
13. Each cabinet shall be provided with at least 20 empty neutral connections to accommodate field wiring. The neutral bus bars shall be of the style in which a lug is not needed to be applied to the neutral field wire(s). All of the neutral bars shall be secured in accordance with the TEES. All neutral bars shall be at the same electrical potential.
14. Equipment Branch Breaker -The equipment receptacle on the rear of either PDA #2LX and 3LX shall be wired in parallel with the ground fault current interrupt (GFCI) receptacle on the front of the PDA, such that if the GFCI trips or is placed in the "Test" mode, power shall not removed from the rear equipment receptacle.

9-29.13(10)C NEMA Controller Cabinets

Each NEMA traffic controller shall be housed in a weatherproof cabinet conforming to the following requirements:

1. Construction shall be of 0.073-inch minimum thickness series 300 stainless steel or 0.125 minimum thickness 5052 H32 ASTM B209 alloy aluminum with mill finish. Stainless steel shall be annealed or one-quarter-hardness complying with ASTM A666 stainless steel sheet. Cabinets may be finished inside with an approved finish coat of exterior white enamel. If no other coating is specified in the Contract Provisions the exterior of all cabinets shall be bare metal. All controller cabinets shall be furnished with front and rear doors.
2. The cabinet shall contain shelving, including, but not limited to, brackets, racks and hardware to support the controller and auxiliary equipment. All equipment shall set squarely on shelves or be mounted in racks and shall be removable without turning, tilting, or rotating or relocating one device to remove another.

3. One 24 position detector rack or two 12 position detector racks shall be installed. The rack(s) shall be wired for 2 channel loop detectors and assigned as follows:

Position	Detector Channel (Phase)
1	1
2	1
3	2
4	2
5	2
6	3
7	3
8	4
9	4
10	4
11	5
12	5

Position	Detector Channel (Phase)
13	6
14	6
15	6
16	7
17	7
18	8
19	8
20	8
21	1 (upper) / 5 (lower)
22	EVP A, C
23	EVP B, D
24	EVP A, B, C, D

Positions 22 and 23 shall be wired for a 2-channel discriminator and position 24 shall be wired for a 4-channel discriminator. Positions 22, 23, and 24 shall be wired to support the emergency preemption channels shown.

All loop detector positions shall be wired for presence/pulse detection/extension. If an external power supply is required for the entire racks(s) to be powered, it shall be included and installed. All rack(s) positions shall be labeled with engraved identification strips.

4. Additional detection utilizing the "D" connector shall be installed in accordance with the Contract. The cabinet shall be of adequate size to properly house the controller and all required appurtenances and auxiliary equipment in an upright position with a clearance of at least 3-inches from the vent fan and filter to allow for proper air flow. In no case shall more than 70 percent of the cabinet volume be used. There shall be at least a 2-inch clearance between shelf mounted equipment and the cabinet wall or equipment mounted on the cabinet wall.
5. The cabinet shall have an air intake vent on the lower half of the front door, with a 12-inch by 16-inch by 1-inch removable throw away filter, secured in place with a spring-loaded framework.
6. Each cabinet door shall be provided with:
- A three-point latch system. Locks shall be spring loaded construction locks capable of accepting a Best 6 pin or 7 pin core. A 6 pin construction core of the type (blue, green, red, or orange) specified in the contract shall be installed in each core lock. One core removal key and two standard keys shall be included with each cabinet and delivered to the Engineer.
 - A police panel assembly shall be installed in the front door and shall have a stainless steel hinge pin and a police panel lock. Two police keys with shafts a minimum of 1¾-inches long shall be provided with each cabinet.
 - A one piece, closed cell, neoprene gasket. This requirement also applies to the police panel and generator transfer switch panel doors.
 - A two position doorstep assembly.

7. LED light strips shall be provided for cabinet lighting. Each LED light strip shall be approximately 12 inches long, have a minimum output of 320 lumens, and have a color temperature of 4100K (cool white) or higher. Two light strips shall be provided. One light strip shall be ceiling mounted and oriented parallel to the door face. The second light strip shall be mounted under the lower shelf, such that the output terminal landings are illuminated. Lighting shall not interfere with the proper operation of any other ceiling or shelf mounted equipment. All lighting fixtures shall energize automatically when any door is opened. Each door switch shall be labeled "Light".

9-29.13(10)D Cabinets for Type 2070 Controllers

Type 2070 controllers shall be housed in a model 332LS cabinet unless specified otherwise in the contract. Type 332LS cabinets shall be constructed in accordance with TEES with the following modifications:

1. Each cabinet door shall be furnished with the equipment listed in Section 9-29.13(10)C item 6 above.
2. Each cabinet shall be furnished with auxiliary equipment described in Section 9-29.13(10)B.
3. Each cabinet shall be fabricated of stainless steel or sheet aluminum in accordance with Section 9-29.13(10)C, Item 1 above. Cabinets shall not be painted or anodized.
4. A disposable paper filter element with dimensions of 12" × 16" × 1" shall be provided in lieu of a metal filter. The filter shall be secured in the filter holder with a louvered aluminum cover. The maximum depth of the cover shall not be more than 0.5" inch to provide the filter to be flush against the door. No incoming air shall bypass the filter element.
5. Field wire terminals shall be labeled in accordance with the Field Wiring Chart.
6. LED light strips shall be provided for cabinet lighting, powered from the Equipment breaker on the Power Distribution Assembly. Each LED light strip shall be approximately 12 inches long, have a minimum output of 320 lumens, and have a color temperature of 4100K (cool white) or higher. There shall be three light strips for each rack within the cabinet. Lighting shall be ceiling mounted – rack mounted lighting is not permitted. Light strips shall be installed in the locations shown in the [Standard Plans](#). Lighting shall not interfere with the proper operation of any other ceiling mounted equipment. All lighting fixtures above a rack shall energize automatically when either door to that respective rack is opened. Each door switch shall be labeled "Light".
7. Rack mounted equipment shall be as shown in the [Standard Plans](#). The cabinet shall use PDA #2LX and Output File #1LX. Where an Auxiliary Output File is required, Output File #2LX (Model 240) shall also be included. Manufacturers may use the designation "LXW" in place of "LX" to designate a module modified to meet additional WSDOT requirements.
8. For Type 332D and 342LX Controller Cabinets
 - a. Each TYPE 332D Controller cabinet shall have the appearance of two Type 332 controller cabinets joined at opposing sides. The cabinet shall use Housing #1X and two Cage #1 as shown in the [Standard Plans](#). Each Type 342LX Controller Cabinet shall use Housing #3 and include two ITS Cages as shown in the [Standard Plans](#) and the TEES.
 - b. As viewed from the front of the cabinet, the right side of each cabinet shall be considered the Signal Control side and the left side of the cabinet shall be considered the ITS/COMM side.

- c. One police access panel shall be installed as shown in the *Standard Plans*.
- d. Three cabinet lights shall be provided over each cabinet rack and as described in item 6 of this Section.
- e. The Signal Control side of the cabinet shall include all equipment required for a Type 332LS cabinet or for Rack 1 of a Type 342LX cabinet, as appropriate, including the applicable Service Panel #1 and Input Panel #1.
- f. The ITS/COMM side of the cabinet shall contain ITS and Communication equipment and shall be furnished with the following:
 - i. One PDA-ITS as described in Section 9-29.13(12).
 - ii. One drawer shelf unit, mounted 36 inches from the bottom of the cabinet opening to the front of the cabinet and attaching to the front rails of the EIA rack, shall be provided. The shelf shall be fabricated from aluminum and shall contain a rollout flip-top drawer for storage of wiring diagrams and manuals.
 - iii. One mirrored Service Panel #1, sized as appropriate for a Type 332LS or 342LX cabinet, installed on the right side of the rack, such that it is back to back with the Service Panel for the Signal Control side. This second service panel shall use a Service Panel Assembly (SPA) and not a Service PDA. The power input terminals of this second service panel shall be wired to the load side of the main cabinet service panel input terminals (daisy-chained) of the Signal Control side service panel, unless otherwise specified in the Contract.
 - iv. Additional ITS and Communication equipment as described in the Contract Plans and the ITS section of the Contract Special Provisions.
- 9. Output Files #1LX and #2LX (Model 420) shall use the WSDOT field terminal connector panels shown in the *Standard Plans* in place of the field terminal connector panels shown in the TEES.
- 10. Each rack shall include a 1U rack-mounted terminal strip mounted at the top rear of the rack. The terminal strip shall have a minimum of 6 NEMA 5-15R receptacles on the front, oriented vertically (with the ground pin down), and spaced at least 2 inches apart. The terminal strip may have additional receptacles on the back, which shall also be spaced at least 2 inches apart. Single-width cabinets shall have one terminal strip; double-width cabinets shall have two (one for each rack). Each terminal strip shall be plugged into the PDA for its associated rack (equipment receptacle, unless otherwise directed).
- 11. Each cabinet shall include one Type 2070 Controller as specified in the Contract.
- 12. Each cabinet shall include a fiber-optic patch panel when specified in the Contract. Fiber-optic patch panels shall be installed such that all fiber connections and patch cord connections are fully clear of all doors in all positions (open or closed).

9-29.13(11) Traffic Data Accumulator and Ramp Meters

All cabinets designated for use as a traffic data or ramp meter shall be Type 334LS cabinets furnished to meet the requirements of Section 9-29.13(10)D, items 1 through 5, and the following:

- 1. Each cabinet shall be equipped with a Type 2070 ATC Controller meeting the requirements of Section 9-29.13(3), unless otherwise specified in the Contract.
- 2. Rack mounted equipment shall be as shown in the *Standard Plans*. Each cabinet shall use modified versions of Input Panel #1 and Service Panel #1 as shown in the *Standard Plans*.

3. PDA #3LX shall be modified as follows:
 - a. The PDA shall be designated #3LXW to show that it has been modified from the base TEES standard.
 - b. The C6P connector shall be included and wired as referenced in TEES Drawing A6-17, Note 9.
 - c. A second Model 430 transfer relay (TR2) shall be mounted on the rear of the PDA and wired as shown in the [Standard Plans](#).
 - d. The following terminals shall be wired together:

From	To	Function
T2-8	T4-6	TR1 Output to Field Green 2
T2-6	MU-3	Energizes TR1 and TR2 when MU is normal
T1-1	SR-3	Field Output - Sign On
T1-2	SR-3	Field Output - Sign On
T1-3	SR-4	Field Output - Sign Off
T1-4	SR-4	Field Output - Sign Off

- e. Load switches of sufficient quantity to fully populate the PDA shall be provided. Load switches shall conform to the TEES and shall have indicator lights for both input and output circuits.
- f. The field terminals on Terminal Block #1 and Terminal Block #4 shall include WSDOT standard terminal labels as follows:

Terminal Block Position	WSDOT Terminal Number	Function
T1-2	641	Sign On
T1-4	643	Sign Off
T1-5	644	Flasher Output NC
T1-6	645	Flasher Output NO
T4-1	631	Lane 3 - Red
T4-2	632	Lane 3 - Yellow
T4-3	633	Lane 3 - Green
T4-4	621	Lane 2 - Red
T4-5	622	Lane 2 - Yellow
T4-6	623	Lane 2 - Green
T4-7	611	Lane 1 - Red
T4-8	612	Lane 1 - Yellow
T4-9	613	Lane 1 - Green

The WSDOT field terminal connector panel shown in the [Standard Plans](#) shall be used in place of the field terminal connector panel for terminal block T4 shown in the TEES.

4. The Police Panel shall contain only one DPDT toggle switch. The switch shall be labeled POLICE CONTROL, with the two positions labeled ON and OFF.
5. Each cabinet shall include a Display Panel. The Display Panel shall meet the following requirements:
 - a. General.

The Display Panel shall show and provide detection for inputs and specified controller outputs. The display panel shall be fabricated from 0.125-inch thick brushed aluminum and constructed according to the details in the [Standard Plans](#). The panel shall be mounted at the top of the front of the rack, above the controller unit, as shown in the [Standard Plans](#).

b. Text.

All text on the detector panel shall be black in color and silk screened directly to the panel, with the exception of the Phenolic detector label and cabinet nameplates.

A nameplate for each loop shall be engraved with a 0.375-inch nominal text according to the Cabinet Field Wiring Charts provided in the Contract. The nameplates shall be permanently affixed to the detector panel.

c. LEDs.

All LEDs shall be size T 1-3/4 (5 mm) with tinted diffused lenses, with a 50-degree minimum viewing angle and a brightness of 8 millicandelas. All LEDs shall be red in color, with the exceptions that the three LEDs labeled "YELLOW" shall be yellow in color, and the three LEDs labeled "GREEN" shall be green in color.

d. Detector Panel Control Switch.

Each Display Panel shall be equipped with one Detector Display control switch on the panel with labels and functions as follows:

i. **ON:**

Detector panel LEDs shall operate consistent with their separate switches.

ii. **OFF:**

All detector indicator LEDs shall be de-energized. Detector calls shall continue to reach the controller.

iii. **TEST:**

All detector indicator LEDs shall illuminate and no calls shall be placed to the controller.

e. Advance Warning Sign Control Switch.

Each display panel shall be equipped with one Advance Warning Sign control switch on the panel with labels and functions as follows:

i. **AUTOMATIC:**

Sign Relay shall energize upon ground true call from controller.

ii. **SIGN OFF:**

Sign Relay shall de-energize.

iii. **SIGN ON:**

Sign Relay shall energize.

f. Sign Relay.

A Sign Relay and socket shall be installed on the rear of the display panel. The relay shall be wired as shown in the Plans. The relay coil shall draw (or sink) 50 milliamperes \pm 10 percent from the controller and have a DPDT contact rating not less than 10 amperes. A 1N4004 diode shall be placed across the relay coil to suppress voltage spikes. The anode terminal shall be connected to terminal #7 of the relay as labeled in the plans. The relay shall energize when the METERING indicator LED is lit.

g. Detector Input Indicators.

One LED and one spring-loaded two-position SPST toggle switch shall be provided for each of the 40 detection inputs. Each LED and switch pair shall function as follows:

i. **TEST:**

A call shall be placed to the controller and energize the associated LED. The switch shall automatically return to the run position when it is released.

ii. **RUN:**

The associated LEDs shall illuminate for the duration of each call to the controller.

h. Controller Output Indicators.

The display panel shall contain a series of output indicator LEDs mounted below the detection indicators, as shown in the *Standard Plans*. These LEDs shall illuminate upon a ground true output from the controller via the C5 connector.

Each output indicator LEDs shall have a resistor in series to drop the voltage from 24 volts DC to its rated voltage and limit current below its rated current. The anode connection of each LED to +24 VDC shall be wired through this resistor.

i. Connectors.

The Display Panel shall include three connectors. One plug (labeled P1P) and one socket (labeled P2S) shall be Type DD50 D-Sub connectors as described in the *Standard Plans*. The third connector shall be a 37 pin C5P connector as shown in the TEES. The associated P1S and P2P connectors shall connect to the cabinet input files and C1 connector, respectively. Connectors P1S and P2P shall be compatible such that the two connectors can be connected directly to one another to bypass the Display Panel and normal operations will be maintained.

Wiring for connectors P1P, P1S, P2P, P2S, C1P, C2, C4, C5 and C6 shall be in accordance with the pin assignments shown in the *Standard Plans*.

6. Each cabinet shall be supplied with one Model 204 flasher unit and socket mounted on the right rear side panel, which shall be designated as the Sign Flasher, as shown in the *Standard Plans*. The flasher unit socket shall be wired as shown in the *Standard Plans*.
7. Each cabinet shall include a fiber-optic patch panel when specified in the Contract. Fiber-optic patch panels shall be installed such that all fiber connections and patch cord connections are fully clear of all doors in all positions (open or closed).
8. Loop lead-in cables shall be labeled and connected to cabinet terminals according to the Cabinet Field Wiring Chart provided in the Contract.
9. Type 334D Cabinets shall be identical to Type 332D cabinets, as described in Section 9-29.13(10)D, with the following exceptions:
 - a. As viewed from the front of the cabinet, the right side of each cabinet shall be considered the Ramp Metering/Data Station side, and the left side of each cabinet shall be considered the ITS/COMM side.
 - b. The Ramp Meter/Data Station side shall include all equipment required for a Type 334LS cabinet, including the applicable Service Panel #1 and Input Panel #1.

10. Each rack shall include a 1U rack-mounted terminal strip mounted at the top rear of the rack. The terminal strip shall have a minimum of 6 NEMA 5-15R receptacles on the front, oriented vertically (with the ground pin down), and spaced at least 2 inches apart. The terminal strip may have additional receptacles on the back, which shall also be spaced at least 2 inches apart. Single-width cabinets shall have one terminal strip; double-width cabinets shall have two (one for each rack). Each terminal strip shall be plugged into the PDA for its associated rack (equipment receptacle, unless otherwise directed).

9-29.13(12) Type 331L ITS Cabinet

Basic ITS cabinets shall be Model 331LS Cabinets, unless otherwise specified in the Contract. Type 331LS Cabinets shall be constructed in accordance with the TEES, with the following modifications:

1. The basic cabinet shall be furnished with only Housing 1 B, Mounting Cage 1, Service Panel #1, a Drawer Shelf, and Controller Unit Supports. Additional equipment may be specified as part of the cabinet function-specific standards.
2. Each cabinet shall be fabricated of stainless steel or sheet aluminum in accordance with Section 9-29.13(10)C, item 1. Cabinets shall not be painted or anodized.
3. Each cabinet door shall be furnished with the equipment listed in Section 9-29.13(10)C, item 6.
4. A disposable paper filter element with dimensions of 12" × 16" × 1" shall be provided in place of a metal filter. The filter shall be secured in the filter holder with a louvered aluminum cover. The maximum depth of the cover shall not be more than 0.5" inch to ensure that the filter will remain flush against the door. No incoming air shall bypass the filter element.
5. Each cabinet shall include a 120VAC electric strip heater with a rating of 100 watts, which shall be thermostat controlled. The heater strip shall be fed by wire with a temperature rating of 400°F or higher, and shall be shielded to prevent contact with wiring, equipment, or personnel. If the heater thermostat is separate from the fan thermostat, the heater thermostat must meet the same requirements as the fan thermostat as defined in TEES.
6. LED light strips shall be provided for cabinet lighting, powered from the Equipment breaker on the Power Distribution Assembly. Each LED light strip shall be approximately 12 inches long, have a minimum output of 320 lumens, and have a color temperature of 4100K (cool white) or higher. There shall be three light strips for each rack within the cabinet. Lighting shall be ceiling mounted – rack mounted lighting is not permitted. Light strips shall be installed in the locations shown in the [Standard Plans](#). Lighting shall not interfere with the proper operation of any other ceiling mounted equipment. All lighting fixtures above a rack shall energize automatically when either door to that respective rack is opened. Each door switch shall be labeled "Light".
7. Each cabinet shall be equipped with a rack mounted power distribution assembly (PDA-ITS) as shown in the Contract, with the same exterior dimensions as shown in the TEES for PDA #2LX. The PDA-ITS shall include the following equipment:
 - a. One duplex NEMA 5-15R GFCI receptacle on the front of the PDA.
 - b. Four duplex NEMA 5-15R receptacles on the rear of the PDA. These receptacles shall remain energized on a trip or failure of the GFCI receptacle.
 - c. Five 1P-15A, 120VAC Equipment/Field Circuit Breakers.
 - d. Terminal Block T4 as shown in the TEES for PDA #2LX.

The rear of the PDA shall be a fold down panel, similar to that shown in the TEES for PDA #2LX, with Terminal Block T4 mounted on the inside of the fold down panel.

8. Type 331D Cabinets shall be identical to Type 332D cabinets, as described in Section 9-29.13(10)D, with the following exceptions:
 - a. As viewed from the front of the cabinet, the right side of each cabinet shall be considered ITS/COMM Rack #1, and the left side of each cabinet shall be considered ITS/COMM Rack #2.
 - b. Both sides of the cabinet shall include all equipment required for a Type 331LS cabinet, including the applicable Service Panel #1, with the service panel for rack #2 mirrored as required. The two service panel input power connections shall be wired together as described in Section 9-29.13(10)D.
9. Each rack shall include a 1U rack-mounted terminal strip mounted at the top rear of the rack. The terminal strip shall have a minimum of 6 NEMA 5-15R receptacles on the front, oriented vertically (with the ground pin down), and spaced at least 2 inches apart. The terminal strip may have additional receptacles on the back, which shall also be spaced at least 2 inches apart. Single-width cabinets shall have one terminal strip; double-width cabinets shall have two (one for each rack).
10. Each cabinet shall include a fiber-optic patch panel when specified in the Contract. Fiber-optic patch panels shall be installed such that all fiber connections and patch cord connections are fully clear of all doors in all positions (open or closed).

9-29.14 Vacant

9-29.15 Flashing Beacon Control

Line Voltage flashers shall conform to the latest NEMA publication, and shall be solid state. When used as a beacon control, they may be jack mounted or panel mounted and shall be installed in raintight aluminum or hot-dipped galvanized steel cabinet.

Control units for rectangular rapid flashing beacon (RRFB) systems shall be as provided by the RRFB system manufacturer in a weatherproof housing.

9-29.16 Vehicular Signal Heads, Displays, and Housing

Each signal head shall be of the adjustable, vertical type with the number and type of displays detailed in the Contract; shall provide an indication in one direction only; shall be adjustable through 360 degrees about a vertical axis; and shall be mounted at the location and in the manner shown in the Plans. Except for optically programmed signal heads, all vehicular signal heads at any one intersection shall be of the same make and type.

Backplates shall be constructed of 5-inch-wide, 0.050-inch-thick aluminum. Backplates shall be powder-coated flat black, louvered, and attached with stainless steel hardware. A 1-inch-wide strip of yellow retro-reflective, type IV prismatic sheeting (tape), conforming to the requirements of Section 9-28.12, shall be applied around the perimeter of each backplate for displays used in conventional traffic signal systems and overhead intersection control beacons. Retro-reflective tape shall not be installed on backplates for other flashing beacon systems (ground or overhead) or for systems where all sections of the display will be dark as part of normal operation such as ramp meters, hawk signals and tunnels.

9-29.16(1) Optically Programmed, Adjustable Face, and Programmable Array 12-Inch Traffic Signal

The signal shall permit the visibility zone of the indication to be determined optically and require no hoods or louvers. The projected indication may be selectively visible or veiled anywhere within the optical axis. No indication shall result from external illumination, nor shall one light unit illuminate a second. The display shall operate from 85 VAC to 130 VAC.

9-29.16(1)A Optical System**9-29.16(1)A1 Vacant****9-29.16(1)A2 LED Programmable Array**

1. LED array shall have a programmable visibility from a portable hand-held device from ground level.
2. Lens shall be clear unless color lenses are specified.

The LED array shall be 22 watt maximum and shall operate directly from 120-volt AC.

The LED array shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1,200 feet distant, and permit an effective veiling mask to be variously applied as determined by the desired visibility zone.

The optical system shall accommodate projection of diverse selected indicia to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer after optically limiting procedures have been accomplished. The projected indication shall conform to ITE transmittance and chromaticity standards.

9-29.16(1)B Housing Construction

Die cast aluminum parts shall conform to ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with a high quality, baked enamel prime and finish paint.

The lens holder and interior of the case shall be optical black.

Signal case and lens holder shall be predrilled for backplates and visors. Hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather resistant rubber gaskets.

9-29.16(1)C Mounting

The signal shall mount to standard 1½-inch fittings as a single section, as a multiple section face, or in combination with other signals. The signal section shall be provided with an adjustable connection that permits incremental tilting of at least 0 to 10 degree above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connection shall permit external adjustment about the mounting axis in five degree increments. The signal shall be mountable with ordinary tools and capable of being serviced with no tools.

Attachments such as visors, backplates, or adapters shall conform and readily fasten to existing mounting surfaces without affecting water and light integrity of the signal.

9-29.16(1)D Housing Electrical**9-29.16(1)D1 Electrical - Non-LED**

The lamp fixture shall be comprised of a separately accessible housing and integral lamp support, indexed ceramic socket, and self-aligning, quick release lamp retainer. The electrical connection between case and lamp housing shall be accomplished with an interlock assembly which disconnects lamp holder when opened. Each signal section shall include a covered terminal block for clip or screw attachment of lead wires. Concealed 18 AWG-AWM, stranded and coded wires shall interconnect all sections to permit field connection within any section.

9-29.16(1)D2 Electrical - LED

The Light Emitting Diode (LED) array shall be accessible from the front of the housing. Each multi-section assembly shall include a terminal block for clip or screw attachment of lead wires.

9-29.16(1)E Photo Controls**9-29.16(1)E1 Conventional Photo Controls**

Each signal section shall include integral means for regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 1,000 foot-candles (fc) ambient and shall reduce to 15 plus or minus 2 percent of maximum at less than 1 fc ambient. Response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 1,000 fc ambient and damped for any decrease from 100 fc ambient.

The intensity controller shall comprise an integrated, directional light, sensing and regulating device interposed between lamp and line wires. It shall be compatible with 60 Hz input and responsive within the range 105 VAC to 135 VAC. Output may be phase controlled, but the device shall provide a nominal terminal impedance of 1,200 ohms open circuit and a corresponding holding current.

9-29.16(1)E2 LED Photo Controls

Each signal section shall include an integral means to automatically regulate the display intensity for day and night operation.

9-29.16(1)F Installation

The signal shall be installed, directed, and veiled in accordance with published instructions and the project visibility requirement. Each section of the signal shall be masked with prescribed materials in an acceptable and workmanlike manner.

9-29.16(2) Conventional Traffic Signal Heads**9-29.16(2)A Optical Units**

LED light sources are required for all displays. The Contractor shall provide test results from a Nationally Recognized Testing Laboratory documenting that the LED display conforms to the current ITE Specification for Vehicle Traffic Control Signal Heads, Light Emitting Diode Circular Signal Supplement VTCSH ST-052 or Vehicle Traffic Signal Heads, Light Emitting Diode Vehicle Arrow Traffic Signal Supplement ITE VTCSH ST-054, and the following requirements:

1. The LED traffic signal module shall be operationally compatible with controllers and conflict monitors on this project, and the LED lamp unit shall contain a disconnect that will show an open switch to the conflict monitor when less than 60 percent of the LEDs in the unit are operational.
2. LEDs shall have a 50-degree minimum viewing angle.
3. **Wattage (Maximum)** – 12 inch red, yellow, and green ball displays – 25 W
12 inch red, yellow, and green arrow displays – 15 W
8 inch red, yellow, and green ball displays – 15 W
4. **Voltage** – The operation voltages shall be between 85 VAC and 130 VAC.
5. The LED display shall be a module type and shall replace the lens, socket, bail, and reflector and be directly connected to the terminal strip in the signal head.
6. **Label** – Each optical unit shall be listed by and bear the label of a Nationally Recognized Testing Laboratory. In addition, the manufacturer's name, trademark, serial number, and other necessary identification shall be permanently marked on the back side of the LED signal module, and the installation date shall be indicated on a separate label with an indelible ink marker.
7. LED ball displays shall have a uniform "incandescent" appearance. Individual LEDs or pixels shall not be visible.

9-29.16(2)B Signal Housing

The signal head housing, or case, shall consist of an assembly of separate sections, expandable type for vertical mounting, substantially secured together in a weathertight manner. Each section shall house an individual optical unit.

Each section shall be complete with a one-piece, corrosion-resistant aluminum alloy die cast door and shall have a nominal 8- or 12-inch diameter opening for the lens. Each door shall be of the hinged type having two integrally cast hinge lugs and latch jaw. The door shall be attached to the housing by means of two noncorrosive, stainless steel hinge pins that are removable without the use of a special press or tool. A noncorrosive, stainless steel, threaded latch bolt and matching wing nut shall provide for opening and closing the door without the use of any special tools. Each door shall have a cellular neoprene gasket around the entire outer edge of the door, which, when the door is closed, shall make a positive weather and dust-tight seal. Each door shall have four tapped holes spaced about the circumference of the lens opening with four noncorrosive screws to accommodate the signal head visors. Each door shall have some device such as washers, clips, or keys, or be constructed so as to keep it from dismounting from the housing accidentally when it is open.

The body of each signal section shall consist of a one piece corrosion resistant, die cast aluminum alloy. Each section shall have serrated rings top and bottom so when used with proper brackets, each section may be adjustable in respect to an adjoining section, and the hangers shall be locked securely to prevent moving. Cast integrally with the housing shall be two hinge lugs and one latch jaw. The top and bottom of the housing shall have an opening to accommodate standard 1½-inch pipe brackets. The sections shall be so designed that when assembled, they interlock with one another forming one continuous weathertight unit. The sections shall be interchangeable and shall be dust and weathertight when assembled with the door and appropriate furnished hardware.

A terminal block of an approved type shall be mounted inside at the back of the housing. All sockets shall be so wired that a white wire will be connected to the shell of the socket and a wire, the color of the lens, to the bottom, or end terminal of the socket. These wires shall in turn be connected to the terminal block mounted in the housing, in the proper manner. The terminal block shall have sufficient studs to terminate all field wires and lamp wires independently to the block with separate screws. The terminals to which field wires are attached shall be permanently identified to facilitate field work.

Each face shall be protected with a removable visor. The visor shall be tunnel type unless noted otherwise in the Contract. Tunnel, cap, and cut away type visors shall be molded using ultraviolet and heat stabilized polycarbonate plastic or be constructed of 0.050-inch corrosion resistant aluminum material throughout as specified in the Contract, or as ordered by the Engineer in accordance with Section 1-04.4. Visors shall be flat black in color inside and shall be flat black or dark green on the outside. Visors shall have attaching ears for installation to the housing door. The signal display shall have square doors. End caps shall be made from aluminum or plastic material and shall be installed with fittings to provide a watertight seal. A bead of silicone sealant shall be applied around the perimeter of all top end cap openings prior to installation of the end cap assembly. Plastic end caps shall utilize a threaded stud with seal and wing nut. Plastic end caps utilizing a metal screw that may damage the cap if overtightened will not be allowed. Plastic end caps shall have the same color as the signal housing.

9-29.16(2)C Louvered Visors

Where noted in the Contract, louvered tunnel visors shall be furnished and installed. Directional, Geometrically Programmed louvers shall be constructed to have a snug fit in the signal visor. Louvers shall be flat black, constructed of aluminum or ABS and polycarbonate plastic. Dimensions and arrangement of louvers shall be as shown in the Contract.

9-29.16(2)D Vacant**9-29.16(2)E Painting Signal Heads**

Traffic signal heads shall be finished with two coats of factory applied traffic signal green baked enamel or shall be finished with a dark green oven baked powder coating comprised of resins and pigments. Aluminum end caps shall be painted to match the color of the signal housing.

9-29.16(3) Polycarbonate Traffic Signal Heads

Polycarbonate signal heads shall be provided only when specifically identified in the Contract. With the exception of top and bottom bracket mountings, polycarbonate signal heads shall be installed with approved reinforcing plates located in signal sections adjacent to the mounting hardware.

Polycarbonate employed in traffic signal fabrication shall tolerate an elongation prior to break in excess of 90 percent. The green color shall be molded throughout the head assembly. The optical system shall be Light Emitting Diodes as defined in Section 9-29.16(2)A. The entire optical system shall be sealed by a single neoprene gasket. The signal head shall be formed to be used with standard signal head mounting accessories as shown in Section 9-29.17. All hinge pins, latch assemblies, and reflector assemblies shall conform to Section 9-29.16(2)B.

9-29.16(4) Traffic Signal Cover

Traffic signal display covers shall be manufactured from a durable fabric material with a mesh front. Plastic bags, plastic sheeting, burlap, or similar makeshift covers are not allowed. The covers shall have an attachment method that will hold the cover securely to the signal in heavy wind, such as straps, buckles, or elastic drawstrings – no adhesives may be used. The covers shall be provided with a drain to expel any accumulated water.

One cover shall cover an entire signal display – separate covers for each lens are not allowed. For vehicle displays, if the cover is not designed to go over the backplate, the backplate shall be removed until the display is placed into service.

At any intersection where there is a combination of operational and covered signal heads, signal head covers shall be yellow or orange in color. At an intersection where there are no existing operational signal displays, the covers may be black in color. The text “Not in Service”, “Out of Service”, or similar may be included on the cover, but it is not required.

9-29.17 Signal Head Mounting Brackets and Fittings

Vehicle and pedestrian signal head mountings shall be as detailed in the [Standard Plans](#). Material requirements for signal head mounts are as follows:

Aluminum

1. Hinge fittings for Type E mount.
2. Arms and slotted tube fittings for Type N mount.
3. Tube clamp and female clamp assembly for Type N mount.
4. Lower arms for Type Q, R, and S mounts.
5. Tether assemblies and extensions for Type P, Q, R, and S mounts.

Bronze

1. Terminal compartments for Type A, B, C, F, H, and K mounts.
2. Collars for Type C, D, and F mounts.
3. Ell fittings for Type L and LE mounts.
4. Plumbizer for type M mounts.

5. Messenger hanger and wire entrance fittings for Type P, Q, R, and S mounts.
6. Balance adjuster for Type Q, R, and S mounts.
7. Lock (chase) nipples.

Galvanized Steel

1. Washers for Type A, B, C, D, F, H, and K mounts.
2. Fasteners for Type A, B, E, H, and K mounts.

Iron

1. Elbow, tee, and cross fittings.

Stainless Steel

1. All set screws and cotter Keys.
2. Bands or cables for Type N mount.
3. Hinge pins for Type E mount.
4. Bolts, nuts, and washers for Type M mount.
5. Bolt, nut, and washers for Type L mount.
6. Bolts, nuts, washers, and screw buckle swivels.

Steel

1. Center pipes and nipples for Type A, B, C, F, H, and K mounts.
2. Nipples for Type L, LE, P, Q, R, and S mounts.

Fittings for Type N mounts shall be installed unpainted. All other hardware for other mounts shall be painted with two coats of factory applied traffic signal green baked enamel.

Pins for messenger hanger fittings shall be a minimum of ½ inch in diameter.

Terminal compartments for Type A, B, C, F, H, and K mounts shall contain a 12 section terminal block.

9-29.18 Vehicle Detector

Induction loop detectors and magnetometer detectors shall comply with current NEMA Specifications when installed with NEMA control assemblies and shall comply with the current California Department of Transportation document entitled "Transportation Electrical Equipment Specifications", specified in Section 9-29.13(7) when installed with Type 170, Type 2070, or NEMA control assemblies.

9-29.18(1) Induction Loop Detectors

When required in the Contract, amplifier units shall be provided with supplemental timing features identified as follows:

1. **Delay Timing** – When delay timing is required, the unit shall delay detector output for up to 15 seconds minimum, settable in one second maximum intervals.
2. **Delay Timing With Gate** – When delay timing with gate is required, the unit shall provide delay timing features as noted above with the additional capability of inhibiting delay timing when an external signal is applied.
3. **Extension Timing** – When extension timing is required, the unit shall extend the detector output for up to 7 seconds minimum, settable in 0.5 second minimum intervals.

4. **Delay and Extension Timing With Gate** – When delay and extension timing with gate is required, the unit shall provide both delay and extension timing features as noted above with the additional capability of inhibiting delay while enabling extension upon application of an external signal. Without external signal, the unit shall inhibit extension and enable delay.

9-29.18(2) Magnetometer Detectors

Magnetometer detector units and sensors shall conform to the following Specifications:

1. **Operation** – The magnetometer detector unit shall respond to changes in the earth's local magnetic field caused by the passage of a vehicle containing iron or steel over the sensor unit.
2. **Environmental Requirements** – Satisfactory operation shall be attained over the ambient temperature range from -30°F to 160°F. Operation shall be unaffected by temperature change, water, ice, pavement deterioration, or electromagnetic noise.
3. **Modes of Operation** – Each detector channel shall be capable of functioning in any of four front-panel selectable modes:
 - a. **Presence** – Time of detection shall be unlimited.
 - b. **Extended Presence** – The detection output shall extend for a timer set value of up to 5 seconds after the detection zone has cleared.
 - c. **Pulse** – A single 30- to 50-millisecond pulse will be generated per detection actuation.
 - d. **Inhibited Pulse** – The detection output will be inhibited for a time set value of up to 5 seconds after the detection zone has cleared.
4. **Response Time.** Pick up and drop out times shall be consistently within 10 milliseconds.
5. **Approach Speed.** The unit shall be capable of detecting vehicles traveling from 0 to 80 mph.
6. **Sensor Probes.** Each channel of the detector unit shall be capable of operating up to three sensing probes.

9-29.19 Pedestrian Pushbuttons

Pedestrian pushbuttons shall be accessible type unless otherwise specified in the Contract. Pedestrian pushbuttons shall either be Accessible Pedestrian Signal (APS) type or Accessible Information Device (AID) type. Each pushbutton shall be a complete pushbutton system for each pedestrian pushbutton location shown in the Plans and include the following:

1. Flat dark green colored housing. For two-piece housings, the back section may be flat black if flat dark green is not available as a stock color.
2. High contrast pushbutton arrow (dark on a light background or light on a dark background). White on silver or silver on white are not acceptable as high contrast.
3. Integral sign. Signs shall not include braille. Adaptor plates shall be included if required to accommodate the sign.
 - a. APS pushbuttons shall include a 9" x 15" R10-3e sign.
 - b. AID pushbuttons shall include a 9" x 12" R10-25 sign. The sign may include integral yellow warning lights.
4. Voice messages as specified, pre-installed. Voice shall be male.

5. Any other equipment necessary to support accessing the pushbutton from a computer running Microsoft Windows™.

APS pushbuttons shall include the following additional features:

6. Percussive tone / rapid tick walk indication.
7. Vibrotactile walk indication. AID pushbuttons shall not include any motors or similar equipment capable of providing a vibrotactile indication.
8. Interface unit for installation in the associated pedestrian signal display.
9. Interconnect cable for installation between the pushbutton and the pedestrian signal display interface unit. Interconnect cable shall be provided by the pushbutton manufacturer or shall be four conductor cable meeting the requirements of Standard Specifications 9-29.3(2)B or 9-29.3(2)G if they meet manufacturer's requirements.

Copies of all speech messages audio files shall be provided electronically to the Contracting Agency. Speech messages for APS pushbuttons shall also be provided on a USB flash drive placed in the drawer of the traffic signal controller cabinet for the intersection (one for each intersection).

Dual pushbutton adaptors shall be provided when needed for installation of two pushbuttons on a single pole. Each adaptor shall be from the same manufacturer as the pushbutton.

Only one brand of pushbutton may be used for a particular application (APS or AID) for the entire Contract.

Each APS pushbutton shall include a label tape with the text "Crossing (A) at (B)", where "(A)" and "(B)" are the street names as described in Section 9-29.19(1). The label shall be installed directly on the side or back of the pushbutton and shall remain intact and legible until final installation.

All pushbuttons shall be delivered to the Operating Agency for verification and owner setup. Upon completion of setup, the Contractor will be notified that the pushbuttons are ready for pickup and installation.

9-29.19(1) Speech Messages for Pedestrian Pushbuttons

APS pushbutton speech messages shall be provided in the following format:

1. "Wait".
2. "Wait to cross "(A)" at "(B)".
3. "Walk sign is on to cross "(A)".

Where (A) and (B) are the applicable street names as provided in the Contract. Order forms shall be completed by the Contractor.

9-29.20 Pedestrian Signals

Pedestrian signals shall be Light Emitting Diodes (LED) type.

The LED pedestrian signal module shall be operationally compatible with controllers and conflict monitors. The LED lamp unit shall contain a disconnect that will show an open switch to the conflict monitor when less than 60 percent of the LEDs in the unit are operational.

The Pedestrian signal heads shall be on the QPL or Contractor shall submit a Manufacturer's Certificate of Compliance, in accordance with Section 1-06.3, with each type of signal head. The certificate shall state that the lot of pedestrian signal heads meet the following requirements:

1. All pedestrian signal heads shall be a Walk/Don't Walk module with a countdown display.
2. All pedestrian displays shall comply with the MUTCD and ITE publication ST 011B, VTC SH2 or current ITE Specification and shall have an incandescent appearance. The Contractor shall provide test results from a Nationally Recognized Testing Laboratory documenting that the LED display conforms to the current ITE and the following requirements:
 - a. All pedestrian signals supplied to any one project shall be from the same manufacturer and type but need not be from the same manufacturer as the vehicle heads.
 - b. Each pedestrian signal face shall be a single unit housing with the signal indication size, a nominal 16 inch × 18 inch with side by side symbol messages with countdown display.
 - c. Housings shall be green polycarbonate or die-cast aluminum and the aluminum housings shall be painted with two coats of factory applied traffic signal baked green enamel. All hinges and latches and interior hardware shall be stainless steel.
3. Optical units for traffic signal displays shall conform to the following:
 - a. Pedestrian "RAISED HAND" and "WALKING PERSON" modules shall be the countdown display type showing the time remaining in the pedestrian change interval. When the pedestrian change interval is reduced due to a programming change, the display may continue to show the previous pedestrian change interval for one signal cycle. During the following pedestrian change interval the countdown shall show the revised time, or shall be blank. In the event of an emergency vehicle preemption, during the following two cycles, the display shall show the programmed pedestrian change interval or be blank. In the event the controller is put in stop time during the pedestrian change interval, during the following two cycles the display shall show the programmed clearance or be blank. In the event there is railroad preempt during the pedestrian change interval, during the following two cycles the display shall show the programmed clearance or be blank. Light emitting diode (LED) light sources having the incandescent appearance are required for Portland Orange Raised Hand and the Lunar White Walking Person.
4. LED displays shall conform to the following:
 - a. Wattage (Maximum) – Portland Orange Raised Hand, 15 watts: Lunar White Walking Person, 15 watts.
 - b. Voltage – The operating voltages shall be between 85 VAC and 135 VAC.
 - c. Temperature – Temperature range shall be -35°F to +165°F.
 - d. LED pedestrian heads shall be supplied with Z crate visors. Z crate visors shall have 21 members at 45 degrees and 20 horizontal members.
 - e. LED pedestrian displays shall have a uniform "incandescent" appearance. Individual LEDs or pixels shall not be visible.

9-29.21 Flashing Beacon

9-29.21(1) Conventional Flashing Beacons

Conventional flashing beacons shall be installed as detailed in the Plans, as specified in the Special Provisions, and as described below:

Controllers for flashing beacons shall be as specified in Section 9-29.15.

Beacons shall consist of single section, 8 or 12-inch traffic signal heads, three or four-way adjustable, meeting all of the applicable requirements of Section 9-29.16. Displays (red or yellow) may be either LED type or incandescent. Twelve-inch yellow displays shall be dimmed 50 percent after dark.

Mounting brackets, mountings, and installation shall meet all applicable requirements of Section 9-29.17.

Lenses shall be either red or amber, glass or polycarbonate as noted in the Plans.

9-29.21(2) Rectangular Rapid Flashing Beacons

Rectangular Rapid Flashing Beacons (RRFBs) shall meet all physical, material, and operational requirements defined by the MUTCD / FHWA.

9-29.22 Vacant

9-29.23 Vacant

9-29.24 Service Cabinets

In addition to the requirements for service cabinets indicated in the Contract, the following requirements shall apply:

1. Display an arc flash and shock hazard warning label that meets the requirements of NFPA 70E Article 130.5(H) and ANSI Z535, with the following information:
 - a. Nominal System Voltage
 - b. Arc Flash Boundary (in inches)
 - c. Available Incident Energy (in cal/cm²)
 - d. Working Distance (in inches)
 - e. Minimum arc rating of clothing (in cal/cm²)
 - f. Shock Hazard Limited Approach Distance (in inches)
 - g. Shock Hazard Restricted Approach Distance (in inches)
 - h. Date of calculation.

The top of the tag shall normally include the word "WARNING" in black text on an orange background. For systems over 600 volts or where the incident energy exceeds 40 cal/cm², the word "DANGER" shall be used with a red background instead.

2. All electrical conductors, buss bars, and conductor terminals shall be copper. Conductor insulation shall be either THW, XHHW, USE, or SIS.
3. Where the Contract requires field wiring that is too large to terminate at the designated contactor or breaker, a terminal board shall be supplied for use as a splicing block.
4. The minimum size of all other load carrying conductors used within the service cabinets shall be based on the National Electrical Code ampacity tables for not more than three conductors in a raceway or cable.
5. Type B, B Modified, C, D, and E Cabinets shall have ventilation louvers on the lower sides complete with screens. Type D and E shall also have rain-tight cabinet vents with screens at the top. Cabinet vents shall be gasketed.
6. The Type B modified cabinets shall have one future use double pole circuit breaker. Type D and E cabinets shall have two future use double pole circuit breakers. The dead front cover shall have cutouts with for the entire breaker array, with blank covers where no circuit breakers are installed. The receptacle shall be ground fault interrupter equipped.

7. The minimum size of control circuit conductors used in service cabinets shall be 14 AWG stranded copper.
All electrical Contactors shall have the load side terminals toward the front (door side) of the service cabinet.
8. Lighting contactors shall meet the requirements of Section 9-29.24(2).
9. All service enclosures shall be fabricated from steel or aluminum. If aluminum, they shall be fabricated from 0.125 inch (minimum) 5052 H 32 ASTM designator or B209 aluminum. If steel, they shall be fabricated from 12-gage (minimum) steel, hot-dipped galvanized per AASHTO M111.
10. All doors and dead front panels installed in service cabinets shall incorporate a hinge placed in a vertical plane. Service doors shall be sealed with closed cell gasket material. The side opposite the hinge shall be secured with quarter turn screws or slide latch. No electrical devices shall be connected to the dead front panel. However, every switch serviced through the dead front panel shall be appropriately identified with its respective circuit designation by means of a screwed or riveted engraved name plate. Such circuit identification shall be submitted for approval together with the appropriate fabrication drawings. Dead front panels shall prevent access to any exposed, live components, and shall cover all equipment except for circuit breakers (including blank covers), the photocell test/bypass switch, and the GFCI receptacle.
11. A typed index of all circuits shall be mounted on the cabinet door. Each index shall show an entire panel section without folding. Index holders shall have metal returns on the sides and bottom. A schematic of the main panel, any subpanels, circuits, and control circuits shall be provided. The schematic shall be plastic coated and secured in a metal holder.

9-29.24(1) Vacant

9-29.24(2) Electrical Circuit Breakers and Contactors

All circuit breakers shall be bolt-on type, with the RMS-symmetrical interrupting capacity described in this Section. Circuit breakers for 120/240/277 volt circuits shall be rated at 240 or 277 volts, as applicable, with an interrupting capacity of not less than 10,000 amperes. Circuit breakers for 480 volt circuits shall be rated at 480 volts, and shall have an interrupting capacity of not less than 14,000 amperes.

Lighting contactors shall be rated for tungsten or ballasted (such as sodium vapor, mercury vapor, metal halide, and fluorescent) lamp loads. Contactors for 120/240/277 volt circuits shall be rated at 240 volts maximum line to line voltage, or 277 volts maximum line to neutral voltage, as applicable. Contactors for 480 volt circuits shall be rated at 480 volt maximum line to line voltage.

9-29.25 Amplifier, Transformer, and Terminal Cabinets

Amplifier, Terminal, and Transformer cabinets shall be NEMA 3R and the following:

1. All cabinets shall be constructed of welded 14 gage (minimum) hot-dipped galvanized sheet steel, 14-gage, minimum type 316 stainless steel or 0.125 inch, minimum 5052 alloy aluminum H32 ASTM designator minimum.
2. Nominal cabinet dimensions shall be:

	Depth	Height	Width
a. Terminal	8"	16"	12"
b. Terminal	8"	24"	18"
c. Transformer up to 12.5 KVA	20"	48"	24"
Transformer 12.6 to 35 KVA	30"	60"	32"

3. Cabinet doors shall have a stainless steel piano hinge or shall meet the requirements for the alternate hinge detailed for type B modified service cabinets. Doors less than 3 feet in height shall have two hinges. Doors from 3 feet to 4' 8" in height shall have three hinges. Spacing of hinges for doors greater than 4' 8" in height shall not exceed 14 inches center to center. The door shall also be provided with a three-point latch and a spring loaded construction core lock capable of accepting a Best six pin CX series core. The locking mechanism shall provide a tapered bolt. The Contractor shall supply construction cores with two master keys. The keys shall be delivered to the Engineer. Three-point latches are not required for terminal cabinets.
4. All seams shall be continuously welded.
5. All cabinets shall provide a gasketed door flange.
6. Transformer cabinets shall provide a 9-square-inch minimum louvered vent.
7. Insulated terminal blocks shall be 600 volt, heavy-duty, barrier type. The terminal blocks shall be provided with a field-side and a control-side connector separated by a marker strip. One spare 12-position insulated terminal block shall be installed in each terminal cabinet and amplifier cabinet.
8. Each non-pad mounted Terminal, Amplifier and Transformer cabinet shall have ¼ inch drain holes in back corners. Each pad mounted Terminal, Amplifier and Transformer cabinet shall drain to a sump and through a ¾ inch diameter drain pipe to grade as detailed in the *Standard Plans*.
9. Mounting shall be as noted in the Contract.
10. Transformer cabinets shall have two separate compartments, one for the transformer and one for the power distribution circuit breakers. Each compartment shall be enclosed with a dead front. There shall be an isolation breaker on the input (line) side of the transformer, and a breaker array on the output (load) side. Each breaker shall be labeled with the device name by means of a screwed or riveted engraved name plate.

9-30 Water Distribution Materials

This Specification addresses pipe and appurtenances 16 inches in diameter and smaller. Water distribution material incorporated in the Work shall be new.

The Contractor shall provide to the Engineer the names of the manufacturer(s) of the water distribution materials proposed for inclusion in the Work, which materials shall conform in every respect to these Specifications. If so required by the Special Provisions, the Contractor shall provide to the Engineer in addition to the names of the manufacturer(s) of the water distribution materials, a Manufacturer's Certificate of Compliance meeting the provisions of Section 1-06.3, for the materials proposed for inclusion in the Work. As used in this Specification, the term "lot of material delivered to the Work" shall mean a shipment of the water distribution materials as it is delivered to the Work.

The Engineer shall have free access to all testing and records pertaining to material to be delivered to the job site. The Engineer may elect to be present at any or all material testing operations.

9-30.1 Pipe

All pipe shall be clearly marked with the manufacturer's name, type, class, and thickness as applicable. Lettering shall be legible and permanent under normal conditions of handling and storage.

9-30.1(1) Ductile Iron Pipe

1. Ductile iron pipe shall meet the requirements of AWWA C151. Ductile iron pipe shall have a cement mortar lining and a 1-mil thick seal coat meeting the requirements of AWWA C104. Ductile iron pipe to be joined using bolted flanged joints shall be Special Thickness Class 53. All other ductile iron pipe shall be Special Thickness Class 50, minimum Pressure Class 350, or the class indicated in the Plans or the Special Provisions.
2. Nonrestrained joints shall be either rubber gasket type, push on type, or mechanical type meeting the requirements of AWWA C111.
3. Restrained joints shall be as specified in Section 9-30.2(6).

9-30.1(2) Polyethylene Encasement

Polyethylene encasement shall be tube-form high-density cross-laminated polyethylene film or linear low-density polyethylene film meeting the requirements of ANSI/AWWA C105. Color shall be natural or black.

9-30.1(3) Vacant**9-30.1(4) Steel Pipe****9-30.1(4)A Steel Pipe (6 inches and Over)**

Steel pipe 6 inches in diameter and larger shall conform to AWWA C200. The type of protective coating and lining and other supplementary information required by AWWA C200 shall be included in the Special Provisions.

9-30.1(4)B Steel Pipe (4 inches and Under)

Steel pipe 4 inches in diameter and smaller shall be hot-dip galvanized inside and out and meet the requirements of ASTM A53.

9-30.1(5) Polyvinyl Chloride (PVC)**9-30.1(5)A Polyvinyl Chloride (PVC) Pipe (4 inches and Over)**

PVC pipe for water mains shall meet the requirements of ANSI/AWWA C900 or ANSI/AWWA C905. PVC pipe shall have the same outside dimensions as ductile iron pipe. PVC pipe for distribution pipelines shall be a minimum of SDR 18. Pipe shall be listed by Underwriters' Laboratories, Inc.

PVC pipe shall be considered flexible conduit. Joints shall meet the requirements of ASTM D3139 using a restrained rubber gasket conforming to ASTM F477. Solvent welded pipe joints are not permitted.

9-30.1(5)B Polyvinyl Chloride (PVC) Pipe (Under 4 inches)

Polyvinyl chloride (PVC) under 4 inches shall meet the requirements of ASTM D2241. Pipe material shall be PVC 1120, PVC 1220, or PVC 2120, and shall have minimum wall thickness equal or greater than a standard dimension ratio (SDR) of 21. Pipe shall bear the National Sanitation Foundation Seal for use to transport potable water. Pipe shall be considered flexible conduit. Joints shall meet the requirements of ASTM D3139 using a restrained rubber gasket meeting the requirements of ASTM F477.

9-30.1(6) Polyethylene (PE) Pressure Pipe (4 inches and Over)

PE pressure pipe for water mains shall meet the requirements of ANSI/AWWA C906. Pipe materials shall be high-density polyethylene PE 4710 conforming to a minimum cell class 345464 C, D or E in accordance with ASTM D3350. Pipe diameter shall be either iron pipe size in accordance with Table 3 and Table 4 of ANSI/AWWA C906. Pipe pressure class shall be as listed in Table 5 of ANSI/AWWA C906 for DR 9 PE 4710 material.

9-30.2 Fittings

Bolts, nuts, and washers used for securing fittings shall be of similar materials. Steel bolts shall meet the requirements of ASTM A307 or ASTM F568 for carbon steel or ASTM F593 or ASTM F738 for stainless steel. Nuts shall meet the requirements of ASTM A563 for carbon steel or ASTM F594 or ASTM F836 for stainless steel. Iron bolts and nuts shall meet the requirements of ASTM A536, grade 65-45-12.

9-30.2(1) Ductile Iron Pipe

Fittings for ductile iron pipe shall meet the requirements of AWWA C110 or AWWA C153. Joints shall meet the requirements of AWWA C111. Fittings shall be cement mortar lined, meeting the requirements of AWWA C104. Gaskets for flat faced or raised faced flanges shall be 3/8-inch-thick neoprene having a durometer of 60 plus or minus 5 or 1/16 cloth inserted. The type, material, and identification mark for bolts and nuts shall be provided.

9-30.2(2) Vacant**9-30.2(3) Vacant****9-30.2(4) Steel Pipe****9-30.2(4)A Steel Pipe (6 inches and Over)**

Fittings for steel pipe 6 inches and larger shall be bell and spigot or welded to match the pipe joints. Welded joints shall conform to AWWA C206. Field couplings shall be bolted, sleeve-type for plain-end pipe conforming to AWWA C219. Expansion joints shall be fabricated steel mechanical slip-type conforming to AWWA C221.

When flanges are required, they shall conform to AWWA C207. Linings and coatings for fittings shall be the same as specified for the adjacent pipe.

9-30.2(4)B Steel Pipe (4 inches and Under)

Fittings for steel pipe 4 inches and under shall be malleable iron threaded type with a pressure rating of 150 psi. Dimensions shall meet the requirements of ANSI B16.3. Threading shall meet the requirements of ANSI B2.1. Material shall meet requirements of ASTM A47M, Grade 32510. Fittings shall be banded and hot-dip galvanized inside and out.

9-30.2(5) Polyvinyl Chloride (PVC) Pipe**9-30.2(5)A Polyvinyl Chloride (PVC) Pipe (4 inches and Over)**

Fittings for PVC pipe shall be the same as specified for ductile iron pipe.

9-30.2(5)B Polyvinyl Chloride (PVC) Pipe (Under 4 inches)

Fittings for PVC pipe under 4 inches shall meet the requirements of ASTM D2466.

9-30.2(6) Restrained Joints

The restraining of ductile iron pipe, fittings, and valves shall be accomplished by the use of either a bolted or boltless system. Any device utilizing round point set screws shall not be permitted.

All couplings installed underground to connect ductile iron or PVC pipe shall be manufactured of ductile iron.

9-30.2(7) Bolted, Sleeve-Type Couplings for Plain End Pipe

Bolted, sleeve-type couplings, reducing or transition couplings, and flanged coupling adapters used to join plain-end pipe shall meet the requirements of AWWA C219. Buried couplings to connect ductile iron, gray cast iron, or PVC pipe shall be ductile iron. Buried couplings for connecting steel pipe to steel pipe shall be steel.

9-30.2(8) Restrained Flexible Couplings

Restrained flexible couplings shall be locking type couplings in accordance with the Plans or Special Provisions. Any couplings that utilize set screws tightened against the outside pipe wall are not acceptable. Coupling shall be epoxy coated.

9-30.2(9) Grooved and Shouldered Joints

Grooved and shouldered joints shall conform to AWWA C606. Rigid or flexible grooved or shouldered joints shall be as specified in the Special Provisions.

9-30.2(10) Polyethylene (PE) Pipe (4 inches and Over)

Fittings for PE pipe shall meet the requirement of ANSI/AWWA C906. Pipe material shall be high-density polyethylene PE3408 conforming to minimum cell class 345464 C, D or E per ASTM D3350. Pipe diameter shall be either iron pipe size per Table 3 and Table 5 of ANSI/AWWA C906 or ductile iron pipe size per Table 7 and Table 8 of ANSI/AWWA C 906. Pipe pressure class shall be as listed in Table 9 of ANSI/AWWA C 906 for DR 9 PE3408 material.

9-30.2(11) Fabricated Steel Mechanical Slip-Type Expansion Joints

Fabricated steel mechanical slip-type expansion joints shall meet the requirements of ANSI/AWWA C 221. Buried Expansion joints to connect ductile iron or PVC pipe shall be ductile iron. Buried expansion joints for connecting steel pipe to steel pipe shall be steel.

9-30.3 Valves

Valves shall be provided with hand wheels or operating nuts as designated. Where operating nuts are called for, a standard 2-inch operating nut shall be furnished. Valves shall be nonrising stem type, open counterclockwise, and be equipped with an O ring stuffing box.

9-30.3(1) Gate Valves (3 to 16 inches)

Gate valves shall meet the requirements of AWWA C509 or AWWA C515. Gate valves 16 inches in size shall be arranged for operation in the horizontal position by enclosed bevel gearing.

The Contractor shall provide an affidavit of compliance stating that the valve furnished fully complies with AWWA C509 or AWWA C515.

9-30.3(2) Vacant**9-30.3(3) Butterfly Valves**

Butterfly valves shall be rubber seated and shall meet the requirements of AWWA C504, Class 150B. Butterfly valves shall be suitable for direct burial.

Valve operators shall be of the traveling nut or worm gear type, sealed, gasketed, and permanently lubricated for underground service. Valve operators shall be constructed to the standard of the valve manufacturer to withstand all anticipated operating torques and designed to resist submergence in ground water.

The Contractor shall provide an affidavit of compliance stating that the valve furnished fully complies with AWWA C504.

9-30.3(4) Valve Boxes

Valve boxes shall be installed on all buried valves. The box shall be of cast iron, two piece slip type standard design with a base corresponding to the size of the valve. The box shall be coal tar painted by the manufacturer using its standard. The cover shall have the word "WATER" cast in it.

9-30.3(5) Valve Marker Posts

Posts shall have a 4-inch minimum square section and a minimum length of 42 inches, with beveled edges and shall contain at least one No. 3 bar reinforcing steel.

The exposed portion of the marker posts shall be coated with two coats of concrete paint in a color selected by the Contracting Agency.

The size of the valve and the distance in feet and inches to the valve shall be stenciled on the face of the post, using black paint and a stencil which will produce letters 2 inches high.

9-30.3(6) Valve Stem Extensions

Valve stem extensions shall have a 2-inch-square operating nut and self-centering rockplate support. Valves with an operating nut more than 4 feet below grade shall have a valve stem extension to raise the operating nut to within 36 inches of the ground surface.

9-30.3(7) Combination Air Release/Air Vacuum Valves

Combination air release/air vacuum valves shall be designed to operate with potable water under pressure to permit discharging a surge of air from an empty line when filling and relieve the vacuum when draining the system. The valves shall also release an accumulation of air when the system is under pressure. This shall be accomplished in a single valve body designed to withstand 300 psi.

The body and cover shall be cast iron conforming to ASTM A48, Class 30. Floats shall be stainless steel conforming to ASTM A240 and designed to withstand 1,000 psi. Seats shall be Buna N rubber. Internal parts shall be stainless steel or bronze.

9-30.3(8) Tapping Sleeve and Valve Assembly

Tapping valves shall be furnished with flanged inlet end connections. The outlet ends shall conform in dimensions to the AWWA Standards for hub or mechanical joint connections, except that the outside of the hub shall have a large flange for attaching a drilling machine. The seat opening of the valve must permit a diameter cut no less than $\frac{1}{2}$ inch smaller than the valve size. Valves specifically designed for tapping meeting the requirements of AWWA C500, and valves meeting the requirements of AWWA C509, will be permitted. Tapping valves shall be of the same type as other valves on the project. Tapping sleeves shall be cast iron, ductile iron, stainless steel, epoxy-coated steel, or other approved material.

9-30.4 Vacant**9-30.5 Hydrants**

Fire hydrants shall conform to AWWA C502 and shall be of standard manufacture and of a pattern approved by the Contracting Agency.

9-30.5(1) End Connections

The end connections shall be mechanical joint or flanged, meeting the requirements of AWWA C110 and C111.

9-30.5(2) Hydrant Dimensions

Hydrant connection pipes shall be 6 inches inside diameter with 6-inch auxiliary gate valves. Barrels shall have a 7-inch minimum inside diameter. Hydrant length, measured from the bottom of the hydrant to the sidewalk ring, shall provide proper cover at each installed location. Valve openings shall be $5\frac{1}{4}$ inches minimum diameter. Hydrants shall have two $2\frac{1}{2}$ -inch hose nozzles and one pumper nozzle to match Contracting Agency's connection requirements.

Nozzles shall be fitted with cast iron threaded caps with operating nuts of the same design and proportions as the hydrant stem nuts. Caps shall be threaded to fit the corresponding nozzles and shall be fitted with suitable neoprene gaskets of positive water tightness under test pressures. The direction of opening shall be counterclockwise and shall be clearly marked on the operating nut or hydrant top. Hydrants shall be with O ring stem seals. The hydrant shall be painted with two coats of paint to match the owner's existing hydrants.

9-30.5(3) Hydrant Extensions

Hydrant extensions shall have a $6\frac{3}{4}$ -inch minimum inside diameter and shall be gray cast iron or ductile iron and shall conform to the AWWA Standards for such castings. The drillings of the connecting flanges on the extensions shall match the drillings of the flanges on the hydrant.

Hydrant extensions shall also include the necessary hydrant operating stem extensions.

9-30.5(4) Hydrant Restraints

Shackle rods shall be $\frac{3}{4}$ -inch diameter with threaded ends, and shall be ASTM A36 steel. Shackle rods shall be coated with two coats of asphalt varnish. If a restrained joint system is used, it shall meet the requirements of Section 9-30.2(6).

9-30.5(5) Traffic Flange

Hydrants shall be provided with a traffic flange and shall be equipped with breaking devices at the traffic flange which will allow the hydrant barrel to separate at this point with a minimum breakage of hydrant parts in case of damage. There shall also be provided at this point, a safety stem coupling on the operating stem that will shear at the time of impact.

9-30.5(6) Guard Posts

Guard posts for hydrants shall be provided where shown in the Plans. Guard posts shall be reinforced concrete having a compressive strength of 3,500 psi and shall be 6 feet in length by 9 inches in diameter. Reinforcing shall consist of a minimum of five No. 3 deformed steel bars.

9-30.6 Water Service Connections (2 inches and Smaller)**9-30.6(1) Saddles**

Saddles shall be ductile iron, bronze, brass, or stainless steel.

Saddles used for ¾- and 1-inch services shall be single strap and may be either AWWA tapered thread or female iron pipe thread outlet. Saddles used for 1½- and 2-inch services shall be double strap and shall be female iron pipe thread outlet. Saddles used on PVC pipe shall be formed for PVC pipe and have flat, stainless steel straps.

9-30.6(2) Corporation Stops

Corporation stops shall be made of bronze or brass alloy.

Corporation stops for direct tapping shall have AWWA tapered thread inlet and an outlet connections compatible with either copper or polyethylene tubing.

Corporation stops used with ¾- and 1-inch outlet saddles shall have either AWWA tapered thread or male iron pipe thread inlets and outlet connections compatible with either copper or polyethylene tubing. Thread patterns for the saddle outlet and corporation stop inlet shall be the same.

Corporation stops used with 1½- and 2-inch outlet saddles shall have male iron pipe thread inlets and outlet connections compatible to connecting service pipes or have male iron pipe thread outlets.

9-30.6(3) Service Pipes**9-30.6(3)A Copper Tubing**

Copper pipe or tubing shall be annealed, seamless, and conform to the requirements of ASTM B88, Type K rating.

9-30.6(3)B Polyethylene Tubing

Polyethylene tubing shall meet the requirements of AWWA C901. Tubing shall be high molecular mass with a 200 psi rating. Tubing used for ¾ and 1 inch shall be either SIDR 7 (iron pipe size) or SDR 9 (copper tube size). Tubing used for 1½ and 2 inches shall be SDR 9 (copper tube size).

9-30.6(3)C PEX-a Tubing

PEX-a tubing shall be a minimum of ¾ inch or a maximum 2-inch in diameter and shall be manufactured in accordance with AWWA C904 and ASTM F876. The tubing shall have a minimum materials designation code of 3306 in accordance with ASTM F876, a pressure rating of 200 psi at 73.4 degrees using a design factor of 0.63 as outlined in PPI TR-3, Part F-7, and shall have a minimum SDR of 9. Tubing color shall be blue in accordance with APWA Uniform color standards.

9-30.6(4) Service Fittings

Fittings used for service connections shall be made of bronze or brass alloy.

Fittings used for copper tubing shall be either compressions or flare type.

Fittings used for polyethylene tubing shall be either compression or stab type. Stab type fittings shall utilize an internal grip ring and O ring seal. Stainless steel liners shall be used when utilizing compression fittings on polyethylene tubing.

Fittings for PEX-a tubing shall meet the requirements of AWWA C904.

9-30.6(5) Meter Setters

Meter setters shall be manufactured and tested in accordance with all applicable parts of AWWA C800.

Meter setters shall have an angle meter stop with drilled padlock wing, an angle check valve, measure 12 inches in height, and shall have an inlet and outlet threads compatible with fittings connecting to service pipes.

Meter setters for $\frac{1}{2}$ by $\frac{3}{4}$, $\frac{3}{4}$, and 1-inch services shall have meter saddle nuts for installation and removal of the meter.

Meter setters for 1½- and 2-inch services shall be equipped with a locking bypass.

9-30.6(6) Bronze Nipples and Fittings

Bronze threaded nipples and fittings shall meet the requirements of ANSI B-16.15, ASA 125 pound class.

9-30.6(7) Meter Boxes

Meter boxes and covers located in the non-traffic areas shall be constructed of either reinforced concrete or high-density polyethylene. High-density polyethylene meter boxes and covers shall have a tensile strength conforming to ASTM D638. Meter box covers shall include a reading lid.

Meter boxes located in traffic areas shall be constructed of reinforced concrete, cast iron, or ductile iron. Traffic covers shall be constructed of aluminum, steel, cast iron, or ductile iron. Meter boxes and covers shall be designed for H-20 loading.

9-31 Fabricated Bridge Bearing Assemblies

9-31.1 Steel Plates and Bars

Steel plates and bars, including anchor array templates, shall conform to ASTM A 36.

Recessed steel surfaces retaining PTFE shall have an average surface roughness of 250-microinches or less.

Steel surfaces in contact with pre-formed fabric pad or polyether urethane disc shall have an average surface roughness of 250-microinches or less.

Steel surfaces in contact with stainless steel sheet, or with the bearing block of a pin bearing assembly, shall have an average surface roughness of 125-microinches or less.

All other steel surfaces in contact with other fabricated bridge bearing assembly components shall have an average surface roughness of 250-microinches or less.

9-31.2 Stainless Steel

Stainless steel sheet shall conform to ASTM A 240 Type 304L. Stainless steel in contact with PTFE shall be polished to a Number 8 mirror finish. Stainless steel sheet for fabric pad bearing assemblies shall have a thickness greater than or equal to 14-gage.

Stainless steel countersunk screws shall be hexagon socket type conforming to the geometric requirements of ANSI B 18.3 and shall conform to ASTM F 593 Type 304L.

9-31.3 Bearing Blocks and Keeper Rings

Bearing block forgings for pin bearing assemblies shall conform to Section 9-06.11, including AASHTO M 102 Supplemental Requirement S4. The grade shall be Grade F. The bearing block forging surfaces in contact with other pin bearing assembly components shall have an average surface roughness of 63-microinches or less. All other bearing block forging surfaces shall have an average surface roughness of 250-microinches or less.

Keeper ring forgings for pin bearing assemblies shall conform to Section 9-06.11, and the grade shall be Grade H. All keeper ring surfaces shall have an average surface roughness of 125-microinches or less.

9-31.4 Pin Assembly

Pins shall conform to ASTM A 276 UNS Designation 21800. The pin surfaces in contact with the bearing block shall have an average surface roughness of 63-microinches or less.

Nuts shall conform to ASTM A 563 Grade DH. Nuts with a thread diameter equal to or less than six-inches shall have a minimum Rockwell Hardness of HRC 24. Nuts with a thread diameter greater than six-inches shall have a Rockwell Hardness between HRC 20 and HRC 30.

Washers shall conform to ASTM A 572 Grade 50.

Cotter pins shall be stainless steel.

9-31.5 Welded Shear Connectors

Welded shear connectors shall conform to Section 9-06.15.

9-31.6 Bolts, Nuts and Washers

Bolts, nuts and washers shall conform to Section 9-06.5(3).

9-31.7 Anchor Array Rods, Nuts and Washers

Anchor array rods, nuts and washers shall conform to Section 9-06.5(4). The top 1'-0", minimum, of the exposed end of the anchor rods, and the associated nuts and washers, shall be galvanized in accordance with AASHTO M 232 or ASTM F 2329 as applicable.

Pipe sleeves for anchor array templates shall conform to ASTM A 53 Grade B Type E or S, black.

9-31.8 Bearing Pads**9-31.8(1) Elastomeric Pads**

Elastomeric pads shall conform to the requirements of AASHTO M251 unless otherwise specified in the Plans or Special Provisions. The elastomer shall be low-temperature Grade 3 and shall not contain any form of wax. Unless otherwise specified in the Plans or Special Provisions, the elastomer shall have a shear modulus of elasticity of 165 psi at 73°F.

All elastomeric pads with steel laminates shall be cast as units in separate molds and bonded and vulcanized under heat and pressure. Corners and edges of molded pads may be rounded at the option of the Contractor. Radius at corners shall not exceed $\frac{3}{8}$ inch, and radius of edges shall not exceed $\frac{3}{8}$ inch. Elastomeric pads shall be fabricated to meet the tolerances specified in AASHTO M251.

Shims contained in laminated elastomeric pads shall be mill rolled steel sheets not less than 20 gage in thickness with a minimum cover of elastomer on all edges of:

$\frac{1}{4}$ inch for pads less than or equal to 5 inches thick and,

$\frac{1}{2}$ inch for pads greater than 5 inches thick.

Steel shims shall conform to ASTM A1011, Grade 36, unless otherwise noted. All shim edges shall be ground or otherwise treated so that no sharp edges remain.

9-31.8(2) Polytetrafluoroethylene (PTFE)

PTFE shall be unfilled (100-percent virgin) PTFE or fiberglass fiber filled PTFE (or woven fabric PTFE for disc or spherical bearing assemblies) conforming to Section 18.8 of the AASHTO *LRFD Bridge Construction Specifications*, and the following additional requirements:

1. PTFE shall be unfilled (100-percent virgin) PTFE except where filled PTFE is specified in the Plans.
2. Filled PTFE shall be composed of PTFE resin uniformly blended with 15-percent maximum fiberglass fiber.
3. The substrate shall limit the flow (elongation) of the confined PTFE to not more than 0.009-inch under a pressure of 2,000 psi for 15-minutes at 78°F for a two-inch by three-inch test sample.
4. Unfilled PTFE shall have a hardness of 50 to 65 Durometer D, at 78°F, in accordance with ASTM D 2240.
5. The PTFE may be dimpled.

9-31.8(3) Pre-formed Fabric Pad

Pre-formed fabric pads shall be composed of multiple layers of duck, impregnated and bound with high-quality oil resistant synthetic rubber, compressed into resilient pads. The pre-formed fabric pads shall conform to MIL C 882 and the following additional requirements:

1. The pre-formed fabric pad shall have a shore A hardness of 90 ± 5 in accordance with ASTM D 2240.
2. The number of plies shall be as required to produce the specified thickness after compression and vulcanization.

9-31.9 Polyether Urethane

Polyether urethane shall be a molded polyether urethane compound conforming to the following properties:

Physical Properties	Specification			
Hardness, Type D durometer	ASTM D 2240	45	55	65
Minimum tensile stress, ksi	ASTM D 412			
At 100-percent elongation		1.5	1.9	2.3
At 200-percent elongation		2.8	3.4	4.0
Minimum tensile strength, ksi	ASTM D 412	4.0	5.0	6.0
Minimum ultimate elongation, percent	ASTM D 412	350	285	220
Maximum compression set (22 hours at 158°F) Method B, percent	ASTM D 395	40	40	40

Required minimums for tensile stress at specific elongations, tensile strength, ultimate elongation, and compression set may be interpolated for durometer hardness values between 45 and 55, and 55 and 65.

9-31.10 Silicone Grease

Silicone grease for use with dimpled PTFE shall conform to SAE AS 8660.

9-31.11 Epoxy Gel

Epoxy gel shall be Type 1, Grade 3, Class A, B, or C, conforming to Section 9-26.1.

9-31.12 Resin Filler

Resin filler shall be a two-component, resin and catalyst, liquid thermoset material, with the following properties:

1. The viscosity of the resin-catalyst mixture shall be $35,000 \pm 5,000$ cP at 75°F immediately after mixing.
2. The flash point shall be 100°F minimum.
3. After mixing, the resin-catalyst mixture shall be pourable for a minimum of 8-minutes at 60°F and shall harden in 15-minutes maximum. Heating of the mixture to a maximum temperature of 250°F after placement is permissible to obtain a full cure.

The properties of the cured resin-catalyst mixture shall be:

1. The fully cured compressive strength shall be 12,000 psi, minimum.
2. The maximum allowable shrinkage shall be 2-percent. To control shrinkage, an inert filler may be used in the resin provided the specified viscosity requirements are met.
3. The hardness shall be between 40 and 55 in accordance with ASTM D 2583.

The resin and catalyst components shall be supplied in separate containers.

9-32 Mailbox Support**9-32.1 Steel Posts**

The Mailbox Support Type 1 post shall be 2 inches outside diameter, 14-gage, mechanical tubing, and shall conform to ASTM A513. Type 1 mailbox supports shall meet the Manual for Assessing Safety Hardware (MASH) crash test criteria. Galvanizing shall conform to G 90 coating as defined in ASTM A653, or an approved equal.

Any damage to galvanized paint surfaces shall be treated with two coats of paint conforming to Section 9-08.1(2)B.

9-32.2 Bracket, Platform, and Anti-Twist Plate

The bracket and platform for the Mailbox Support Types 1 and 2 shall be 16-gage sheet steel, conforming to ASTM A1011 or ASTM A1008. The anti-twist plate for the Mailbox Support Type 1 shall be 16-gage sheet steel, conforming to ASTM A1011 or ASTM A1008.

9-32.3 Vacant**9-32.4 Vacant****9-32.5 Fasteners**

Unless otherwise specified, bolts and nuts shall be Grade 5 commercial bolt stock, galvanized in accordance with ASTM A153. Washers, unless otherwise specified, shall be malleable iron, or cut from medium steel or wrought iron plate. Washers and other hardware shall be galvanized in accordance with AASHTO M111.

9-32.6 Vacant**9-32.7 Type 2 Mailbox Support**

Type 2 mailbox supports shall be 2-inches outside diameter, 14-gage steel tube and shall meet the Manual for Assessing Safety Hardware (MASH) crash test criteria. Type 2 mailbox supports shall be installed in accordance with the manufacturer's recommendations.

9-32.8 Concrete Base

The concrete in the concrete base shall meet or exceed the requirements of Section 6-02.3(2)B.

9-32.9 Steel Pipe

The requirements for commercially available, Schedule 40, galvanized steel pipe, elbows, and couplings shall be met for all parts not intended to be bent or welded. Welded and bent parts shall be galvanized after fabrication in accordance with AASHTO M 111.

9-32.10 Vacant

9-33 Construction Geosynthetic

9-33.1 Geosynthetic Material Requirements

The term geosynthetic shall be considered to be inclusive of geotextiles, geogrids, and prefabricated drainage mats.

Geotextiles, including geotextiles attached to prefabricated drainage core to form a prefabricated drainage mat, shall consist only of long chain polymeric fibers or yarns formed into a stable network such that the fibers or yarns retain their position relative to each other during handling, placement, and design service life. At least 95 percent by weight of the material shall be polyolefins or polyesters. The material shall be free from defects or tears. The geotextile shall also be free of any treatment or coating which might adversely alter its hydraulic or physical properties after installation.

Geogrids shall consist of a regular network of integrally connected polymer tensile elements with an aperture geometry sufficient to permit mechanical interlock with the surrounding backfill. The long chain polymers in the geogrid tensile elements, not including coatings, shall consist of at least 95 percent by mass of the material of polyolefins or polyesters. The material shall be free of defects, cuts, and tears.

Prefabricated drainage core shall consist of a three dimensional polymeric material with a structure that permits flow along the core laterally, and which provides support to the geotextiles attached to it.

The geosynthetic shall conform to the properties as indicated in Tables 1 through 8 in Section 9-33.2, and additional tables as required in the [Standard Plans](#) and Special Provisions for each use specified in the Plans. Specifically, the geosynthetic uses included in this section and their associated tables of properties are as follows:

Geotextile Geosynthetic Application	Applicable Property Tables
Underground Drainage, Low and Moderate Survivability, Classes A, B, and C	Tables 1 and 2
Separation	Table 3
Soil Stabilization	Table 3
Permanent Erosion Control, Moderate and High Survivability, Classes A, B, and C	Tables 4 and 5
Ditch Lining	Table 4
Temporary Silt Fence	Table 6
Permanent Geosynthetic Retaining Wall	Table 7 and Std. Plans
Temporary Geosynthetic Retaining Wall	Tables 7 and 10
Prefabricated Drainage Mat	Table 8
Table 10 will be included in the Special Provisions.	

Geogrid and geotextile reinforcement in geosynthetic retaining walls shall conform to the properties specified in the [Standard Plans](#) for permanent walls, and Table 10 for temporary walls.

For geosynthetic retaining walls that use geogrid reinforcement, the geotextile material placed at the wall face to retain the backfill material as shown in the Plans shall conform to the properties for Construction Geotextile for Underground Drainage, Moderate Survivability, Class A.

Thread used for sewing geotextiles shall consist of high-strength polypropylene, polyester, or polyamide. Nylon threads will not be allowed. The thread used to sew permanent erosion control geotextiles, and to sew geotextile seams in exposed faces of temporary or permanent geosynthetic retaining walls, shall also be resistant to ultraviolet radiation. The thread shall be of contrasting color to that of the geotextile itself.

9-33.2 Geosynthetic Properties

9-33.2(1) Geotextile Properties

Table 1 Geotextile for Underground Drainage Strength Properties for Survivability

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹			
		Low Survivability		Moderate Survivability	
		Woven	Nonwoven	Woven	Nonwoven
Grab Tensile Strength, in machine and x-machine direction	D4632	180 lb min.	115 lb min.	250 lb min.	160 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632	< 50%	≥ 50%	< 50%	≥ 50%
Seam Breaking Strength	D4632 ³	160 lb min.	100 lb min.	220 lb min.	140 lb min.
Puncture Resistance	D6241	370 lb min.	220 lb min.	495 lb min.	310 lb min.
Tear Strength, in machine and x-machine direction	D4533	67 lb min.	40 lb min.	80 lb min.	50 lb min.
Ultraviolet (UV) Radiation Stability	D4355	50% strength retained min., after 500 hours in a xenon arc device			

Notes in Section 9-33.2(3), Table 8.

Table 2 Geotextile for Underground Drainage Filtration Properties

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹		
		Class A	Class B	Class C
AOS	D4751	No. 40 max.	No. 60 max.	No. 80 max.
Water Permittivity	D4491	0.5 sec ⁻¹ min.	0.4 sec ⁻¹ min.	0.3 sec ⁻¹ min.

Notes in Section 9-33.2(3), Table 8.

Table 3 Geotextile for Separation or Soil Stabilization

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹			
		Separation		Soil Stabilization	
		Woven	Nonwoven	Woven	Nonwoven
AOS	D4751	No. 30 max.		No. 40 max.	
Water Permittivity	D4491	0.02 sec ⁻¹ min.		0.10 sec ⁻¹ min.	
Grab Tensile Strength, in machine and x-machine direction	D4632	250 lb min.	160 lb min.	315 lb min.	200 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632	< 50%	≥ 50%	< 50%	≥ 50%
Seam Breaking Strength	D4632 ³	220 lb min.	140 lb min.	270 lb min.	180 lb min.
Puncture Resistance	D6241	495 lb min.	310 lb min.	620 lb min.	430 lb min.
Tear Strength, in machine and x-machine direction	D4533	80 lb min.	50 lb min.	112 lb min.	79 lb min.
Ultraviolet (UV) Radiation Stability	D4355	50% strength retained min., after 500 hours in xenon arc device			

Notes in Section 9-33.2(3), Table 8.

Table 4 Geotextile for Permanent Erosion Control and Ditch Lining

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹					
		Permanent Erosion Control				Ditch Lining	
		Moderate Survivability		High Survivability			
		Woven	Non Woven	Woven	Non Woven	Woven	Non Woven
AOS	D4751	See Table 5		See Table 5		No. 30 max.	
Water Permittivity	D4491	See Table 5		See Table 5		0.02 sec ⁻¹ min.	
Grab Tensile Strength, in machine and x-machine direction	D4632	250 lb min.	160 lb min.	315 lb min.	200 lb min.	250 lb min.	160 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632	15% -50%	≥ 50%	15% -50%	≥ 50%	< 50%	≥ 50%
Seam Breaking Strength	D4632 ³	220 lb min.	140 lb min.	270 lb min.	180 lb min.	220 lb min.	140 lb min.
Puncture Resistance	D6241	495 lb min.	310 lb min.	620 lb min.	430 lb min.	495 lb min.	310 lb min.
Tear Strength, in machine and x-machine direction	D4533	80 lb min.	50 lb min.	112 lb min.	79 lb min.	80 lb min.	50 lb min.
Ultraviolet (UV) Radiation Stability	D4355	70% strength retained min., after 500 hours in xenon arc device					

Notes in Section 9-33.2(3), Table 8.

Table 5 Filtration Properties for Geotextile for Permanent Erosion Control

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹		
		Class A	Class B	Class C
AOS	D4751	No. 40 max.	No. 60 max.	No. 70 max.
Water Permittivity	D4491	0.7 sec ⁻¹ min.	0.4 sec ⁻¹ min.	0.2 sec ⁻¹ min.

Notes in Section 9-33.2(3), Table 8.

Table 6 Geotextile for Temporary Silt Fence

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹	
		Unsupported Between Posts	Supported Between Posts With Wire or Polymeric Mesh
AOS	D4751	No. 30 max. for slit wovens, No. 50 for all other geotextile types, No. 100 min.	
Water Permittivity	D4491	0.02 sec ⁻¹ min.	
Grab Tensile Strength, in machine and x-machine direction	D4632	180 lb min. in machine direction, 100 lb min. in x-machine direction	100 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632	30% max. at 180 lb or more	
Ultraviolet (UV) Radiation Stability	D4355	70% strength retained min., after 500 hours in xenon arc device	

Notes in Section 9-33.2(3), Table 8.

9-33.2(2) Geotextile Properties for Retaining Walls and Reinforced Slopes

Table 7 Minimum Properties Required for Geotextile Reinforcement Used in Geosynthetic Reinforced Slopes and Retaining Walls

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹	
		Woven	Nonwoven
AOS	D4751	No. 20 max.	
Water Permittivity	D4491	0.02 sec ⁻¹ min.	
Grab Tensile Strength, in machine and x-machine direction	D4632	200 lb min.	120 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632	< 50%	≥ 50%
Seam Breaking Strength	D4632 ^{3,4}	160 lb min.	100 lb min.
Puncture Resistance	D6241	370 lb min.	220 lb min.
Tear Strength, in machine and x-machine direction	D4533	63 lb min.	50 lb min.
Ultraviolet (UV) Radiation Stability	D4355	70% (for polypropylene and polyethylene) and 50% (for polyester) Strength Retained min., after 500 hours in a xenon arc device	

Notes in Section 9-33.2(3), Table 8.

9-33.2(3) Prefabricated Drainage Mat

Prefabricated drainage mat shall have a single or double dimpled polymeric core with a geotextile attached and shall meet the following requirements:

Table 8 Minimum Properties Required for Prefabricated Drainage Mats

Geotextile Property	ASTM Test Method ²	Geotextile Property Requirements ¹
AOS	D4751	No. 60 max.
Water Permittivity	D4491	0.4 sec ⁻¹ min.
Grab Tensile Strength, in machine and x-machine direction	D4632	Nonwoven – 100 lb min.
Width Thickness	D1777	12 inch min. 0.4 inch min.
Compressive Strength at Yield	D1621	100 psi min.
In Plan Flow Rate Gradient = 0.1, Pressure = 5.5 psi Gradient = 1.0, Pressure = 14.5 psi	D4716	5.0 gal./min./ft. min. 15.0 gal/min./ft. min.

¹All geotextile properties in Tables 1 through 8 are minimum average roll values (i.e., the test results for any sampled roll in a lot shall meet or exceed the values shown in the table).

²The test procedures used are essentially in conformance with the most recently approved ASTM geotextile test procedures, except for geotextile sampling and specimen conditioning, which are in accordance with WSDOT T 914, Practice for Sampling of Geotextiles for Testing, and T 915, Practice for Conditioning of Geotextiles for Testing, respectively. Copies of these test methods are available at the State Materials Laboratory, PO Box 47365, Olympia, WA 98504-7365.

³With seam located in the center of 8-inch-long specimen oriented parallel to grip faces.

⁴Applies only to seams perpendicular to the wall face.

9-33.3 Aggregate Cushion of Permanent Erosion Control Geotextile

Aggregate cushion for permanent erosion control geotextile, Class A shall meet the requirements of Section 9-03.9(2). Aggregate cushion for permanent erosion control geotextile, Class B or C shall meet the requirements of Sections 9-03.9(3) and 9-03.9(2).

9-33.4 Geosynthetic Material Approval and Acceptance**9-33.4(1) Geosynthetic Material Approval**

Geosynthetics listed in the WSDOT Qualified Products List (QPL) are approved for use. If the geosynthetics material is not listed in the current WSDOT QPL, a Manufacturer's Certificate of Compliance including Certified Test Reports of each proposed geosynthetic shall be submitted to the State Materials Laboratory in Tumwater for evaluation. Geosynthetic material approval will be based on conformance to the applicable properties from the Tables in Section 9-33.2 or in the [Standard Plans](#) or Special Provisions. Approval/Disapproval information will be provided within 30 calendar days after the sample and required information for each geosynthetic type have been received at the State Materials Laboratory in Tumwater.

The Contractor shall submit to the Engineer the following information regarding each geosynthetic material proposed for use:

- Manufacturer’s name and current address,
- Full product name,
- Geosynthetic structure, including fiber/yarn type,
- Geosynthetic polymer type(s) (for permanent geosynthetic retaining walls, reinforced slopes, reinforced embankments, and other geosynthetic reinforcement applications),
- Geosynthetic roll number(s),
- Geosynthetic lot number(s),
- Proposed geosynthetic use(s), and
- Certified test results for minimum average roll values.

Geosynthetics used as reinforcement in permanent geosynthetic retaining walls, reinforced slopes, reinforced embankments, and other geosynthetic reinforcement applications require proof of compliance with the National Transportation Product Evaluation Program (NTPEP) in accordance with AASHTO Standard Practice R 69, Standard Practice for Determination of Long-Term Strength for Geosynthetic Reinforcement.

9-33.4(2) Vacant

9-33.4(3) Acceptance Samples

A satisfactory test report is required when the quantities of geosynthetic materials proposed for use in the following geosynthetic applications are greater than the following amounts:

Application	Geosynthetic Quantity
Underground Drainage	100 sq. yd.
Permanent Geosynthetic Reinforced Slopes, Retaining Walls, Reinforced Embankments, and other Geosynthetic Reinforcement Applications	All quantities

The samples for acceptance testing shall include the information about each geosynthetic roll to be used as stated in Section 9-33.4(4).

Samples from the geosynthetic roll will be taken to confirm that the material meets the property values specified. Samples will be randomly taken at the job site by the Contractor in accordance with WSDOT T 914 in the presence of the Engineer.

Acceptance will be based on testing of samples from each lot. A “lot” shall be defined for the purposes of this Specification as all geosynthetic rolls within the consignment (i.e., all rolls sent to the project site) that were produced by the same manufacturer during a continuous period of production at the same manufacturing plant and have the same product name. Test results from Section 9-33.4(1) Geosynthetic Material Approval testing may be used for acceptance provided the tested roll(s) are part of the “lot” as defined above.

Acceptance testing information will be provided within 30 calendar days after the sample and the required information for each geosynthetic type have been received at the State Materials Laboratory in Tumwater.

If the results of the testing show that a geosynthetic lot, as defined, does not meet the properties required for the specified use as indicated in Tables 1 through 8 in Section 9-33.2, and additional tables as specified in the Special Provisions, the roll or rolls which were sampled will be rejected. Geogrids and geotextiles for temporary geosynthetic retaining walls shall meet the requirements of Table 7, and Table 10 in the Special

Provisions. Geogrids and geotextiles for permanent geosynthetic retaining wall shall meet the requirements of Table 7, and Table 9 in the Special Provisions, and both geotextile and geogrid acceptance testing shall meet the required ultimate tensile strength T_{ult} as provided in the current QPL for the selected product(s). If the selected product(s) are not listed in the current QPL, the result of the testing for T_{ult} shall be greater than or equal to T_{ult} as determined from the product data submitted and approved by the State Materials Laboratory during source material approval.

For each geosynthetic roll that is tested and fails, the Engineer will select two additional rolls from the same lot for sampling and retesting. The Contractor shall sample the rolls in accordance with WSDOT T 914 in the presence of the Engineer. If the retesting shows that any of the additional rolls tested do not meet the required properties, the entire lot will be rejected. If the test results from all the rolls retested meet the required properties, the entire lot minus the roll(s) that failed will be accepted. All geosynthetic that has defects, deterioration, or damage, as determined by the Engineer, will also be rejected. All rejected geosynthetic shall be replaced at no additional expense to the Contracting Agency.

9-33.4(4) Acceptance by Certificate of Compliance

When the quantities of geosynthetic proposed for use in each geosynthetic application are less than or equal to the following amounts, acceptance shall be by Manufacturer's Certificate of Compliance:

Application	Geosynthetic Quantity
Underground Drainage	100 sq. yd.
Soil Stabilization and Separation	All quantities
Permanent Erosion Control	All quantities
Prefabricated Drainage Mat	All quantities

The Manufacturer's Certificate of Compliance shall include the following information about each geosynthetic roll to be used:

- Manufacturer's name and current address,
- Full product name,
- Geosynthetic structure, including fiber/yarn type,
- Geosynthetic Polymer type (for all temporary and permanent geosynthetic retaining walls only),
- Geosynthetic roll number(s),
- Geosynthetic lot number(s),
- Proposed geosynthetic use(s), and
- Certified test results.

9-33.4(5) Approval of Seams

If the geotextile seams are to be sewn in the field, the Contractor shall provide a section of sewn seam that can be sampled by the Engineer before the geotextile is installed. The seam sewn for sampling shall be sewn using the same equipment and procedures as will be used to sew the production seams. If production seams will be sewn in both the machine and cross-machine directions, the Contractor must provide sewn seams for sampling which are oriented in both the machine and cross-machine directions.

The seam sewn for sampling must be at least 2 yards in length in each geotextile direction. If the seams are sewn in the factory, the Engineer will obtain samples of the factory seam at random from any of the rolls to be used. The seam assembly description shall be submitted by the Contractor to the Engineer and will be included with the seam sample obtained for testing. This description shall include the seam type, stitch type, sewing thread type(s), and stitch density.

9-34 Pavement Marking Material

9-34.1 General

Pavement marking materials in this section consist of paint, plastic, tape or raised pavement markers as described in Sections 8-22 and 8-23 as listed below:

- Low VOC Solvent Based Paint
- Low VOC Waterborne Paint
- Temporary Pavement Marking Paint
- Type A - Liquid Hot Applied Thermoplastic
- Type B - Pre-Formed Fused Thermoplastic
- Type C - Cold Applied Pre-Formed Tape
- Type D - Liquid Cold Applied Methyl Methacrylate
- Glass Beads
- Temporary Pavement Marking Tape
- Temporary Raised Pavement Markings

9-34.2 Paint

White and yellow paint shall comply with the Specifications for low VOC (volatile organic compound) solvent-based paint or low VOC waterborne paint. Blue paint for "Access Parking Space Symbol with Background" and black paint for contrast markings shall be chosen from a WSDOT QPL-listed manufacturer for white and yellow paint.

Blue and black paint shall comply with the requirements of yellow paint in Section 9-34.2(4) and Section 9-34.2(5), with the exception that blue and black paints do not need to meet the requirements for titanium dioxide, directional reflectance, and contrast ratio.

9-34.2(1) Vacant

9-34.2(2) Color

Paint draw-downs shall be prepared according to ASTM D823. Colors shall conform to the following:

Color	SAE AMS Standard 595A Number
White	37875
Yellow	33538
Blue	35180
Green	34230
Orange	12246
Red	11136
Black	37038

9-34.2(3) Prohibited Materials

Traffic paint shall not contain mercury, lead, chromium, diarylide pigments, toluene, chlorinated solvents, hydrolysable chlorine derivatives, ethylene-based glycol ethers and their acetates, nor any other EPA hazardous waste material over the regulatory levels per CFR 40 Part 261.24.

9-34.2(4) Low VOC Solvent Based Paint

Paint Properties	Test Method	Low VOC Solvent-Based Paint			
		White		Yellow	
		Min.	Max.	Min.	Max.
Density of Paint (lb/gal)	ASTM D1475	11.8		11.8	
Viscosity, KU	ASTM D562				
@35°F					
@50°F			105		105
@77°F		75	85	75	85
@90°F					
@120°F		65		65	
Nonvolatile Content, % by weight	ASTM D2369	65		65	
Pigment Content, % by weight	ASTM D2698		53		53
Titanium Dioxide Content (lb/gal), Rutile Type II	ASTM D5381	1.0			0.2
Volatile Organic Content (VOC) lbs/gal	ASTM D3960		1.25		1.25
Directional Reflectance %, @ 15 mils wet	WSDOT T 314	80		50	
Package Stability	ASTM D1849	6		6	
Bleeding, %	ASTM D868 ¹	90		90	
Flexibility	ASTM D522 ²	No cracking, flaking, or loss of adhesion			
Settling Properties during Storage, inch	ASTM D1309 ³		8		8
Skinning	ASTM D154	The paint shall not skin within 48 hours in a ¾ filled, tightly closed container			

¹The reflectance of the paint over asphalt paper shall be a minimum of 90 percent of the reflectance measurement of the paint over a taped (nonbleeding) surface.

²The paint shall be applied at a wet film thickness of 6 mils to a 3 by 5 inch panel that has been solvent cleaned and lightly buffed with steel wool. With the panel kept in a horizontal position, the paint shall be allowed to dry for 18 hours at 77° ± 2°F, and then baked for 3 hours at 140° ± 2°F. The panel shall be cooled to 77° ± 2°F for at least 30 minutes, bent over a 0.25 inch mandrel, and then examined without magnification. The paint shall show no cracking, flaking, or loss of adhesion.

³The sample shall show no more than 0.5 inch of clear material over the opaque portion of the paint and there shall be no settling below a rating of eight.

Paint Properties	Test Method	Standard Waterborne Paint				Semi-Durable Waterborne Paint				High-Build Waterborne Paint				Cold Weather Waterborne Paint			
		Type 1 and 2		Type 3		Type 4		Type 5		Type 4		Type 5		Type 4		Type 5	
Heat Stability	ASTM D562 ²	White	Yellow	White	Yellow	White	Yellow	White	Yellow	White	Yellow	White	Yellow	White	Yellow	White	Yellow
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Low Temperature Film Formation	ASTM D2805 ³	± 10 KU from the initial viscosity		± 10 KU from the initial viscosity		± 10 KU from the initial viscosity		± 10 KU from the initial viscosity		± 10 KU from the initial viscosity		± 10 KU from the initial viscosity		± 10 KU from the initial viscosity		± 10 KU from the initial viscosity	
Cold Flexibility ⁵	ASTM D522	No Cracks		No Cracks		No Cracks		No Cracks		No Cracks		No Cracks		No Cracks		No Cracks	
Test Deck Durability ⁶	ASTM D913	Pass at 0.5 in mandrel ^β		Pass at 0.25 in mandrel		≥70% paint retention in wheel track ⁸		≥70% paint retention in wheel track		No Cracks		No Cracks		No Cracks		No Cracks	
Mud Cracking	See note 7	No Cracks		No Cracks		No Cracks		No Cracks		No Cracks		No Cracks		No Cracks		No Cracks	

¹Use the following formula for calculating nonvolatile in vehicle (NVV): $NVV = (N-P/100-P) \times 100$. Where: N= % of nonvolatile content as determined by ASTM D2369 and P= % of pigment content as determined by ASTM D3723.

²Put approximately 15-fluid ounces of paint in a 1-pint lined container, close the container, seal it with tape, and put it in an oven maintained at $140^{\circ} \pm 2^{\circ}\text{F}$ for 7 days. Equilibrate the paint at $77^{\circ} \pm 2^{\circ}\text{F}$ and mix thoroughly with gentle stirring. Perform consistency test as specified in ASTM D562. Consistency shall not vary by ± 10 KU from the initial viscosity.

³Apply paint at 15 mils wet per ASTM D2805 over a 2A Leneta Chart. Immediately and carefully lay the applied film horizontally in a refrigerator that maintains a temperature of 35°F . After 24 hours, remove the applied film and inspect. Paint film should show no cracks when held at arm's length and observed by the naked eye.

⁴Cross-linking acrylic shall meet the requirements of federal specification TT-P-1952F Section 3.1.1.

⁵Cold Flexibility: The paint shall be applied to an aluminum panel at a wet film thickness of 15 mils and allowed to dry under ambient conditions ($50 \pm 10\%$ RH and $72 \pm 5^{\circ}\text{F}$) for 24 hours. A cylindrical mandrel apparatus (in accordance with ASTM D522 method B) shall be put in a 40°F refrigerator when the paint is drawn down. After 24 hours, the aluminum panel with dry paint shall be put in the 40°F refrigerator with the mandrel apparatus for 2 hours. After 2 hours, the panel and test apparatus shall be removed and immediately tested to according to ASTM D522 to evaluate cold flexibility. Paint must show no evidence of cracking, chipping or flaking when bent 180 degrees over a mandrel bar of specified diameter.

⁶NTPEP test deck, or a test deck conforming to ASTM D713, shall be conducted for a minimum of six months with the following additional requirements: it shall be applied at 15 wet mils to a test deck that is located at 40N latitude or higher with at least 10,000 ADT and which was applied during the months of September through November.

⁷Paint is applied to an approximately 4" x 12" aluminum panel using a drawdown bar with a 50 mil gap. The coated panel is allowed to dry under ambient conditions ($50 \pm 10\%$ RH and $72 \pm 5^{\circ}\text{F}$) for 24 hours. Visual evaluation of the dry film shall reveal no cracks.

⁸Only applies to Standard Waterborne Paint Type 2.

9-34.2(6) Temporary Pavement Marking Paint

Paint used for temporary pavement marking shall conform to the requirements of Section 9-34.2.

9-34.3 Plastic

White and yellow plastic pavement marking materials shall comply with the Specifications for:

Type A – Liquid hot applied thermoplastic

Type B – Pre-formed fused thermoplastic

Type C – Cold applied pre-formed tape

Type D – Liquid cold applied methyl methacrylate

Colors shall be in accordance with Section 9-34.2(2). For black plastic retro-reflectance requirements do not apply.

9-34.3(1) Type A – Liquid Hot Applied Thermoplastic

Type A material consists of a mixture of pigment, fillers, resins and glass beads that is applied to the pavement in the molten state by extrusion or by spraying. The material can be applied at a continuously uniform thickness or it can be applied with a profiled pattern. Glass beads, intermixed and top dress, shall conform to the manufacturer's recommendations necessary to meet the retroreflectance requirements. Type A material shall conform to the requirements of AASHTO M 249 and the following:

Resin – The resin shall be alkyd or hydrocarbon.

Retroreflectance – ASTM E1710

Newly applied pavement markings shall have a minimum initial coefficient of retroreflective luminance of $250 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for white and $175 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for yellow in accordance with ASTM E1710 when measured with a 30-meter retroreflectometer. WSDOT will measure retroreflectivity for compliance with a Delta LTL-X retroreflectometer.

Skid Resistance – ASTM E303

45 BPN units minimum

9-34.3(2) Type B – Pre-Formed Fused Thermoplastic

Type B material consists of a mixture of pigment, fillers, resins and glass beads that is factory produced in sheet form. The material is applied by heating the pavement and top heating the material. The material shall contain intermixed glass beads. The material shall conform to AASHTO M 249, with the exception of the relevant differences for the materials being applied in the pre-formed state and the following:

Resin – The resin shall be alkyd or hydrocarbon.

The sample material submitted for approval shall be fused to a suitable substrate prior to performing the following tests.

Retroreflectance – ASTM E1710

The fused samples shall have a minimum initial coefficient of retroreflective luminance of $250 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for white and $175 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for yellow in accordance with ASTM E1710 when measured with a 30-meter retroreflectometer. WSDOT will measure retroreflectivity for compliance with a Delta LTL-X retroreflectometer.

Skid Resistance – ASTM E303

45 BPN units minimum

9-34.3(3) Type C – Cold Applied Pre-Formed Tape

Type C material consists of plastic pre-formed tape that is applied cold to the pavement. The tape shall be capable of adhering to new and existing hot mix asphalt or cement concrete pavement. If the tape manufacturer recommends the use of a surface primer or adhesive, use a type approved by the pavement marking manufacturer. The tape shall also be capable of being inlaid into fresh hot mix asphalt during the final rolling process. The material is identified by the following designations: Type C-1 tape has a surface pattern with retroreflective elements exposed on the raised areas and faces and intermixed within its body and shall conform to ASTM D4505, Reflectivity Level I, Class 2 or 3, Skid Resistance Level A. Type C-2 tape has retroreflective elements exposed on its surface and intermixed within its body and shall conform to the requirements of ASTM D4505, Reflectivity Level II, Class 2 or 3, Skid Resistance Level A.

9-34.3(4) Type D – Liquid Cold Applied Methyl Methacrylate

Type D material consists of a two-part mixture of methyl methacrylate and a catalyst that is applied cold to the pavement. The material can be applied at a continuously uniform thickness or it can be applied with profiles (bumps). The material is classified by Type designation, depending upon the method of application.

Glass beads shall conform to the manufacturer's recommendations necessary to meet the retroreflectance requirements. Type D-1, D-2, D-3, D-4, and D-6 material shall have intermixed glass beads in the material prior to application.

Type D-5 material shall have glass beads injected into the material at application and a second coating of top dressing beads applied immediately after material application. Type D materials shall conform to the following:

Type D – Liquid Cold Applied Methyl Methacrylate Properties					
Property	Test Method	White		Yellow	
		Min.	Max.	Min.	Max.
Adhesion to PCC or HMA, psi	ASTM D7234 ¹	200 or substrate failure		200 or substrate failure	
Chemical Resistance	²	No Effect		No Effect	
Hardness	ASTM D2240 ³	50		50	
No Track Time	ASTM D711 ⁴		30		30
Skid Resistance, BPN	ASTM E303	45		45	
Tensile Strength, psi	ASTM D638	125		125	

¹Part A and B mixed, applied at 60 mils thickness.

²Cured markings shall be resistant to calcium chloride, sodium chloride, fuels, oils, and UV effects. Cure three days for motor oil, gas, diesel, ATF, salt, and anti-freeze.

³Shore Durometer Type D and measurement made after 24 hours.

⁴Sample applied at 40 mils.

Type D liquid cold-applied methyl methacrylate shall meet the following formulations:

4:1 Formulation Type D – Liquid Cold Applied Methyl Methacrylate

Type D-1 – One-gallon of methyl methacrylate and 3-fluid ounces of benzoyl peroxide powder (by weight).

Type D-2, D-3, D-4, and D-5 – Four parts methyl methacrylate and one part liquid benzoyl peroxide (by volume).

98:2 Formulation Type D – Liquid Cold Applied Methyl Methacrylate

Type D-1– One-gallon of methyl methacrylate and 3-fluid ounces of benzoyl peroxide powder (by weight).

Type D-2, D-3, D-4, D-5, and D-6 – Ninety-eight parts methyl methacrylate and two parts liquid benzoyl peroxide (by volume).

D liquid cold applied methyl methacrylate shall meet the following requirements for viscosity for Part A of the mixture:

4:1 Formulations Type D – Liquid Cold Applied Methyl Methacrylate													
Property	Test Method	D-1		D-2		D-3		D-4		D-5 White		D-5 Yellow	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity cP @ 77°F, 50-rpm, spindle #7	ASTM D2196 Method B, LV Model	11,000	15,000	26,000	28,000	17,000	21,000						
Viscosity cP @ 77°F, 50-rpm, spindle #4	ASTM D2196 Method B, LV Model							8,000	10,000	5,000	8,000	7,000	11,000

98:2 Formulations Type D – Liquid Cold Applied Methyl Methacrylate													
Property	Test Method	D-1		D-2		D-3		D-4		D-5		D-6	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity Daniel Scale	Daniel Method ¹	12	14	6	12	12	14	13	15				
Viscosity cP @ 77°F, 50-rpm, spindle #4	ASTM D2196 Method B, LV Model									100	118		

¹Follow Daniel Gauge method; measure flow at 60-seconds.

9-34.4 Glass Beads for Pavement Marking Materials

Glass beads for traffic marking paint shall be coated with silicone for moisture resistance and a silane to promote adhesion. The beads shall be transparent, clean, colorless glass; smooth and spherically shaped; and free from milkiness, pits, or excessive air bubbles.

Glass beads used with plastic traffic markings shall be per the manufacturer's recommendations.

The glass beads for paint and plastic traffic markings shall not contain any metals in excess of the following established total concentration limits when tested in accordance with the listed test methodology:

Metal Concentration Limits		
Element	Test Method	Max. Parts Per Million (ppm)
Arsenic	EPA 3052 SW-846 6010D	10.0
Barium	EPA 3052 SW-846 6010D	100.0
Cadmium	EPA 3052 SW-846 6010D	1.0
Chromium	EPA 3052 SW-846 6010D	5.0
Lead	EPA 3052 SW-846 6010D	50.0
Silver	EPA 3052 SW-846 6010D	5.0
Mercury	EPA 3052 SW-846 7471B	4.0

Glass beads for traffic marking paint shall meet the following requirements for quality:

Glass Bead Property	Test Method	Type A		Type B ¹	
		Min.	Max.	Min.	Max.
Refractive Index @ 77 ± 9°F	AASHTO M 247 Section 5.2.3	1.50	1.55	1.50	1.55
Moisture Resistances	AASHTO M 247 Section 5.3.2	Flow Without Stopping			
Adherence	AASHTO M 247 Section 5.3.4	Pass			
Roundness, %	ASTM D1155	70		80 ²	
	FLHT 520			80 ³	
Appearance	TT-B-1325D Section 4.3.1	Beads shall be transparent, clean, dry, and free from bubbles and foreign matter.			
Resistance to Acid	TT-B-1325D Section 4.3.6	Beads shall not develop any surface haze or dulling.			
Resistance to Calcium Chloride	TT-B-1325D Section 4.3.7	Beads shall not develop any surface haze or dulling.			
Resistance to Sodium Sulfide	TT-B-1325D Section 4.3.8	Sodium sulfide should not darken the beads.			
Water Resistance	TT-B-1325D Section 4.3.9	Water shall not produce haze or dulling of the beads.			

¹WSDOT Type B Glass Beads are high-performance glass beads for improved retroreflectivity and durability for high-performance pavement markings. A minimum of 50 percent of the glass beads shall be made from the direct-melt molten kiln process.

²Roundness will be determined on material < No. 30 sieve.

³Roundness will be determined on material ≥ No. 30 sieve.

Glass beads for traffic marking paint shall meet the following requirements for grading when tested in accordance with ASTM D1214:

Sieve Size	Percent Passing			
	Type A ¹		Type B	
	Min.	Max.	Min.	Max.
No. 14			100	
No. 16	100			
No. 18			65	80
No. 20	95	100		
No. 30	75	95	30	50
No. 50	15	35	0	5
No. 100	0	5		

¹Same gradation as AASHTO M 247 Type 1.

9-34.5 Temporary Pavement Marking Tape

Biodegradable tape with paper backing is not allowed.

9-34.5(1) Temporary Pavement Marking Tape – Short Duration

Temporary pavement marking tape for short duration (usage is for up to two months) shall conform to ASTM D4592 Type II except that black tape, black mask tape and the black portion of the contrast tape, shall be non-reflective.

9-34.5(2) Temporary Pavement Marking Tape – Long Duration

Temporary pavement marking tape for long duration (usage is for greater than two months and less than one year) shall conform to ASTM D4592 Type I. Temporary pavement marking tape for long duration, except for black tape, shall have a minimum initial coefficient of retroreflective luminance of 200 mcd*m⁻²lx⁻¹ when measured in accordance with ASTM E2832. Black tape, black mask tape and the black portion of the contrast tape, shall be non-reflective.

9-34.6 Temporary Flexible Raised Pavement Markers

Temporary flexible raised pavement markers shall consist of an L-shaped body with retroreflective tape on the top of one face for one-way traffic and reflective tape on the top of both faces for two-way traffic. The marker body shall be made from 0.060-inch minimum thick polyurethane. The top of the vertical leg shall be between 1.75 and 2.0 inches high and shall be approximately 4 inches wide. The base width shall be approximately 1.125 inches wide. The base shall have a pressure sensitive adhesive material, a minimum of 0.125 inch thick with release paper. The reflective tape shall be a minimum of 0.25 inch high by 4 inches wide. The reflective tape shall have a minimum reflectance of 3.5 candlepower per foot-candle for white and 2.5 candlepower per foot-candle for yellow measured at 0.2-degree observation angle and 0-degree entrance angle.

9-34.7 Field Testing**9-34.7(1) Requirements**

Field performance evaluation is required for low VOC solvent-based paint per Section 9-34.2(4), Type A – liquid hot applied thermoplastic per Section 9-34.3(1), Type B – preformed fused thermoplastic per Section 9-34.3(2), Type C – cold applied preformed tape per Section 9-34.3(3), and Type D – liquid applied methyl methacrylate per Section 9-34.3(4).

Testing on a northern AASHTO National Transportation Product Evaluation Program (NTPEP) pavement marking test deck is recommended. Test decks conducted by other public entities may be considered provided they produce data similar to a northern NTPEP test deck. Retroreflectivity, Durability, and Auto No-Track shall conform to the following requirements after being installed on a northern NTPEP test deck for a minimum of 12 months.

Successful use of a product in five other States may be considered in lieu of the field test requirement.

9-34.7(1)A Retroreflectivity

Retroreflectivity is measured as a coefficient of retroreflective luminance (RL) in accordance with the requirements of ASTM E1710 for 30-meter geometry. The minimum initial retroreflectivity is $250 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for white and $175 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for yellow, except Type C preformed tape shall meet the minimum initial values in ASTM D4505. The minimum retroreflectivity after 12 months is $150 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for white and $100 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ for yellow, when measured in the skip line area. However, the Department will review the results of each test deck to determine the minimum value in effect for that deck, in order to approve only the better-performing materials.

9-34.7(1)B Durability

Durability rating shall be a minimum of seven in the skip line area and six in the wheel paths after 12 months. The rating system used will be as indicated by NTPEP procedures. However, the department will review the results for each test deck to determine the minimum value in effect for that deck, in order to approve only the better-performing materials.

9-34.7(1)C Auto No-Track Time

Auto No-Track Time will only be required for low VOC solvent-based paint in accordance with Section 9-34.2(4).

No-track time shall be determined in accordance with NTPEP procedures by passing over an applied test line with a standard size passenger car without tracking of the line when viewed from a distance of 50 feet. The maximum no-track time shall not be exceeded when the pavement temperature is between 50°F and 120°F, with relative humidity less than 85 percent, and the pavement is dry.

9-34.7(1)D Approval

The Department will evaluate the results of laboratory and test deck data. This information will be reviewed for each material by color and roadway surface to determine compliance with this Specification. Approved product formulas will remain active for a period of approximately 5 years after completion of the NTPEP evaluation; afterwards, the product will need to be reevaluated.

9-35 Temporary Traffic Control Materials

9-35.0 General Requirements

Temporary traffic control materials in this section consist of various traffic communication, channelization and protection items described in Section 1-10 and listed below:

- Stop/Slow Paddles
- Construction Signs
- Wood Sign Posts
- Sequential Arrow Signs
- Portable Changeable Message Signs
- Barricades
- Traffic Safety Drums
- Traffic Cones
- Tubular Markers
- Warning Lights and Flashers
- Transportable Attenuator
- 42-Inch Tall Channelizing Devices
- Portable Temporary Traffic Control Signal
- Temporary Pedestrian Curb Ramps
- Pedestrian Channelization Devices

The basis for acceptance of temporary traffic control devices and materials shall be visual inspection by the Engineer's representative. No sampling or testing will be done except that deemed necessary to support the visual inspection. Unless otherwise noted, requests for Approval of Material (RAM) and Qualified Products List (QPL) submittals are not required. Certification for crashworthiness according to NCHRP 350 or the Manual for Assessing Safety Hardware (MASH) will be required as described in Section 1-10.2(3).

"MUTCD", as used in this section, shall refer to the latest WSDOT adopted edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways*. In the event of conflicts between the MUTCD and the Contract provisions, then the provisions shall govern.

9-35.1 Stop/Slow Paddles

Paddles shall conform to the requirements of the MUTCD, except that the minimum width shall be 24 inches.

9-35.2 Construction Signs

Construction signs shall conform to the requirements of the MUTCD and shall meet the requirements of NCHRP Report 350 for Category 2 devices or MASH. Except as noted below, any sign/sign stand combination that satisfies these requirements will be acceptable. Post mounted Class A construction signs shall conform to the requirements of this section and additionally shall conform to the requirements stated in Section 9-28.

Aluminum sheeting shall be used to fabricate all construction signs. The signs shall have a minimum thickness of 0.080 inches and a maximum thickness of 0.125 inches.

All orange background signs shall be fabricated with fluorescent orange Type VIII, IX or XI reflective sheeting in accordance with Section 9-28.12. All post-mounted orange signs shall use a nylon washer between the twist fasteners (screw heads, bolts or nuts) and the reflective sheeting.

The use of plywood, fiberglass reinforced plastic, fabric rollup signs, and any other previously approved sign materials except aluminum or aluminum composite is prohibited.

All Class A and Class B signs shall utilize materials and be fabricated in accordance with Section 9-28 and the Washington State *Sign Fabrication Manual* M 55-05. A fabrication decal as stated in Section 9-28.1 is not required for construction signs. All regulatory signs having a red background (i.e., Stop, Yield) shall be fabricated with Type III or IV sign sheeting. All other regulatory information signs (i.e., Speed Limit, Traffic Fines Double in Work Zones) shall have Type IV sheeting.

9-35.3 Work Zone Sign Posts

Post sizes for construction signs shall be as follows:

One Post Installation

Post Size	Max. Sign Sq. Ft.
Wood 4x4	16.0
Wood 4x6	20.0
Wood 6x6	25.0
Wood 6x8	36.0
Steel 2" (ST-1, ST-3)	12.0
Steel 2¼" (ST-1, ST-2, ST-3)	17.0
Steel 2½" 12-gage perforated square tube (ST-1, ST-3)	21.0
Steel 2½" with 2¼" 7' Insert 12-gage perforated steel (ST-2)	38.0

Two Post Installation

(For signs 5 feet or greater in width)

Post Size	Max. Sign Sq. Ft.
4x4	36.0
4x6	40.0
6x6	50.0
6x8	75.0*

Two Post Installation

(For signs 5 feet or greater in width)

Post Size	Max. Sign Sq. Ft.
**Steel 2¼" 12-gage perforated square tube	34.0
**Steel 2½" 12-gage perforated square tube	42.0
**Steel 2½" with 2¼" 7' Insert 12-gage perforated steel	77.0

*The Engineer shall determine post size for signs greater than 75 square feet.

Wood sign posts shall conform to the grades and usage listed below. Grades shall be determined by the current standards of the West Coast Lumber Inspection Bureau (WCLIB) or the Western Wood Products Association (WWPA).

4 × 4	Construction grade (Light Framing, Section 122-b WCLIB) or (Section 40.11 WWPA)
4 × 6	No. 1 and better, grade (Structural Joists and Planks, Section 123-b WCLIB) or (Section 62.11 WWPA)
6 × 6, 6 × 8, 8 × 10	No. 1 and better, grade (Posts and Timbers, Section 131-b WCLIB) or (Section 80.11 WWPA)
6 × 10, 6 × 12	No. 1 and better, grade (Beams and Stringers, Section 130-b WCLIB) or (Section 70.11 WWPA)

Steel sign posts shall conform to the Standard Plans and Section 9-06 and 9-28. Two post installations require slip bases per Standard Plan G-24.40. See Standard Plan G-24.50 for single post sign support (ST-1, ST-2, ST-3) details.

9-35.4 Sequential Arrow Signs

Sequential Arrow Signs shall meet the requirements of the Arrow Boards in accordance with the MUTCD and supplemented with the following:

Sequential arrow signs furnished for stationary lane closures on Freeways and multi-lane roadways 45 mph and higher shall be Type C. Sequential arrow signs for mobile operations and for multi-lane roadways 40 mph or less may be Type B.

The color of the light emitted shall be yellow.

The dimming feature shall be automatic, reacting to changes in light without a requirement for manual adjustment.

9-35.5 Portable Changeable Message Signs

A PCMS will be a full-sized PCMS, mPCMS, or truck-mounted PCMS and shall meet the following requirements:

1. PCMSs shall meet the requirements of the MUTCD.
2. PCMSs shall use light emitting diode (LED) technology capable of emitting a yellow or amber image when displayed with a flat black image matching the background when not activated.
3. PCMSs shall be capable of displaying 3-lines of at least 8 alphanumeric characters with a minimum of one pixel separation between each line.
4. PCMSs shall be capable of displaying 2 phases of messages at 2.0 second display each in addition to 3 phases of messages at 1.5 second display each.
5. The PCMS panels and related equipment shall be permanently mounted on a trailer or truck with all needed controls and power generating equipment.
6. The sign display shall be covered by a stable, impact resistant polycarbonate face. The sign face shall be non-glare from all angles and shall not degrade due to exposure to ultraviolet light.
7. PCMSs shall be capable of simultaneously activating all pixels for the purpose of pixel diagnostics. This feature shall not occur when the sign is displaying an active message.
8. The light source shall be energized only when the sign is displaying an active message.
9. Primary source of power shall be solar power with a battery backup to provide continuous operation when failure of the primary power source occurs.
10. The sign controller software shall be NTCIP compliant.
11. Minimum PCMS character shall be:
 - a. For full sized PCMSs characters shall be at least 18 inches in height.
 - b. For mPCMS characters shall be at least 12 inches in height.
 - c. For truck-mounted PCMS characters shall be at least 10 inches in height.

9-35.6 Barricades

Barricades shall conform to the requirements of the MUTCD. The alternating orange and white retroreflective bands shall be fabricated from IV (High Intensity) or a higher type sheeting as described in Section 9-28.12.

9-35.7 Traffic Safety Drums

Traffic safety drums shall conform to the requirements of the MUTCD and shall have the following additional physical characteristics:

Material	Fabricated from low-density polyethylene that meets the requirements of ASTM D4976 and is UV stabilized.
Overall Width	18-inch minimum regardless of orientation.
Shape	Rectangular, hexagonal, circular, or flat-sided semi-circular.
Color	The base color of the drum shall be fade resistant safety orange.
Base	A separate ballast shall be used to resist overturning or other movement from wind gusts or other external forces.

If a warning light is attached to a traffic safety drum, the method of attachment shall ensure that the light does not separate from the drum upon impact. The drum and light units shall meet the crashworthiness requirements of NCHRP 350 or MASH in accordance with the manufacturer as described in Section 1-10.2(3). Beginning on January 1, 2027 warning lights shall no longer be used on drums.

Until December 31, 2026 traffic safety drums may have 4-inch or 6-inch retroreflective bands fabricated from Type III or Type IV or higher sheeting type as described in Section 9-28.12.

Beginning January 1, 2027 traffic safety drums shall have 6-inch retroreflective bands. A minimum of 4 retroreflective horizontal bands, alternating fluorescent orange and white starting with the top stripe being fluorescent orange, shall be used. Retroreflective bands shall be fabricated from Type VIII, IX, or XI (Super/Very High Intensity) reflective sheeting as described in Section 9-28.12. Drums of different retroreflective band types shall not be intermixed within the same closure (place all the High Intensity drums together, then switch to the Super/Very High Intensity drums for the remainder of the closure, or vice versa). When recommended by the manufacturer, drums shall be treated to ensure proper adhesion of the reflective sheeting.

9-35.8 Vacant**9-35.9 Traffic Cones**

Cones shall conform to the requirements of the MUTCD, except that the minimum height shall be 28 inches or 36 inches, as specified in the traffic control plan.

White retroreflective bands shall be fabricated from Type IV (High Intensity) or a higher reflective sheeting as described in Section 9-28.12.

9-35.10 Tubular Markers

Tubular markers shall conform to the requirements of the MUTCD, except that the minimum height shall be 28 inches or 42 inches, as specified in the traffic control plan.

For portable tubular makers, the base color shall be fade resistant safety orange with white retroreflective sheeting. A separate ballast shall be used to resist overturning or other movement from wind gusts or other external forces.

When pavement-mounted tubular markers are specified, they shall be stabilized by affixing them to the pavement using an adhesive. Adhesive used to glue the device to the pavement shall meet the requirements of Sections 9-02.1(8) or 9-26.2. Pavement-mounted tubular makers base color and retroreflective sheeting shall match the color of the adjacent pavement marking, either white or yellow.

White retroreflective bands shall be fabricated from Type IV (High Intensity) or a higher reflective sheeting as described in Section 9-28.12. When recommended by the manufacturer, tubular markers shall be treated to ensure proper adhesion of the reflective sheeting.

9-35.11 Warning Lights and Flashers

Warning lights and flashers shall conform to the requirements of the MUTCD.

9-35.12 Transportable Attenuator

Transportable attenuators are Truck-Mounted Attenuators (TMA) or Trailer-Mounted Attenuators (TMA-trailer). The transportable attenuator shall be mounted on, or attached to, a host vehicle that complies with the manufacturer's recommended weight range. Ballast used to obtain the minimum weight requirement, or any other object that is placed on the vehicle, shall be securely anchored such that it will be retained on the vehicle during an impact. The Contractor shall provide certification that the transportable attenuator complies with NCHRP 350 Test level 3 or MASH Test Level 3 requirements. Lighter host vehicles proposed by the Contractor are subject to the approval of the Engineer. The Contractor shall provide the Engineer with roll-ahead distance calculations and crash test reports illustrating that the proposed host vehicle is appropriate for the attenuator and the site conditions.

The transportable attenuator shall have a chevron pattern on the rear of the unit. The pattern shall consist of 4-inch to 8-inch alternating nonreflective black and retroreflective yellow or alternating retroreflective red and white sheeting, slanted at 45 degrees in an inverted "V" with the "V" at the center of the unit.

9-35.12(1) Truck-Mounted Attenuator

The TMA may be selected from the approved units listed on the QPL or submitted using a RAM.

The TMA shall have an adjustable height so that it can be placed at the correct elevation during usage and to a safe height for transporting. If needed, the Contractor shall install additional lights to provide fully visible brake lights at all times.

9-35.12(2) Trailer-Mounted Attenuator

The TMA-trailer may be selected from the approved units listed on the QPL or submitted using a RAM.

If needed, the Contractor shall install additional lights to provide fully visible brake lights at all times.

9-35.12(3) Submittal Requirements

For transportable attenuators listed on the QPL, the Contractor shall submit the QPL printed page or a QPL Acceptance Code entered on the RAM (WSDOT Form 350-071) for the product proposed for use to the Engineer for approval. The Contractor shall submit a RAM for transportable attenuators not listed on the QPL.

9-35.13 42-Inch Tall Channelizing Devices

42-inch tall channelization devices shall have the following physical characteristics:

Material	Fabricated from low-density polyethylene that meets the requirements of ASTM D4976 and is UV stabilized.
Overall Height	42-inch minimum regardless of orientation
Overall Width	4-inch minimum at the top tapered to 8-inch minimum at the bottom regardless of orientation.
Shape	Rectangular, hexagonal, circular, or flat-sided semi-circular.
Color	The base color of the device shall be fade resistant safety orange.
Base	A separate ballast shall be used to resist overturning or other movement from wind gusts or other external forces.

If a warning light is attached to a 42-inch tall channelization device, the method of attachment shall ensure that the light does not separate from the channelization device upon impact. The channelization device and light units shall meet the crashworthiness requirements of NCHRP 350 or MASH per the manufacturer as described in Section 1-10.2(3). Beginning on January 1, 2027 warning lights shall no longer be used on 42-inch tall channelization devices.

Until December 31, 2026 42-inch tall channelization devices may have 4-inch or 6-inch retroreflective bands fabricated from Type III or Type IV or higher sheeting type as described in Section 9-28.12.

Beginning January 1, 2027 42-inch tall channelization devices shall have 6-inch retroreflective bands. A minimum of 4 retroreflective horizontal bands, alternating fluorescent orange and white starting with the top stripe being fluorescent orange, shall be used. Retroreflective bands shall be fabricated from Type VIII, IX or XI (Super/Very High Intensity) reflective sheeting as described in Section 9-28.12. 42-inch tall channelization devices of different retroreflective band types shall not be intermixed within the same closure (place all the High Intensity drums together, then switch to the Super/Very High Intensity drums for the remainder of the closure, or vice versa). When recommended by the manufacturer, 42-inch tall channelization devices shall be treated to ensure proper adhesion of the reflective sheeting.

9-35.14 Portable Temporary Traffic Control Signal

Portable temporary traffic control signals systems (PTSS) shall meet the requirements of the MUTCD and these specifications.

The PTSS shall be fully operational for traffic actuated, pre-timed, or manual control. The PTSS shall support the number of signal phases necessary to control traffic through the applicable Work area.

Controllers shall be capable of controlling all displays required for each PTSS system. Controllers shall demonstrate conflict-monitoring capability, consistent with the requirements of Section 9-29.13(2) item number 5, with a flashing red display in all directions. The controller shall be capable of terminating the all red clearance for the preceding movement, such that the previous movements can be repeated.

Signal head displays shall be either hard wired or controlled by radio signal. Manual operation will not require hardwiring or radio control except for the use of two-way radio communication by manufacturer trained qualified operators.

The system shall be equipped with a means of informing the operator of signal indications, such as a light on the back of each signal head that illuminates when the signal displays a red indication, during manual operation.

Each PTSS shall include vehicle detection and shall be capable of operating either as fixed time or traffic actuated. The detection system shall provide presence detection (continuous call to the controller) while there is a vehicle, including bicycles, in the detection zone. When specified in the Contract, each designated PTSS shall include a pushbutton for bicycles that will extend the all-red time to accommodate bicycle travel through the applicable work area. Each pushbutton shall be placed such that it is accessible to bicycle users and include signing with instructions for bicyclists.

PTSS signal displays shall be trailer mounted. PTSS trailers with overhead signal displays shall provide two signal displays, with at least one display mounted overhead and the two displays at least 8 feet apart horizontally. The minimum vertical clearance to the traveled way for this signal display is 16.5 feet. Where there is no direct line of sight between stop line locations, each trailer shall include a digital timer display showing the time remaining to the next green indication; digits shall be a minimum of 6 inches in height. Ground mounted signal display trailers shall provide one signal display. Vertical height to the bottom of a single signal display shall be a minimum of 8 feet (10 feet preferable).

Vehicular signal heads shall be of the conventional type with standard ITE approved, 12-inch ball LED display. Tunnel visors shall be provided for all indications.

Back plates shall be furnished and attached to the signal heads. Back plates shall be constructed of 5-inch-wide .050-inch-thick corrosion resistant louvered aluminum, with a flat black finish. A highly retroreflective yellow strip, 1 inch wide, shall be placed around the perimeter of the face of all vehicle signal backplates to project a rectangular image at night toward oncoming traffic.

Trailers shall have a leveling jack installed at all four corners. The crank for the leveling jacks and trailer hitch shall be locked. The signal pole and mast arm assemblies shall be of the collapsible type, which can be erected and extended at the job site. The mast arm assemblies shall be firmly attached to the trailer to form a stable unit, which can withstand an 80 mph design wind speed with a 1.3 gust factor.

The portable temporary traffic control signal shall be powered using a self-contained battery system capable of providing over 12 days of continuous operations without solar array assistance. A solar panel array will be allowed.

9-35.15 Temporary Pedestrian Curb Ramps

Temporary pedestrian curb ramps shall be constructed as shown in the traffic control plans or be pre-manufactured devices meeting the requirements of the ADA Accessibility Standards, see Chapter 4: Ramps and Curb Ramps at www.access-board.gov.

9-35.16 Pedestrian Channelizing Devices

When exposed to vehicular traffic, pedestrian channelizing devices shall meet the crashworthiness requirements of NCHRP 350 or MASH as described in Section 1-10.2(3). The bottom and top surfaces of the pedestrian channelizing device shall have 6-inch retroreflective bands matching the body color of the device fabricated from IV (High Intensity) or a higher type reflective sheeting as described in Section 9-28.12.

9-36 Shaft-Related Materials**9-36.1 Shaft Casing****9-36.1(1) Permanent Casing**

Permanent casing shall be of steel base metal conforming to ASTM A36, ASTM A252 Grades 2 or 3, ASTM A572, or ASTM A588.

Permanent casing for CFST shafts shall conform to Section 9-10.5 requirements for steel pipe piling.

9-36.1(2) Temporary Casing

Temporary casing shall be a smooth wall structure of steel base metal, except where corrugated metal pipe is shown in the Plans as an acceptable alternative material. Use of corrugated metal pipe as temporary casing will not be allowed for shaft foundations of monotube sign bridges and cantilever sign structures.

9-36.2 Shaft Slurry**9-36.2(1) Mineral Slurry**

Mineral slurry shall conform to the following requirements:

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1, Section 1	63 to 75
Viscosity (seconds/quart)	Marsh Funnel and Cup API 13b-1, Section 2.2	26 to 50
PH	Glass Electrode, pH Meter, or pH Paper	8 to 11
Sand Content (percent)	Sand API 13B-1, Section 5	
Prior to final cleaning		4.0 max.
Immediately prior to placing concrete		4.0 max.

Use of mineral slurry in salt water installations will not be allowed.

Slurry temperature shall be at least 40F when tested.

9-36.2(2) Synthetic Slurry

Synthetic slurries shall be used in conformance with the manufacturer's recommendations and shall conform to the quality control plan specified in Section 6-19.3(2)B, item 4. The synthetic slurry shall conform to the following requirements:

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1, Section 1	64 max.
Viscosity (seconds/quart)	Marsh Funnel and Cup API 13b-1, Section 2.2	32 to 135
PH	Glass Electrode, pH Meter, or pH Paper	6 to 11.5
Sand Content (percent)	Sand API 13B-1, Section 5	
prior to final cleaning		1.0 max.
immediately prior to placing concrete		1.0 max.

If the product is not listed on the Qualified Products List, the Contractor shall submit a Request for Approval of Materials Source (RAM) form with the following information:

- Test data showing conformance to the properties in the table above, and
- Documentation showing that the synthetic slurry (with load-tested additives) has been approved by the California Department of Transportation (Caltrans).

9-36.2(3) Water Slurry

Water without site soils may be used as slurry when casing is used for the entire length of the drilled hole. Water slurry without full length casing may only be used with the approval of the Engineer.

Water slurry shall conform to the following requirements:

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1, Section 1	65 max.
Sand Content (percent)	Sand API 13B-1, Section 5	1.0 max.

Use of water slurry in salt water installations will not be allowed.

Slurry temperature shall be at least 40°F when tested.

9-36.3 Steel Reinforcing Bar Centralizers

Steel reinforcing bar centralizers shall be steel, conforming to the details shown in the Plans. The Contractor may propose the use of alternative steel reinforcing bar devices as part of the shaft installation narrative as specified in Section 6-19.3(2)B, item 9, subject to the Engineer's review and approval of such devices.

9-36.4 Access Tubes and Caps

Access tubes for CSL or TIP testing shall be steel pipe of 0.145 inches minimum wall thickness and at least 1½ inch inside diameter.

The access tubes shall have a round, regular inside diameter free of defects and obstructions, including all pipe joints, in order to permit the free, unobstructed passage of 1.3-inch maximum diameter source and receiver probes used for the crosshole sonic log tests. The access tubes shall be watertight and free from corrosion, with clean internal and external faces to ensure a good bond between the concrete and the access tubes.

The access tubes shall be fitted with watertight threaded PVC caps on the bottom, and shall be fitted with watertight PVC caps, secured in position by means as approved by the Engineer, on the top.

9-36.5 Grout for Access Tubes

Grout for filling the access tubes at the completion of the crosshole sonic log tests shall be a homogeneous mixture of neat cement grout and potable water, conforming to Section 9-20.3(4), except that the maximum water/cement ratio shall be 0.45.

9-37 Vacant

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