

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 AASHTO Designation M 92 or ASTM Designation E 11, or (2) square-hole, perforated plates conforming to ASTM Designation E 323.

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 AASHTO M 298, 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 Portland Cement

9-01.1 Types of Cement

Cement shall be classified as portland cement or blended 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(2) Vacant

9-01.2(3) 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(4) 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 minimum of 25 percent and 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 proposed replacement level shall be conducted in accordance with ASTM C1012 at the storage temperature prescribed in Section 9.3 of the test procedure, as well as at a storage temperature of 5.0 ± 2.0 °C. Expansion at 1 year shall be 0.10 percent or less for each test temperature.
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 minimum of 30 percent and 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 at the storage temperature prescribed in Section 9.3 of the test procedure, as well as at a storage temperature of 5.0 ± 2.0 °C. Expansion at 1 year shall be 0.10 percent or less for each test temperature.

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. Type IL(X) shall only be used with either 25 percent to 35 percent replacement with Class F fly ash, or with 30 percent to 50 percent replacement with slag cement. Separate testing of each source of fly ash or slag at each proposed replacement level shall be conducted in accordance with ASTM C1012 at the storage temperature prescribed in Section 9.3 of the test procedure, as well as at a storage temperature of 5.0 ± 2.0 °C. Expansion at 1 year shall be 0.10 percent or less for each test temperature.

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.

9-01.3 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 cement shall participate in the Cement Acceptance Program as described 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 Asphalt Binder (PGAB) 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 approved by the WSDOT State Materials Laboratory. Any change to the QCP will require a new QCP to be submitted. The Asphalt Supplier of PGAB and Emulsified Asphalt shall certify through the Bill of Lading that the PGAB 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 Asphalt Binder (PGAB)

PGAB meeting the requirements of AASHTO M320 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 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 PGAB requirements of AASHTO M320 Table 1 for the grade of asphalt binder specified by the Contract.

In addition to AASHTO M320 Table 1 specification requirements, all performance grade (PG) asphalt binders shall meet the following requirements:

		Additional Requirements by Performance Grade (PG) Asphalt Binders					
Property	Test Method	PG 58-22	PG 64-22	PG 64-28	PG 70-22	PG 70-28	PG 76-28
RTFO Residue: Elastic Recovery ¹	AASHTO T 301 ²			60% Min.	60% Min.	60% Min.	60% Min.

¹Elastic Recovery @ 25°C ± 0.5°C.

²Specimen conditioned in accordance with AASHTO T 240 – RTFO.

The Direct Tension Test (AASHTO T 314) of M 320 is not a Specification requirement.

The recycling agent used to rejuvenate the recovered asphalt from recycled asphalt pavement (RAP) and reclaimed asphalt shingles (RAS) shall meet the specifications in Table 1:

Table 1

Test	ASTM Test Method	RA 1		RA 2		RA 25	
		Min.	Max.	Min.	Max.	Min.	Max.
Viscosity @ 140°F cSt	D2170 or D2171	50	150	200	800	1000	4000
Flashpoint COC, °F	D92	400		400		400	
Saturates, Wt. %	D2007		30		30		30
Specific Gravity	D70 or D2198	Report		Report		Report	
Tests on Residue from RTFC	D2872						
Viscosity Ratio ¹			3		3		3
Mass Change ± %			4		4		4

¹Viscosity Ratio = RTFC Viscosity @ 140°F, cSt
Original Viscosity @ 140°F, cSt

9-02.1(4)A Vacant

9-02.1(5) Vacant

9-02.1(6) Cationic Emulsified Asphalt

Cationic Emulsified Asphalt Table

Grade	Type AASHTO Test Method	Rapid Setting				Medium Setting						Slow Setting					
		CRS-1		CRS-2		CMS-2S		CMS-2		CMS-2h		CSS-1		CSS-1h			
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
Tests on Emulsified Asphalts:																	
Viscosity SFS @ 77°F (25°C)	T 59													20	100	20	100
Viscosity SFS @ 122°F (50°C)	T 59	20	100	150	400	50	450	50	450	50	450						
Storage stability test 1 day %	T 59		1		1		1		1		1				1		1
Demulsibility 35 ml																	
0.8% sodium dioctyl																	
sulfosuccinate, % ^a	T 59	40			40												
Particle charge test	T 59	Pos		Pos		Pos		Pos		Pos		Pos ^b		Pos ^b			
Sieve Test, %	T 59		0.10		0.10		0.10		0.10		0.10		0.10		0.10		0.10
Cement mixing test, %	T 59														2.0		2.0
Distillation:																	
Oil distillate by vol. of emulsions %	T 59		3	1.5	3		20		12		12						
Residue, %	T 59	60			65		60		65		65		57			57	
Tests on Residue From Distillation Tests:																	
Penetration, 77°F (25°C)	T 49	100	250	100	250	100	250	100	250	40	90	100	250	40	90		
Ductility, 77°F (25°C) 5 cm/min., cm	T 51	40			40		40		40		40		40		40		
Solubility in trichloroethylene, %	T 44	97.5			97.5		97.5		97.5		97.5		97.5		97.5		

^aThe demulsibility test shall be made within 30 days from date of shipment.

^bIf the particle charge test for CSS-1 and CSS-1h is inconclusive, material having a maximum pH value of 6.7 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	100	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 and recessed pavement markers to the pavement.

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., 1/8" × 1" × 6" specimen	ASTM D3111 ¹	Pass
Bond Pull-Off Strength	WSDOT T 426	Greater than 50 psi

¹Flexibility test is modified by bending specimen through an arc of 90 degrees at a uniform rate in 10 seconds over a 1-inch diameter mandrel.

9-02.1(9) Vacant

9-02.2 Sampling and Acceptance**9-02.2(1) Certification of Shipment**

Bituminous materials may 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).

9-02.5 Warm Mix Asphalt (WMA) Additive

Additives for WMA shall be approved by the Engineer.

9-03 Aggregates

9-03.1 Aggregates for Portland Cement Concrete

9-03.1(1) General Requirements

Portland cement concrete aggregates shall be manufactured from ledge rock, talus, or sand and gravel in accordance with the provisions of [Section 3-01](#).

The material from which concrete aggregate is manufactured 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\(3\)](#) 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 Project 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\(3\)](#) 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 Project 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 M295 may be approved for use. The Contractor shall submit test results according to ASTM C1567 through the Project Engineer to the State Materials Laboratory that demonstrate that the proposed fly ash when used with the proposed aggregates and portland 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 Portland Cement Concrete

Fine aggregate shall consist of sand or other inert materials, or combinations thereof, approved 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.

9-03.1(2)A Deleterious Substances

The amount of deleterious substances in the washed aggregate shall not exceed the following values:

1. Particles of specific gravity less than 1.95 1.0 percent by weight.
2. Organic matter, by colorimetric test, shall not be darker than the reference standard color (organic plate No. 3) AASHTO T 21 unless other tests prove a darker color to be harmless.

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.
¾"	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(2)C Vacant**9-03.1(3) Vacant**

9-03.1(4) Coarse Aggregate for Portland Cement Concrete

Coarse aggregate for concrete shall consist of gravel, crushed stone, or other inert material or combinations thereof having hard, strong, durable pieces free from adherent coatings. Coarse aggregate shall be washed to remove clay, silt, bark, sticks, alkali, organic matter, or other deleterious material.

9-03.1(4)A Deleterious

The amount of deleterious substances shall not exceed the following values:

Amount finer than No. 200	1.00 percent by weight
Pieces of specific gravity less than 1.95	2.00 percent by weight
Clay lumps	0.50 percent by weight
Shale	2.00 percent by weight
Wood waste	0.05 percent by weight

For coarse aggregate with a minimum single face fracture content of 25 percent by weight, the material finer than the No. 200 sieve may increase to a maximum of 1.5 percent 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.

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

Coarse aggregate for portland cement 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.

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 Portland Cement Concrete

As an option to using Coarse and Fine graded aggregates for portland cement concrete, aggregate gradation may consist of a combined gradation. Aggregates shall consist of sand, gravel, crushed stone, or other inert material or combinations thereof, having hard, strong durable particles free from adherent coatings. Aggregates shall be washed to remove clay, loam, alkali, organic matter, silt, bark, sticks, or other deleterious matter.

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 WSDOT 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 Mortar

Fine aggregate for portland cement mortar shall consist of sand or other inert materials, or combinations thereof, approved 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](#), which meets the following test requirements:

Los Angeles Wear, 500 Rev.	35% 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					
	3/4"-1/2"	5/8"-No. 4	1/2"-No. 4	3/8"-No. 4	No. 4-0
1"	99-100				
3/4"	95-100	99-100			
5/8"		95-100	99-100		
1/2"	0-20		90-100	99-100	
3/8"	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 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 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 size 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 Vacant

9-03.6 Vacant

9-03.7 Vacant

9-03.8 Aggregates for Hot Mix Asphalt

9-03.8(1) General Requirements

Preliminary testing of aggregates for source approval shall meet the following test requirements:

Los Angeles Wear, 500 Rev.	30% 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	HMA Evaluation	
	Statistical and Nonstatistical	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 to < 10	73	76	65	75	65	75	65	75
10 to < 30	73	76	65	75	65	75	65	75
≥ 30	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
Hamburg Wheel-Track Testing, FOP for AASHTO T 324 Rut Depth (mm) @ 15,000 Passes		10		10		10		10
Hamburg Wheel-Track Testing, FOP for AASHTO T 324 Minimum Number of Passes with no Stripping Inflection Point	15,000		15,000		15,000		15,000	
Indirect Tensile (IDT) Strength (psi) of Bituminous Materials FOP for ASTM D6931		175		175		175		175

	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 to < 30	8	100	160
	≥ 30	9	125	205

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	
⅜"	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 and Adjustments

- Job Mix Formula Tolerances** – The constituents of the mixture at the time of acceptance shall conform to the following tolerances:

Aggregate, Percent Passing	Statistical Evaluation	Nonstatistical Evaluation	Commercial Evaluation
1", ¾", ½" and ⅜" sieves	± 6%	± 6%	± 8%
No. 4 sieve	± 5%	± 6%	± 8%
No. 8 sieve	± 4%	± 6%	± 8%
No. 200 sieve	± 2.0%	± 2.0%	± 3.0%
Asphalt binder	± 0.5%	± 0.5%	± 0.7%
Air Voids, Va	2.5% minimum and 5.5% maximum		

These tolerance 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.

2. **Job Mix Formula Adjustments** – An adjustment to the aggregate gradation or asphalt binder content of the JMF requires approval of the Project 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.
 - a. **Aggregates** – The maximum adjustment from the approved mix design shall be 2 percent for the aggregate passing the 1½", 1", ¾", ½", ⅜", 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 Project 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](#).

The material from which ballast is to be manufactured 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:	⅔ 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% 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
5/8"	99-100
1/2"	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 2/3 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:	2/3 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.

9-03.11(1) Streambed Sediment

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

Sieve Size	Percent Passing
2½"	99-100
2"	65-95
1"	50-85
No. 4	26-44
No. 40	16 max.
No. 200	5.0-9.0

All percentages are by weight.

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

9-03.11(2) 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(3) 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
One Man	12" – 18"
Two Man	18" – 28"
Three Man	28" – 36"
Four Man	36" – 48"
Five Man	48" – 54"
Six Man	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.

9-03.11(4) Habitat Boulders

Habitat boulders shall be hard, sound and durable material, free from seams, cracks, and other defects tending to destroy its resistance to weather. Habitat Boulders shall be rounded to sub-angular in shape and the thickness axis shall be greater than 60 percent of the width axis and the length shall be 1.5 to 3 times the width axis. Habitat boulders sizes are approximately as follows, see Plans for sizes specified:

Rock Size ¹	Approximate Size
Three Man	28" - 36"
Four Man	36" - 48"
Five Man	48" - 54"
Six Man	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](#).

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
⅝"	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

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

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 which 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. 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, portland cement 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
1¼"	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 T 2 for Standard Practice for Sampling Aggregates	FOP for AASHTO T 2
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, 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.

Recycled materials obtained from the Contracting Agency's roadways will not require toxicity testing or certification for toxicity characteristics.

Reclaimed asphalt shingles samples shall contain less than the maximum percentage of asbestos fibers based on testing procedures and frequencies established in conjunction with the specifying jurisdiction and state or federal environmental regulatory agencies.

Recycled materials that are imported to the job site will require testing and certification for toxicity characteristics. The recycled material supplier shall keep all toxicity test results on file and provide copies to the Engineer upon request. 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 Hot Mix Asphalt

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\(1\)E](#).

9-03.21(1)B Concrete Rubble

Concrete rubble shall not be placed below the ordinary high water mark of any water of the State.

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

Glass Cullet shall meet the requirements of AASHTO M318 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 Project Engineer that the recycled glass meets the physical properties and deleterious substances requirements in AASHTO M-318.

9-03.21(1)D Recycled Steel Furnace 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 any water of the State.

9-03.21(1)E Table on Maximum Allowable Percent (By Weight) of Recycled Material

Maximum Allowable Percent (by weight) of Recycled Material					
		Hot Mix Asphalt	Recycled Concrete Aggregate	Recycled Glass (glass cullet)	Steel Furnace Slag
Fine Aggregate for Portland Cement Concrete	9-03.1(2)	0	0	0	0
Coarse Aggregates for Portland Cement Concrete	9-03.1(4)	0	0	0	0
Aggregates for Hot Mix Asphalt	9-03.8	See 5-04.2	0	0	20
Ballast	9-03.9(1)	20	100	20	20
Permeable Ballast	9-03.9(2)	20	100	20	20
Crushed Surfacing	9-03.9(3)	20	100	20	20
Aggregate for Gravel Base	9-03.10	20	100	20	20
Gravel Backfill for Foundations – Class A	9-03.12(1)A	20	100	20	20
Gravel Backfill for Foundations – Class B	9-03.12(1)B	20	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)	20	100	20	20
Select Borrow	9-03.14(2)	20	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)	20	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	20	100	20	20

9-04 Joint and Crack 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 $\frac{1}{8}$ 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”.

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

Hot poured joint sealants 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.
3. The hot poured joint sealant shall have a minimum Cleveland Open Cup Flash Point of 205°C in accordance with AASHTO T 48.

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

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. Any failure of the sealer in the test described herein, attributable to the primer, shall be grounds for rejection or re-testing of the sealer.

Acceptance of joint sealing compound for use on a project shall be on the basis of laboratory tests of samples representative of each batch of material to be used on the job. A period of at least two weeks shall be allowed for completion of tests. Each container of the compound shall be clearly identified as to batch number.

9-04.2(3) Polyurethane Sealant

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.

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, three parts fine sand, and sufficient water to allow proper workability.

Cement shall conform to the requirements of AASHTO M85, Type I or Type II.

Sand shall conform to the requirements of AASHTO M45.

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 applicable requirements of AASHTO M198.

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 AASHTO M 198.

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	AASHTO T 229	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	AASHTO T 73	600	
Fire Point COC, F	AASHTO T 48	625	
Volatile Matter	AASHTO T 47		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.

9-05 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) Concrete Drain Pipe

Concrete drain pipe shall meet the requirements of ASTM C118, heavy-duty drainage pipe.

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 M36. 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 M218 (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 M36, 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 M196, 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 M252 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 M294 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) Perforated Concrete Underdrain Pipe

Perforated concrete underdrain pipe shall meet the requirements of AASHTO M175, Type I, except the perforations shall be approximately ½ inch in diameter. Strength requirements shall be as shown in Table I of AASHTO M86.

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 M36, 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 M274 (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 M36. 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 M196, 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 M196. 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 M278. 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 M294 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 M86, 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 AASHTO M198. 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, 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 M170 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 M170, 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 M170, the minimum wall thickness shall be $1\frac{3}{4}$ 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 workmanship 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 M170, 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 M170, 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) Beveled Concrete End Sections

Beveled concrete end sections shall be plain concrete conforming to AASHTO M 86 or reinforced concrete conforming to the applicable sections of AASHTO M170 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 M36, Type I and Type II. Zinc coated steel shall meet the material requirements of AASHTO M218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M274 (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 beveled unless called for in the *Plans*. If beveled 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.

Beveled 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. Beveled pipe ends of these dimensions shall be constructed in conformance with the *Standard Plans*.

9-05.4(3) Protective Treatment

Steel pipe and pipe arch culverts shall be coated by one of the following protective treatments, when such treatment is specified:

- Treatment 1 Coated uniformly inside and out with asphalt as per [Section 9-05.4\(4\)](#) (AASHTO M190 Type A) or with polymer as per [Section 9-05.4\(5\)](#).
- Treatment 2 Coated uniformly inside and out with asphalt and with an asphalt paved invert (AASHTO M190 Type C) or with polymer as per [Section 9-05.4\(5\)](#).
- Treatment 3 This treatment is no longer available.
- Treatment 4 This treatment is no longer available.
- Treatment 5 Coated inside and out with asphalt and a 100 percent periphery inside spun asphalt lining (AASHTO M 190 Type D).
- Treatment 6 This treatment is no longer available.

9-05.4(4) Asphalt Coatings and Paved Inverts

Asphalt for asphalt coatings and paved inverts shall meet the requirements of AASHTO M190, Section 4. The coatings for Treatments 1, 2, and 5 shall be uniform, inside and out, and applied in accordance with the following requirements:

The metal shall be free from grease, dirt, dust, moisture, or other deleterious contaminants. Either process described below may be used for application.

1. **Pipe Not Preheated** – The temperature of the asphalt at the time of pipe immersion shall be 400°F (plus or minus 3 degrees), and the duration of the immersion shall conform to the following schedule:

Thickness in Inches Steel	Minimum Immersion Time Minutes
0.064	2.5
0.079	3.0
0.109	5.0
0.138	6.5
0.168	8.0

2. Pipe Preheated. The asphalt shall have a temperature of 380°F (plus or minus 3 degrees), and the pipe shall be brought to a temperature of 300°F to 350°F before immersion.

The paved invert for Treatment 2 shall consist of bituminous material applied in such a manner that one or more smooth pavements will be formed in the invert filling the corrugations for at least 40 percent of the circumference. The pavement shall have a minimum thickness of $\frac{1}{8}$ inch above the crest of the corrugations except where the upper edges intercept the corrugation. The pavements shall be applied following the coating with asphalt. Treatment 5 may be substituted for Treatment 2, at the option of the Contractor.

9-05.4(5) Polymer Protective Coating

Polymer coated steel pipe and pipe-arch shall meet the fabrication requirements of AASHTO M36 (ASTM A760). Polymer protective coatings shall meet the material requirements of AASHTO M246 (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) Spun Asphalt Lining

Asphalt for spun linings over 100 percent periphery shall conform to AASHTO M 190, Section 4. Asphalt spun linings shall provide a smooth surface for the full interior of the pipe by completely filling the corrugations to a minimum thickness of $\frac{1}{8}$ inch above the crests. The interior lining shall be applied by centrifugal or other approved methods. The interior shall be free from sags or runs, but slight residual corrugations due to cooling shrinkage of the lining will not be cause for rejection. At the three sheet laps, an interior nonuniformity equal to the thickness of the sheet is allowable. The thickness of the lining shall be maintained to the ends of the pipe.

The thickness of the lining over the crest of the corrugation shall not vary by an amount in excess of $\frac{1}{2}$ inch over the entire area of the spun lining.

In the case of helical corrugated pipe manufactured with a continuous lock seam, an interior nonuniformity over the lock seam equal to the thickness of two culvert sheets is allowable.

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 any 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 M232. 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 M36, 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 M36 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 M232.

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 196M.

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 M196, 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 M196 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 Pipe, Pipe Arch, Arch, and Underpass**9-05.6(1) General**

Structural plate pipes shall be full circle of the type, gage or thickness, and diameter specified.

Structural plate pipe arches shall be a multi-centered shape, made up of four circular arcs tangent to each other at their junctions and symmetrical about the vertical axis, and of the type, gage or thickness, and span specified.

Structural plate arches shall be a single-centered circular arc shape placed on a reinforced concrete foundation, and of the design, type, gage or thickness, and span as provided for in the Plans.

Structural plate underpasses shall be a multi-centered shape, made up of a variable number of circular arcs tangent to each other at their junctions and symmetrical about the vertical axis, and of the design, type, gage or thickness, and span specified.

9-05.6(2) Fabrication

The plates at longitudinal and circumferential seams shall be connected by bolts; the bolt holes shall be staggered in rows 2 inches apart, one hole being punched in the valley and one in the crest of each corrugation along both edges of each plate. Bolt holes on circumferential seams shall be spaced at approximate 12-inch intervals. No hole shall be closer to the edge of the plate than twice the diameter of the bolt.

The ends of structural plate pipes, pipe arches, arches, or underpasses shall not be mitered unless called for in the Plans, Special Provisions, or *Standard Plans*. If mitered ends are specified, the slope shall conform to the slope of the embankment in which the culvert is to be placed. The miter on pipe arches shall be limited to the top arc only.

9-05.6(3) Elliptical Fabrication

When elongated structural plate pipes are specified, they shall be fabricated 5 percent out of round to form an elliptical cross-section. The vertical axis (the longer axis of the elliptical section) shall be clearly marked on the plates before shipping.

9-05.6(4) Structural Plate Pipe Arch

Plates for structural plate pipe arches shall be formed so that the top shall be an arc of not more than 180 degrees nor less than 155 degrees; the bottom shall be an arc of not more than 50 degrees nor less than 10 degrees; and the top shall be joined at each end to the bottom by an arc having a radius between 18 and 31 inches and of not more than 87½ degrees nor less than 75 degrees.

9-05.6(5) Structural Plate Arch

Structural plate arches and their foundations shall be as shown in the Plans.

9-05.6(6) Structural Plate Underpass

Structural plate underpasses shall be as provided for in the *Standard Plans*, or, in the case of a special design, as provided for in the Plans.

9-05.6(7) Concrete

Concrete required for constructing structural plate arch foundations shall be Class 3000 concrete in conformance with the requirements of [Section 6-02](#).

Steel reinforcing bars shall conform to the requirements of [Section 9-07.1](#).

9-05.6(8) Plates**9-05.6(8)A Corrugated Steel Plates**

Galvanized corrugated steel plates for constructing structural plate pipe, pipe arches, arches, and underpasses, and nuts and bolts used in their assembly shall conform to the requirements of AASHTO M167 except that the minimum mass of spelter coating on the plates shall be 3 ounces of zinc per square foot of double exposed surface. If the average spelter coating as determined from the required samples is less than 3 ounces, or if any one specimen shows less than 2.7 ounces, the lot samples shall be rejected. Nuts, bolts, and miscellaneous hardware shall be galvanized in accordance with AASHTO M232.

9-05.6(8)B Corrugated Aluminum Plates

Aluminum alloy plates and fasteners intended for use in the construction of structural plate pipe, pipe arches, arches, and underpasses shall conform to the requirements of AASHTO M219. Nuts, bolts, and miscellaneous hardware shall be galvanized in accordance with AASHTO M232.

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 M170 and shall be of the class noted in the Plans or in the Special Provisions. Section 7.3.1 of AASHTO M170 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 AASHTO M198. 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 in an efficient and workmanlike manner.

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 paragraph 8(a) of AASHTO M198, 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, ½ 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 M36 and these Specifications. Zinc coated steel shall meet the material requirements of AASHTO M218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M274 (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. ¾-inch-wide by ¾-inch-deep ribs at 7½ inches on center.
2. ¾-inch-wide by 1-inch-deep ribs at 11½ inches on center.
3. ¾-inch-wide by ⅝-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 M36.

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 any 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 M232. Steel angles, when required for coupling bands, shall meet the requirements of AASHTO M36. 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 M196, 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 shall not be acceptable on any new system. 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 M264.

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 a workmanship defect subject to rejection by the Engineer. Metal castings made from gray iron or ductile iron shall conform to the requirements of AASHTO M306, 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 M306.

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 ½-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 ¼ 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 M111, 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 M196 and these Specifications. Aluminum alloy shall meet the material requirements of AASHTO M97 (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. ¾-inch-wide by ¾-inch-deep ribs at 7½ inches on center.
2. ¾-inch-wide by 1-inch-deep ribs at 11½ inches on center.
3. ¾-inch-wide by ⅝-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 M196.

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 M111.

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 M294 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 cell classification of 345464C and a Plastic Pipe Institute (PPI) designation of PE 3408.

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 M326 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 any pipe that is more 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 30 inches: ASTM F2736.
2. For triple wall pipe sizes from 30 to 60 inches: ASTM F2764.
3. For dual wall profile pipe sizes 36 to 60 inches: AASHTO MP 21, Type S or Type D.
4. 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 30 inches: ASTM F2736.
2. For pipe sizes from 30 to 60 inches: ASTM F2764.
3. 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 M199, 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 M199.

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 knock-outs, 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 Fibers for Precast Units

The synthetic fiber, either nylon multifilament fibers or polypropylene fibrillated fibers, shall meet the requirements of ASTM C1116, Section 4.1.3.3 and ICC ES AC 32, Sections 4.1.1 and 4.1.2. 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 Structural 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 ES Acceptance Criteria 32, Sections 4.1.3 and 4.1.2. Additionally, the vendor or manufacturer must furnish an Engineering Report that provides test data in accordance with ASTM C1018 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 D3822.

Precast drainage units shall have a minimum dosage rate of 3.75-lbs/cu yd. or more in order to obtain an Average Residual Strength (ARS) of 175 psi when tested in accordance with ASTM C1018 and/or ASTM C1399. The fiber supplier shall submit independent laboratory data to support ARS results.

9-06 Structural Steel and Related Materials

9-06.1 Structural Carbon Steel

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

9-06.2 Structural Low Alloy Steel

Structural low alloy steel shall conform to AASHTO M270, Grade 50 or 50W 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, quenched, and tempered structural steel conforming to AASHTO M270, Grades 70W, 100, or 100W as specified in the Plans or Special Provisions, except as otherwise noted.

9-06.4 Vacant

9-06.5 Bolts

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 A325 Type 1 or 3 or ASTM A490 Type 1 or 3, as specified in the Plans or Special Provisions. Tension control bolt assemblies, meeting all requirements of ASTM F1852 may be substituted where ASTM A325 high-strength bolts and associated hardware are specified.

When specified in the Plans or Special Provisions to be galvanized, tension control bolt assemblies shall be galvanized after fabrication in accordance with ASTM B695 Class 55 Type I.

Bolts conforming to ASTM A490 shall not be galvanized.

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

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

ASTM A325 Bolts

Type 1 (black)	ASTM A563 Grade C, C3, D, DH, and DH3 AASHTO M292 Grade 2H
Type 3 (black weathering)	ASTM A563 Grade C3 and DH3
Type 1 (hot-dip galvanized)	ASTM A563 Grade DH AASHTO M292 Grade 2H

ASTM A490 Bolts

Type 1 (black)	ASTM A563 Grade DH and DH3 AASHTO M292 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 A325.

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 A325 and ASTM 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 A325 or ASTM A490 bolts. 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 A325 or ASTM 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

Anchor bolts 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 shall conform to ASTM A563, Grade D or DH. Nuts for ASTM F1554 Grade 105 galvanized bolts shall conform to either ASTM A563, Grade DH, or AASHTO M292, 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 shall conform to ASTM A563, Grade A or DH. Washers shall conform to ASTM F436.

The bolts shall be tested by the manufacturer in accordance with the requirements of the pertinent Specification and as specified in these Specifications. Anchor bolts, nuts, and washers shall be inspected prior to shipping to the project site. The Contractor shall submit to the Engineer for approval a Manufacturer's Certificate of Compliance for the anchor bolts, 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, nut, and washer for testing.

All bolts, 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 M103, 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 M306. 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 M102. 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 M169, Grade Designation 1016 to 1030 inclusive, unless otherwise specified.

9-06.12 Bronze Castings

Bronze castings shall conform to the requirements of AASHTO M107, 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 M169. 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% min.
Reduction of Area	50% min.

Mechanical properties shall be determined in accordance with AASHTO Methods and Definitions 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 A325 and Section 9-06.5(3), except as noted otherwise. All connecting hardware shall be galvanized after fabrication in accordance with AASHTO M232.

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
Casting (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 M111.

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 Vacant

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 M111, shall have a controlled silicon content of either 0.00 to 0.04 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 Vacant

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 M232.

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 M232.

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 4 $\frac{1}{8}$ -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 requirements of AASHTO R 53, "Qualification of Deformed and Plain Reinforcing Steel Bar, Welded Wire, and Wire Producing Mills", and 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 an 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 the 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 by careful and competent workmen. They shall be bent cold to templates, which shall not vary appreciably from the shape and dimension shown in the Plans. 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	5¾"				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 M31 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 (excluding sidewalks and barriers but including shafts and concrete piles), 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 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 M31, 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 \varnothing , $\frac{1}{2}$ inch \varnothing , $\frac{5}{8}$ inch \varnothing , etc.

9-07.5 Dowel Bars (for Cement Concrete Pavement)

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

Epoxy-coated dowel bars shall be round plain steel bars of the dimensions shown in the *Standard Plans*. They shall conform to AASHTO M31, 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.

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

Corrosion resistant dowel bars shall be $\frac{1}{2}$ inch outside diameter plain round steel bars 18 inches in length and meet the requirements one of the following types:

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 M31, 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.
5. Zinc Clad dowel bars shall be of the dimension shown in the Plans and shall have a minimum 0.04 inches A710 Zinc alloy clad to a plain steel inner bar meeting the chemical and physical properties of AASHTO M31, Grade 60, or AASHTO M255, Grade 60. A710 Zinc shall be composed of: ZN-99.5 percent, by weight, minimum; CU – 0.1 – 0.25 percent, by weight; and Fe- 0.0020 percent, by weight, maximum.

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 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 M31, 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 Wire Mesh

Wire mesh for concrete reinforcement shall conform to the requirements of AASHTO M55, Welded Steel Wire Fabric for Concrete Reinforcement or AASHTO M221, Steel Welded Wire Reinforcement, Deformed for Concrete. All wire mesh shall be of an approved kind and quality of manufacture.

9-07.8 Deformed Wire

Deformed wire shall conform to the requirements of AASHTO M225, 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 M32, 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 M203, Grade 270.

All prestressing reinforcement furnished for a given structural member shall have a maximum elongation differential of 3 percent at stress of 0.8 of the ultimate strength of the prestressing steel. 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 M275, 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 M169 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 Steel Structures Painting Council (SSPC) 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

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 Organic Zinc-Rich Primer

Organic zinc-rich primer shall be a high-performance two-component epoxy conforming to SSPC Paint 20 Type II.

9-08.1(2)E Epoxy Polyamide

Epoxy polyamide primer shall be a two-component, VOC-compliant epoxy system, conforming to MIL-DTL-24441.

9-08.1(2)F Primer, Zinc-Filled, Single-Component, Moisture-Cured Polyurethane

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: As specified in the Plans or Special Provisions.

The Top Coat shall meet the following requirements

The resin must be an aliphatic urethane.

Minimum-volume solids 50 percent.

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

9-08.1(2)I Rust-Penetrating Sealer

Rust-penetrating sealer shall be a two-component, chemically-cured, 100 percent solids epoxy with maximum VOC 1.7 pounds/gallon.

9-08.1(2)J Black Enamel

The enamel shall conform to Federal Specification MIL PRF 2463D Type II Class II.

9-08.1(2)K Orange Equipment Enamel

The enamel shall be an alkyd gloss enamel conforming to Federal Specification TT-E-489, except that the Sag Index shall be seven minimum. The color, when dry, shall match that of Federal 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 TT-P-96, Paint, Acrylic Emulsion, Exterior, except that the viscosity shall be 75-85 K.U.

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

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

Except for batches of paint in total project quantities of 20 gallons or less that are accepted upon the manufacturer's certificate, the manufacturer shall not ship any batch of paint until the paint has been tested and released by the WSDOT Materials Laboratory. This release will not constitute final acceptance of the paint. Final acceptance will be based on inspection or testing of job site samples as determined by the Engineer.

Project quantities of 20 gallons or less of the above paint types will be accepted without inspection upon the manufacturer's notarized certificate. This certificate shall contain a statement by the manufacturer to the effect that the material meets the paint type Specification, and it shall include a list of materials and quantities used. One copy of the certificate shall accompany the paint when shipped and one copy with a drawdown sample of the paint shall be sent to the Materials Laboratory. The paint may be used at once without further release from the Materials Laboratory.

9-08.1(8) Standard Colors

When paint is required to match a Federal Standard 595 color, the paint manufacturer or the Contractor may obtain a sample of the required color through the following internet link: www.colorservers.net.

Unless otherwise specified, all top or finish coats shall be gloss or semi-gloss, with the paint falling within the range of greater than 70 for gloss and 35 to 70 for semi-gloss 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 1/8" mandrel bend
Pencil Hardness	ASTM D3363	H Plus
Specific Gravity	ASTM D792	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 selected from one of the approved products listed in the current Qualified Products List and specified in the Contractor's powder coating plan as approved by the Engineer.

9-08.3 Pigmented Sealer Materials for Coating of Concrete Surfaces

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 shall not be permitted. 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. The calculated Delta E shall not exceed 1.0 deviation from the Commission Internationale de l'Eclairage (CIELAB) color measurement analysis method for each pigmented sealer color.

For the respective color pigmented sealer shall conform to the following CIELAB analysis.

Color	III/Obs	L*	a*	b*
Washington Gray	D65/10 degrees	62.59	0.98	5.23
	A/10 degrees	63.06	1.80	5.70
	CWF/10 degrees	63.02	0.73	6.08
Cascade Green	D65/10 degrees	36.62	-6.53	-0.89
	A/10 degrees	35.82	-7.15	-2.53
	CWF/10 degrees	36.34	-5.09	-1.18
Mt. Baker Gray	D65/10 degrees	45.94	1.38	4.46
	A/10 degrees	46.40	1.70	5.05
	CWF/10 degrees	46.46	1.07	5.48
Mt. St. Helens Gray	D65/10 degrees	56.07	2.15	6.68
	A/10 degrees	56.76	3.08	7.52
	CWF/10 degrees	56.67	1.64	7.85

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.

9-08.4 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 Urethane Sealant

Single-component urethane sealant shall conform to ASTM C920 Grade NS Class 25.

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 WHPA)
Hem Fir	Select Structural, grade (Section 131-a WCLIB) or (Section 80.10 WHPA)
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.

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

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-Preservers' 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. 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 AWWPA 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 the requirements of AASHTO M31 Grade 40 or Grade 60.

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 A572 or ASTM A588 material may be used for longitudinal seam welded piles of any diameter.

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.

All steel piling may be accepted by the Engineer based on the Manufacturer's Certification of Compliance submitted in accordance with [Section 1-06.3](#). The manufacturer's certificate of compliance submittal for steel pipe piles shall be accompanied by certified mill test reports, including chemical analysis and carbon equivalence, for each heat of steel used to fabricate the steel pipe piling.

9-11 Waterproofing

9-11.1 Asphalt for Waterproofing

Asphalt for waterproofing shall conform to the requirements of ASTM D312, Type 4.

The material used as primer shall conform to the requirements of ASTM D41, Primer for Use with Asphalt in Dampproofing and Waterproofing.

Acceptance shall be as provided in [Section 9-02.2\(1\)](#).

9-11.2 Waterproofing Fabric

Waterproofing fabric shall be a saturated cotton fabric meeting the requirements of ASTM D173, Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

9-11.3 Portland Cement Mortar

Portland cement and sand for the mortar protection course shall conform to the following requirements:

Portland Cement	9-01
Sand	9-03
Mortar	9-20.4

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

Concrete blocks for manholes and catch basins shall conform to the requirements of ASTM C139.

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 per [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 conform to the following requirements for quality.

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
40% to 90%	1 ton (½ cubic yd.)	
70% to 90%	300 lbs. (2 cu. ft.)	
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.)	
15% to 80%	50 lbs. to 1 ton (½ 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 which 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.
¾"	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.

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:

$$\frac{\text{Length}}{\text{Thickness}} = \leq 3.0 \text{ Suitable Shape}$$

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.

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:

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

Rock for Erosion and Scour Protection shall be visually accepted by the Project Engineer. The Project Engineer shall determine the Suitable Shape, Approximate Size, and Grading of the load before it is placed. If so ordered by the Project Engineer, the loads shall be dumped on a flat surface for sorting and measuring the individual rocks contained in the load.

9-13.5 Concrete Slope Protection

Concrete slope protection shall consist of reinforced portland 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 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 Concrete Slope Protection

Cement – This material shall be portland 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 minimum 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.)
One Man	50 to 200	12 to 18
Two Man	200 to 700	18 to 28
Three Man	700 to 2,000	28 to 36
Four Man	2,000 to 4,000	36 to 48
Five Man	4,000 to 6,000	48 to 54
Six Man	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 Topsoil

Topsoil shall not contain any recycled material, foreign materials, or any listed 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.

9-14.1(1) Topsoil Type A

Topsoil Type A shall be as specified in the Special Provisions.

9-14.1(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. The general limits of the material to be utilized for topsoil will be indicated in the Plans or in the Special Provisions. The Engineer will make the final determination of the areas where the most suitable material exists within these general limits. The Contractor shall reserve this material for the specified use. Material for Topsoil Type B shall not be taken from a depth greater than 1 foot from the existing ground unless otherwise designated by the Engineer.

In the production of Topsoil Type B, all vegetative matter, less than 4 feet in height, shall become a part of the topsoil. Prior to topsoil removal, the Contractor shall reduce the native vegetation to a height not exceeding 1 foot.

9-14.1(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.

9-14.2 Seed

Seed of the type specified shall be certified in accordance with [WAC 16-302](#). 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.

All seed vendors must have a business license issued by supplier's state or provincial Department of Licensing with a "seed dealer" endorsement.

9-14.3 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.

9-14.4 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.

9-14.4(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 provide documentation that the material is steam or heat treated to kill seeds, or shall provide 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.

Straw mulch shall be suitable for spreading with mulch blower equipment.

9-14.4(2) Hydraulically Applied Erosion Control Products (HECPs)

All HECPs shall be biodegradable 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. Up to 5 percent by weight may be photodegradable material.

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 9-14.4\(7\)](#). Under no circumstances will field mixing of additives or components be acceptable.

The Contractor shall provide 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 table requirements:

Table 1
HECP Requirements

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 8260B	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 6020A Total Metals	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 Mercury – < 2 mg/kg Nickel – < 2 mg/kg Selenium – < 10 mg/kg Strontium – < 40 mg/kg Zinc – < 30 mg/kg
Water Holding Capacity	ASTM D7367	800 percent minimum
Organic Matter Content	ASTM D586	90 percent minimum
Moisture Content	ASTM D644	15 percent maximum
Seed Germination Enhancement	ASTM D7322	Long-Term 420 percent minimum Moderate-Term 400 percent minimum Short-Term 200 percent minimum

If the HECP contains cotton or straw, the Contractor shall provide documentation that the material has been steam or heat treated to kill seeds, or shall provide 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.

The HECP shall contain a dye to facilitate placement and inspection of the material. Dye shall be nontoxic to plants, animals, and aquatic life and shall not stain concrete or painted surfaces.

The HECP shall be furnished with a Material Safety Data Sheet (MSDS) that demonstrates that the product is not harmful to plants, animals, and aquatic life.

9-14.4(2)A Long-Term Mulch

Long-Term Mulch shall demonstrate the ability to adhere to the soil and create a blanket-like mass and shall bond with the soil surface to create a continuous, porous, absorbent, and flexible erosion-resistant blanket that allows for seed germination and plant growth and conforms to the requirements in [Table 2](#), Long-Term Mulch Test Requirements.

The Contractor shall provide test results documenting that the mulch meets the requirements in [Table 2](#), Long-Term Mulch Test Requirements.

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

**Table 2
Long-Term Mulch Test Requirements**

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)

9-14.4(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 that allows for seed germination and plant growth and conforms to the requirements in [Table 3](#), Moderate-Term Mulch Test Requirements.

The Contractor shall provide test results documenting that the mulch meets the requirements in [Table 3](#), Moderate-Term Mulch Test Requirements.

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

**Table 3
Moderate-Term Mulch Test Requirements**

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 = 0.05 maximum using Revised Universal Soil Loss Equation (RUSLE)

9-14.4(2)C Short-Term Mulch

The Contractor shall provide test results documenting that the mulch meets the requirements in [Table 4](#), Short-Term Mulch Test Requirements.

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

**Table 4
Short-Term Mulch Test Requirements**

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 National Resources Conservation Service (NRCS) Soil Texture Triangle.	C Factor = 0.15 maximum using Revised Universal Soil Loss Equation (RUSLE)

9-14.4(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 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 when tested shall be according to WSDOT T 123 prior to placement and shall meet the following loose volume gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
2"	95	100
No. 4	0	30

9-14.4(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.

The Contractor shall provide Material Safety Data Sheet (MSDS) that demonstrates that the product is not harmful to plant life and a test report performed in accordance with WSDOT T 125 demonstrating compliance to this specification prior to acceptance.

9-14.4(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.

9-14.4(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.

9-14.4(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.

The Contractor shall provide test results documenting the tackifier meets the requirements for Acute Toxicity, Solvents, and Heavy Metals as required in Table 1 in [Section 9-14.4\(2\)](#). The test shall be performed at the manufacturer's recommended application rate.

9-14.4(7)A Organic Tackifier

Organic tackifiers shall be derived from natural plant sources and shall have an MSDS that demonstrates to the satisfaction of the Engineer that the product is not harmful to plants, animals, and aquatic life.

9-14.4(7)B Synthetic Tackifier

Synthetic tackifiers shall have an MSDS that demonstrates to the satisfaction of the Engineer that the product is not harmful to plants, animals, and aquatic life.

9-14.4(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.

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
3/4"	70	100
1/4"	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.

2. 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".

3. Physical contaminants, defined in [WAC 173-350](#) (plastic, concrete, ceramics, metal, etc.) 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”.
4. 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)”.
5. 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”.
6. Maturity shall be greater than 80 percent in accordance with U.S. Composting Council TMECC 05.05-A, “Germination and Root Elongation”.
7. 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”.
8. 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.
9. 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.

9-14.4(8)A Compost Submittal Requirements

The Contractor shall submit the following information to the Engineer for approval:

1. The Qualified Products List printed page or a Request for Approval of Material (WSDOT [Form 350-071](#)).
2. A copy of the Solid Waste Handling Permit issued to the manufacturer by the Jurisdictional Health Department in accordance with [WAC 173-350](#) (Minimum Functional Standards for Solid Waste Handling).
3. The Contractor shall verify in writing and provide lab analyses that the material complies with the processes, testing, and standards specified in [WAC 173-350](#) and these Specifications. An independent Seal of Testing Assurance (STA) Program certified laboratory shall perform the analyses.
4. A copy of the manufacturer’s Seal of Testing Assurance STA certification as issued by the U.S. Composting Council.

9-14.4(8)B Compost Acceptance

Fourteen days prior to application, the Contractor shall submit a sample of the compost approved for use, an STA test report dated within 90 calendar days of the application, and the list of feed stocks by volume for each compost type to the Engineer for review.

The Contractor shall use only compost that has been tested within 90 calendar days of application and meets the requirements in [Section 9-14.4\(8\)](#). Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall not be used.

9-14.4(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.

9-14.5 Erosion Control Devices**9-14.5(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.

9-14.5(2) Biodegradable Erosion Control Blanket

Biodegradable erosion control blankets shall be made of natural plant fibers, and all netting material, if present, shall biodegrade within a life span not to exceed 2 years.

The Contractor shall provide independent test results from the National Transportation Product Evaluation Program (NTPEP) meeting the requirements of [Section 9-14.5\(2\)B](#), [9-14.5\(2\)C](#) and [9-14.5\(2\)D](#).

9-14.5(2)A Approval and Acceptance of Biodegradable Erosion Control Blankets

The erosion control blanket may be selected from the Qualified Products List, or submitted using a Request for Approval of Materials (RAM) in accordance with [Section 1-06](#).

Erosion control blankets may be accepted by the Engineer based on the modified acceptance criteria when materials are selected from the QPL. The modified acceptance criteria are defined in the QPL for each material.

9-14.5(2)B 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

**Natural Resource Conservation Services

9-14.5(2)C 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

**Natural Resource Conservation Services

9-14.5(2)D 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

**Natural Resource Conservation Services

9-14.5(3) Plastic Covering

Plastic covering shall meet the requirements of ASTM D4397 for polyethylene sheeting.

9-14.5(4) Check Dams

All materials used for check dams shall be non-toxic and not pose a threat to wildlife when installed.

9-14.5(4)A Biodegradable Check Dams

Biodegradable check dams shall meet the following requirements:

Wattle Check Dam	Section 9-14.5(5)
Compost Sock Check Dam	Section 9-14.5(6)
Coir Log Check Dam	Section 9-14.5(7)

The Contractor may substitute a different biodegradable check dam as long as it complies with the following and is approved by the Engineer:

1. Made of natural plant fiber.
2. Netting if present shall be biodegradable.
3. Straw bales shall not be used as check dams.

9-14.5(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 fulfill the requirements of [Section 9-14.5\(4\)](#) and shall be approved by the Engineer prior to installation.

9-14.5(5) Wattles

Wattles shall consist of cylinders of biodegradable plant material such as weed-free straw, coir, compost, wood chips, excelsior, or wood fiber or shavings encased within biodegradable netting. 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 have a minimum lifespan of 6 months and a maximum lifespan of not more than 24 months.

Compost filler shall be Medium Compost and shall meet the material requirements as specified in [Section 9-14.4\(8\)](#). If wood chips are used, they shall meet the material requirements as specified in [Section 9-14.4\(3\)](#). 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.

Wood stakes for wattles shall be made from untreated Douglas fir, hemlock, or pine species. Wood stakes shall be 2 by 2-inch nominal dimension and a minimum 24 inches in length.

9-14.5(6) Compost Socks

Compost socks shall consist of extra heavy-weight biodegradable fabric, with a minimum strand thickness of 5 mils. The fabric shall be filled with Medium Compost. Compost socks shall be at least 8 inches in diameter. The fabric 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. Netting material shall have a minimum lifespan of 6 months and a maximum lifespan of not more than 24 months.

Medium Compost filler shall meet the material requirements as specified in [Section 9-14.4\(8\)](#).

Wood stakes for compost socks shall be made from untreated Douglas fir, hemlock, or pine species. Wood stakes shall be 2 by 2-inch nominal dimension and a minimum 24 inches in length.

9-14.5(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, 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.

9-14.5(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.

9-14.5(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.

9-14.6 Plant Materials

9-14.6(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. The rooting end shall be cut at an approximate 45-degree angle.
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 are 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 ½ 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 which 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.

9-14.6(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 which 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 which renders the plant unsuitable for its intended use.

Plants that are grafted shall have roots of the same genus as the specified plant.

9-14.6(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 Project 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.

9-14.6(4) Tagging

Plants delivered as a single unit of 25 or less of the same size, species, and variety, shall be clearly marked and tagged. Plants delivered in large quantities of more than 25 must be segregated as to variety, grade, and size; and one plant in each 25, or fraction thereof, of each variety, grade, and size shall be tagged.

9-14.6(5) Inspection

The Contracting Agency will make an inspection of plant material at the source when requested by the Engineer. However, such preliminary approval shall not be considered as final acceptance for payment. Final inspection and approval (or rejection) will only occur when the plant material has been delivered to the Contract site. The Contractor shall notify the Engineer, not less than 48 hours in advance, of plant material delivery to the project.

9-14.6(6) Substitution of Plants

No substitution of plant material, species or variety, will be permitted unless evidence is submitted in writing to the Engineer that a specified plant cannot be obtained and has been unobtainable since the Award of the Contract. If substitution is permitted, it can be made only with written approval by the Engineer. The nearest variety, size, and grade, as approved by the Engineer, shall then be furnished.

Container or balled and burlapped plant material may be substituted for bare root plant material. Container grown plant material may be substituted for balled and burlapped plant materials. When substitution is allowed, use current ASNS standards to determine the correct rootball volume (container or balled and burlapped) of the substituted material that corresponds to that of the specified material. These substitutions shall be approved by the Engineer and be at no cost to the Contracting Agency.

9-14.6(7) Temporary Storage

Plants stored under temporary conditions prior to installation shall be the responsibility of the Contractor.

Plants stored on the project shall be protected at all times from extreme weather conditions by insulating the roots, root balls, or containers with sawdust, soil, compost, bark or wood chips, or other approved material and shall be kept moist at all times prior to planting.

Cuttings shall continually be shaded and protected from wind. Cuttings shall be protected from drying at all times and shall be heeled into moist soil or other insulating material or placed in water if not installed within 8 hours of cutting. Cuttings to be stored for later installation shall be bundled, laid horizontally, and completely buried under 6 inches of water, moist soil or placed in cold storage at a temperature of 34°F and 90 percent humidity. Cuttings that are not planted within 24 hours of cutting shall be soaked in water for 24 hours prior to planting. Cuttings taken when the temperature is higher than 50°F shall not be stored for later use. Cuttings that already have developed roots shall not be used.

9-14.6(8) Sod

The available grass mixtures on the current market shall be submitted to the Engineer for selection and approval.

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.

9-14.7 Stakes, Guys, and Wrapping

Stakes shall be installed as shown in the Plans.

Commercial plant ties may be used in lieu of hose and wire guying upon approval of the Engineer. 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, Tubing, and Fittings

Pipe shall be copper, galvanized iron, PVC, or polyethylene, as specified in the Plans or in the Special Provisions.

Copper pipe or tubing shall be annealed, seamless, and conform to the requirements of ASTM B88, and shall be a minimum of Type L rating.

Threaded cast brass or bronze fittings shall meet the requirements of [Section 9-30.6\(6\)](#).

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. Pipe and fittings shall be free from defects in materials, workmanship, and handling. 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.

9-15.1(3) Polyethylene Pipe

Polyethylene pipe shall be Class 80, SDR 15, medium density polyethylene pipe, meet the requirements of ASTM D2239, conform to U.S. Commercial Standard CS-255, and be National Sanitation Foundation (NSF) approved.

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 head. 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

The automatic controller 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. The pedestal shall have a completely removable locking faceplate to allow easy access to wiring.

The automatic controller housing shall have hasp and lock or a locking device. All locks or locking devices shall be master keyed, and three sets of keys shall be provided to the Engineer. 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 setting to remain open for any desired period of time, from 5 minutes or less to at least 99 minutes.
2. Adjustments shall be provided whereby 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 operator desires to make new adjustments.
3. Controls shall allow any position to be operated manually, both on or off, whenever desired, without disrupting the 14-day 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. Output shall be 24-volt AC with battery back-up for memory retention of the 14-day cycle.
7. Each controller shall have both normally-open or normally-closed 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, discharging not more than the amount of gallons per minute listed.

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 boxes 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

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. 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 valves shall be angle type. Service rating shall be not less than 150 psi nonshock cold water. Valves shall be designed for underground installation with suitable cross wheel for operation with a standard key. The Contractor shall furnish three suitable operating keys. 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 with flanged or screwed connections as required. The 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.

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. Electronic solenoids shall have a stainless steel plunger and be directly attached to the valve bonnets or body with all control parts fully encapsulated. Valves shall be of 200 psi heavy-duty glass filled nylon and a standard product of a reputable manufacturer of irrigation valves and equipment. 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 must be fully adjustable.

9-15.8 Quick Coupling Equipment

Quick coupler valves shall have a service rating of not less than 125 psi for nonshock cold water. 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 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 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 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 may be a ½- or ¾-inch PVC or metal gate valve manufactured for irrigation systems. Valves shall be designed for underground installation with suitable cross wheel for operation with a standard key, and shall have a service rating of not less than 150 psi nonshock cold water. The Contractor shall furnish three standard operating keys per Contract. Drain valves shall be installed in a valve box with a vandal-resistant lid as shown in the Plans.

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 3/4-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. When handles are included as an integral part of the valves, the Contractor shall remove the handles and give them to the Engineer.

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. One-quarter inch and smaller flow control valves shall have a minimum pressure absorption range of 2 to 32 psi. One and one half inch and larger flow control valves 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 in 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 psii nonshock cold water.

9-16 Fence and Guardrail

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-gage wire for chain link fence Types 3, 4, and 6, and 9-gage 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 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 3/8-inch diameter and of sufficient length to fasten to the type of post being used.

Tension bars shall be 3/8 by 3/4-inch nominal and cross sectional area shall be 0.141 in² ± 5 percent.

Hog rings shall be 12-gage galvanized steel wire. Tie wire shall be 9-gage galvanized steel wire or 9-gage 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 ⅝-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 ± 2 in², 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 gage 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 gage 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 gage 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-gage wire, twisted with four point 14-gage 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 gage, and the intermediate wires and vertical stays shall be 12½ gage. 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 gage 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-gage steel except for thrie beam reducer sections, thrie beams used for bridge rail retrofits, and Design F end sections, which shall be formed from 10-gage 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 the NCHRP Report 350 or 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:

Creosote oil	10.0 lbs. pcf.
Pentachlorophenol	0.50 lbs. pcf.
ACZA	0.50 lbs. pcf.
CCA	0.50 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 2, except that the rail shall be galvanized after fabrication, with fabrication to include forming, cutting, shearing, punching, drilling, bending, welding, and riveting. In addition, the minimum average mass of zinc coating shall be 2 ounces per square foot of surface (not sheet), the average to be determined on the basis of three individual tests, no one of which may be less than 1.8 ounces per square foot of surface (not sheet). The aluminum content of the zinc bath during actual galvanizing operations shall not exceed 0.01 percent. 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 installing any 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.

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 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 workmanship 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 workmanship which 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 soil anchor deadmen 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 soil anchor deadmen 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-gage) iron or steel wire which shall meet all of 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 gage 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 ⅜-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, ½-inch diameter, with standard take-up of 6 inches and provided with ⅜-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 $\frac{3}{4}$ 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°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 for any particular fence 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 $\frac{3}{4}$ inch nominal or $\frac{3}{16}$ 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-gage aluminum wire complying with the ASTM B211 for alloy 1100 H14 or 9-gage galvanized wire meeting the requirements of AASHTO M 279. Galvanizing shall be Class 1.

Hog rings shall be 12-gage galvanized steel wire.

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 exhibit good workmanship and 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 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 Type III, IV, V, or VII conforming to 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 Precast Traffic Curb

9-18.1 Precast Traffic Curb

9-18.1(1) Aggregates and Proportioning

The cement, fine and coarse aggregate, and reinforcing steel to be used in the manufacture of precast concrete traffic curb shall meet the following requirements:

1. Portland cement shall conform to the requirements of [Section 9-01](#) except that it may be Type I portland cement conforming to AASHTO M85.
2. Aggregates shall conform to the requirements of [Section 9-03](#) except that they shall be uniformly graded up to a maximum size of $\frac{3}{8}$ inch and shall contain sufficient fine fractions to permit securing the type of surface finish specified herein. The aggregate shall be approved by the Materials Laboratory before it is used.
3. Reinforcing steel shall conform to the requirements of [Section 9-07.1](#).
4. The cement concrete mix shall be composed of not less than one part portland cement to approximately two parts of fine aggregate and $3\frac{1}{4}$ parts of coarse aggregate adjusted to secure proper workability. The Contractor will be allowed to use a different concrete mix if approved by the Engineer, provided that it develops not less than 4,000 psi compressive strength when tested at the age of 28 days.

9-18.1(2) Mixing

The mixers shall be kept in good repair and be equipped with an automatic timing device and a positive device for regulating the quantity of water added to each batch. Such a device must be approved by the Engineer before use.

After all materials, including water, have been placed in the mixer, the materials shall be mixed for a period of not less than $1\frac{3}{4}$ minutes, or as much longer as may be necessary to produce a thorough and uniform mixture of the concrete. No water shall be added to any batch after the completion of the initial mixing period. Each batch of concrete shall be completely emptied from the mixer before placing more materials in it. A batch which has not been placed within 30 minutes from the time water was first added shall not be used.

The amount of water in the concrete shall be kept at a minimum consistent with the manufacture of dense curb, free from air bubbles and surface defects in excess of the tolerance limits specified.

9-18.1(3) Forms

Forms shall be of concrete or steel. The use of forms or molds made of plaster of paris, wood, or other absorptive material will not be permitted.

Bulkheads shall be tight fitting so that there is no leakage of mortar between the bulkhead and form.

The materials and methods used for lubricating the forms shall be such that they will not result in discoloration of the curb at any time. A minimum quantity of lubricant shall be used and all excess lubricant shall be removed.

9-18.1(4) Placing Concrete

The concrete shall be consolidated by external vibration, or by other means if approved by the Engineer, to produce a dense concrete throughout, having a minimum of air bubbles and honeycombing.

Reinforcing steel shall be placed and maintained in its proper position as shown in detail drawings.

Curb or buttons shall not be manufactured in an atmospheric temperature of less than 50°F.

9-18.1(5) Removal of Forms

The curb shall be removed from the molds or forms in accordance with the instructions or by some other method acceptable to the Engineer.

The loosening of the curb from the molds shall be carefully performed to avoid excessive shock and straining of the curb. When, in the opinion of the Engineer, undue shock is required to remove the curb from the molds, the stripping operation shall be deferred until such time as the curb may be removed without breakage.

9-18.1(6) Curing Concrete

Immediately after the concrete has been placed and consolidated in the mold, each unit shall be placed in a curing room fitted with water sprays and maintained at a relative humidity of not less than 90 percent and a temperature of not less than 60°F, nor more than 100°F. Each unit shall remain in the curing room for a period of not less than 10 days, except that if Type III cement is used, the period in the curing room may be reduced to 5 days.

9-18.1(7) Finish

The curb shall have a smooth, glassy finish on all exposed surfaces.

Excess honeycombing in the back of the curb may be cause for rejection of the curb. Honeycombing areas in the back of the curb which, in the opinion of the Engineer, are not detrimental to the curb need not be patched. The workmanship of the bottom finish shall be such that no mechanical interlocking of the mortar bed and the curb bottom or anchor groove will occur.

9-18.1(8) Surface Treatment

As soon as the units have been taken out of the curing room and thoroughly surface dried to a depth of at least $\frac{1}{4}$ inch, two coats of a water repellent compound, meeting the requirements of [Section 9-18.4](#), shall be brush applied. When the first coat has dried, the second coat of water repellent compound shall be applied.

9-18.1(9) Dimensions and Shape

The curb shall conform to the dimensions and shape shown in the Plans within a tolerance of $\frac{1}{4}$ inch in length and $\frac{1}{8}$ inch in alignment.

9-18.1(10) Curb Lengths

Curb lengths shall be in accordance with the *Standard Plans*, except in special cases where different lengths are specified. Circular curbing shall be made only for such radii as called for in the detail plans.

9-18.1(11) Defective Curb

Not more than 2 percent of the top area in any one piece of curb shall be defective, and not more than 5 percent of the total length of the top corners of reflecting faces in any one piece of curb shall be broken or rounded. There shall be not more than 50 holes in any linear foot of curb. All curb having defects in excess of any of the above will be rejected immediately upon inspection after removal from the forms. However, failure to reject the curb at that time will not ensure its final acceptance. Ninety percent of the curb laid shall not have more than 10 percent of the maximum allowable number of defects specified above.

An air hole shall be defined as any hole $\frac{1}{8}$ inch or larger in diameter or depth.

All defects within the limits permitted, apparent upon removal of forms, shall be repaired immediately.

The sum of the length of the lines of discoloration caused by a cracked mold in any one piece of curb shall not exceed 50 percent of the length of the curb, and the maximum length of any single line of discoloration shall not exceed 18 inches. 75 percent of the curb laid shall be entirely free from lines of discoloration. The employment of heat to obliterate lines of discoloration will not be permitted. The process used to obliterate lines of discoloration shall be subject to the approval of the Engineer.

The repairing of molds which are chipped or broken shall be done in a manner that the broken or chipped areas will not be apparent on the curb made in those molds.

All curb in which surface checking develops during the first five days after manufacture will be rejected.

Hidden air holes at or immediately below the exposed surface of the curb, in excess of the limits specified that are disclosed by testing the surface by means of a rubber hammer will be cause for rejection of the curb.

All curb in which cracking is in evidence immediately after removal from the molds will be rejected. A crack is defined as any separation of the concrete of a continuous length greater than 3 inches.

All curb which varies in dimensions, alignment, or surface contour in excess of the tolerance specified will be rejected.

Failure to comply with the Plans, Specifications, or instructions of the authorized representative of the Contracting Agency in the manufacture and laying of any curb will be cause for rejection of such curb.

9-18.1(12) Repairing Curb

Curb having defects which are not sufficient cause for its rejection shall be neatly repaired immediately after removal from the molds in a manner subject to the approval of the Engineer. However, no patching or other repairs shall be made without the permission of the Engineer. Patches shall be undercut if, in the opinion of the Engineer, this operation is necessary to achieve a satisfactory patch.

All holes larger than $\frac{1}{16}$ -inch diameter in the exposed surface of acceptable curb or buttons shall be filled with cement mortar.

9-18.1(13) Identification Marking

The date of manufacture, the length, and identification number corresponding to the detail layout shall be marked in black paint on the back or end of each piece of curb.

Rejected curb shall be marked on the back or end surfaces in a practical and semi-permanent manner to identify each cause of rejection.

9-18.1(14) Shipping

No unit of curb shall be shipped from the manufacturing plant prior to 21 days after manufacture, except, however, that if Type III cement has been used, the units may be shipped 14 days after manufacture.

9-18.1(15) Sampling and Inspection

The Contractor shall submit, for the approval of the Engineer, an advance sample of curb which shall be at least equivalent in color, surface texture, and bottom finish to the standard as set forth in these Specifications. No repairing of any kind shall be done on the advance sample. Upon approval, the advance sample shall be stored at the plant or site of manufacture in a location readily accessible to the Inspector where there is adequate daylight for examination. The advance sample shall be protected from damage and discoloration and shall be used as a standard of comparison for color, surface texture, and bottom finish for all curb manufactured. All curb furnished shall be equivalent in the foregoing respects.

The inspection at the plant will be made just prior to shipment, at which time examination will be made of the alignment, contour, color, cracks, surface damage or discoloration, broken corners or edges, and any other defects which may have developed, and to check the laboratory test reports for strength. However intermediate inspections may be made to determine surface checking and hidden air holes if it is impractical to examine for these defects at the final inspection.

9-18.2 Vacant**9-18.3 Vacant****9-18.4 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 the methods used in the State Materials Laboratory, shall not exceed 2 percent after being partially immersed in water for 72 hours immediately after curing.

The average moisture vapor transpiration (breathing) of three test specimens, when tested in accordance with the methods used in the State Materials Laboratory, shall be not less than 50 percent at 7 days.

The water repellent compound shall be approved by the State Materials Laboratory before it is used.

9-18.5 Sodium Metasilicate

Sodium metasilicate shall comply with ASTM D537.

9-19 Vacant

9-20 Concrete Patching Material, Grout, and Mortar

9-20.1 Patching Material

Concrete patching material will be prepackaged mortar extended with aggregate. The amount of aggregate for extension shall conform to the manufacturer's recommendation.

9-20.2 Specifications

Patching mortar and patching mortar extended with aggregate shall contain cementitious material and meet the requirements of Sections 9-20.2(1) and 9-20.2(2). The Manufacturer shall use the services of a laboratory that has an equipment calibration verification system and a technician training and evaluation process per AASHTO R 18 to perform all tests specified in Section 9-20.

9-20.2(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 8.5)	Minimum 1,000 psi
Scaling Resistance (at 25 cycles of freezing and thawing)	C 672 (As modified by C 928, Section 8.4)	1 lb/ft ² maximum

9-20.2(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 8.5)	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%

9-20.2(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 Manufacturers 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.

9-20.2(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.

9-20.3 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 T 23 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, pumpable, nonbleed, nonshrink, and high-strength material conforming to the requirements of AASHTO LRFD Bridge Construction Specifications, Section 10.9.3. The water/cement ratio shall not exceed 0.45.

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 Bearing Pad Applications

Grout Type 3 shall be a prepackaged material meeting the requirements of ASTM C928 – Table 1, R2 Concrete or Mortar.

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.

9-21 Raised Pavement Markers (RPM)

9-21.1 Raised Pavement Markers Type 1

Markers Type 1 shall be plastic or thermoplastic markers composed of thermosetting resins, pigments, and inert ingredients and be of uniform composition. Markers shall not contain glass.

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

The marker housing shall contain reflective faces as shown in the Plans to reflect incident light from either a single or opposite directions.

9-21.2(1) Physical Properties

The markers shall be not less than 4 inches nor more than 5 inches in width, and not more than $\frac{3}{4}$ inch in height.

The outer surface of the marker housing shall be smooth except for the purpose of identification.

The base of the markers shall be substantially free from gloss or substances that may reduce its bond to adhesive.

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(2) Optical Requirements

- Definitions** – Horizontal entrance angle shall mean the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker. Observation angle shall mean the angle at the reflector between observer’s line of sight and direction of the light incident on the reflector.

Specific intensity (S.I.) shall mean candle power of the returned light at the chosen observation and entrance angles for each foot-candle of illumination at the reflector on a plane perpendicular to the incident light.
- Optical Requirements** – The specific intensity of each reflecting surface at 0.2 degrees observation angle shall be not less than the following when the incident light is parallel to the base of the marker.

Hor. Ent. Angle	S.I.
0	3.0
20	1.2

Yellow reflectors shall be not less than 60 percent and red reflectors not less than 25 percent of the above values.

- Optical Testing Procedure** – A random lot of markers will be tested. The markers to be tested shall be located with the center of the reflecting face at a distance of 5 feet from a uniformly bright light source having an effective diameter of 0.2 inch.

The photocell width shall be 0.05 inch. It shall be shielded to eliminate stray light. The distance from light source center to the photocell center shall be 0.21 inch. If a test distance of other than 5 feet is used, the source and receiver dimensions and the distance between source and receiver shall be modified in the same proportion as the test distance.

Failure of more than 4 percent of the samples shall be cause for rejection of the lot.

9-21.2(3) Strength Requirements

Markers shall support a load of 2,000 pounds as applied in the following manner:

A marker shall be centered over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 1 inch high with an internal diameter of 3 inches and wall thickness of ¼ inch. The load shall be slowly applied to the top of the marker through a 1-inch diameter by 1-inch high metal plug centered on the top of the marker.

Failure shall constitute either a breakage or significant deformation of the marker at any load of less than 2,000 pounds.

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% min.
Concavity & Convexity	
Transverse	¼ inch, max.
Longitudinal	⅛ 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 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 Vacant

9-23.4 Vacant

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 optional chemical requirements as set forth in Table 2 and with a further limitation that the loss on ignition shall be a maximum of 1.5 percent.

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 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 Metakaolin

Metakaolin shall conform to the requirements of AASHTO M295 Class N, including optional chemical requirements as set forth in Table 2 and with a further limitation that the loss on ignition shall be a maximum of 1.5 percent.

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, microsilica fume, and metakaolin. 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](#). Metakaolin shall meet the requirements of [Section 9-23.12](#). 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. 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 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.

Containers shall be identified as “Component A” (Contains the Epoxy Resin) and “Component B” (Contains the Curing Agent) and shall show the type, grade, class, and mixing directions as defined by these Specifications. Each container shall be marked with the name of the manufacturer, the lot or batch number, the date of packaging, and the quantity contained in pounds or gallons.

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 mesh or from welded wire mesh. Only one type of mesh 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 mesh openings with nominal dimensions not to exceed 4½ inches and the maximum area of any mesh opening shall not exceed 10 square inches.

1. Hexagon Twisted Wire Mesh

- a. Wire for galvanized or aluminized hexagonal twisted wire mesh shall be nominal sized 0.120 inch galvanized steel wire or aluminized steel wire.
- b. Hexagonal wire mesh be formed from galvanized or aluminized wire in a uniform hexagonal pattern with nonraveling double twist. The perimeter edges of the mesh for each panel shall be tied to a selvage wire of the same composition as the body mesh and have a minimum diameter of 0.150 inch so that the selvage is at least the same strength as the body of the mesh.

2. Welded Wire Mesh

- a. Welded wire mesh shall be fabricated from galvanized steel wire having a diameter of 0.106 inch. Wire shall be galvanized prior to fabrication.
- b. Welded wire mesh 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 A185.
- 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 Mesh 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 D 1499 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 mesh openings with nominal dimensions not to exceed 3.3 inches, and the maximum area of any mesh opening shall not exceed 6 square inches.

1. Hexagonal Twisted Wire Mesh

- a. Wire for galvanized or aluminized hexagonal twisted wire mesh shall be nominal sized 0.086 inch galvanized steel wire or aluminized steel wire.
- b. Hexagonal wire mesh shall be formed from galvanized or aluminized wire in a uniform hexagonal pattern with nonraveling double twisted. The perimeter edges of the mesh for each panel shall be tied to a selvage wire of the same composition as the body mesh and have a minimum diameter of 0.1062 inch so that the selvage is at least the same strength as the body of the mesh.

2. Welded Wire Mesh

- a. Welded wire mesh shall be fabricated from galvanized steel wire having a diameter of 0.080 inch. Wire shall be galvanized prior to fabrication.
- b. Welded wire mesh 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 A185.
- 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. 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 mesh.

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 wire mesh. 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 wire mesh 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 mesh when a single strand in a section of mesh 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 III or IV reflective sheeting. All M series, I series, and D-10 series signs and all signs with blue or brown backgrounds shall be constructed entirely of Type II reflective sheeting unless otherwise specified. Background reflective sheeting for all other signs shall be as noted in the Plans. Sign legends for all other signs shall be constructed of Type III or IV reflective sheeting. 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, 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 $\frac{1}{4}$ 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 area immediately surrounding the bolt or rivet head. 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 workmanship, 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 $\times 10^3$	D638
Tensile Modulus	1.2 psi $\times 10^6$	D638
Flexural Strength	20.0 psi $\times 10^3$	D790
Flexural Modulus	1.2 psi $\times 10^6$	D790
Compression Strength	32.0 psi $\times 10^3$	D695
Compression Modulus	1.4 psi $\times 10^6$	D695
Punch Shear	12.0 psi $\times 10^3$	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 $\frac{1}{8}$ inch for dimensions of 12 feet or less and shall be within $\frac{1}{8}$ 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 $\frac{1}{2}$ 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 $\frac{1}{2}$ 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 Vacant

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 per AASHTO M111. Steel bolts and related connecting hardware shall be galvanized per AASHTO M232.

9-28.12 Reflective Sheeting

Type I and Type II reflective sheeting shall consist of spherical lens elements embedded within a transparent plastic having a smooth, flat outer surface. Type III and Type IV reflective sheeting shall consist of spherical or prismatic lens elements adhered to a synthetic resin and encapsulated by a flexible, transparent, weatherproof plastic having a smooth outer surface. Type V reflective sheeting shall consist of metallized microprismatic lens bonded to a flexible, smooth-surfaced, weather resistant polymeric film. Type VI reflective sheeting shall consist of unmetallized microprismatic lens formed on a flexible vinyl material. Type VII, VIII, IX and Type X Fluorescent Orange reflective sheeting shall consist of unmetallized microprismatic lens formed in a synthetic resin and encapsulated by a flexible, transparent, weatherproof plastic having a smooth outer surface. All sheeting shall be weather resistant and have a protected pre-coated adhesive backing. Type II reflective sheeting shall contain an identifying marking, such as a water mark, which is visible after sheeting application. The marking shall not adversely affect the performance or life of the sheeting.

The reflective sheeting shall have the following minimum coefficient of retroreflection values at 0.2 degrees and 0.5 degrees observation angle expressed as average candelas per foot-candle, per square foot of material. Measurements shall be conducted in accordance with ASTM E810.

Type I Glass Bead Retroreflective Element Material								
Obs. Angle	Entrance Angle	Silver White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	70	50	25	9.0	14	4.0	1.0
0.2°	+30°	30	22	7.0	3.5	6.0	1.7	0.3
0.5°	-4°	30	25	13	4.5	7.5	2.0	0.3
0.5°	+30°	15	15	4.0	2.2	3.0	0.8	0.2

Type II Glass Bead Retroreflective Element Material								
Obs. Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	140	100	60	30	30	10	5.0
0.2°	+30°	60	36	22	10	12	4.0	2.0
0.5°	-4°	50	33	20	9.0	10	3.0	2.0
0.5°	+30°	28	20	12	6.0	6.0	2.0	1.0

Type III Glass Bead Retroreflective Element Material								
Obs. Angle	Entrance Angle	Silver White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	250	170	100	45	45	20	12
0.2°	+30°	150	100	60	25	25	11	8.5
0.5°	-4°	95	62	30	15	15	7.5	5.0
0.5°	+30°	65	45	25	10	10	5.0	3.5

Type IV Micro Prismatic Retroreflective Element Material							
Obs. Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Brown
0.2°	-4°	250	170	35	35	20	7.0
0.2°	+30°	80	54	9	9	5.0	2.0
0.5°	-4°	135	100	17	17	10	4.0
0.5°	+30°	55	37	6.5	6.5	3.5	1.4

Type VI Vinyl Micro Prismatic Retroreflective Element Material							
Obs. Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.2°	-0.4°	250	170	70	30	35	20
0.2°	+30°	95	64	26	11	13	7.6
0.5°	-0.4°	200	136	56	24	28	18
0.5°	+30°	60	40	17	7.2	8.4	4.8

Type VII Micro Prismatic Retroreflective Element Material							
Obs. Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.2°	-0.4°	750	560	280	75	150	34
0.2°	+30°	430	320	160	43	86	20
0.5°	-0.4°	240	180	90	24	48	11
0.5°	+30°	135	100	50	14	27	6.0

Type VIII Micro Prismatic Retroreflective Element Material								
Obs. Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-0.4°	700	525	265	70	105	42	21
0.2°	+30°	325	245	120	33	49	20	10
0.5°	-0.4°	250	190	94	25	38	15	7.5
0.5°	+30°	115	86	43	12	17	7	3.5

Type IX Micro Prismatic Retroreflective Element Material							
Obs. Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.2°	-0.4°	380	285	145	38	76	17
0.2°	+30°	215	162	82	22	43	10
0.5°	-0.4°	240	180	90	24	48	11
0.5°	+30°	135	100	50	14	27	6.0
1.0	-0.4°	80	60	30	8.0	16	3.6
1.0	+30°	45	34	17	4.5	9.0	2.0

Type X Micro Prismatic Retroreflective Element Material		
Obs. Angle	Entrance Angle	Fluorescent Orange
0.2°	-0.4°	200
0.2°	+30°	90
0.5°	-0.4°	70
0.5°	+30°	26

The wet performance measurements on unweathered sheeting shall be conducted in accordance with one of the following methods:

1. The standard rainfall test specified in Federal Specification LS 300C and the brightness of the reflective sheeting totally wet by rain shall not be less than 90 percent of the above values.
2. Samples shall be submerged in a tank of clean water (approximately 72°F) for a period of 5 minutes. Reflex-reflective performance of the sheeting shall be viewed in a darkened room by reflected light through the surface of the water or through a transparent plane surface of the tank parallel to the sample surface. Light source shall be such as a hand flashlight held close to the eye. The wet sheeting shall show no apparent loss of reflective performance as compared to dry material.

The sheeting shall conform to the applicable daytime color and luminance factor requirements of ASTM D4956 when tested instrumentally in accordance with Section 8.4 of that Specification; OR, the diffuse day color of the reflective sheeting shall be visually evaluated by comparison with the applicable Highway Color Tolerance Chart. Color comparison shall be made under north daylight or a scientific daylight having a color temperature from 6500 degrees to 7500 degrees Kelvin. Daytime color evaluation shall be illuminated at 45 degrees and viewed at 90 degrees. There shall be no significant color shift when viewed under nighttime (retroreflective) conditions.

The reflective sheeting shall have a pre-coated pressure sensitive adhesive (Class 1) or a heat-activated adhesive (Class 2) either of which will adhere to flat, clean surfaces without necessity of additional adhesive coats on the reflective sheeting or application surface. Chemical activators shall not be used to activate Class 2 adhesive. The pre-coated adhesive shall be protected by an easily removed liner which, when removed, shall not have a staining effect on the reflective sheeting and shall be mildew resistant. The protective liner attached

to the adhesive shall be removable by peeling without soaking in water or other solvents and shall be easily removed after storage for 4 hours at 150°F under weight of 215 psi. The sheeting with liner removed, conditioned for 24 hours at 72°F and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a 1.2-inch diameter mandrel with the adhesive side contacting the mandrel. For ease of testing, talcum powder may be spread on the adhesive to prevent sticking to the mandrel. The sheeting surface shall be smooth and flat to facilitate self-cleaning in the rain, regular cleaning, and wet performance, and exhibit 85 degrees glossmeter rating of not less than 50 when tested in accordance with ASTM D523. The sheeting surface shall be readily processed and compatible with transparent and opaque process colors and show no loss of the color coat with normal handling, cutting, and application. The sheeting shall permit cutting and color processing at temperatures of 60°F to 100°F and 20 to 80 percent RH. The sheeting shall be heat resistant and permit force curing without staining of unapplied sheeting or applied sheeting at temperatures recommended by the manufacturer not to exceed 150°F for unapplied sheeting or 200°F for applied sheeting. The sheeting surface shall be solvent resistant to permit cleaning by wiping with a clean soft cloth dampened with VM&P Naphtha or mineral spirits.

The adhesive shall form a durable bond to smooth, corrosion and weather resistant surfaces and permit the reflective sheeting to adhere securely, 48 hours after application at temperatures of -30°F to 200°F. The adhesive bond shall be sufficient to render the applied sheeting vandal-resistant and prevent its shocking off when subjected to an impact energy of 20 ft. lbs. applied with a hemispherical tipped object 1 inch in diameter at -0°F. The test specimen shall be applied to aluminum backing not less than 0.080 inch thick and having a dimension of not less than 4 inches square. During testing, the specimen shall be supported on a 3-inch diameter ring.

The adhesion test shall conform to ASTM D4956 with the addition of the temperatures noted above.

The resistance to accelerated weathering shall be as described in ASTM D4956 except the weathering apparatus and procedure shall be in accordance with ASTM G154.

The reflective sheeting shall be sufficiently flexible to be cut to shape easily and permit application over, and conform to, moderate shallow embossing characteristic of certain sign borders and symbols. The tensile strength of the sheeting shall be 5 to 20 pounds per square inch width when conditioned for 48 hours in accordance to ASTM D685 and tested in accordance with ASTM D828. Following liner removal, the reflective sheeting shall not shrink more than $\frac{1}{32}$ inch in 10 minutes nor more than $\frac{1}{8}$ inch in 24 hours in any dimension per 9 inch square at 72°F and 50 percent relative humidity.

The sheeting, when applied according to manufacturer's recommendations to cleaned and etched 0.020 by 2 by 8-inch aluminum, conditioned (24 hours) and tested at 72°F and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a $\frac{3}{4}$ -inch diameter mandrel.

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 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 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 ASTM F1554 Grade 105, including Supplemental Requirements S2, S3, and S5. 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 AASHTO M232. 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 0.04 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 to the Engineer, for approval, six copies of the proposed modifications, prior to fabrication.

9-28.14(3) Aluminum Structures

Welding of aluminum shall be in accordance with ANSI/AWS D1.2, latest edition, Structural Welding Code.

Aluminum materials shall conform to ASTM B209 grades as follows: the filler alloy shall be 4043, 5365, or 5556 for welding base metals 6061 or 6063 to 6061, 6063, 356, or A356. Filler alloy for welding base metal 5086 shall be 5356 or 5556.

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/apurtenances shall be listed by a Nationally Recognized Testing Laboratory.

9-29.1(1) Rigid Metal Conduit, Galvanized Steel Outerduct, and Fittings

Rigid metal conduit 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 rigid metal-type conduits may be either hot-dip or electroplated galvanized.

Conduit bodies and fittings for rigid steel conduit 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 rigid galvanized steel conduit 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 rigid galvanized steel conduit 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 rigid galvanized steel conduit 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 rigid galvanized steel conduit 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 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
- Deflection Fittings
- Offset Fittings
- Expansion/Contraction Fittings
- Repair Kits
- Conduit and Innerduct Plugs
- Pull string
- Pull rope
- Conduit spacers
- 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 air tight seal.

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 any 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 any 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) Standard Duty and Heavy-Duty Junction Boxes

For the purposes of this Specification concrete is defined as portland cement concrete and non-concrete is all others.

Standard Duty Junction Boxes are defined as Type 1, 2, and 8, and Heavy-Duty Junction Boxes are defined as Type 4, 5, and 6.

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, and each sheet shall be carry the following:

1. Professional Engineer's original signature, date of signature, original seal, registration number, and date of expiration.
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.
4. Design calculations shall carry on the cover page, the Professional Engineer's original signature, date of signature, original seal, registration number, and date of expiration.

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

All Standard Duty Junction Boxes shall have a minimum load rating of 22,500 pounds and be tested in accordance with [Section 9-29.2\(1\)C](#). 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.

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, 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, or 316 steel in accordance with approved shop drawing
Locking and Latching Mechanism Hardware and Bolts	In accordance with approved shop drawings

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 concrete in a direct burial application.

Type 1, 2, and 8 non-concrete junction boxes shall have a Design Load of 22,500 lbs. and shall be tested in accordance with [Section 9-29.2\(1\)C](#). 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 include a pull slot embedded 6 by 6 by ¼-inch steel plate and shall be secured with two ½-inch stainless steel Penta-head bolts factory coated with anti-seize compound and 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 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\(1\)C](#).

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(1)C Testing Requirements

The Contractor shall provide for testing of 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.

For concrete junction boxes, vaults and pull boxes, 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, registration number, and date of expiration. 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 a concrete junction box, 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.
7. A brief description of type and location of failure.

For non-concrete junction boxes 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, registration number, and date of expiration. 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 a non-concrete junction box, and shall include the following information:

1. Product identification.
2. Date of testing.
3. Description of testing apparatus and procedure.
4. All load deflection data.
5. Weight of box and cover tested.

Testing for Standard Duty Concrete Junction Boxes

Standard Duty Concrete Junction 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 any impairment to the function of the lid.
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.

Testing for the Standard Duty Non-Concrete Junction Boxes

Non-concrete Junction Boxes shall be tested as defined in the ANSI/SCTE 77-2007 Tier 15 test method with test load minimum of 22,500 lbs. In addition, the Contractor shall provide a Manufacture Certificate of Compliance for each non-concrete junction box installed.

Testing for Heavy-Duty Junction Boxes

Heavy-Duty Junction 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 pounds test if none of the following conditions are exhibited:

1. Permanent deformation of the lid or any impairment to the function of the lid.
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 pounds 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.

9-29.2(2) Small Cable Vaults, Standard Duty Cable Vaults, Heavy-Duty Cable Vaults, Standard Duty Pull Boxes, and Heavy Duty Pull Boxes

Small, Standard Duty and Heavy-Duty Cable Vaults and Standard Duty and Heavy-Duty Pull Boxes shall be constructed as a concrete box and as a concrete lid. The lid for the Heavy-Duty and Standard Duty 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 any 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, and each sheet shall carry the following:

1. Professional Engineer's original signature, date of signature, original seal, registration number, and date of expiration.
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.
4. Design calculations shall carry on the cover page, the Professional Engineer's original signature, date of signature, original seal, registration number, and date of expiration.

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 Small Cable Vaults, Standard Duty Cable Vaults, and Standard Duty Pull Boxes

Small and Standard Duty Cable Vaults and Standard Duty 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\(1\)C](#) for concrete Standard Duty Junction Boxes.

Concrete for Small and Standard Duty Cable Vaults and Standard Duty 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 Small and Standard Duty Cable Vaults and Standard Duty 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 Small and Standard Duty Cable Vaults and Standard Duty 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	Slip Resistant Lid
Frame	Frame
Slip Resistant Frame	Slip Resistant Frame
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\(1\)C](#) for Heavy-Duty Junction Boxes.

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 junction boxes installed in cast-in-place structures shall be stainless steel NEMA 4X.

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 stainless steel junction boxes and cover screws shall conform to ASTM A304. 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 (6pr)	COMM	WSTA to temp sensor, weather station	ITS
Fiber Optic Trunk Lines	ITS	DS to loops (2cs)	ITS
HUB to TC (25pr)	ITS	DS to ramp meter (5c)	ITS
Fiber Optic Laterals to CC	ITS	Flashing Beacons	ITS
TC to DS (6pr)	ITS	Neon Power	ITS
TC to HAR (6pr) SC&DI	ITS	Transformers to Cabinets	ITS
TC to CC (6pr)	ITS	Service to Transformers	LT
TC to VMS (6pr)	ITS	All power for lighting	LT
TC to WSTA (6pr)	ITS	Signal Controller to Displays	TS
All other lateral 6pr (i.e. neon control, etc)	TS	Signal Controller to Loops	TS
CC to camera (coax, control cables, old style)	ITS	Signal Controller to emergency preempt	TS
CC to camera (fiber, new style)	ITS	Telephone Service Drop	TEL
HAR to antenna (coax)	ITS	Telephones at Flyer Stops, Park and Rides, etc.	TEL
VMS to sign (control cables)	ITS		

9-29.3 Fiber Optic Cable, Electrical Conductors, and Cable**9-29.3(1) Fiber Optic Cable**

Each fiber optic cable shall be suitable for placement in an underground duct.

All fibers in the cable shall be usable fibers and shall be sufficiently free of surface imperfections and inclusions to meet or exceed the optical, mechanical, and environmental requirements contained in this Specification.

Cables shall be all dielectric cable (with no armoring) and shall be jacketed (sheathed) with medium density polyethylene. The minimum nominal jacket thickness shall be 71 mils. Jacketing material shall be applied directly over the tensile strength members. The polyethylene shall contain carbon black to provide ultra-violet light protection, and it shall not promote the growth of fungus.

The jacket or sheath shall be free of any holes, splits, or blisters.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

The shipping, storage, and operating temperature range of the cable shall be -40°F to +160°F. The installation temperature range of the cable shall be -20°F to +160°F.

The fiber optic cable shall withstand a maximum pulling tension of 600 pounds (lbs.) during installation (short term) with no damage and 135 pounds (long term).

Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.

Void areas around the individual buffer tubes shall be protected with a moisture resistant compound as a block against moisture migration.

All cables shall be free of material or manufacturing defects and dimensional non-uniformity that would:

1. Interfere with the cable installation using accepted cable installation practices.
2. Degrade the transmission performance and environmental resistance after installation.

3. Inhibit proper connection to interfacing elements.
4. Otherwise yield an inferior product.

The outer jacket material shall be a medium density polyethylene (MDPE) conforming to ASTM D1248, Type II, Class C, Category 4 or 5, Grade J4. The light absorption coefficient, when measured in accordance with ASTM D3349, shall be a minimum of 400 at a wavelength of 375 nanometers.

The outer jacket material used in construction of this cable shall be fungus inert as described in ASTM G21.

Fibers shall contain no factory splices.

The fiber optic cables shall be shipped on wooden reels in lengths as specified in the purchase order with a maximum overage of 10 percent. The diameter of the drum shall be at least 20 times the diameter of the cable.

9-29.3(1)A Singlemode Fiber Optic Cable

Singlemode fibers utilized in the cables specified herein shall be fabricated from 100 kpsi proof stress glass and primarily composed of silica, which shall provide a matched clad index of refraction (n) profile and the following physical and performance characteristics:

1. Maximum Attenuation: 0.4/0.3 dB/km at 1310/1550 nanometers, respectively;
2. Typical Core Diameter: 8.3 microns;
3. Cladding Diameter: 125 micron;
4. Core-to-Cladding Offset (Defined as the distance between the core center and the cladding center: < 0.8 microns;
5. Cladding Non-Circularity (Defined as $\{[1 - (\text{minimum cladding diameter} - \text{maximum cladding diameter})] \times 100\}$: < 2.0 percent;
6. Coating Diameter of 250 microns \pm 15 microns with a minimum coating thickness at any point of not less than 50 microns;
7. The coating shall be a dual-layered, UV-cured acrylate applied by the fiber manufacturer; and
8. The coating shall be mechanically or chemically strippable without damaging the fiber.

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 conforming to ASTM B3 and B8. Insulation shall be chemically XLP (cross-linked polyethylene) or EPR (Ethylene Propylene Rubber) Type USE rated for 600-volt.

9-29.3(2)A2 Grounding Electrode Conductor

Grounding electrode conductor shall be bare or insulated stranded copper. 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 bare or green insulated, stranded copper with cross-linked polyethylene insulation rated USE 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).

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 any conductor or drain wire 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(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, $\frac{3}{2}$ -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 and AASHTO M232.

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, as submitted in accordance with Sections [6-01.9](#) and [8-20.2\(1\)](#) and the Special Provisions, and as approved by the Engineer.

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 A325. Fasteners for handhole covers, bands on lighting brackets, and connector attachment brackets shall conform to ASTM F593.

Light and signal standards shall be hot-dip galvanized in accordance with AASHTO M111 and AASHTO M232.

Steel used for light and signal standards shall have a controlled silicon content of either 0.00 to 0.04 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(1)A Vacant

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 28 gage, conforming to ASTM A653 coating designation G 90. Clamping bolts for slip base assemblies and slip base adapters shall conform to ASTM A325. Studs and bolts for slip base adapters shall conform to ASTM 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.

All poles shall be treated with pentachlorophenol in accordance with [Section 9-09.3\(1\)](#).

Topps 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 a solution of the above preservative.

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).

All foundation hardware shall be 100 percent hot-dip galvanized in accordance with AASHTO M111 and AASHTO M232.

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

9-29.8 Vacant**9-29.9 Ballast, 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	any	70 400	Mag. Reg. Lag	10%	18%
HPS	any	750 1000	Auto Reg. Lead CWA	10%	30%
MH	any	175 400	Mag. Reg. Lag	10%	18%
MH	any	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 slipfitter 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, shall be weathertight.

The temperature rating of all wiring internal to the luminaire housing, excluding the pole and bracket cable, shall equal or exceed 200°F.

All luminaires shall be provided with markers for positive identification of light source type and wattage in accordance with ANSI C136.15-2011. Legends shall be sealed with transparent film resistant to dust, weather, and ultraviolet exposure.

Legends shall correspond to the following code:

Lamp	Wattage Legend
70	7
100	10
150	15
175	17
200	20
250	25
310	31
400	40
700	70
750	75
1,000	XI

9-29.10(1) Conventional Roadway Luminaires

1. Conventional highway luminaires shall be IES Type III medium distribution cutoff cobra head configuration with horizontal lamp, rated at 24,000 hours minimum.
2. 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).
3. The reflector of all luminaires shall be of a snap-in design or secured with screws. The reflector shall be manufactured of polished aluminum or molded from prismatically formed borosilicate glass. The refractor or 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 refractor or lens and doorframe assembly, when closed, shall exert pressure against a gasket seat. The refractor 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.
4. Each housing shall be provided with a four-bolt slipfitter capable of mounting on a 2-inch pipe tenon and capable of being adjusted within 5 degrees from the axis of the

tenon. The clamping bracket(s) and the cap screws of the slipfitter 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 pounds feet.

5. Refractors shall be formed from heat-resistant, high-impact, molded borosilicate glass. Flat lenses shall be formed from heat-resistant, high-impact borosilicate or tempered glass.
6. High-pressure sodium conventional roadway luminaires shall be capable of accepting a 150, 200, 250, 310, or 400 watt lamp complete with ballast.
7. Housings shall be fabricated from aluminum. Painted housings shall be painted flat gray, Federal Standard 595 color chip No. 26280. Housings that are painted shall withstand a 1,000-hour salt spray test as specified in ASTM B117.
8. All luminaires to be mounted on horizontal mast arms shall be capable of withstanding cyclic loading in:
 - a. A vertical plane at a minimum peak acceleration level of 3.0 g's peak-to-peak sinusoidal loading (same as 1.5 g's peak), with the internal ballast removed, for a minimum of 2 million cycles without failure of any luminaire parts, and;
 - b. A horizontal plane perpendicular to the direction of the mast arm at a minimum peak acceleration level of 1.5 g's peak-to-peak sinusoidal loading (same as 0.75 g's peak), with the internal ballast installed, for a minimum of 2 million cycles without failure of any luminaire parts.
9. All luminaires shall have leveling reference points for both transverse and longitudinal adjustment. Luminaires shall have slipfitters capable of adjusting through a 5-degree axis for the required leveling procedure.

9-29.10(2) Decorative Luminaires

Decorative fixture shall provide for a 50 to 400 watt HPS lamp fully enclosed fixture with mogul lamp socket, adjustable where required to alternate cutoff distributions.

The fixture shall be a one piece, raintight, dusttight, and corrosion resistant integral unit. The unit shall consist of an accessible ballast compartment and a sealed housing, which permits filtered pressure equalization.

The ballast housing shall be adequately constructed to contain ballasts for 50 to 400 watt alternate high-intensity discharge sources.

Each housing shall consist of an integral reflector, containing a mogul-based high-intensity discharge lamp and a one-piece heat- and shock-resistant, clear-tempered lens mounted in a gasketed hinged frame. The reflector shall be a snap-in design or secured with screws. The reflector assembly shall have a lamp vibration damper. The reflector shall be manufactured of polished aluminum or molded from prismatic formed borosilicate glass. The housing shall have a heat-resistant finish. The lens frame shall be secured to the housing with ANSI 300 series chrome-nickel grade stainless steel, zinc dichromate-coated steel, or ceramic-coated steel hardware.

The auxiliary equipment compartment for ballast terminals shall be separated from the lamp compartment by a metal heat barrier. The chassis shall be designed to provide effective heat sinking from the ballast cores.

The finish shall meet the requirements of ASTM B117, with the exception that the finish shall be salt spray resistant after 300 hours exposure.

A slipfitter assembly shall be provided for leveling purposes, between fixture and tenon. Two $\frac{7}{16}$ inch or larger stainless steel bolts, series 300, shall be used to mount the fixture to the tenon. An approved gasket shall be utilized to seal against weather. A smooth wireway shall be provided.

All decorative fixtures shall be of the same manufacturer and external appearance.

9-29.10(3) Vacant**9-29.10(4) Underdeck and Wall Mount Luminaires**

Underdeck luminaires shall be weatherproof and corrosion resistant. Light distribution shall be as shown on the Contract. Each flush-mounted underdeck luminaire shall consist of a metal body, a prismatic refractor mounted in a doorframe, a prismatic glass or specular anodized aluminum reflector, a ballast, and a ceramic lamp socket and be supplied complete with all fasteners. The body shall have provisions for anchoring to concrete. The refractor shall be glass and shall be clearly identified as to “street side”. The doorframe assembly shall be hinged, gasketed and secured to the body.

Each wall-mounted luminaire shall consist of a metal body, a prismatic refractor mounted in a doorframe, an aluminum reflector with a specular anodized finish, an integral ballast and a ceramic lamp socket and supplied with all fasteners. The refractor shall be glass. A gasket shall be provided between the refractor and the body of the fixture.

All lamp sockets shall be positioned to locate the light center of the lamp within ½ inch of the light center location for which the luminaire is designed.

Ballasts for underdeck and wall luminaires shall conform to the provisions in [Section 9-29.9](#). Ballasts for underdeck and wall mount luminaires shall be installed in the luminaire housing.

9-29.10(5) Sign Lighting Luminaires

Sign lighting luminaires shall be the Induction Bulb type.

9-29.10(5)A Sign Lighting Luminaires – Isolation Switch

The isolation switch shall be installed in a terminal cabinet per [Section 9-29.25](#), with the exception that the cabinet shall be NEMA 3R and stainless steel. The terminal cabinet shall be installed in accordance with the *Standard Plans*. The switch shall be either single pole, single throw, or double pole single throw as necessary to open all conductors to the luminaires other than neutral and ground conductors. The switch shall contain 600-volt alternating current (VAC) terminal strips on the load side with solderless lugs as required for each load-carrying conductor plus four spare lugs per strip.

9-29.10(5)B Sign Lighting Fixtures-Induction

Sign lighting luminaires shall have a cast aluminum housing and door assembly with a polyester paint finish.

Each fixture shall consist of a housing, a reflector, refractor or lens, lamp socket, lamp, power coupler, a high frequency (HF) generator and a fuse block, door, front entry (the side facing the sign) suitable for ½-inch conduit and mounting holes for attaching to a fixture mounting plate. Any additional entries shall have suitable plugs. The sign lighting luminaire shall be supported by a lighting bracket assembly as detailed in the Plans. The door shall be hinged to the housing on the side of the fixture away from the sign panel and shall be provided with two captive devices. The door shall be provided with the means to allow the door to be locked in the open position 70 to 90 degree from the plane of the door opening. The juncture of the door and housing shall be gasketed to provide a rain tight and dust tight joint.

Refractors or lens shall be manufactured from heat resistant glass. The refractor or lens shall be shielded so that no light source is visible from the sign viewing approach. The shield shall be an integral part of the door assembly. When called for in the Plans, fixtures shall be provided with a wire guard to prevent damage to the refractor.

The ratio of the maximum to minimum illuminance level on a panel 10 feet high by 16 feet wide shall not numerically exceed 9:1 approaching 1:1. In addition, the illuminance gradient shall not numerically exceed 2:1, illuminance gradient being defined as the ratio of the minimum illuminance of a square panel 1 foot on a side to that of any adjacent panel of the same size. This performance shall be obtained when the fixture is mounted 1 foot below the bottom edge of the sign and 5 feet out from the sign face.

The average to minimum uniformity ratio for a panel as dimensioned above shall not numerically exceed 4:1. Average initial illuminance shall exceed 10 foot candles for an induction lamp of 85 watts as specified.

The system lifetime shall be rated at 60,000 hours with a failure rate of less than 10 percent. The system shall be rated at a nominal wattage of 85 W, 120/240 or 480V(ac). The power factor of the system shall be greater than 90 percent and the total harmonic distortion (THD) shall be less than 10 percent. The system shall be UL approved for wet locations and be FCC Class A listed.

The mounting assembly shall be either cast aluminum, hot-dip galvanized steel plate or steel plate that has been galvanized and finished with a polymeric coating system or the same finish that is used for the housing. The overall weight of the fixture shall not exceed 44 pounds. The manufacturer's brand name, trademark, model number, serial number and date of manufacture shall be located on the packaged assembly and on the outside and inside of the housing.

Housing

The housing shall have a door designed to hold a refractor or lens. The housing door shall be designed to be opened without the use of tools. The housing and door shall have polyester paint finish of a gray color resembling unfinished fabricated aluminum.

Reflector

The reflector may be designed to be removed as a unit that includes the lamp and power coupler.

Lamp

Each fixture shall be furnished with an 85-W induction lamp. The interior lamp walls shall be fluorescent phosphor coated. Lamp light output shall be not less than 70 percent at 60,000 hours. Lamps shall have a color-rendering index (CRI) of not less than 80. Lamps shall be rated at a color temperature of 4,000 K. Lamps shall be removable without the use of tools.

Power Coupler

The power coupler shall consist of a construction base with antenna, heat sink and electrical connection cable. The power coupler shall be designed so that it can be removed with no more than common hand tools.

High Frequency Generator

High frequency (HF) generators shall provide reliable lamp starting and operation at ambient temperatures down to -15°F for the rated life of the lamp.

The generator output frequency shall be 2.65 MHz \pm 10 percent. The generator radio frequency interference shall meet the requirements of Part 18 of the FCC.

High frequency generators shall be designed for continuous operation at ambient air temperatures from -5°F to 80°F without reduction in generator life. High frequency generators shall have a design life of not less than 100,000 hours at 130°F.

A Manufacturer's Certificate of Compliance, conforming to the provisions in [Section 1-06.3](#), and a copy of the high frequency generator test methods and results shall be submitted by the manufacturer with each lot of sign lighting fixtures. The certificate shall state that the high frequency generators meet, in every respect, the above requirements and the generator Specifications of the lamp manufacturer. High frequency generators shall also conform to the following:

1. High frequency generators shall be capable of being easily replaced. All conductor terminals shall be identified as to the component terminal to which they connect.
2. High frequency generators shall be mounted so as to use the portion of the sign lighting fixture upon which they are mounted as a heat sink.

9-29.11 Control Equipment

Illumination circuits shall be controlled by a combination of photoelectric controls and lighting contactors or mercury relays 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 push button 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 twistlock 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 split bolt vice-type connectors or solderless crimped connections to securely join the wires, both mechanically and electrically, as defined in [Section 8-20.3\(8\)](#).

9-29.12(1)A Heat Shrink Splice Enclosure

Heat shrink insulating materials shall be the moisture blocking mastic type meeting Mil Spec I230053.

9-29.12(1)B Molded Splice Enclosure

Epoxy resin cast-type insulation shall employ a clear rigid plastic mold or a clear mylar sheet bonded to butyrate web, forming a flexible 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(2) Traffic Signal Splice Material

Induction loop splices and magnetometer splices shall include an uninsulated barrel-type crimped connector capable of being soldered. The insulating material shall be a heat shrink type meeting requirements of [Section 9-29.12\(1\)A](#), an epoxy resin cast type with clear rigid plastic mold meeting the requirements of [Section 9-29.12\(1\)B](#), or a re-enterable type with a

silicone-type filling compound that remains flexible and enclosed in a re-enterable rigid mold that snaps together.

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 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.

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 Project 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 170E controllers shall conform to the TEES. The 170E controller shall be provided with a program card, one blank ROM chip, and two 64K non-volatile memory chips.
3. Type 170E/HC-11 controllers shall conform to the current Oregon Department of Transportation Specification for model 170E/HC-11 controller. The 170E controller with the HC11 chip shall be compatible with the software specified in the Contract. The controller shall be provided with one ROM chip and one 64K non-volatile memory chip.
4. Type 2070 controllers shall conform to the TEES. The standard 2070 controller shall consist of the following:

2070	2070E	2070N1
2070-5 VME cage		
2070-1E CPU Card	2070-1E CPU Card	2070-1E CPU Card
2070-3B Front Panel	2070-3B Front Panel	2070-3B Front Panel
2070-4 Power Supply	2070-4 Power Supply	2070-4 Power Supply
2070-2A Field I/O	2070-2A Field I/O	2070-2B Field I/O
X	X	2070-8 Interface

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	
Global Configuration	moduleType	Value 3
Database Management	dBCreateTransaction	All Values
	dBErrorType	All values
Time Management	globalsDaylightSavings	Values 2 and 3
Timebase Events Schedule	maxTimeBaseScheduleEntries	16
	MaxDayPlans	15
	MaxDayEvents	10
Report	maxEventLogCongifs	50
	MventConfigMode	Values 2 thru 5
	mventConfigAction	Values 2 and 3
	MaxEventLogSize	255
	MaxEventClasses	7
PMPP	maxGroupAddress	2
ASC Phase	maxPhases	8
	pPhaseStartp	Values 2 thru 6
	phaseOptions	All Values
	maxPhaseGroups	1
Rings	maxRings	2
	maxSequences	16
Detector	maxVehicleDetectors	64
	vehicleDetectorOptions	All Values
	maxPedestrianDetector	8
Unit	unitAutoPedestrianClear	All Values
	unitControlStatus	All Values
	unitFlashStatus	All Values
	unitControl	All Values
	maxAlarmGroups	1
Special Function	maxSpecialFunctionsOutputs	8
Coordination	coordCorrectionMode	Values 2 thru 4
	coordMaximumMode	Values 2 thru 4
	coordForceMode	Values 2 and 3
	maxPatterns	48
	patternTableType	Either 2,3 or 4
	maxSplits	16
	splitMode	Values 2 thru 7
	localFreeStatus	Values 2 thru 11
Time Base	maxTimebaseAscAction	48
Preempt	maxPreempts	4
	preemptControl	All Values
	preemptState	Values 2 thru 9
Overlaps	maxOverlaps	4
	overlapType	Value 2 and 3
	maxOverlapstatusGroup	1
Channels	maxChannels	16
	channelControlGroup	Values 2 thru 4
	channelFlash	Value 0,2,4,6,8,10,12 and 14
	channelDim	Values 0 thru 15
	maxChannelStatusGroup	2
TS 2 Port 1	maxPortAddresses	18
	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 CD. ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format shall be provided on CD-ROM:

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 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 170 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 2070 type 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) 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 of the cabinet wiring diagram and component wiring diagrams shall be furnished with each cabinet and a pdf file of the cabinet wiring and component drawings. 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 push buttons and a phase diagram.

9-29.13(8) Generator Transfer Switch

When specified in the contract, a generator transfer switch shall be included. 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 Special Provision 9-29.13(10)D except that the enclosure door shall include a spring loaded construction core lock capable of accepting a Best 6-pin CX series core. The core lock shall be installed with a green construction core. Upon contract completion, two master keys for the construction core shall be delivered to the Engineer.

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. Two 30 amp, 120 volt, single pole, single phase, circuit breakers. One circuit breaker shall be labeled "Generator" and the other circuit breaker shall be labeled "Utility". Both labels shall be engraved phenolic name plates.
5. 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. The circuit breakers shall be capable of being independently switched.
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, Type 170E, 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 ampere minimum.
 - b. A 15 ampere accessory breaker wired parallel to the control display breaker. The breaker will carry accessory loads, including vent fan, cabinet light, plug receptacle, etc.
 - 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 crow bar 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 lead-ins, 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 push buttons; 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. Push button 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 170E, 2070 Assemblies

The following requirements apply to required auxiliary equipment furnished with Type 170E, 170E-HC-11 and 2070 controllers:

1. Flashers, flash transfer relays, conflict monitor, AC isolators, DC isolators, discriminator modules, program modules, modem modules, breakers, buses, police panel switches, receptacle requirement, vent fan and auxiliary control panel switches shall conform to the requirements noted in the TEES.
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.

An individual supplemental load resistor shall be installed within the output file, and shall be installed on each of the following terminal circuits:

FT1-105 (SP 4P-Y)	FT1-111 (SP 8P-Y)	FT2-114 (SP 2P-Y)	FT2-120 (SP 6P-Y)
FT2-117 (SP 3-Y)	FT2-118 (SP 3-G)	FT2-123 (SP 7-Y)	FT2-124 (SP 7-G)
FT3-126 (SP 1-Y)	FT3-127 (SP 1-G)	FT3-132 (SP 5-Y)	FT3-133 (SP 5-G)

6. Load switches of sufficient quantity to fully populate the output files shall conform to TEES and shall have indicator lights on input and output circuits.
7. A detection panel, which 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. 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 “detection Panel” and the C-1 connector. The panel shall utilize 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), 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, 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. 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. The main breaker on the SPA shall be provided with a cover to prevent accidental tripping. The cover shall be removable and replaceable without the use of tools.

15. Equipment Branch Breaker –The duplex receptacle on the rear of either PDA #2L or 3L shall be wired in parallel with the ground fault current interrupt receptacle on the front of the power supply. The ground fault current interrupt receptacle being in the “Test” mode shall not remove power to the rear 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. The 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, brackets, racks, etc., 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. A 24 slot rack or racks shall be installed. The rack(s) shall be wired for 2 channel loop detectors and as follows. Slots 1 & 2 phase 1 loop detectors. Slots 3, 4, & 5 phase 2 loop detectors. Slots 6 & 7 phase 3 loop detectors. Slots 8, 9, & 10 phase 4 loop detectors. Slots 11 & 12 phase 5 loop detectors. Slots 13, 14, & 15 phase 6 loop detectors. Slots 16 & 17 phase 7 loop detectors. Slots 18, 19 & 20 phase 8 loop detectors. Slot 21 upper phase 1 loop detector. Slot 21 lower phase 5 detector. Slot 22 wired for a 2 channel discriminator channels A, C. Slot 23 wired for a 2 channel discriminator, channels B, D. Slot 24 wired for a 4 channel discriminator, wired for channel A, B, C, and D. All loop detector slots shall be wired for presence/ pulse detection/extension. If an external power supply is required in order for the entire racks(s) to be powered it shall be installed. All rack(s) slots shall be labeled with engraved identification strips.
3. 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.
4. 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.
5. The cabinet door(s) shall be provided with:
 - a. Cabinet doors shall each have a three point latch system. Locks shall be spring loaded construction locks capable of accepting a Best 6 pin core. A 6 pin construction core of type (blue, green, or Red) 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.
 - b. 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.
 - c. All doors and police panel door shall have one piece, closed cell, neoprene gaskets.
 - d. A two position doorstop assembly.

6. Fluorescent fixtures or LED light strips (only one type per cabinet) for cabinet lighting. Color temperature shall be 4100K (cool white) or higher. Fluorescent fixtures shall use 12 inch (nominal), 8W, type T5 shatterproof tubular bulbs. LED light strips shall be approximately 12 inches long, and have a minimum output of 320 lumens. Lighting shall be ceiling mounted and oriented parallel to the door face. Lighting shall not interfere with the proper operation of any other ceiling mounted equipment. All lighting fixtures shall energize whenever any door is opened. Each door switch shall be labeled "Light".

9-29.13(10)D Cabinets for Type 170E and 2070 Controllers

Type 170E and 2070 controllers shall be housed in a model 332L cabinet unless specified otherwise in the contract. Type 332L cabinets shall be constructed in accordance with TEES with the following modifications:

1. Each door shall be furnished with the equipment listed in [Section 9-29.13\(10\)C](#) item 5 above.
2. The cabinet shall be furnished with auxiliary equipment described in [Section 9-29.13\(10\)B](#).
3. The cabinet shall be fabricated of stainless steel or sheet aluminum in accordance with [Section 9-29.13\(10\)C](#), Item 1 above. Painted steel, painted or anodized aluminum is not allowed.
4. A disposable paper filter element with dimensions of 12" × 6" × 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. Fluorescent fixtures or LED light strips (only one type per cabinet) for cabinet lighting. Fluorescent fixtures shall use 12 inch (nominal), 8W, type T5 tubular bulbs. Tubular bulbs shall be contained within a shatterproof lamp cover. Led strips shall be approximately 12 inches long, and have a minimum output of 320 lumens. There shall be one fixture for each rack within the cabinet. Lighting shall be ceiling mounted and oriented perpendicular to the door face. Rack mounted lights are not allowed. Lighting shall be positioned such that the fixture is centered between the front and rear of the cabinet. Lighting shall not interfere with the proper operation of any other ceiling mounted equipment. Each lighting fixture shall energize automatically when either door to that respective rack is opened. Each door switch shall be labeled "Light".
7. One drawer shelf, as shown in the TEES
8. 332D Controller Cabinet
 - a. The 332D Controller cabinet shall have the appearance of two Type 332 controller cabinets joined at opposing sides. The outside Dimensions of the cabinet shall be 67" High × 48½" Wide × 30¼" Deep.
 - b. The right side of the cabinet, as viewed from the front, shall be considered the Signal Control side. The left side of the cabinet, when viewed from the front, shall be considered the ITS/COMM side.
 - c. One police access panel shall be installed on the right side of the cabinet, as viewed from the front.
 - d. Two cabinet lights shall be provided one on each side and as described in [Section 9-29.13\(10\)D6](#).
 - e. The Traffic Signal Control side of the cabinet shall contain the Traffic Signal Controller assembly and shall be furnished with equipment as described in the contract specifications. The Traffic Signal Control side of the cabinet shall also meet all the additional equipment requirements of the Type 332 Signal Controller cabinet as indicated in the contract specifications.

- f. The ITS/COMM side of the cabinet shall contain ITS and Communication equipment and shall be furnished with the following:
1. One controller 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.
 2. One aluminum sheet metal panel, $\frac{1}{8}'' \times 15'' \times 54''$, shall be installed to the rear of the cabinet on the right hand (when facing the front) side railing.
 3. Additional ITS and Communication equipment as described in the Contract Plans and the ITS section of the Contract Special Provisions.

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 334L cabinets furnished to meet the TEES with the modifications listed in [Section 9-29.13\(10\)D](#) and include the following accessories:

1. Each cabinet shall be equipped with a fully operable controller equipped as specified in the Contract Provisions.
2. Two input files, shall be provided.
3. The PDA #3L shall contain three Model 200 Load Switches.
A second transfer relay, Model 430, shall be mounted on the rear of the PDA #3L and wired as shown in the Plans.
4. Police Panel shall contain only one DPDT toggle switch. The switch shall be labeled POLICE CONTROL, ON-OFF.
5. Display Panel

a. General

Each cabinet shall be furnished with a display panel. The panel shall be mounted, showing and providing detection for inputs and specified controller outputs, at the top of the front rack above the controller unit. The display panel shall be fabricated from brushed aluminum and constructed according to the detail in the Plans.

b. Text

All text on the detector panel shall be black in color and silk screened directly to the panel except the Phenolic detector and cabinet nameplates.

A nameplate for each loop shall be engraved with a $\frac{1}{4}$ -inch nominal text according to the ITS Field Wiring Charts. The nameplates shall be permanently affixed to the detector panel.

c. LEDs

The LEDs for the display panel shall meet the following Specifications:

Case size	T 1- $\frac{3}{4}$
Viewing angle	50° minimum
Brightness	8 Milli candelas

LEDs with RED, YELLOW or GREEN as part of their labels shall be red, yellow or green in color. All other LEDs shall be red. All LEDs shall have tinted diffused lenses.

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:

ON

Detector panel LEDs shall operate consistent with their separate switches.

OFF

All detector indicator LEDs shall be de-energized. Detector calls shall continue to reach the controller.

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:

AUTOMATIC

Sign Relay shall energize upon ground true call from controller.

SIGN OFF

Sign Relay shall de-energize.

SIGN ON

Sign Relay shall energize.

f. Sign Relay

The sign relay shall be plugged into a socket 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 170E/HC11 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. These LEDs and switches shall function as follows:

TEST

When the switch is in the test position, 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.

RUN

In the run position the 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. The layout shall be according to the detail in the Plans. These LEDs shall illuminate upon a ground true output from the controller via the C5 connector.

The output indicator LEDs shall have resistors in series to drop the voltage from 24 volts DC to their rated voltage and limit current below their rated current. The anode connection of each LED to +24 VDC shall be wired through the resistor.

i. Connectors

Connection to the display panel shall be made by three connectors, one pin (labeled P2) and one socket (labeled P1) and one labeled C5. The P1 and P2 connectors shall be 50-pin cannon D series, or equivalent 50 pin connectors and shall be compatible such that the two connectors can be connected directly to one another to bypass the input detection. Wiring for the P1, P2 and C5 connectors shall be as shown in the Plans.

The Contractor shall install wire connectors P1, P2, C1P, C2, C4, C5 and C6 according to the pin assignments shown in the Plans.

6. Model 204 Flasher Unit

Each Model 334 ramp meter cabinet shall be supplied with one Model 204 sign flasher unit mounted on the right rear side panel. The flasher shall be powered from T1-2. The outputs from the flasher shall be wired to T1-5 and T1-6.

7. Fiber Optic Patch Panel

The Contractor shall provide and install a rack-mounted fiber optic patch panel as identified in the Plans.

Cabinet Wiring

Terminal blocks TB1 through TB9 shall be installed on the Input Panel. Layout and position assignment of the terminal blocks shall be as noted in the Plans.

Terminals for field wiring in traffic data and/or ramp metering controller cabinet shall be labeled, numbered and connected in accordance with the following:

Terminal Block Pos.	Terminal and Wire Numbers	Connection Identification
TBS	501-502	AC Power, Neutral
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

Loop lead-in cables shall be labeled and connected to cabinet terminals according to the ITS Field Wiring Chart. This chart will be provided by the Engineer within 20 days of the Contractor's request.

9-29.13(12) ITS Cabinet

Basic ITS cabinets shall be Model 334L Cabinets, unless otherwise specified in the Contract. Type 334L 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. Housing aluminum shall be 5052 alloy with mill finish. Painted or anodized aluminum is not allowed.
3. The door air filter shall be a disposable paper filter element of at least 180 square inches.
4. Locks shall be spring loaded construction core locks capable of accepting a Best 6-pin core. A 6-pin construction core of the type (Blue, Green, or Red) specified in the Contract shall be installed in each core lock. One core removal key and two standard keys (properly marked) shall be included with each cabinet and delivered to the Engineer upon Contract completion.
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. Fluorescent fixtures or LED light strips (only one type per cabinet) for cabinet lighting. Color temperature shall be 4100K (cool white) or higher. Fluorescent fixtures shall use 12 inch (nominal), 8W, type T5 tubular bulbs contained within a shatterproof lamp cover. LED light strips shall be approximately 12 inches long, and have a minimum output of 320 lumens. There shall be two fixtures for each rack within the cabinet. Lighting shall be ceiling mounted and oriented parallel to the door face – rack mounted lighting is not permitted. Lighting shall not interfere with the proper operation of any other ceiling mounted equipment. All lighting fixtures above a rack shall energize whenever either door to that respective rack is opened. Each door switch shall be labeled “Light”.
7. Each cabinet shall be equipped with a power distribution assembly (PDA) mounted in a standard EIA 19-inch (ANSI/EIA RS-310-C) rack utilizing no more than five Rack Mounting Units (RMU) (8.75 inches). The PDA 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. Four 1P-15A, 120VAC Equipment/Field Circuit Breakers.
 - d. Line filter meeting the requirements of [Section 9-29.13\(10\)A.4](#).

PDA components shall be mounted in or on the PDA such that they are readily accessible, provide dead front safety, and all hazardous voltage points are protected to prevent inadvertent contact.
8. Service Panel #1 shall include a service terminal block labeled “TBS”, a Tesco TES-10B or equivalent surge suppressor connected to provide power in line surge suppression, and a 1P-30A Main Breaker. The Service Panel Assembly (SPA) shown in the TEES shall not be included.
9. Each cabinet shall include a rack mounted fiber optic patch panel of the type specified in the Contract.

Cabinet drawings and wiring diagrams shall be provided in the drawer shelf. Additionally, an electronic (PDF format) copy of all drawings and wiring diagrams shall be provided.

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 shall be jack mounted and installed in raintight aluminum or hot-dipped galvanized steel cabinet.

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, .050-inch-thick corrosion-resistant flat black finish, louvered aluminum, or Polycarbonate attached with stainless steel hardware. A 1-inch-wide strip of yellow retro-reflective, type IV prismatic sheeting, conforming to the requirements of [Section 9-28.12](#), shall be applied around the perimeter of each backplate with the exception of installations 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 Non-LED Optical System**

The components of the optical system shall comprise:

1. Lamp,
2. Lamp Collar,
3. Optical Limiter-Diffuser, and
4. Objective Lens.

The lamp shall be nominal 150 watt, 120 volt AC, three prong, sealed beam having an integral reflector with stippled cover and an average rated life of at least 6,000 hours. The lamp shall be coupled to the diffusing element with a collar including a specular inner surface. The diffusing element may be discrete or integral with the convex surface of the optical limiter.

The optical limiter 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 limiter shall be provided with positive indexing means and composed of heat-resistant glass.

The objective lens shall be a high resolution planar incremental lens hermetically sealed within a flat laminant of weather resistant acrylic or approved equal. The lens shall be symmetrical in outline and may be rotated to any 90 degree orientation about the optical axis without displacing the primary image.

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)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 lamphousing 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 ft-c ambient and shall reduce to 15 plus or minus 2 percent of maximum at less than 1 ft-c ambient. Response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 1,000 ft-c ambient and damped for any decrease from 100 ft-c 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 VTSCH 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.

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 dark green (Federal Standard 595) 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

The covers shall be manufactured from a durable fabric material, black in color with a mesh front, and designed to fit the signal head configuration properly. The covers shall have an attachment method that will hold the cover securely to the signal in heavy wind. The covers shall be provided with a drain to expel any accumulated water.

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.

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.

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.

Stainless Steel

1. All set screws and cotter Keys.
2. Bands 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, nipples, elbow, and tee fittings for Type A, B, C, F, H, and K mounts.
2. Multi-head mounting assemblies and spider assemblies for Type Q, R, and S mounts.
3. 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 Push Buttons

Where noted in the Contract, pedestrian push buttons of tamper-resistant construction shall be furnished and installed. They shall consist of a 2-inch nominal diameter plunger. The switch shall be a three-bladed beryllium copper spring, rated at 10 amperes, 125 volts.

The pedestrian push-button assembly shall be constructed and mounted as detailed in the Contract.

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, VTCSH2 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 green enamel (Federal Standard 595-14056). 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.

9-29.21 Flashing Beacon

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.

9-29.22 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 warning label that meets the requirements of ANSI Z535.
2. All electrical conductors, buss bars, and conductor terminals shall be copper. Conductor insulation shall be either THW, XHHW, USE, or SIS.
3. If field wiring larger than that which the contactors or breakers will accommodate is required by the Contract, 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 all circuits. 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 loadside terminals toward the front (door side) of the service cabinet.
8. The lighting contactors used shall be specifically rated for tungsten fluorescent and mercury arc lamp loads.
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 be intended to provide security only to the switching segment of the service enclosure and shall not cover the electrical contactor portion.
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

Lighting contactors shall be rated 240 volts maximum line to line, or 277 volt maximum line to neutral voltage for tungsten and ballasted lamp loads on 120/240/277 volt circuits, whichever is applicable, or they shall be rated 480 volt maximum line to line voltage for higher than 277 volt circuited tungsten or ballasted lamp loads.

As an alternate to the lighting contactor, the Contractor may furnish a double contact mercury relay. The relay ampere rating shall equal or exceed the rating noted in the Contract. The relay shall be normally open and shall be rated for up to 480 VAC resistive. The unit shall have a molded coil enclosure rated for 120 VAC. The contacts shall be evacuated, backfilled with an inert gas and shall be hermetically sealed. The electrode shall be one piece with Teflon wear rings on the internal plunger assembly. All contact terminals and coil connection clamps shall be U.L. approved.

Circuit breakers shall be 240 or 277 volt maximum rated for 120/240/277 volt circuits, whichever is applicable, and shall have an interrupting capacity (R.M.S. – symmetrical) of not less than 10,000 amperes. They shall have not less than 480 volt rated for circuits above 277 volts and shall have an interrupting capacity (R.M.S. – symmetrical) of not less than 14,000 amperes. Circuit breakers shall be bolt-on type.

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 3.0 KVA	12"	18"	18"
Transformer 3.1 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. 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 PE3408 conforming to a 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. Pipe pressure class shall be as listed in Table 9 of ANSI/AWWA C906 for DR 9 PE3408 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 $\frac{1}{8}$ -inch-thick neoprene having a durometer of 60 plus or minus 5 or $\frac{1}{16}$ 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 end 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 ½ 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 5¼ inches minimum diameter. Hydrants shall have two 2½-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 6¾-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 ¾-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(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.

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 ⅝ by ¾, ¾, 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 Elastomeric Pads

9-31.1 Requirements

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 $\frac{1}{8}$ inch. Elastomeric pads shall be fabricated to meet the tolerances specified in either AASHTO M251 or the Special Provisions, as applicable.

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.

9-32 Mailbox Support

9-32.1 Steel Posts

The post shall be 2 inches outside diameter, 14-gage, mechanical tubing, and shall conform to ASTM A513. 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, platform, and anti-twist plate shall be 16-gage sheet steel, conforming to ASTM A1011 or ASTM A1008.

9-32.3 Vacant

9-32.4 Wood Posts

Wood posts shall meet the requirements of [Section 9-28.14\(1\)](#) or Western Red Cedar.

9-32.5 Fasteners

Unless otherwise specified, bolts and nuts shall be 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 Snow Guard

Snow guard shall be fabricated in accordance with ASTM F1071 for expanded metal bulkhead panel, to the dimensioning shown on the *Standard Plans*. After fabrication, the snow guard shall be galvanized in accordance with AASHTO M111.

9-32.7 Type 2 Mailbox Support

Type 2 mailbox supports shall be 2-inch 14-gage steel tube and shall meet the NCHRP 350 or 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 U-Channel Post

U-channel posts shall meet the requirements of ASTM A29, weigh a minimum of 3 pounds per linear foot, and shall be galvanized according to AASHTO M 111.

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	D5199	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. 15.0 gal./min./ft.

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 sample 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 WSDOT Standard Practice T 925 or AASHTO Standard Practice PP 66, 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 Project 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 Project 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 Project 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 D82. For white, the color shall closely match Federal Standard 595, color number 37875. For yellow, the color shall closely match Federal Standard 595, color number 33538. For blue, the color shall closely match Federal Standard 595, color number 35180. For black, the color shall closely match Federal Standard 595, color number 37038.

9-34.2(3) Prohibited Materials

Traffic paint shall not contain mercury, lead, chromium, 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 $\frac{3}{4}$ 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.

9-34.2(5) Low VOC Waterborne Paint

Paint Properties	Test Method	Standard Waterborne Paint				High-Build Waterborne Paint				Cold Weather Waterborne Paint			
		White		Yellow		White		Yellow		White		Yellow	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Density of Paint (lb/gal)	ASTM D1475	Within ± 0.3 of qualification sample											
Viscosity, KU	ASTM D562												
@35°F													
@77°F		80	95	80	95	80	95	80	95	80	95	80	95
@90°F													
Nonvolatile Content, % by weight	ASTM D2369	75		75		77		77		70		70	
Pigment Content, % by weight	ASTM D3723	68		68		62		62		50		50	
Nonvolatile Vehicle (NVV), % by weight	ASTM D2369	40		40		43		43		40		40	
	ASTM D3723 ¹												
Volatile Organic Content (VOC) lbs/gal	ASTM D3960	1.25		1.25		1.25		1.25		1.25		1.25	
Fineness of Grind, (Hegman Scale)	ASTM D1210	3		3						3		3	
Contrast Ratio, @ 15 mils wet	ASTM D2805	0.98		0.96		0.98		0.96		0.99		0.98	
Directional Reflectance %, @ 15 mils wet	WSDOT T 314	88		50		90		50		87		50	
Flash Point, °F	ASTM D93	100°		100°									
pH	ASTM E70	9.5		9.5		9.5		9.5		9.5		9.5	
Laboratory Dry Time (Minutes)	ASTM D711	10		10						10		10	
Vehicle Composition	ASTM D2621	100% acrylic emulsion or approved equal											
Freeze-Thaw Stability, KU	ASTM D2243 and D562	@ 5 cycles show no coagulation or change @ 5 cycles show no coagulation or change @ 3 cycles show no coagulation or change											
Heat Stability	ASTM D562 ²	± 10 KU from the initial viscosity											
Low Temperature Film Formation	ASTM D2805 ³	± 10 KU from the initial viscosity											

¹Use the following formula for calculating nonvolatile in vehicle (NVV); NVV = (N-P)/(100-P) x 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° ± 2°F for 7 days. Equilibrate the paint at 77° ± 2°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.

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

For black, the color shall closely match Federal Standard 595, color number 37038, and shall be chosen from a WSDOT QPL-listed manufacturer for white or yellow plastic. Black plastic shall comply with Sections 9-34.3(2), 9-34.3(3), and 9-34.3(4) for yellow, except for retroreflectance.

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 M249 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 M249, 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

The blue color shall match Federal Standard 595, color number 35180, and the tolerance of variation shall match that shown in the FHWA "Highway Blue Color Tolerance Chart".

The red color shall match Federal Standard 595, color number 11136, and the tolerance of variation shall match that shown in the FHWA "Highway Red Color Tolerance Chart".

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 4541 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:

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.										
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 6010C	10.0
Barium	EPA 3052 SW-846 6010C	100.0
Cadmium	EPA 3052 SW-846 6010C	1.0
Chromium	EPA 3052 SW-846 6010C	5.0
Lead	EPA 3052 SW-846 6010C	50.0
Silver	EPA 3052 SW-846 6010C	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 M247 Section 5.2.3	1.50	1.55	1.50	1.55
Moisture Resistances	AASHTO M247 Section 5.3.2	Flow Without Stopping		Flow Without Stopping	
Adherence	AASHTO M247 Section 5.3.4	Pass		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 M247 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 shall conform to ASTM D4592 Type II except that black tape, black mask tape and the black portion of the contrast removable tape, shall be non-reflective.

9-34.5(2) Temporary Pavement Marking Tape – Long Duration

Temporary pavement marking tape for long duration 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 $200 \text{ mcd}\cdot\text{m}^{-2}\cdot\text{lx}^{-1}$ when measured in accordance with ASTM E2832 or ASTM E2176. Black tape, black mask tape and the black portion of the contrast removable 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\(4\)](#), standard waterborne paint and high-build water borne paint per [Section 9-34.2\(5\)](#), 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.

Cold weather waterborne traffic paint per [Section 9-34.2\(5\)](#) will be accepted based solely on the laboratory testing.

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 per [Section 9-34.2\(4\)](#), and standard waterborne paint and high-build water borne paint per [Section 9-34.2\(5\)](#).

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. Standard paint shall have a no-track time of 90 seconds or less when applied at a wet film thickness of 15 ± 1 mil, with glass beads applied at a minimum rate of 6 pounds per gallon of paint. High-build paint shall have a no-track time of 120 seconds or less when applied at a wet film thickness of 20 to 30 mils, with glass beads applied at a minimum rate of 10 pounds per gallon of paint. 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
- Portable Temporary Traffic Control Signal
- Tall Channelizing 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 Type X reflective sheeting. All post-mounted signs with Type X sheeting 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\(2\)](#) 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 II sheeting in rural areas and Type III or IV sheeting in urban areas. All signs having a green background (i.e., Exit arrow) shall have Type II sheeting for the background and Type III or IV sheeting for the letters, border, and symbols.

9-35.3 Wood Sign Posts

Post sizes for construction signs shall be as follows:

One Post Installation

Post Size	Min. Sign Sq. Ft.	Max. Sign Sq. Ft.
4x4		16.0
4x6	17.0	20.0
6x6	21.0	25.0
6x8	26.0	31.0

Two Post Installation

(For signs 5 feet or greater in width)

Post Size	Min. Sign Sq. Ft.	Max. Sign Sq. Ft.
4x4		16.0
4x6	17.0	36.0
6x6	37.0	46.0
6x8	47.0	75.0*

*The Engineer shall determine post size for signs greater than 75 square feet.

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)

9-35.4 Sequential Arrow Signs

Sequential Arrow Signs shall meet the requirements of the [MUTCD](#) supplemented with the following:

Sequential arrow signs furnished for stationary lane closures on this project shall be Type C.

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

Portable Changeable Message Signs (PCMS) shall meet the requirements of the [MUTCD](#) and the following:

The PCMS shall employ one of the following technologies:

1. Fiber optic/shutter
2. Light emitting diode
3. Light emitting diode/shutter
4. Flip disk

Regardless of the technology, the PCMS shall meet the following general requirements:

1. Be light emitting and must not rely solely on reflected light. The emitted light shall be generated using fiber optic or LED technology.
2. Have a display consisting of individually controlled pixels no larger than 2½ by 2½ inch. If the display is composed of individual character modules, the space between modules must be minimized so alphanumeric characters of any size specified below can be displayed at any location within the matrix.
3. When activated, the pixels shall display a yellow or orange image. When not activated, the pixels shall display a flat black image that matches the background of the sign face.
4. Be capable of displaying alphanumeric characters that are a minimum of 18 inches in height. The width of alphanumeric characters shall be appropriate for the font. The PCMS shall be capable of displaying three lines of eight characters per line with a minimum of one pixel separation between each line.
5. The PCMS message, using 18-inch characters, shall be legible by a person with 20/20 corrected vision from a distance of not less than 800 feet centered on an axis perpendicular to the sign face.
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. Be capable of simultaneously activating all pixels for the purpose of pixel diagnostics. Any sign that employs flip disk or shutter technology shall be programmable to activate the disks/shutters once a day to clean the electrical components. 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.

The PCMS panels and related equipment shall be permanently mounted on a trailer with all controls and power generating equipment.

The PCMS shall be operated by a controller that provides the following functions:

1. Select any preprogrammed message by entering a code.
2. Sequence the display of at least five messages.
3. Blank the sign.
4. Program a new message, which may include animated arrows and chevrons.
5. Mirror the message currently being displayed or programmed.

9-35.6 Barricades

Barricades shall conform to the requirements of the [MUTCD](#) supplemented by the further requirements of the [Standard Plans](#).

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.

The traffic safety drums shall be designed to accommodate at least one portable light unit. The method of attachment shall ensure that the light does not separate from the drum upon impact.

Drums and light units shall meet the crashworthiness requirements of NCHRP 350 or MASH as described in [Section 1-10.2\(3\)](#).

When recommended by the manufacturer, drums shall be treated to ensure proper adhesion of the reflective sheeting. Retroreflective bands shall be fabricated from Type III or Type IV reflective sheeting as described in [Section 9-28.12](#).

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.

Retroreflective bands shall be fabricated from Type III or Type IV 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.

The devices shall be stabilized by affixing them to the pavement by using either weighted bases or adhesive. Adhesive used to glue the device to the pavement shall meet the requirements of Sections [9-02.1\(8\)](#) or [9-26.2](#). Retroreflective bands shall be fabricated from Type III or Type IV reflective sheeting as described in [Section 9-28.12](#).

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 with a minimum weight of 15,000 pounds and a maximum weight in accordance with the manufacturer's recommendations. 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 standard chevron pattern shall consist of 4-inch yellow stripes, alternating nonreflective black and retroreflective yellow 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 Tall Channelizing Devices

Tall channelizing devices shall meet the requirements of the [MUTCD Part VI](#) for channelizing devices and shall conform to these general Specifications:

Fabricated of fade resistant, safety orange color, low-density polyethylene that is resistant to deformation upon impact and meets the requirements of ASTM D4976 and is UV stabilized.

Forty-two inches in height minimum, using a tapered cone type shape of consistent dimensions regardless of orientation to traffic.

Four inches in width minimum at the top and 8 inches in width minimum at the base, which incorporates a separate ballast that is designed to resist overturning or other movement from wind gusts or other external forces.

Four retroreflective 6-inch-wide horizontal bands, alternating orange and white beginning 6 inches from the top of the device. Retroreflective bands shall be fabricated from Type III or Type IV reflective sheeting as described in [Section 9-28.12](#).

Warning lights are not required unless specifically shown on the traffic control Plan but provisions for securely attaching a warning light are required. The method of attachment must ensure that the light does not separate from the device upon impact and light units shall meet the crashworthiness requirements of NCHRP 350 or MASH as described in [Section 1-10.2\(3\)](#).

Devices shall be regularly maintained to ensure that they are clean and the reflective sheeting is in good condition.

Except for the Specifications and requirements specifically listed above, Tall Channelizing Devices are defined to be Traffic Cones. All non-conflicting Contract provisions related to "Cones" shall apply to Tall Channelizing Devices.

9-35.14 Portable Temporary Traffic Control Signal

Portable traffic control signals shall meet the requirements of the [MUTCD](#) and these specifications.

The portable temporary traffic control signal shall be fully operational for two-phase traffic actuated, pre-timed, or manual control. The portable temporary traffic control signal shall conform to the following requirements:

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 both directions. The portable traffic control signal shall be capable of terminating the movement one (1) or movement two (2) all red clearance, in order to repeat the previous movements operation.

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.

A vehicle detection system is required. The system shall be capable of operating either as fixed time or traffic actuated controller. The detection system shall provide presence detection (continuous call to the controller) while there is a vehicle in the detection zone.

Signal supports used with portable traffic control signals shall provide a minimum of two signal displays, spaced a minimum of 8 feet apart. When trailer-mounted portable traffic signals are used to provide alternating one-way control, a minimum of one of the signal displays shall be suspended over the traveled way. The minimum vertical clearance to the traveled way for this signal display is 16.5 feet. 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, 3 inches 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.

9-36 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.

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.

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 CSL Access Tubes and Caps

Access tubes for crosshole sonic log 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 CSL 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.

