

PART 02000 - MATERIALS

Concrete Materials and Additives

Section 02001 - Concrete

Description

02001.00 Scope - This work consists of the furnishing and testing of quality portland cement concrete, hereafter referred to as concrete, for all structures, bridges and concrete paving according to these Specifications.

Provide quality control and certified technicians according to Section 00165.

02001.01 Abbreviations and Definitions :

AEA	- Air Entrainment Admixture
ASTV	- Actual Strength Test Value - The average of the test cylinders' compressive strengths
c	- Cement
$f'c$	- Minimum Specified or Design Compressive Strength at 28 days
$f'cr$	- Average Over-design. The average compressive strength required to assure that normal variations in compressive strength will still meet or exceed $f'c$.
HRWRA	- High-Range Water-Reducing Admixture (super-plasticizer)
LSL	- Lower Specified Limit
p	- Pozzolan (fly ash)
SSTV	- Sublot Strength Test Value
USL	- Upper Specified Limit
w	- Water
WRA	- Water Reducing Admixture
cm	- Cementitious Materials (portland cement, fly ash, silica fume, ground granulated blast furnace slag)
GGBFS	- Ground Granulated Blast Furnace Slag

High Performance Concrete (HPC) - Structural concrete, with enhanced durability and strength characteristics, for use in structures where improved durability and performance is required.

Current Mix Design - A mix design that meets the tolerances and limits for a specified class of concrete, and that is currently being used or has been used on any project, public or private, within the past 12 months.

Moderate Exposure - Concrete exposed to the environment at elevations below 1,000 feet.

Severe Exposure - Unless otherwise designated by the Engineer, concrete exposed to the environment at elevations above 1,000 feet.

Tolerance - The permitted variation from a given dimension, quality, quantity or range of variation permitted in maintaining a specified limit.

Materials

02001.10 General - Materials shall meet the following requirements of Part 02000:

Chemical admixtures	02040
Modifiers (fly ash, silica fume, latex, GGBFS)	02030
PCC aggregates	02690
Portland cement and blended hydraulic cement.....	02010
Water	02020

Aggregate Quality

02001.20 General - Blending of two or more products or sources, for the purpose of improving the properties of specification materials is permitted unless otherwise specified. Blending involving one or more non-specification materials, with the exception of non-specification gradations, is not permitted unless approved.

Provide quality control sampling and testing according to Section 00165.

Classes of Concrete

02001.30 General - Provide concrete as shown below and conforming to Table 02001-1.

(a) Structural Concrete - Required for bridges, structures and concrete paving when the total quantity of concrete for the Project exceeds 100 cubic yards or when high performance concrete (HPC) is specified.

(b) Structural Concrete (Option A) - This option is suitable for smaller projects and bridges or other structures when the total estimated quantity of concrete is equal to or less than 100 cubic yards, and for use in severe exposures for sidewalks, curbs and exposed pole and sign foundations.

(c) Commercial Grade Concrete - Concrete for use in sidewalks, curbs, pole foundations and sign foundations, etc. in moderate exposures.

(d) Classes - The class of concrete designates the f'_c followed by the nominal maximum size of aggregate to be used in the concrete. For example, Class 3600 - 1 1/2 indicates an f'_c of 3,600 psi with a nominal maximum size aggregate of 1 1/2 inch.

HPC is required when the letters "HPC" precede the f'_c . For example, HPC4400 - 3/4 indicates high performance concrete with an f'_c of 4400 psi with a nominal maximum size aggregate of 3/4 inch.

Table 02001-1

Type of Concrete	Class	Minimum Cement Content	Maximum Water Cement Ratio	Trial Batch for New Designs	Test Records for Existing Designs	Aggregate Source Quality Tests	Aggregate Quality Control Testing	Certified Technicians Required
Structural Concrete	3600	570 lb	0.50	Required	Required	Required	Required	QCT CCT CAgT
	3600 (Seal)	660 lb	0.45					
	4350 (Paving)	570 lb	0.44					
	4350	590 lb	0.48					
	4350 (Decks)	630 lb	0.40					
	5000 and above	660 lb	0.40					
Structural Concrete	HPC3600	570 lb ²	0.40 ²	Required	Required	Required	Required	OCT CCT CAgT
	HPC4350	630 lb ²	0.40 ²					
	HPC 5000 and above	660 lb ²	0.40 ²					
Structural Concrete Option A	3000	570 lb	0.48	Optional Note ¹	Not required	Required	Not required	QCT CCT (Required to develop the mix design)
	3600	600 lb	0.48					
	3600 (Seal)	690 lb	0.43					
	4350	630 lb	0.46					
	4350 (Decks)	660 lb	0.38					
	5000 and above	690 lb	0.38					
Commercial Grade Concrete	3000	570 lb	Not specified	Not required	Not required	Not required	Not required	QCT
	3600	590 lb						

¹ For structural concrete under Option 'A' - When a trial batch is performed and the compressive strength test results show performance in accordance with 02001.42 and 02001.43, or 02001.46, the maximum water-cement ratio for that mix design may be increased by 0.02. The minimum cement contents shown for structural concrete under Option 'A' may be reduced by up to 30 pounds for each class in which a trial batch is performed and the compressive strength performance is shown to comply with the provisions of 02001.43 or 02001.46.

² All cementitious material (portland cement, fly ash, and silica fume). Fly ash shall be 30% by weight of the total cementitious materials.

Concrete Mix Designs

02001.40 Proportioning of Concrete Mixes - Prepare and submit either new mix designs or current mix designs for each class of concrete required. The Engineer will review the mix design for compliance with the Specifications. The proportions for structural concrete mixtures shall be determined by a certified CCT. Design each mix by the volumetric method outlined in ACI 211.1 and according to 02001.30, Table 02001-1 and 02001.50.

02001.41 Concrete Mix Design Constituents:

(a) Portland Cement - Furnish only Type I or II portland cement for structural concrete. Type III cement may be used in concrete for precast and prestressed members.

(b) Fly Ash - [Except for HPC](#), fly ash may be used in concrete to replace a portion of the cement and as an additive to increase the total amount of cementitious materials. As a replacement for cement, fly ash may comprise up to 20% of the minimum specified cement content.

Additionally, the maximum allowable percent of fly ash shall be 35% of the total cementitious materials, provided that the mix design contains at least 80% of the minimum specified cement content [as shown in Table 02001-1](#).

(c) Blended Hydraulic Cement - Blended hydraulic cement may be used instead of fly ash and cement subject to the limits of 02001.41(b) and 02010.20.

(d) Chemical Admixtures - Add chemical admixtures to the concrete mix according to the manufacturer's recommendations. Adjust the dosage rates as necessary to obtain the qualities indicated in 02001.50. Do not exceed the manufacturer's recommended dosages.

Use a water reducing chemical admixture in all seal concrete and Class 5000 or greater.

[Use high range water reducing admixtures \(HRWRA\) in all HPC. Add other water reducing admixtures \(WRA\) as needed.](#)

(e) Coarse Aggregate - If the nominal maximum size of the coarse aggregate is not included as a part of the class of concrete shown on the plans, any size from 1 1/2 inch to 3/8 inch nominal maximum size aggregate may be used, as the Contractor elects, except:

- Use 3/4 inch nominal maximum size, or larger, aggregates in bridge decks.
- Use 1 1/2 inch nominal maximum size aggregates in concrete paving unless otherwise indicated.

Proportion all HPC to include a minimum coarse aggregate solid volume of 0.40 cubic yard per cubic yard of concrete.

02001.42 New Mix Designs - New mix designs are those that have not been used previously, or do not meet the requirements of 02001.46 for current mix designs. Structural concrete on projects with a total estimated quantity of concrete greater than 100 cubic yards and all structural concrete, Class HPC will require verification of mix performance by either trial batch method or the procedure described in ACI 318 Chapter 5. The mix performance verification must also comply with the following:

(a) Trial Batch Method - Make at least one trial batch for each class of mixture, except for CGC. Prepare and test the trial batch using the same ingredients and proportions that will be used on the Project. In order to ensure proper workability on site, simulate the haul time and mixing conditions that are forecast to occur on the Project. Cast, cure and test three or more cylinders for compressive strength. Notify the Engineer at least 48 hours in advance of when trial batches will be performed. The Engineer may witness the preparation and testing.

(b) Plastic Concrete - For each trial batch, test the temperature, slump, density, and air content, and compute the water-cementitious ratio and yield, according to the tests listed below. Slump, air content and water-cementitious ratio shall be within the specification limits of this Section. The mix design shall be representative of what will actually be used on the job.

(c) Plastic Concrete Tests - Perform the following sampling and testing of plastic concrete:

Test	Test Method	
	AASHTO	Other
Molding Concrete Specimens in the Field		T 23 ¹
Sampling Fresh Concrete		WAQTC TM 2 ²
Slump	T 119	
Density/Yield Cement Content	T 121	
Air content	T 152	
Concrete Temperature		WAQTC TM 10
Water-Cementitious Ratio		³

¹ Unless otherwise directed, cast cylinders in single-use plastic molds.

² Obtain samples from the discharge of the delivery vehicles unless otherwise directed by the Engineer.

³ Use ODOT's modified field operational procedure for AASHTO T 121, found in the MFTP.

(d) Strength Tests - Cast at least three 6" x 12" or 4" x 8" test cylinders, in single-use plastic molds, for each mix design. Cast and cure all strength specimens according to AASHTO T 23 or T 126, and test according to AASHTO T 22.

Cast three flexural beams for concrete paving mixtures according to AASHTO T 23. Test beams for concrete paving mixtures at 28 days according to AASHTO T 97.

02001.43 Required Strength f'_{cr} for New Mix Designs - The ASTV of the trial batch cylinders must meet or exceed option (a) or (b) below:

(a) $f'_{cr} = f'_c \times 1.20$ ($f'_c \times 1.15$ for Class 5800 and higher).

(b) $f'_{cr} = f'_c + 1.34S$ ($f'_c + 1.28S$ for Class 5800 and higher).

Where S = standard deviation of 28-day cylinder strengths from a similar class, plus or minus 1,000 psi, mix design produced at the same plant. There must be at least 10 sets of 28-day cylinders from this similar class mix design to use option (b).

Additionally, concrete paving must also meet the following:

(c) Flexural Beams - The required strength for flexural beams for concrete paving mixtures shall be at least 600 psi at 28 days.

02001.44 Review of Mix Designs - Submit mix designs for review for all classes of concrete to the Engineer. Do not proceed with concrete placement using the mix design until the Engineer has determined that it complies with the Specifications. Review of concrete mixes will not relieve the Contractor of the responsibility to provide concrete conforming to the Specifications.

02001.45 Required Submittals for All New Structural Mix Designs - Submit the following information:

(a) Contractor's Unique Number - To identify the mix design.

(b) Mix Design Proportions - The weight per cubic yard and absolute volumes of cement, fly ash and aggregates (SSD), and mix water. Indicate dosage rates for chemical admixtures.

(c) Aggregates - Identify the source of the aggregates by the ODOT source number. Report current values obtained for:

- Bulk SSD specific gravities
- Fine and coarse aggregate absorptions
- Dry-rodded density of coarse aggregates
- Fineness modulus of sand used in the mix design calculations

(d) Cement - Identify the:

- Manufacturer or brand
- Type
- Source or location of cement plant

(e) Fly Ash - Identify the:

- Manufacturer or Brand
- Class
- Source or location of power plant

(f) Admixtures - Identify the:

- Manufacturer
- Brand name of each admixture
- Anticipated dosage rate

(g) Water - Identify the source of water to be used.

(h) Additional Requirements for All Structural Concrete - When compressive strength performance is verified by trial batches, also do the following:

(1) Tests on Plastic Concrete - Report the temperature, slump, density, air content, yield, cementitious content and water-cementitious ratio of the trial batch or batches representing this mix design.

(2) Compressive Strength Test Results - Report both the individual test results and the ASTV from the trial batch cylinders representing this mix design.

(3) Strength Analysis - Perform an analysis showing the calculations that were used to demonstrate that the mix performance meets or exceeds the minimum over-design criteria.

(4) CCT - Furnish the name and certification number of the CCT who prepared and submitted the mix design.

(i) Latex - Identify the:

Manufacturer or Brand
Type

(j) Silica Fume - Identify the:

Manufacturer or Brand
Trade name
Type - slurry or dry densified

02001.46 Current Mix Designs - Current mix designs must meet the tolerances and limits in 02001.30 and 02001.50. Demonstrate that the average of all 28-day strength tests from cylinders cast and cured according to AASHTO T 23 and tested according to AASHTO T 22 exceeds the f'_{cr} determined from the following formula:

$$f'_{cr} = f'_c + 1.34S$$

where S = standard deviation of 28-day cylinder strengths

For Class 40 and higher,

$$f'_{cr} = f'_c + 1.28S$$

If these requirements are not met, or if aggregates from a different source are used, submit a new mix design according to 02001.42 unless otherwise approved.

02001.47 Required Submittals for Current Mix Designs - If the current mix design has not been used on City projects, submit the information required for new mix designs (field tests may be substituted for trial batches). If the current mix design has been reviewed and accepted by the City within the past 12 months, only the following information is required:

(a) Mix Design Identification - Identify in writing the mix design proposed for use by the Contractor's unique number and the City number.

(b) Adjustments - If mix proportions have been adjusted since the design was originally reviewed, provide the adjusted mix proportions, the reasons for the adjustments, and the name and certification number of the CCT who made the adjustments. Also note changes in cement, fly ash, aggregates or admixtures, and brands.

(c) Product Source Compliance - Provide product compliance test results on samples of the coarse and fine aggregates to be used in the mix. If the test results are more than 12 months old, sample the aggregates and submit samples to the Engineer for testing according to the MFTP.

(d) Compressive Strength History - Furnish compressive strength test results obtained within the past 12 months.

02001.48 Adjusting Mix Proportions - After a mix design has been reviewed and accepted, submit any proposed adjustments to mix proportions for approval. Significant changes to the mix design (such as decreases in cement content, increases in fly ash that replaces cement, or the use of aggregates from a different source) require verification of compressive strength performance by trial batch, according to 02001.43, or test results from field tests according to 02001.46. Aggregates from new sources must meet aggregate source quality requirements according to Section 02690.

02001.49 Contractor Costs - Furnish all materials, equipment and work required for designing the mixes, testing materials and making trial batches to verify the design for final use at the Contractor's expense. Costs of City personnel monitoring or performing check tests will be paid by the City.

02001.50 Concrete Mix Tolerances and Limits General - The concrete shall be a workable mixture, uniform in composition and consistency, and have the following properties or limits:

Entrained Air Content Limits

Type of Concrete	Entrained Air Content Tolerances	Test Method
Seal Concrete Drilled Shaft Concrete Prestressed Members under Cast-in-Place Decks	Not required	N/A
All Other Concrete	+/- 1.5% from design targets shown in Table 02001-2.	AASHTO T 152

Table 02001-2

Target Air Content

Nominal Maximum Size Aggregate	Severe Exposure	Moderate Exposure
3/8"	7.0 %	6.0 %
1/2"	6.5 %	5.5 %
3/4"	6.0 %	5.0 %
1"	5.5 %	4.5 %
1 1/2"	5.0 %	4.5 %

If exposure is not denoted by the Engineer, use the values for severe exposure for elevations above 1,000 feet.

Table 02001-3

Tolerances and Limits

Type of Test	Conditions	Limits	Test Method
Temperature	Concrete Temperature at Time of Placing	50 °F min. 90 °F max. ¹	WAQTC TM 10
Slump ²	Concrete without WRA Concrete with WRA Concrete with HRWRA Seal Concrete	4" maximum 5" maximum 3" - 8" 6" - 10"	AASHTO T 119
Maximum Water-Cementitious Ratio expressed as w/cm		Water-cementitious ratio may not exceed the values in Table 02001-1	

¹ Except for bridge decks, where 80 °F is maximum.

² Take corrective action as necessary to maintain a consistent slump at the point of discharge from the delivery vehicle.

Section 02010 - Portland Cement

Description

02010.00 Scope - This Section includes the requirements, Specifications and tolerances for portland cement and blended hydraulic cement.

Materials

02010.10 Portland Cement:

(a) Types - Furnish one or another of the following types as elected:

- Type I
- Type II
- Type III

Do not mix or alternately use differing brands or types of cement, or the same brand or type of cement from different mills without prior written approval.

(b) Specifications - Portland cement shall conform to the requirements of AASHTO M 85 for low alkali cement except as follows:

- Cement used west of the summit of the Cascade Mountains shall have a total alkali content (sodium and potassium oxide calculated as $\text{Na}_2\text{O} + 0.658 \text{ K}_2\text{O}$) not exceeding 0.80%.
- Types I or III shall contain a maximum of 10% tricalcium aluminate.
- The time-of-setting tests will be by either the Gillmore Test or the Vicat test.
- The maximum fineness (specific surface, square yards/lb) as determined by the air permeability test shall be 430 for any field-sampled check test. Results of field-sampled check tests will not be averaged.

(c) Acceptance - Portland cement shall be from the CPL.

02010.20 Blended Hydraulic Cement - Blended hydraulic cement shall be either Type IP portland-pozzolan cement or Type SM slag-modified portland cement conforming to AASHTO M 240, supplemented and/or modified as follows:

- The cement constituent of the blended cement shall conform to 02010.10.
- The pozzolan constituent of the blended cement shall be a fly ash conforming to 02030.10 or ground granulated blast furnace (GGBF) slag conforming to 02030.40.

Section 02020 - Water

Description

02020.00 Scope - This Section includes the requirements for water used in mixing concrete, mortar, grout, cement treated base and other applications when specified or directed.

Materials

02020.10 Water:

(a) General - Water used in mixing or curing concrete, for mortar and grout, and in mixing cement-treated base shall be reasonably clean, and free of oil, sugar, organic matter or other substances injurious to the finished product.

(b) Potable - Potable water may be used without testing if the Contractor provides a quality compliance certificate verifying that the water has met the limits of this Section according to tests made within the last two years.

Water approved for public use by the Oregon Health Division may be accepted for use without testing.

(c) Nonpotable or Unknown Quality - Water of non-potable, unknown or suspected quality will be tested at the Contractor's expense according to AASHTO T 26 before use in the Project and shall meet the following limits:

	Minimum	Maximum
pH	6.0	8.0
Chloride Ion, %	-	0.15
Sulphate Ion, %	-	0.50
Total Dissolved Solids, ppm	-	6500
Total Suspended Solids, ppm	-	2000

If any of the test data are outside these limits, the water may be accepted on the basis of an evaluation of the reduction in seven-day compressive strength, which shall not exceed 10.0%.

In marine environments, the chloride ion percentage shall be limited to a maximum of 0.10%.

(d) Recycled Mix Water - Water from mixer washout operations may be used in mixing concrete provided it is:

- Within the limits of ASTM C 94/C 94M, Table 1, Acceptance Criteria for Questionable Water Supplies, and Table 2, Chemical Limitations for Wash Water. In addition the specific gravity maximum limit is 1.03.

- Tested at a weekly interval for at least four weeks prior to use on the Project. The testing frequency may be reduced to monthly thereafter providing no single test exceeds the limits set above. Required tests include the physical tests in Table 1 of ASTM C 94/C 94M, the chemical tests in Table 2 and testing for specific gravity. The testing shall be at the Contractor's expense. The test results shall be provided to the Engineer prior to use on the Project.
- Made up from a dilution process rather than a concentration process. (A dilution process is one in which the reclaimed water is extensively diluted and continuously agitated to keep solids in a state of suspension).
- Free of coloring agents.
- Not used when the ambient temperature is 85 °F or above.
- Not used when the ambient temperature is 40 °F or lower.
- Not used as more than 75% of the water added to the batch.
- Not used in structure decks.

Section 02030 - Modifiers

Description

02030.00 Scope - This Section includes the requirements and tolerances for fly ash, silica, fume, latex, and ground granulated blast furnace slag (GGBFS) used in portland cement concrete.

Materials

02030.10 Fly Ash:

(a) Types - Fly ash shall be Class C, Class F, or Class N from the CPL, and shall conform to AASHTO M 295, including Table 2, except that:

- Loss on Ignition (LOI) shall be 1.5% maximum
- Moisture content shall be 1% maximum
- Amount retained on the No. 325 sieve shall be 30% maximum

(b) Acceptance - Fly ash will be accepted for immediate use if accompanied by a test results certificate according to 00165.35.

As a check on material conformance, fly ash may be sampled at the site of work for verification testing.

02030.20 Silica Fume:

(a) Types - Provide the silica fume admixture as a slurry containing silica fume, water and a high range water reducer, or as a densified powder. The silica fume portion shall conform to AASHTO M 307, including Table 1a, Optional Chemical Requirements.

(b) Acceptance - Silica fume will be accepted for immediate use if accompanied by a test results certificate according to 00165.35. If the silica fume admixture is supplied as a slurry, the certificate shall indicate the silica fume content of the slurry as a percent by weight. If the silica fume is supplied as a densified powder, do not allow the packaging to enter the concrete mixture.

02030.30 Formulated Latex Admixture - Formulated latex admixture shall be from the CPL and be a nontoxic, film-forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture. It shall be homogeneous and uniform in composition, and meet the following requirements:

Polymer Type Stabilizers

Latex
 Portland Cement Composition
 Solids, % by weight, min.
 Volume Density, lb/gal, min
 pH
 Color

Styrene Butadiene

Nonionic Surfactants
 Polydimethyl Siloxane
 46.0
 8.4 at 77 °F
 9.0 to 11.0
 White

Latex admixtures that have not been stored according to the manufacturer's recommendations will not be accepted.

02030.40 Ground Granulated Blast Furnace Slag (GGBFS) - GGBF slag shall meet the requirements of AASHTO M 302.

Section 02040 - Chemical Admixtures**Description**

02040.00 Scope - This Section includes the requirements for air-entraining, water-reducing, retarding and accelerating admixtures.

Materials

02040.10 General - Use admixtures from the CPL, except as follows:

An admixture that does not appear on the CPL may be used if, prior to use, the Contractor provides a test results certificate demonstrating the admixture has been tested and conforms to these Specifications. The City may sample and test admixtures according to 00165.35.

Chloride content of any admixture used in portland cement concrete in contact with embedded metals shall not exceed 0.5% by weight of the admixture when tested according to ODOT TM 505.

Admixtures shall conform to the following requirements:

Admixture	Specification
Air-entraining	ASTM C 260
Water-reducing	ASTM C 494/C 494M
Retarding	ASTM C 494/C 494M
Accelerating	ASTM C 494/C 494M

Section 02050 - Curing Materials

Description

02050.00 Scope - This Section includes the requirements for liquid compounds, evaporation reducers, polyethylene films and curing blankets used to cover concrete and other surfaces to retain moisture and to cure.

Materials

02050.10 Liquid Compounds - Liquid membrane-forming curing compounds shall be from the CPL and shall conform to the requirements of AASHTO M 148, except that testing will be done according to ODOT TM 721. The specified drying time requirement will be waived. The test application rate shall be 1 gallon per 200 square feet.

All compounds shall be class A. Solvent-based compounds shall be Type 1-D.

02050.20 Polyethylene Films - Clear or white polyethylene films for curing concrete shall conform to the requirements of AASHTO M 171.

02050.30 Curing Blankets - Furnish curing blankets from the CPL.

02050.40 Liquid Evaporation Reducer Compounds - Furnish evaporation reducer compounds from the CPL.

Section 02060 - Sealers

Description

02060.00 **Scope** - This Section includes the requirements for epoxy cement sealers.

Materials

| **02060.10** **Epoxy Cement** - Furnish epoxy cement from the [CPL](#).

Section 02070 - Bonding Agents**Description**

02070.00 Scope - This Section includes the requirements for epoxy and non-epoxy bonding agents.

Materials

| **02070.10 Epoxy Bonding Agents** - Furnish epoxy bonding agents from the [CPL](#).

| **02070.20 Non-epoxy Bonding Agents** - Furnish non-epoxy bonding agents from the [CPL](#).

Section 02080 - Grout

Description

02080.00 Scope - This Section includes the requirements for epoxy, non-epoxy, keyway, and portland cement grout.

Materials

02080.10 Epoxy Grout - Furnish epoxy grout from the CPL.

02080.20 Non-epoxy Grout - Furnish non-epoxy grout from the CPL.

02080.30 Keyway Grout - Grout used in the keyways of precast, prestressed concrete members shall be non-shrink, nonferrous, non-epoxy grout with a minimum design strength of 5,000 psi in 28 calendar days. Furnish keyway grout from the CPL and use according to the manufacturer's recommendations.

02080.40 Portland Cement Grout - Furnish portland cement grout consisting of one part portland cement and three parts sand by weight, thoroughly mixed with a minimum amount of water to produce a thick, creamy consistency. Sand shall meet the requirements of 02690.30 and cement shall meet the requirements of Section 02010.

02080.50 Tendon Grout - Furnish tendon grout from the CPL that meets vertical rise requirements.

02080.60 Grout for Mortar Beds and Joints – Furnish portland cement mortars that meet the requirements of ASTM C 270-01a and the following:

Type	Average Compressive Strength At 28 days min (psi)	Application
M	2500	Sidewalk mortar bed
M	3000	Street mortar bed
N	750	Sidewalk grout joint
M	3000	Street grout joint

Type M – Typically three parts portland cement, one part lime and twelve parts sand.

Type N – Typically one part portland cement, one part lime, six parts sand.

Mortar/unit paver bond strength (shear and tensile): 500 psi minimum

Mortar water absorption: 4% maximum

Section 02090 - Lime

Description

02090.00 Scope - This Section includes the requirements for granular quicklime and hydrated lime.

Materials

02090.10 Granular Quicklime - Granular quicklime (CaO) shall conform to the following:

Calcium Hydroxide Content - 113% Minimum

Grading Requirements

Sieve Size	Percent Passing (by weight)
3/8"	100
No. 100	25 maximum

Determine grading and hydroxide content by testing according to AASHTO T 27 and T 219.

02090.20 Hydrated Lime - Hydrated lime shall conform to the requirements of ASTM C 1097.

02090.30 Acceptance - Provide a quality compliance certificate for lime according to 00165.35.

Wood Products

Section 02110 - Posts, Blocks and Braces

Description

02110.00 Scope - This Section includes the requirements for fabricating and treating wood posts and blocks for guardrail, median barrier, signs, fence posts, and braces for fencing.

Materials

02110.10 Guardrail Posts:

(a) General - Posts for guardrail and median barrier shall be of the size shown, manufactured from Douglas fir (Coast Type), or Hem-fir. Wood for posts shall have a minimum extreme fiber bending stress (f_b) of 1,200 psi.

(b) Grading - Grading of posts shall conform to the following:

- **Douglas Fir** - Conform to the requirements for No. 1 posts and timbers as specified in either paragraph 80.11 of the current WWPAA Grading Rules, or paragraph 131-b of the current WCLIB Grading Rules.
- **Hem-fir** - Conform to the requirements for select structural posts and timbers as specified in either paragraph 80.10 of the current WWPAA Grading Rules, or paragraph 131-a of the current WCLIB Grading Rules, except that seasoning checks, single or opposite each other, shall be limited to a total of half the thickness.

(c) Certificates - Furnish certificates of lumber inspection by a recognized inspection City.

(d) Fabrication - Before preservative treatment of the post, bore the required holes perpendicular to the longitudinal axis of the post and cut the top and bottom of the post square with the longitudinal axis of the post, as shown.

(e) Preservative Treatment - Treatment shall be according to Section 02190.

(f) Seasoning and Checking - Each preservative treated post shall show evidence of reasonable amount of seasoning and/or conditioning having occurred prior to treatment, so that further shrinkage of treated posts will not create checking which would expose untreated wood.

At the time of inspection at the plant and at the time of installation each treated post will be subject to inspection for evidence of seasoning having occurred. The presence of checking on the surface of the post will not be cause for rejection unless the width of the widest check, shake, or split exceeds 1/2 inch (surface measurement).

If an otherwise acceptable treated post has a through check, shake, or end split in the same slope of grain or plane as the bolt hole and extending from the top of the post to within 3 inches of the bolt hole, the post will be rejected unless it is provided with a tight fastening across the separation, centered on the post, and 2 inches below the top. Fasten with a 1/2 inch diameter galvanized bolt and nut with a galvanized washer under the bolt head and under the nut. Treat holes for fastenings according to the requirements of AWP Standard M 4.

(g) Inspection, Rejection and Marking at Plant - Posts shall be subject to inspection at the treating plant at any time before, during or after treatment. Normally, inspection of treated posts will be made by the City's inspector not later than 10 calendar days after treatment, provided the inspector is notified of the time that treating is to be done. The purpose of inspection is to cull out and reject posts that fail to meet all requirements of the Specifications, by entire lot where determinable. A "lot" comprises the posts in any charge of the treating cylinder.

Inspection of treated posts for compliance with the requirements of 02110.10(e) will be according to applicable AWP standards, except as follows:

- The inspector will choose the number of treated posts from any one charge of the treating cylinder for determining penetration of treatment.
- Each post selected for testing shall be representative as a basis of acceptance or rejection of a pro rata number of posts in the charge.
- If 20% of the posts selected for testing fail to conform to requirements, all of the posts in the entire charge from which they are selected may be classed as unacceptable.

As the inspector's discretion, each treated post or a representative random selection of treated posts may be inspected for compliance with the requirements of 02110.10(f) "Seasoning and Checking".

Posts which fail to conform to requirements of this subsection will be subject to rejection at the treating plant singly, by partial lots, or by whole lots.

Each treated post shall bear a permanent mark or metal tag which identifies the supplier and year of treatment, placed by the supplier either:

- On the top of the post, or
- On the back of the post, 8 inches to 10 inches below the bolt hole.

(h) Field Inspection, Acceptance and Rejection - Use only treated posts from approved suppliers as listed in the "Non-field" Testing and Acceptance Guide." At the time of installation, inspect each post for:

- Width of widest check, shake, or split
- Damage to treated wood affecting soundness
- Visible exposure of untreated wood
- Conformance to the requirements of 02110.10(b) through (f)
- Preservative visibly oozing or bleeding from the post

Posts that show a check, shake, or split exceeding 1/2 inch in width (surface measurement) on any surface will be rejected.

Posts that show surface damage may be repaired by field treating with preservatives according to AWWPA Standard M 4. Posts on which splits, checks, or shakes have opened or deepened sufficiently to expose untreated wood may be repaired by treating with a field preservative from the CPL applied to all such opened or deepened wood separations and completely filling the separations to the surface of the post.

Remove from the work treated wood posts that have been rejected for any one or more of the above deficiencies or faults and not repaired as stated above.

Acceptance of material will be according to 00165.35, 02110.10(g) and these Specifications.

02110.20 Guardrail Blocks:

(a) General - Furnish wood guardrail blocks of the dimensions shown. Blocks shall be either Douglas fir (Coast Type) or Hem-fir meeting the requirements of 02110.10, or pine meeting the requirements of 02110.20(b) and 02110.10 except for 02110.10(b). The requirements of marking and branding the treated blocks, according to the last paragraph of 02110.10(g), will be waived provided that the supplier of the treated blocks furnishes certification with each shipment stating that the blocks conform to Specifications and that the preservative treating was done under the inspection and with the approval of the Engineer.

(b) Grading - Pine guardrail blocks shall conform to the requirements of paragraph 80.11 of the current WWSA Grading Rules.

(c) Recycled Plastic - Recycled plastic guardrail blocks from the CPL may be used.

(d) Acceptance - Acceptance of material will be according to 00165.35 and this Section.

02110.30 Fence Posts and Braces - Fence posts and brace rails shall be of the sizes and dimensions shown and shall be of sound Douglas fir, western hemlock, or western pine free from decay, end splits, and multiple crooks. Seasoning checks of not more than 5/16 inch width (surface measurement) will be permitted. Allowable crooks may be in one plane only. A line drawn between the centers of the butt and tip of each post and brace rail shall not fall outside of the actual longitudinal centerline of the post or rail by more than 1.67% of its length, with an allowable maximum of 2 inches.

Posts and brace rails may be square, rough, or dressed lumber, or may be peeled round posts, as the Contractor elects. Round members shall be free from bark, protruding knots and irregularities detrimental to a pleasing appearance.

Fabricate posts and brace rails before pressure treatment. Holes in gate posts for gate hinge bolts and holes for dowels may be bored before pressure-treating, or may be bored in the field and treated with a field preservative from the CPL, applied by swabbing according to AWWPA Standard M4, or applied under pressure by an approved bolt-hole treater. Where field boring or field cutting of a treated member is required, field-treat the exposed untreated surface of the member to be used in a similar manner. The size of holes after treatment shall not exceed the size of the dowels or bolts to be inserted by more than 1/16 inch.

Posts intended to be driven may be machine-pointed on either the small end or the large end, before pressure treatment.

Pressure-treat the posts and brace rails according to Section 02190.

Acceptance of material will be according to 00165.35 and these Specifications.

02110.40 Wood Sign Posts - Fabricate wood sign posts from either Douglas fir, surface four sides (S4S) and free of heart center (FOHC) or Hem-fir (S4S) (FOHC).

(a) Grading - Grading requirements for wood sign posts shall conform to the applicable paragraphs of either the current WCLIB Grading Rules or the current WWPA Grading Rules, as follows:

Species	Size, Inch		
	4" x 4"	4" x 6"	6" x 6" and Larger
Douglas Fir	124-c WCLIB	123-c WCLIB	131-b WCLIB
	42.12 WWPA	62.12 WWPA	80.11 WWPA
Hem-Fir	124-b WCLIB	123-b WCLIB	131-a WCLIB
	42.11 WWPA	62.11 WWPA	80.10 WWPA

(b) Posts - Construct wood sign posts according to the applicable portions of Section 00570, modified or supplemented as follows:

(1) Length - The length of the posts shall be shown or, where not shown, each post shall be of sufficient length to provide proper sign mounting, a proper mounting height and the required foundation depth.

(2) Framing and Boring - Cut, frame and bore treated timber before pressure treating, to the extent practical.

(3) Preservative Treatment - Pressure-treat wood sign posts after fabrication according to Section 02190.

(4) Cuts and Abrasions - Treat cuts, abrasions and bolt-holes with the same preservative as originally used to treat the post, except that if the post was originally treated with pentachlorophenol - volatile petroleum solvent (LPG) solution, cuts, abrasions and bolt-holes shall be treated with pentachlorophenol - mineral spirits solvent solution according to AWWA Standard M4.

(5) Field Repair - Field treat damaged or drilled pressure-treated posts with a preservative listed in the [CPL](#).

(c) Acceptance - Acceptance of material will be according to 00165.35 and this Section.

Section 02120 - Poles and Piling

Description

02120.00 Scope - This Section includes the requirements for wood poles for use in illumination and signal installations, and timber piling for structures.

Materials

02120.10 Wood Poles - All wood poles shall conform to ANSI O5.1, Wood Poles, for Class 4 machine shaved Pacific Coast Douglas fir, and shall be treated according to Section 02190. All poles shall be round, sound, well proportioned from butt to tip, without short kinks or crooks, and of the dimensions specified by ANSI O5.1.

02120.20 Timber Piling - Timber piling shall conform to the requirements of ASTM D 25.

The butt or tip size, or whether the piling are to be friction or bearing piles, will be stated in the Special Provisions. All foundation piles shall be Douglas fir.

Treat timber piling according to Section 02190.

02120.30 Timber Pile Straps - Straps shall be approximately 1 1/4 inch wide, 0.03 inch thick, manufactured from cold-rolled, heat-treated steel having a minimum ultimate tensile strength of 150,000 psi. The strap shall encircle the pile once and be fastened with a clip that is crimped so that the joint will have a minimum tensile strength of 80% of the tensile strength of the strap. Install the strap after pressure treating of the pile.

02120.40 Acceptance - Acceptance of poles and piling will be according to 00165.35 and this Section.

Section 02130 - Timber and Lumber

Description

02130.00 **Scope** - This Section includes the requirements for timber and lumber.

Materials

02130.10 **Timber and Lumber** - Unless otherwise shown or specified, all lumber and timber shall be S4S Douglas fir. Grading requirements shall be according to the Special Provisions.

All lumber shall be grade-stamped by an American Lumber Standards certified inspection agency.

Acceptance of material will be according to 00165.35 and this Section.

Section 02140 - Glued Laminated Timber Members

Description

02140.00 **Scope** - This Section includes the requirements for glued laminated timber members.

02140.01 **Abbreviations:**

AITC - American Institute of Timber Construction

Materials

02140.10 **General** - Furnish all structural glued laminated lumber as shown and specified.

Manufacture of structural glued laminated work shall conform to the manufacturing requirements of the current ANSI/AITC American National Standard, Structural Glued Laminated Timber, Manufacturing Requirements for Glulam.

Provide quality control according to the AITC Inspection Manual.

Lumber shall be Douglas fir, southern pine, western larch, or other species, as shown or specified. Lumber used shall be of a stress grade to provide glued laminated members with the minimum stress values in bending and tension shown or specified, but not less than 12,400 psi.

Adhesives shall meet the requirements of the glued laminated lumber standards, and be waterproof.

Appearance of members shall be architectural appearance grade as defined in AITC Standard Appearance Grades for Structural Glued Laminated Timber.

Seal surfaces of members with penetrating sealer and apply a coat of end sealer to the ends of all members as soon as practical after end trimming, according to AITC Standard for Preservative Treatment of Structural Glued Laminated Timber. Use a clear sealer compatible with creosote stain.

Bundle wrap members according to AITC Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage and Erection.

Furnish shop details from the fabricator and obtain approval before commencing the work. Details shall conform to the current AITC Typical Construction Details.

02140.20 **Acceptance** - Glued laminated timber members will be accepted according to 00165.35 and this Section.

Section 02150 - Lumber and Timber Connectors

Description

02150.00 Scope - This Section includes the requirements for connectors, bolts, nuts, nails, and miscellaneous hardware for joining lumber and timber.

Materials

02150.10 Lumber and Timber Connectors:

(a) General - Galvanize connectors for treated structures, except those of malleable iron, according to ASTM A 123/A123M.

(b) Split Ring Connectors - Provide 2 5/8 inch and 4 inch inside diameter split rings manufactured from steel conforming to AISI C1010, SAE 1010. Each ring shall form a closed true circle with the principal axis of the cross section of the ring metal parallel to the geometric axis of the ring. Bevel the metal section from the central portion toward the edges to a thickness less than the mid-section. Cut through the ring in one place in its circumference to form a tongue and slot.

Cut connector grooves in timber concentric with the bolt hole and conforming to the cross-sectional shape of the rings, to provide a snug fit. The inside diameter of the groove shall be larger than nominal ring diameter so that the ring can expand slightly during installation.

(c) Shearplate Connectors:

(1) Pressed Steel Type - Provide 2 5/8 inch diameter pressed steel shearplates manufactured from steel conforming to AISI C1010, SAE 1010. Each plate shall be a true circle with a flange around the edge, extending from one face of the plate only and at right angles to the face. The plate portion shall have a central bolt hole and two small perforations on opposite sides of the hole and midway between the center and circumference.

(2) Malleable Iron Type - Provide 4 inch diameter malleable iron shearplates manufactured according to ASTM A 47/A 47M, Grade No. 22010, for malleable iron castings. Each casting shall consist of a perforated round plate with a flange around the edge projecting from one face of the plate only and at right angles to the face. The plate portion shall have a central bolthole reamed to size with an integral hub concentric with the bolt hole and extending from the same face as the flange.

(d) Bolts, Nuts, Nails, and Miscellaneous Hardware - Provide machine bolts, drift bolts and dowels according to ASTM A 307 or ASTM A36/A 36M. Washers may be cast ogee or malleable castings, or they may be cut from steel plate.

Galvanize rough hardware, drive pins, expansion bolts, clamps, washers, anchors, joist hangers, bolts and nuts, lag screws, wood screws, spikes and nails according to ASTM A 153/A 153M. Provide these items in standard type and make, or as shown.

02150.20 Acceptance - Lumber and timber Connectors will be accepted according to 00165.35 and this Section.

Section 02190 - Preservative Treatment of Timber

Description

02190.00 Scope - This Section includes the requirements for preservative treatment of lumber, timber, timber piling, guard rail posts and blocks, sign posts, fence posts, and other items as specified.

Materials

02190.10 General - All preservative treatment shall be according to AASHTO M 133 and its referenced AWPA Standards, except that only the following preservatives are allowed:

- Creosote
- Pentachlorophenol (any solvent)
- Ammoniacal Copper Zinc Arsenate
- Chromated Copper Arsenate, Type A, B, or C
- Copper Naphthenate
- Amoniactal Copper Quat, Type B, C, or D

02190.20 Drying Time - Air-dry items treated with waterborne preservatives, as defined in AWPA P5, a minimum of 30 calendar days before installation. Kiln drying for two calendar days may be substituted for 30 calendar days of air-drying. During the period September 1 through May 31, the air-drying shall be under cover at the treatment facility. During the 30 calendar day drying period and until the treated items are installed on the Project, separate each layer of treated items using spacers that are at least 1/2 inch thick. Collect all spacers and other treated wood waste from the construction site and dispose of them in a sanitary landfill.

02190.30 Field Treatment - Field-treat damaged or drilled wood surfaces with a preservative listed in the [CPL](#).

Coatings

Section 02210 - Coating Materials for Timber and Concrete

Description

02210.00 Scope - This Section includes the general requirements for coating materials used on timber and concrete. Detailed coating materials Specifications for the Project will be as specified.

Materials

02210.10 General:

(a) Manufacturing - The coating material shall:

- Be prepared at the factory ready for application or mixing of multi-component coatings. Multi-component coating materials shall be proportioned by the manufacturer with each component in its correct proportion and furnished in separate containers ready for field mixing.
- Be homogeneous, free of contamination, and of a consistency suitable for the specified use.
- Include additives for control of sagging, pigment settling, leveling, drying, dryer absorption, skinning, or other properties that affect application and curing.
- Not require a pretreatment chemical or material prior to application of the prime coat except as specifically stipulated in these specifications.
- Include required tinting and coloring materials at the time of manufacture. When successive coats are specified, each coat shall be tinted to provide contrast between coats. The tinting material shall be compatible with the coating material and not detrimental to performance.
- Not vary in composition without prior notice by the manufacturer and approval of the Engineer. No reformulation will be allowed.

Apply coating materials before expiration of the manufacturer's recommended shelf life.

(b) Packaging - Each container shall:

- Be new steel or plastic of not more than 6 gallon capacity.
- Have a lug-type crimp lid with a ring seal, and shall be equipped with ears and bails.

- Meet U.S. Department of Transportation's Hazardous Material Shipping Regulations.
- Be lined, if necessary, to prevent attack by the coating material. The lining shall not come off the container.
- Be labeled with a quality compliance certificate showing the following:
 - Manufacturer's name
 - Exact title of coating material
 - City Specification number, if any
 - Manufacturer's batch number
 - Date of manufacture
 - Identification of all toxic substances
 - Handling and application precautions

(c) Sampling and Testing - Have the coating material manufacturer furnish the following to the City's Materials Laboratory:

- Two unopened 1 quart containers of each coating material, each component of multi-component coating material and each thinner, for testing of each batch of each coat, and sampled at the factory at the time of containerizing. The City may, at its discretion, place an inspector at the site of manufacture and/or obtain check samples at the Project Site.
- A test results certificate according to ODOT's Nonfield-Tested Materials Acceptance Guide for each batch of each coat
- A product data sheet for each type of coating material and thinner
- A material safety data sheet with the initial sample for each type of coating material and thinner

City testing will only include those of the following tests necessary to ensure that the coating materials conform to specifications and such other testing as the City determines appropriate.

Test	Test Method
Density Determination of Paints and Coatings	ODOT TM 613
Determination of Zinc in Dry Films of Paints and Coatings	ODOT TM 614
Coarse Particles in Pigments, Pastes, and Paints	ASTM D 185
Consistency of Paints Using the Stormer Viscometer	ASTM D 562
Fineness of Dispersion of Pigment-Vehicle Systems	ASTM D 1210
Drying, Curing, or Film Formation of Organic Coatings at Room Temperatures	ASTM D 1640
Volatile Content of Paints	ASTM D 2369
Pigment Content of Solvent-Type Paints	ASTM D 2371
Infrared Identification of Vehicle Solids From Solvent-Type Paints	ASTM D 2621
Volume Nonvolatile Matter in Clear or Pigmented Coatings	ASTM D 2697
Vehicle Solids (Ordinary Centrifuge)	FTMS 141, Method 4051
Nonvolatile Vehicle Content	FTMS 141, Method 4053

City testing is not to be construed as determining or predicting the performance or compatibility of the individual coating material or the total coating system.

02210.20 Coating Materials for Timber - Coating shall be as specified.

02210.30 Coating Materials for Concrete:

(a) Concrete Sealers - Unless otherwise specified, concrete sealers shall meet the requirements of 02060.10.

(b) Solvent-based Coating Materials for Concrete:

(1) System One Primer:

Generic Type:	Single-component, moisture-cured polyurethane
Vehicle Type:	Moisture-cured polyurethane
Solids:	50% minimum by volume
Color:	Close conformance to ODOT Formula 100-82 or Federal Standard 595B #26357, concrete gray. Color chips are available from the ODOT Materials Laboratory.

(2) System One Top Coating Material:

Generic Type:	Single-component, moisture-cured, graffiti-resistant polyurethane
Vehicle Type:	Moisture-cured polyurethane
Solids:	52% minimum by volume
Density:	8.25 lb/gal minimum
Color:	Clear

(c) Water-Based Coating Materials for Concrete:

Generic Type:	Exterior, water based, acrylic emulsion
Vehicle Type:	100% acrylic emulsion latex
Vehicle Content:	62.0% minimum by volume
Pigment Content in Dry Film:	38.0% maximum

Pigment Composition
(by weight of pigment):

Titanium dioxide	7.0% minimum
Calcium carbonate	50.0% maximum
Fungicide:	Mercury-free
Color:	ODOT Formula 100-82 or Federal Standard 595B #26357
Solids:	58.0% minimum by weight
Density:	11.0 lb/gal minimum
Fineness:	4 minimum
Viscosity, Krebs Units (KU):	80 - 95 at 77 °F
Dry Time:	15 minutes to touch, 60 minutes to recoat

Geosynthetics and Slope Protection

Section 02320 - Geosynthetics

Description

02320.00 Scope - Geosynthetics will be accepted for use in various applications according to the provisions of this Section.

02320.01 Definitions - Geosynthetic terms are defined in 00350.01.

Materials

02320.10 Acceptance:

(a) General Requirements - All geosynthetics shall be:

- Free of defects, cuts or tears
- Resistant to ambient temperatures, acid and alkaline conditions, micro-organisms and insects
- For the intended purpose and have dimensional stability
- Free of asbestos containing material

(1) Geotextiles - Woven or non-woven geotextiles shall:

- Be composed of long chain, synthetic polymeric filaments or yarns formed into a stable network that retains its relative structure during handling, placement and design service life. At least 95%, by weight, of the long chain polymers shall be a polyolefin or polyester
- Meet or exceed the properties specified in 02320.20 Table 2320-1
- Be free of any chemical treatment or coating which might significantly reduce permeability
- Have the selvage finished so the outer fibers are prevented from pulling away from the fabric

(2) Geogrids - Geogrids shall be:

- A regular network of integrally connected, polymer, tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil or rock
- Dimensionally stable and able to retain their geometry under manufacture, transport and installation

(3) HDPE Geo-membrane Swale Liner

- Material shall be 40-mil High Density Polyethylene (HDPE) geo-membrane, textured on both sides or approved equal. An experienced firm regularly engaged in manufacturing textured HDPE shall manufacture the geo-membrane.

(b) Acceptance Requirements - The actual minimum average roll values furnished by the manufacturer shall be based on representative test results from the manufacturing plant which produced the geosynthetic, and shall meet or exceed each of the specified minimum values. All geosynthetics shall be clearly labeled as being part of the same production run certified as meeting all applicable requirements.

(c) Manufacturer's Documentation - Furnish a Level A or Level B certification, as indicated in the Special Provisions for the applicable geosynthetics.

(1) Level A - Manufacturer's Test Result Certificate - Furnish a Test Result Certificate according to 00165.35 from the geosynthetic manufacturer. The certificate shall:

- Include the minimum average roll values for each of the specified properties from the same production run as the delivered material
- Include test results for factory seams
- Include production run number, production plant name and location

If the geosynthetic material is modified, remanufactured, relabeled or sewn, furnish an additional certificate from the supplier making the changes that explain the altered properties, seam strength or relabeling.

(2) Level B - Manufacturer's Quality Compliance Certificate - As a basis of acceptance, furnish either a manufacturer's brochure or a Quality Compliance Certificate, according to 00165.35, with geosynthetic properties shown.

If the brochure or certificate lists typical or average roll values instead of minimum average roll values, then increase by 25% the specified minimum values in Table 02320-1 for grab tensile strength, burst strength and puncture strength to determine compliance.

(d) Manufacturer's Sampling/Testing - The manufacturer's reported property values shall be based on the following sampling and testing requirements:

(1) Sampling - Sample all geosynthetics according to ASTM D 4354. The production unit used for sampling shall be a roll or sheet.

(2) Testing - Perform the specified tests to determine geotextile properties for the intended application(s). The tensile strength requirements shall be tested in both machine and cross-machine directions.

(e) City Check Tests - The City reserves the right to sample and test products for compliance with pertinent requirements, according to 00165.02.

When the City performs check tests, the entire production run will be accepted or rejected according to 00150.80(g), if any of the average roll values of tested rolls are less than the specified minimum values.

02320.11 Seam Testing and Acceptance:

(a) Factory Seams - Where factory seams are made, the sheets of geotextile shall:

- Be sewn together using a lock-type stitch Type 301 or 401 as shown on the plans
- Be sewn with polymeric thread that is at least 95%, by weight, polyolefin or polyester, and as resistant to deterioration as the geotextile being sewn
- Have test results showing that the seams meet or exceed 90% of the specified tensile strength minimum values for the intended application
- Nylon thread will not be allowed

(b) Field Seams - Where field sewn seams will be used, furnish:

- The manufacturer's test result certificate, according to 00165.35, that includes wide strip, tensile strength test results and verifies that seam tensile strength and seam grab tensile strength meet or exceed 90% of the minimum specified tensile strength values for the geotextile
- A field-stitched seam test sample

Table 02320-1 Geotextile Property Values

Geotextile Property	Test Method	Units	Filtration							Separation		Reinforcement	
			Drainage ¹ Geotextile		Riprap ¹ Geotextile		Supported	Sediment Fence Geotextile		Subgrade Geotextile	Embankment Geotextile	Pavement Overlay ¹ Geotextile	
								Unsupported	Elongation				
			Type 1	Type 2	Type 1	Type 2	—	Elongation ≥ 50% ²	Elongation ≤ 50% ²	—	—		
Grab tensile strength (minimum) Machine Direction Cross Machine Direction	ASTM D 4632	lb	80 80	180 180	200 200	260 260	90 90	120 100	120 100	180 180	230 230	80 80	
Grab Elongation (minimum)	ASTM D 4632	%	15		15		—	—	—	—	—	50	
Burst Strength, Diaphragm method (minimum)	ASTM D 3786	psi	130	290	320	435	—	—	—	290	435	—	
Puncture strength (minimum)	ASTM D 4833 or ODOT TM 816	lb	35		80		—	—	—	80	110	—	
Apparent opening size (AOS) (maximum), U.S. Standard Sieve	ASTM D 4751 (CW-02215 Corps of Engr.)	in	No. 70		No. 70		No. 30	No. 30	No. 30	No. 30	No. 30	—	
Permittivity (minimum)	ASTM D 4491	s ⁻¹	0.5		0.5		0.05	0.05	0.05	0.01	0.01	—	
Ultraviolet stability (Retained Strength) (minimum)	ASTM D 4355 At 500 hours	%	—		70		70 after 500 hours of exposure			—	—	—	
Asphalt retention (minimum)	ODOT TM 817	oz/ft ²	—		—		—	—	—	—	—	2.8	
Melting point (minimum)	ASTM D 276	°F	—		—		—	—	—	—	—	300	

¹ Slit film or slit tape fabrics are not acceptable

² As measured according to ASTM D 4632

02320.21 Geogrid Property Values:

Biaxial Geogrid Property	Test Method	Units	Values	
			MD	TD
True Initial Modulus (Secant Modulus)	ASTM D 6637-01	lb/ft	27,420	41,130
Tensile Strength at 2% Strain	ASTM D 6637-01	lb/ft	410	545
Rib Thickness	ASTM D 1777	inch	0.05	
Flexural Stiffness	ASTM D 5732-95	mg-cm	750,000	
Junction Efficiency	GRI:GG2-87	%	90	
Secant Aperture Stability Modulus at 20 kg-cm	US Army Corp Methodology of Torsional Rigidity	kg-cm/deg	6.0	
Aperture Size Range	I.D. Caliper	inch	0.75 - 1.50	

MD= Machine Direction along roll length

TD= Transverse Direction or cross-machine direction across the roll

GRI= Geosynthetic Research Institute

02320.22 HDPE Resin - Resin shall be new, first quality, compounded and manufactured specifically for producing geo-membrane.

02320.23 DPE Sheet - Shall meet the following standards for textured 40-mil HDPE:

Tested Property	Test Method	Min. Value
Thickness, (minimum average) mil	ASTM D 5994	38
Lowest individual for 8 out of 10 values		36
Lowest individual for any of the 10 values		34
Density, g/cm ³	ASTM D 1505	0.94
Tensile Properties (each direction)	ASTM D 6693, Type IV Dumbell, 2 ipm	
Strength at Break, lb/in-width		60
Strength at Yield, lb/in-width		84
Elongation at Break, %		100
Elongation at Yield, %		12
Tear Resistance, lb	ASTM D 1004	28
Puncture Resistance, lb	ASTM D 4833	60
Carbon Black Content, %	ASTM D 1603	2.0

Shall not exceed a combined maximum total 1 percent by weight additives other than carbon black.

Shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.

Furnish in roll form. Identify each roll with labels indicating roll number, thickness, length, width and manufacturer.

Section 02340 - Rock Gabion Baskets

Description

02340.00 General - Fabricate gabion baskets from twisted or welded wire mesh. Provide wire mesh material free of breaks in the wire, breaks at weld points or other deficiencies. Individual wires of either style mesh shall meet the following minimum requirements:

Wire diameter tolerance limit.....	±0.004"
Tensile strength ¹	60,000 psi minimum
Galvanizing	0.80 oz/ft ² minimum

¹ Tensile area includes galvanizing

Welded wire shall also conform to ASTM A 185 except that the weld shears shall be 600 pounds for 11 gage, and 800 pounds for 9 gage wires. All wire sizes are after galvanizing.

Tie wires and internal connecting wires shall be galvanized and no smaller than 13 1/2 gage. Spiral binders may be used as an alternate to tie wire for basket assembly and basket-to-basket connections. Spiral binders shall be 3.9 gage, galvanized, and have a 3 inch pitch. High tensile fasteners of the locking spring steel clip or clamp-on ring type may be used as alternates to tie wire for basket assembly only. High tensile fasteners shall be fabricated from 11 gage steel wire with a minimum tensile strength of 240,000 psi. Provide a Class 3 zinc coating according to ASTM A 764. High tensile fasteners shall provide a closed position tensile strength of 600 pounds.

All wire shall be galvanized according to ASTM A 641/A 641M.

Materials

02340.10 Twisted Wire Mesh Gabion Baskets - Gabion panels of the twisted mesh style shall be manufactured from 11 gage with 9 gage selvage wires. The mesh shall form a uniform hexagonal pattern and shall be formed with a non-raveling twist. The major axis (maximum line dimensions) of any hexagonal opening shall not exceed 4.75 inches. The area of the hexagonal opening, approximately 3.2 inches by 4.5 inches, shall not exceed 9.5 square inches.

02340.20 Welded Wire Mesh Gabion Baskets - Gabion panels of the welded mesh style shall be manufactured from 11 gage or 9 gage wire. The mesh shall form a nominal 3 inch by 3 inch grid pattern and conform to ASTM A 185. The maximum line dimension of any opening shall not exceed 4.75 inches. The 12 inch and 18 inch high mattresses shall be made from 11 gage panels. Gabions of square cross section (cubical-celled units) may be made with either 9 gage or 11 gage panels, except that within the same unit, panels of dissimilar wire sizes may not be mixed.

Galvanized 9 gage stiffeners, placed diagonally in the baskets at the vertical one-third points, as shown on the plans or as recommended by the manufacturer, may be used instead of perpendicular cross ties.

02340.30 PVC Coated Wire Mesh Gabion Baskets - The wire type used for PVC coated wire mesh gabions shall be either twisted wire mesh or welded wire mesh and shall conform to 02340.00 and 02340.10 or 02340.20.

The PVC coating for twisted wire mesh gabions shall be extruded onto the wire core before weaving the coated wire into a double twisted hexagonal mesh. The use and minimum diameter of the various wires is as follows:

- Gabion Panel wire core shall be manufactured from galvanized 12 gage wire core. The overall minimum diameter of the galvanized wire core plus PVC coating shall be 0.136 inch.
- Selvage and reinforcing wire shall be of heavily galvanized 10 gage wire core coated with PVC and having an overall minimum diameter (galvanized wire core plus PVC coating) of 0.165 inch.
- Lacing and connecting wire shall be of heavily galvanized 13 1/2 gage wire core coated with PVC and having an overall minimum diameter (galvanized wire core plus PVC coating) of 0.120 inch.

02340.40 Fabrication - Fabricate gabions so that the sides, ends, lid and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. Dimensions for heights, lengths and widths of gabion baskets shall be as indicated on the plans with a tolerance of plus or minus 3%. Gabions shall be of single unit construction. Either connect the base, lid, ends and sides into a single unit or connect one edge of these members to the base section of the gabion in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

If the length of the gabion exceeds its horizontal width, equally divide the gabion by diaphragms into cells whose length does not exceed the horizontal width. The diaphragm material shall be of the same mesh and size as the body of the gabions. Furnish the gabion with the necessary diaphragms secured in proper position on the base in such manner that no additional tying at this juncture will be necessary.

Assemble the wire mesh panels (base, ends, sides, diaphragms and lid) so strength and flexibility at connections is at least equal to that of a single panel.

02340.50 Acceptance - Provide a quality compliance certificate for gabion baskets according to 00165.35.

Section 02350 - Metal Bin Retaining Walls

Description

02350.00 Scope - This Section includes the requirements for designing and fabricating galvanized steel sheets and hardware for the assembly of metal bin retaining walls.

Materials

02350.10 Base Metal, Galvanizing and Thickness - Design all members, fittings and appurtenances as integral units or parts of the whole assembly. The galvanized sheets used in fabricating the members shall conform to the requirements of AASHTO M 218. Bolts, nuts and miscellaneous hardware shall be galvanized or otherwise protected with approved coatings and shall be of sizes and shapes suitable for use with the members furnished.

Fabricate the members from the specified base metal of the thickness shown. In the absence of given thickness or dimensions for any member, fitting or appurtenance, the thickness of metal or dimensions of the member shall be as required to fully develop the strength of the members whose thickness and dimensions are given, and which are used in structural combination.

02350.20 Fabrication - Fabricate all members so members of the same nominal size are fully interchangeable. Fabricate and punch the members so no drilling, punching or drifting to correct defects in manufacture will be required during field assembly. Any members having improperly punched holes will be rejected. Replace with a member with properly punched holes.

Section 02410 - Concrete and Plastic Pipe

Description

02410.00 Scope - This Section includes the requirements for non-reinforced and reinforced concrete pipe, polyethylene pipe and polyvinyl chloride (PVC) pipe.

Materials

02410.10 Concrete Pipe - Use concrete sewer pipe conforming to the requirements of the Material Specifications for Precast Concrete Products (MSPCP) Manual published by the City of Portland Materials Testing Laboratory.

(a) Defects on Sealing Surfaces – The surfaces of the pipe bell and spigot in contact with the gasket, and any adjacent surfaces that could contact the gasket within the specified joint movement range, shall be free from defects.

(b) Reinforced Concrete Pipe – Any fabrication or procurement of concrete pipe materials performed before approval of the pipe details is at the Contractor's risk. City approval of the pipe details will not relieve the Contractor of its responsibility to meet all the requirements of these Specifications and to provide pipe with details that conform to the MSPCP. The Contractor is responsible for checking pipe dimensions and for any problems arising from incorrect pipe dimensions.

(c) Lubricants - Use only manufacturer approved jointing material lubricants.

(d) Jointing Materials - Jointing materials for concrete sewer pipe shall conform to the requirements of the MSPCP.

02410.60 High Density Polyethylene Pipe - Use pipe made from Premium High Density Polyethylene resin qualified as Type III, Category 5, Class C, Grade P34 in ASTM D1248. This material shall have a long term hydrostatic strength of 1600 psi when tested and analyzed by ASTM D2837, and shall be listed by the Plastic Pipe Institute as a P.E. 3408 Resin. Pipe sizing shall conform to ASTM F714 and ASTM D3035.

(a) Applicable ASTM Specifications:

HDPE material shall comply with the following minimum engineering design specifications:

ASTM D638	Tensile Strength Yield (2 in./min.) > 3200 psi.
ASTM D638	Elongation at break 750%
ASTM D638	Modulus of Elasticity 105,000 psi
ASTM D3350	Flexural Modulus 124,000 psi
ASTM D1693	Environmental stress crack resistance > 5000 F20 hrs. (E.S.C.R.) Condition C,
ASTM D2837	Long Term Hydrostatic Strength at 73.4° F. 1600 psi. (L.T.H.S)

(b) Recycled Resin - The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material supplier.

(c) Uniformity - The polyethylene pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions or other injurious defects. The pipe shall be uniform in color, opacity, density and other physical properties.

(d) Marking - The following information shall be continuously marked on the pipe or spaced at intervals not exceeding 5 feet:

1. Name and/or trademark of the pipe manufacturer
2. Nominal pipe size
3. Standard Dimensional Ratio (SDR).
4. Resin Type
5. Manufacturer's Standard reference.
6. A production code from which the date and place of manufacture can be determined.

(e) Certification - The pipe supplier shall certify compliance with requirements of these specifications in writing.

(f) Method of Joining - Join all High Density Polyethylene (HDPE) pipe and fittings by the heat fusion process per ASTM A2657 and the manufacturer's specific recommendations or by approved coupler. The tensile strength at yield of the butt fusion joints shall not be less than the pipe.

(g) Record Keeping - Record and document the profile of each fusion joint made during the project. The data recording system shall be fully compatible with the pipe, and fusion equipment manufacturer's recommendations. Submit documentation to confirm this agreement.

(h) Data to be Recorded - The data recording system shall document all recordable information for each heat fusion process joint. Information may include but it is not limited to: Date and Time, Joint Number, Project Number, Employee ID, Machine ID, Piston Area, Pipe Material and size, Interfacial Pressures, Recommended Gauge pressures and other recorded data.

(i) Data Reporting and Compliance - Provide the Engineer with a copy of each joint profile printout immediately after its completion. The Engineer must receive and review each joint profile printout for conformity with pipe and equipment manufacturers recommendation before accepting any joint. The Engineer has discretion to waive this requirement at any time. Repair and replace any joint that fails to meet these specifications at no additional cost to the City.

(j) Fittings for HDPE Pipe - Standard fittings and special fittings shall be manufactured from the same class of material as the pipe is manufactured and be fully compatible. Fittings shall be manufactured in accordance with ASTM D3261. Fabricated fittings shall be pressure rated to match the system piping.

(k) Couplings - Mechanical connections to fittings or other materials shall be by means of flanged connections (flanged coupling adapters and ANSI backup rings rated for the same pressure service as the system piping) or flexible couplings designed for joining similar or different pipe material such as a PVC coupler, as approved. Flanged joints shall use bolts of compatible material. Provide gaskets when joining to non-polyethylene materials. Evenly torque the flange bolts using a crisscross pattern following the manufacturer's recommendation. Retorque flanged joints after 1 hour or more has passed or as recommended by manufacturer.

(l) Service Laterals - Tee and wye fittings to connect service laterals shall be either molded butt fusion fittings, or molded saddle fusion fittings in accordance with ASTM D3261.

(m) Connections to Manholes - Make connection to manholes and other structures with an approved cast in place gasketed adapter, sanded manhole adapter or other approved method.

02410.70 Polyvinyl Chloride (PVC) Pipe - All PVC pipe and fittings shall conform to ASTM D3034 SDR 35 standards. Unless otherwise approved, joints shall be bell and spigot with a rubber gasket conforming to ASTM D3212 and ASTM F477. Additives and fillers, including but not limited to, stabilizers, antioxidants, lubricants, etc. shall not exceed 10 parts by weight per 100.

(a) Gravity pipe applications 4" to 15" Diameter PVC Pipe - All PVC pipe and fittings shall be integral wall and spigot, rubber gasket joint, unplasticized Polyvinyl chloride (PVC) pipe. All PVC pipe shall have a minimum pipe stiffness of 46 psi at 5 percent deflection at 32 °F when tested in accordance with ASTM Designation D2412, external loading properties of plastic pipe. Pipe shall have a minimum impact strength based on test methods of ASTM D3034 with the exception that conditioning temperature for sample shall be 32 °F plus or minus 2 °F.

All PVC pipe and fittings manufactured and installation shall meet or exceed the ASTM recommended specifications D3034, SDR 35, unless otherwise specified, and all installation shall be in strict compliance with ASTM D2321 and the manufacturer's instructions. All pipe shall be clearly marked with the date of manufacture. All pipe shall be provided with the reference mark for proper spigot insertion. Joint gaskets shall be fabricated from a compound of which the basic polymer shall be a synthetic rubber consisting of styrene, butadiene, polyisoprene or any combination thereof and shall meet the requirements of ASTM F477.

(b) Gravity pipe applications 18" to 36" Diameter PVC Pipe - All PVC pipe and fittings shall be integral wall and spigot, rubber gasket joint, unplasticized Polyvinyl chloride (PVC) pipe. All PVC pipe shall have a minimum pipe stiffness of 46 psi at 5 percent deflection at 32 °F when tested in accordance with ASTM Designation D2412, external loading properties of plastic pipe. The pipe shall be made of PVC plastic having a minimum cell classification of 12364 or 12454 as defined in ASTM D 1784. Homopolymer PVC compounds must equal or exceed the requirements of above listed minimum cell classification number. Pipe shall have a minimum impact strength based on test methods of ASTM F679.

All PVC pipe and fittings manufactured and installation shall meet or exceed the ASTM recommended specification F679, unless otherwise specified, and all installation shall be in strict compliance with the manufacturer's directions. All pipe shall be clearly marked with the date of manufacture. All pipe shall be provided with the reference mark for proper spigot insertion. Joint gaskets shall be fabricated from a compound of which the basic polymer shall be a synthetic rubber consisting of styrene, butadiene, polyisoprene or any combination thereof and shall meet the requirements of ASTM F477.

(c) Perforated PVC Pipe - When specified, the perforations shall consist of two rows of 3/8 inch diameter holes at 3 inches on center. The holes shall be oriented 60° from the invert on each side of the pipe. The two rows of holes shall be 120° apart. Do not use perforated pipe greater than 8 inches without written approval.

02410.71 Proof Tests and Allowable Joint Deflections - The intent of this requirement is to prequalify joint system components that meet the joint requirements as to the water tightness capability of the joint system. This proof test shall be understood to apply to all pipes that are to be tested for water tightness before Acceptance. The manufacturer shall provide material and test equipment for proof testing. Joints shall meet the requirements of yard testing specified below. The pipe manufacturer shall submit results of the yard tests made, certified by an approved testing agency. When approved, a suitable joint tester may apply internal hydrostatic pressure. In general, each pipe material and joint assembly shall be subject to the following three proof tests at the discretion of the Engineer.

(a) Pipe in Straight Alignment - Assemble no less than three nor more than five pipes selected from stock by the Project Manager according to the manufacturer's installation instructions with the ends suitably plugged and restrained against internal pressure. Subject the pipe to 10 pounds per square inch (psi) hydrostatic pressure for 10 minutes. Free movement of water through the pipe joint or pipe wall will be ground for rejection of the pipe.

(b) Pipe in Maximum Deflection Position - Deflect a test section as described hereinafter for each pipe material. Subject the pipe to 10 psi hydrostatic pressure for 10 minutes. Free movement of water through the pipe joint or pipe wall will be ground for rejection of the pipe.

(c) Joints under Differential Load - Support the test section on blocks or otherwise as described hereinafter for each pipe material. There shall be no visible leakage when the stressed joint is subjected to 10 psi internal hydrostatic pressure for 10 minutes.

(d) Alternative to Hydrostatic Test - An external hydrostatic test or a vacuum test effectively meeting the same time and pressure requirements will be an alternative to the internal hydrostatic pressure test as approved.

02410.80 Acceptance - Except as provided in 02410.10(b)(3) above, acceptance of non-reinforced concrete pipe, reinforced concrete pipe, concrete drain pipe, concrete drain tile, polyethylene pipe, polyvinyl chloride pipe, and hardware will be according to 00165.35 and this Section.

Section 02420 - Metal Pipe

Description

02420.00 Scope - This Section includes the requirements for corrugated steel pipe, helical rib pipe, arch type pipe, aluminum pipe, ductile iron pipe, and special sections intended for use for storm drainage, underdrains and culverts, and not intended for the conveyance of sanitary or industrial waste.

Materials

02420.10 Corrugated Steel Pipe and Pipe Arches - Provide corrugated steel pipe, helical rib pipe, pipe arches and special sections conforming to the requirements of ASTM A 760/A 760M Types I, IA, and II, except as follows:

(a) Shapes - Provide either full-circle or elliptical pipe, as the Contractor may elect, unless otherwise shown or specified. The shapes of pipe fabricated and furnished may include any of the following:

- **Full-Circle Pipe** - Fabricate helical rib pipe in full-circle cross section only.
- **Arch-Type Pipe**
- **Elliptical Pipe** - Full-circle pipe distorted 5% out-of-round by shop fabrication to form an elliptical cross section with the major axis vertical.
- **Half-Circle Pipe** - Fabricate as half sections of full-circle pipe of the same diameter.
- **Nestable Pipe** - Fabricate in two separate half sections designed to fit and fasten together to form a full-circle cross section of specified diameter. Fasten the two half sections together by approved means which shall provide at least 90% of the strength of a standard riveted longitudinal seam.

(b) Connecting Bands - Use connecting bands conforming to the details shown on the plans to make field joints for pipes and pipe arches not requiring watertight joints.

(c) Special Sections - Furnish special sections such as elbows, wyes, tees, crosses, bends, reducers and flared inlets as shown or as directed.

Generally, special sections shall conform to the requirements specified for the pipe with which they are used, and shall be connected to the pipe or to each other with connecting bands specified for use with the pipe to which they are connected.

For elbows of 30° or greater total angle, use three-piece sections of approximately equal length and equal-angle segments or pieces.

Weld joints according to recognized standard practice and repair any damaged zinc or aluminum coating according to 02420.10(d).

(d) Repair of Damaged Coating - In addition to the methods given in ASTM A 760/A 760M the Contractor may repair damaged zinc or aluminum coating by removing all loose or cracked coating, removing all welding flux, wire brushing the damaged area, and applying two coats (minimum 2 mils total thickness) of a high zinc dust content paint conforming to the general requirements of ASTM A 780.

Damaged zinc or aluminum coating within 3/8 inch of the ends of pipe sections caused by production cut-off of pipe need not be repaired. Coating damage on edges of connecting bands need not be repaired.

(e) Irrigation Pipe - In irrigation pipe installations, where Type D coating (AASHTO M 190) is not specified, the Contractor will be permitted to furnish pipe with Type D coating.

(1) Riveted Seams - If pipes are not furnished with Type D coating, do the following:

- Place a bead or strip of approved caulking compound, 1/8 inch minimum diameter or thickness, between the laps of all riveted seams.
- Rivet the annular seams of riveted pipe at spacings not greater than 3 inches. Rivet in a single row the longitudinal seams of pipes less than 42 inches in diameter. Place one rivet in each valley and one on each crest of the corrugations.
- Double rivet the longitudinal seams of pipes 42 inches and larger in diameter in each valley of the corrugations and place a single rivet on each crest of the corrugations.
- At the intersection of longitudinal and circumferential seams, close the gap caused by the three-sheet lap by special fabrication. Fabricate a special longitudinal seam at the ends of pipe sections for a sufficient distance to clear the coupling bands.

Spot welding of the seams of corrugated metal pipe used in irrigation pipe installations will not be permitted.

(2) Field Joints - Use connecting bands conforming to the details shown, and make the field joints watertight.

(f) Siphon Pipe - Fabricate corrugated steel pipe used in siphons with watertight seams.

Field joints shall provide circumferential and longitudinal strength to preserve the pipe alignment, prevent separation of pipe sections and provide a watertight joint. Attach the connecting bands so they lap a nearly equal portion of each pipe section to be connected.

(g) Sloped or Skewed Ends - If the ends of pipe culverts require sloped ends, skewed ends or both, fabricate the ends in a manner that provides good workmanship and a smooth finish. Restore zinc or aluminum coating as directed according to 02420.10(d), and bituminous protective coatings and linings when specified.

02420.11 Ductile Iron - Use ductile iron pipe conforming to the requirements of AWWA C150. Use Pressure Class 150 - 350 or Special Thickness Class 50 - 56, as directed.

02420.20 Protective Coatings - If specified or shown, furnish corrugated metal pipes with protective coatings as follows:

(a) Bituminous Protective Coatings - Provide corrugated metal pipe and connecting bands with bituminous coatings conforming to the requirements of AASHTO M 190 and the following:

- Before immersion, the metal shall be free of grease, dirt, dust, moisture or other contaminants.
- Apply the initial bituminous coating by one of the processes under 002420.20(a)(1) or (a)(2).
- If a second dip is required to meet the coating thickness requirements of AASHTO M 190, the time and temperature requirements of 02420.20(a)(1) or (a)(2) need not be followed for the second dip.
- The paved invert for both Type B and Type C coatings on either circular or arch-type pipe shall fill the corrugations for at least 40% of the circumference of the pipe.

(1) Pipe Not Preheated - The temperature of the asphalt at the time of pipe immersion shall be 400 °F plus or minus 5 °F and the duration of the immersion shall conform to the following schedule:

Metal Thickness (inch)		Minimum Immersion Time (minutes)
Steel	Aluminum	
0.064	0.060	2.5
0.079	0.075	3.0
0.109	0.105	5.0
0.138	0.135	6.5
0.168	0.164	8.0

(2) Pipe Preheated - At the time of pipe immersion the asphalt shall have a temperature of 380 °F plus or minus 5 °F and the pipe shall be preheated to a temperature 300 °F to 350 °F.

(b) Type D, Fully-Bituminous Coated, Fully-Lined - The interior lining shall be smooth, uniform and free from sags and runs. Slight residual corrugations due to cooling and shrinkage of the lining will not be cause for rejection. At the three-sheet lap an interior non-uniformity equal to the thickness of the sheet will be permitted. Maintain the thickness of the lining to the ends of the pipe.

(c) Optional Paved Invert - If an asphalt coated pipe with a paved invert (Type C coating) is shown or specified, a centrifugally-applied interior lining conforming to Type D coating may be furnished as an alternate, providing the minimum thickness of bituminous coating over the crests of the corrugations is not less than 1/4 inch.

(d) Polymeric Coatings - If polymeric coating is shown on the pipe data sheet, use a coating from section 02420.20 of the CPL.

02420.30 Corrugated Steel Pipe for Underdrains - Provide corrugated steel pipe for underdrains conforming to the requirements of ASTM A 760/A 706M Type III - Underdrain Pipes, except as modified in 02420.10(c) and (d), and as follows:

(a) Class IV - Semicircular pipe may be used only as an alternate with the 6 inch size of perforated full-circle drain pipe.

(b) Connecting Bands - Connecting bands for underdrain pipe field joints shall conform to the designs shown.

02420.40 Corrugated Aluminum Alloy Pipe - Provide corrugated aluminum alloy pipe, helical rib pipe, pipe arches and special sections conforming to the requirements of ASTM B 745/B 745M, Types I, II and III, except as follows:

(a) Shapes - The shapes of the pipes to be furnished may include any of the shapes described in 02420.10(a).

(b) Connecting Bands - Use connecting bands conforming to the requirements of ASTM B 745/B 745M and the details shown to make field joints for pipes and pipe arches not requiring watertight joints.

(c) Special Sections - Furnish special sections such as elbows, wyes, tees, crosses, bends, reducers and flared inlets as shown or as directed.

Generally, special sections shall conform to the requirements specified for the pipe with which they are used, and shall be connected to the pipe or to each other with connecting bands specified for use with the pipe to which they are connected.

For elbows of 30° or greater total angle, use a three-piece section of approximately equal length and equal-angle segments or pieces.

(d) Irrigation Pipe - In irrigation pipe installations where Type D coating is not shown or specified, the Contractor will be permitted to furnish pipe with Type D coating.

If pipes are not furnished with Type D coating, all riveted seams shall conform to the applicable provisions of 02420.10(e)(1).

Use connecting bands conforming to ASTM B 745/B 745M and the details shown, and make the field joints watertight for pipe installations used in irrigation.

(e) Siphon Pipe - Fabricate corrugated aluminum alloy pipe used in siphons with watertight seams.

Field joints shall provide circumferential and longitudinal strength to preserve the pipe alignment, prevent separation of pipe sections and provide a watertight joint. Fabricate the connecting bands from aluminum alloy conforming to ASTM B 745/B 745M. Attach the connecting bands so they lap a nearly equal portion of each pipe section to be connected.

(f) Sloped or Skewed Ends - If the ends of pipe culverts require sloped ends, skewed ends or both, fabricate the ends in a manner that provides good workmanship and a smooth finish. Repair bituminous protective coatings and linings when specified.

02420.50 Corrugated Aluminum Alloy Pipe for Underdrains - Provide corrugated aluminum alloy pipe for underdrains conforming to the requirements of ASTM B 745/B 745M Type III, except as follows:

(a) Special Sections - The provisions of 02420.40(c) apply.

(b) Connecting Bands - Connecting bands for field joints shall conform to the requirements of ASTM B 745/B 745M and the details shown.

02420.60 Acceptance - Acceptance of pipes, underdrains, and protective coatings will be according to 00165.35 and this Section.

Section 02430 - Structural Plate Pipe

Description

02430.00 Scope - This Section includes the requirements for steel and aluminum alloy plates and hardware for structural plate pipe.

Materials

02430.10 Galvanized Steel Plates:

(a) General - Use galvanized steel plates for structural plate pipe conforming to the requirements of ASTM A 761/ A761M.

(b) Plates for Pipe Arches - The top plate(s) shall form an arc between 180 and 155°. The bottom plate(s) shall form an arc between 50° and 10°. Join the top plate(s) at each end to the bottom plate(s) with corner plates to form an arc with a radius between 16 inches and 21 inches or between 29 inches and 34 inches, as applicable, and forming an arc between 87.5° and 75°.

(c) Forming and Punching Plates - Form plates to provide lap joints. Punch the bolt holes so that all plates with the same dimensions, curvature, thickness, and number of bolts per foot of seam are interchangeable. Curve each plate to the proper radius so that the cross-sectional dimensions of the finished structure will be as indicated on the drawings or as specified.

Unless otherwise specified, fabricate bolt holes as follows:

- Two rows along longitudinal seams
- Center-to-center spacing not more than 10 inches along circumferential seams
- Center of hole to edge of the plate at least 1.75 times the diameter of the bolt
- Longitudinal seam bolt holes shall not exceed the diameter of the bolt by more than 1/8 inch

The above provisions are for standard punching. Provide additional bolt holes for special conditions of installation when specified or shown.

(d) Sloped and Skewed Ends - Cut plates for forming sloped ends, skewed ends or both, to give the angle of slope or skew shown. Burnt edges shall be free from oxide and burrs. Legibly identify each cut plate to designate its proper position in the finished structure.

02430.20 Aluminum Alloy Plates - Provide aluminum alloy plates for structural plate pipe conforming to the requirements of ASTM B 746/B 746M. Fabricate according to 02430.10(b) through (d).

02430.90 Bolts, Nuts, and Washers - Bolts, nuts and washers for use with galvanized steel structural plate pipe shall conform to the requirements of ASTM A 761/A 761M and be galvanized according to ASTM A 153/A 153M.

Bolts, nuts and washers for use with aluminum alloy structural plate pipe shall conform to the requirements of ASTM B 746/B 746M and be galvanized according to ASTM A 153/A 153M.

02430.95 Acceptance - Acceptance of structural plate pipe and hardware will be according to 00165.35 and this Section.

Section 02440 - Joint Materials

Description

02440.00 Scope - This Section includes the requirements for joint fillers, seals, gaskets and water stop for concrete pipe joints, manhole section joints and miscellaneous concrete applications.

Materials

02440.10 Preformed Expansion Joint Fillers for Concrete - Use preformed expansion joint fillers for concrete conforming to the requirements of ASTM D 1752 or ASTM D 1751. Fillers conforming to ASTM D 1751, except the binder, if other than bituminous material, may be used provided they otherwise meet this Specification and they have been demonstrated to be rot and vermin proof for a period of at least five years. Unless otherwise specified or indicated, the Contractor may elect to furnish either type specified in this subsection.

02440.11 Poured Silicone Sealant - Use a two-component, low modulus, rapid-cure silicone sealant.

02440.14 Backer Rod - Use a closed-cell, non-gassing foam material backer rod from the CPL.

02440.15 Lubricant/Adhesive - Use a lubricant/adhesive that is a 100% solid, two-component, modified epoxy adhesive designed for bonding polychloroprene seals to concrete or steel.

02440.19 Steel Bridging Plate - Use a merchant quality steel bridging plate with a minimum thickness of 1/8 inch and a width of 8 inches, cut in lengths of 4 feet or more. Drill spike holes at 12 inch centers along the centerline of the plate. Sand blast the steel bridging plate prior to installation.

02440.20 Preformed Elastomeric Joint Seals - Use preformed elastomeric joint seals, compression joint seals and strip joint seals conforming to the requirements of ASTM D 2628.

02440.21 Elastomeric Concrete - Use a multi-component binder-base material designed to provide a strong matrix and to promote bond between the concrete nosing and the substrates. Mix the binder and aggregate according to the manufacturer's recommendations. Use an aggregate gradation recommended by the manufacturer.

02440.22 Epoxy Adhesive for Steel Members - Use a low-modulus epoxy adhesive to bond steel members when indicated. Bond steel members together using a Type 3 non-sag epoxy resin from the CPL, or as approved.

02440.30 Poured Joint Filler - Use poured joint filler from the CPL and conforming to the requirements of AASHTO M 173 (ASTM D 1190).

02440.40 Rubber Gaskets for Concrete Pipe and Precast Manhole Section Joints:

(a) Preformed Plastic Gaskets - Use materials for tongue and groove or key lock manhole joints conforming to the requirements of ASTM C 990.

(b) Rubber Gaskets - Use materials for O-ring manhole and concrete pipe joints conforming to ASTM C 443/C 443M.

02440.50 Joint Materials for Concrete Precast Manhole Section Joints-

(a) Mortar - Use mortar conforming to the requirements of ASTM C 387.

The consistency of the mortar shall be such that it will readily adhere to the precast concrete if using the standard tongue-and-groove type joint.

(b) Non-Shrink Grout - Use non-metallic cementitious commercial grout from the CPL that exhibits zero shrinkage according to ASTM C 827. Do not amend grout with cement or sand, or recondition it with water after initial mixing. Place or pack non-shrink grouts only with the use of an approved commercial concrete bonding agent applied to all cured concrete surfaces being grouted. Use a bonding agent compatible with the grout used. Do not use water as a substitute for the commercial bonding agent.

02440.60 Plastic Compound for Precast Manhole Section Joints - Use a plastic compound that is specifically manufactured for the intended use and:

- Has a putty-like, preformed homogeneous blend of hydrocarbon resins and rubber or plasticizing materials with not more than 50% by weight of inert mineral filler
- Is pliable at temperatures between 32 °F and 135 °F. A specimen at 77 °F and 1/2 inch square in cross section shall stretch at least 1 1/2 inches before rupture when tested with the apparatus described in ASTM D 113.
- Adheres firmly and cohesively to the precast manhole sections when the compound-sealed joint is flexed to its maximum extent
- Includes a primer solution recommended by the compound manufacturer
- Conforms with Federal Specification SS-S-00210 (GSA-FSS)

02440.70 Water Stop - Use either plastic or rubber water stop, as the Contractor elects, manufactured to the dimensions called for on the plans and meeting the following:

(a) Plastic - Polyvinyl chloride water stop shall be manufactured from virgin polyvinyl chloride (PVC) compound. No reclaimed PVC will be allowed. The water stop shall have the following properties:

Test	ASTM Test	
	Method	Specification
Tensile Strength, psi	D 412	1,800
Elongation, %	D 412	350
100% Modulus, psi	D 412	760
Low Brittle Temperature	D 746	-50 °F
Cold Bend Test ¹		No Failures

¹ Samples maintained at -70 °F for two hours, then bent quickly around a 1/4 inch mandrel to 180°.

Furnish test samples of the material from which water stop is to be manufactured. Samples shall be in sheet form having a uniform thickness of from 1/16 inch to 1/8 inch and a total area of not less than 2 square feet. Each sample shall be comprised of pieces not smaller than 6 inch by 6 inch.

(b) Rubber - Manufacture rubber water stop to the dimensions shown, in such a manner that the finished product has an integral cross section which will be dense, homogeneous, and free from porosity and other imperfections. The water stop shall have the following properties:

- **Hardness** - The Shore A Durometer hardness of 60 to 70 when tested according to ASTM D 2240.
- **Elongation** - Minimum of 450%.
- **Tensile Strength** - Minimum of 3,000 psi.
- **Water Absorption** - Maximum of 5% by weight after immersion in water for two days at 158 °F.
- **Tensile Strength after Aging** - The test specimen, after accelerated aging of seven days at 158 °F, shall retain not less than 80% of the original tensile strength. The tensile strength of the test specimen, after accelerated aging of 48 hours in oxygen at 158 °F and tensile stress of 300 psi, shall be not less than 80% of the original tensile strength.
- **Compression Set** - Not more than 30% when tested according to ASTM D 395, method B after 22 hours at 158 °F.
- **Specific Gravity** - 1.17 plus or minus 0.03.
- **Defects** - Minor surface defects such as surface peel covering less than 1 square inch, surface cavities or bumps less than 1/4 inch in longest lateral dimensions and less than 1/16 inch deep will be acceptable.

02440.80 Acceptance - Acceptance of joint materials will be according to 00165.35 and this Section.

Section 02450 - Manhole and Inlet Materials

Descriptions

02450.00 Scope - This Section includes the requirements for precast manhole sump sections, metal frames, covers, grates and ladders.

Materials

02450.10 Precast Concrete Manhole Sections - Precast risers, cones and cover slabs for precast concrete manholes shall conform to the requirements of [ASTM C 478/C 478M](#) and the requirements of the Material Specifications for Precast Concrete Products (MSPCP) Manual published by the City of Portland Materials Testing Laboratory.

02450.20 Precast Concrete Sump Sections - Precast rings and lids for precast concrete sumps shall be of portland cement concrete conforming to [ASTM C 478/C 478M](#) and the requirements of the Material Specifications for Precast Concrete Products (MSPCP) Manual published by the City of Portland Materials Testing Laboratory.

02450.30 Metal Frames, Covers, Grates and Ladders - Comply with the following:

Item	AASHTO/ASTM Designation	Grade
Manhole frames and covers	M 105	Class 30 B
Inlet frames and grates	M227/A 663	65
	M270/A 709/A 36	36
	M 103/A 27	65 - 35
Manhole ladder rails	M270/A 709/A 36	36
	M 227/A 663	65

Fabricate steps for manholes and rungs for manhole ladders from structural steel having a minimum yield strength of 28,000 psi and galvanized according to [ASTM A 123/A 123M](#).

As an alternate, steps for manholes may be steel-reinforced plastic conforming to ASTM C 478/C 478M and ASTM C 497. The steel shall be deformed reinforcing bar conforming to ASTM A 615/A 615M Grade 60, #4 minimum. The plastic material surrounding the reinforcing steel bar shall be injection molded, with a textured, non-slip surface and a minimum thickness over the steel of 1/16 inch. Voids in the plastic will be cause for rejection of the step.

Welding shall conform to AWS D1.1. Frames, covers and grates for use one with another shall have even and uniform bearings. Miscellaneous metal items and hardware shall conform to the appropriate requirements of Section 00560.

02450.40 Damaged Zinc or Aluminum Coating - Repair damaged zinc or aluminum coating according to 02420.10(d).

02450.50 Acceptance - Acceptance of manholes and inlets will be according to 00165.35 and this Section.

Section 02470 - Potable Water Pipe Materials

Description

02470.00 Scope - This Section includes the requirements for various potable water pipe materials.

02470.10 General - Clearly mark all pipe with the type, class, thickness, and manufacturer's name, as applicable. Lettering shall be legible and permanent under normal conditions of handling and storage. All materials in contact with potable water shall conform to ANSI/NSF Standard 61, Drinking Water System Components - Health Effects, or equivalent (NSF 61).

Materials

02470.20 Ductile Iron Pipe:

(a) Conformance Requirements - Use centrifugally cast ductile iron pipe meeting the requirements of AWWA C151. Ductile iron pipe shall be fully gauged, standard thickness Class 52 or the thickness class specified or indicated. Nonrestrained joints shall be rubber gasket, push-on type, or mechanical type meeting the requirements of AWWA C111. Restrained joints shall conform to 02475.50.

(b) Lining and Coating - Ductile iron pipe shall have a shop applied double thickness cement-mortar lining and a seal coat of asphaltic material in accordance with AWWA C104 and NSF 61.

(c) Flanged Pipe - Flanged ductile iron pipe with threaded ductile iron flanges shall conform to AWWA C115. Flanges shall be drilled in accordance with ASME/ANSI B16.1, Class 125 complete with styrene butadiene rubber (SBR) full face gaskets. Bolts shall protrude through the assembled nut at least two threads but not more than 1/2-inch. Flanged connections shall not be buried, unless shown buried. Flanges shall be wrapped with two layers of 10 mil tape along edge of flanges.

02470.30 Steel Pipe 6 Inch and Larger:

(a) Conformance Requirements - Steel pipe 6 inches in diameter and larger shall conform to AWWA C200, and shall have a minimum wall thickness of 1/4 inch and a minimum working pressure rating of 150 psi, or as shown. The type of protective coating and lining and other supplementary information required by AWWA C200 shall be as called for in the specifications or as indicated.

(b) Length and Diameter - Steel pipe shall have inside diameters as specified in uniform lengths with a range of 20 to 40 feet. Provide shorter lengths as required for changes in alignment and grade.

(c) Pipe Ends - Pipe shall have ends fabricated for bell and spigot (push-on) joints, flanged joints, or welded joints, as specified. Joint grout shall be chloride free and NSF 61 approved.

(1) Push-On Joints - Pipe ends and joints shall conform to AWWA C200. Push-on joints are not acceptable on pipe larger than 48 inches in diameter.

(2) Flanged Joints - Flanges, gaskets and bolts shall conform to AWWA C207 and shall be rated for the working pressures specified but not less than 150 psi.

(3) Welded Joints - Joints shall conform to the requirements of AWWA C206. For pipe 36-inch nominal diameter and larger, lap joints shall be full fillet double welded.

(d) Lining and Coating:

(1) Mortar Lining - Pipe shall be supplied with a shop-applied NSF 61 approved, double Type II cement mortar lining, conforming to AWWA C205.

(2) Exterior Coating - Pipe shall be supplied with an exterior protective coating in accordance with AWWA C203 (hot applied, cold tar enamel coating) or AWWA C214 (cold applied, tape coating) or AWWA C205 (cement-mortar protective coating). The hot applied, coal tar enamel coating (AWWA C203) shall consist of Type B primer, coal tar enamel, and glass-fiber outerwrap.

02470.35 Steel Pipe under 6 Inch - Steel pipe less than 6 inches in diameter shall be hot-dip galvanized inside and out and meet the requirements of ASTM A 53/A 53M. Steel pipe thickness shall be Schedule 40 or the thickness class specified or indicated.

02470.36 Concrete Cylinder Pipe:

(a) General - Concrete cylinder pipe shall conform to AWWA C303 with a minimum cylinder thickness of 3/16 inches.

(1) Bonding Connection Points - Concrete cylinder pipe shall have bonding connection points as recommended by the manufacturer.

(2) Length and Diameter - Concrete cylinder pipe shall have inside diameters as specified in uniform lengths with a range of 20 to 40 feet. Provide shorter lengths as required for closures and changes in alignment and grade.

(3) Manufacturer Testing - Hydrostatically test the pipe at the manufacturing plant in accordance with AWWA C303. Pipe shall have ends fabricated for bell and spigot (push-on) joints, flanged joints, or welded joints, as specified. If no information is provided about the type of joint to be used, provide push-on joints. Joint grout shall be chloride free and NSF 61 approved.

(b) Push-On Joints - Pipe ends and joints shall conform to AWWA C303. Push on joint gasket shall conform to AWWA C303.

(c) Flanged Joints - Flange joints, including gaskets, nuts and bolts shall conform to AWWA C207 and shall be rated for the working pressures specified but not less than 150 psi.

(d) Welded Joints - Joints shall conform to the requirements of AWWA C206.

(e) Lining and Coating - Pipe shall be supplied with Type II cement mortar lining and coating conforming to AWWA C303 and NSF 61 approved.

02470.50 Polyethylene Encasement - Polyethylene tube encasement shall conform to AWWA C105 and tube encasement shall be provided by the pipe manufacturer. Polyethylene sheet is not acceptable.

02470.60 Detectable Marking Tape or Wire:

(a) External Properties - Detectable marking tape shall consist of inert polyethylene plastic impervious to all known alkalis, acids, chemical reagents and solvents likely to be encountered in the soil, with a metallic foil core to provide the most positive detection by pipeline locators. The width of the tape shall be as recommended by the manufacturer for the depth of installation. Tape shall be blue and imprinted continuously over its entire length in permanent black ink with the words "Caution - Water", or "Water" or "Water-line".

(b) Internal Properties - Detectable marking wire shall be No. 12 AWG, minimum, solid copper with blue colored polyethylene insulation. Joints or splices in wire shall be waterproof. Runs less than 500 feet shall have no more than one splice for new construction.

02470.70 Acceptance - Potable water pipe materials will be accepted according to 00160.06, 00165.35, and this Section.

Section 02475 - Potable Water Fitting Materials

Description

02475.00 Scope - This Section includes the requirements for fittings, restrained joints and couplings for ductile iron pipe, steel pipe, **concrete cylinder pipe** and polyvinyl chloride (PVC) pipe for potable water systems.

Materials

02475.10 General:

(a) Securing Fittings - Bolts, nuts and washers used for securing fittings shall be of similar materials.

(b) Nuts and Bolts - Steel bolts shall meet the requirements of ASTM A 307 for carbon steel, or ASTM F 593 for stainless steel. Nuts shall meet the requirements of ASTM A 563 for carbon steel and ASTM F 594 for stainless steel. Iron bolts and nuts shall meet the requirements of ASTM A 536, grade 65-45-12.

(c) Galvanize - Galvanize carbon steel bolts, nuts and washers according to Section 02560.

(d) Conformance Requirements - All materials in contact with potable water shall conform to ANSI/NSF Standard 61, Drinking Water System Components - Health Effects, or equivalent.

(e) Pressure Ratings - All fittings and appurtenances shall meet or exceed the design pressure rating for the pipe.

02475.20 Ductile Iron Pipe Fittings:

(a) Conformance Requirements - Fittings for ductile iron pipe shall meet the requirements of AWWA C110 or AWWA C153, and shall have a minimum working pressure rating of 250 psi. Joints shall meet the requirements of AWWA C111.

(b) Linings and Coatings - Fittings shall be cement mortar lined and seal coated, meeting the requirements of AWWA C104. **Double thickness cement mortar lining is preferred, but single thickness cement mortar lining will be accepted.**

(c) Gaskets - Gaskets for flat faced or raised faced flanges shall be 1/8 inch thick **rubber** having a Durometer reading of 60, plus or minus 5.

(d) Bolts and Nuts - The type, material and identification mark for bolts and nuts shall be provided.

(e) Large Fittings - Fittings 24 inches to 48 inches shall be of non-compact mechanical joint type conforming to AWWA C110.

02475.30 Fittings for Steel Pipe 6 Inches and Larger - Fittings for steel pipe 6 inches in diameter and larger shall conform to AWWA C200, have a minimum working pressure rating of 150 psi or as specified or indicated, and shall receive a protective coating and lining to match the steel pipe provided. Flex couplings shall be compression type. When flanges are required, they shall meet the requirements of AWWA C207, and gaskets shall conform to 02475.20. Steel pipe fittings shall have a minimum wall thickness of 1/4 inch.

02475.31 Fabricated Steel Drip Tee Fittings:

(a) General - Drip tee fittings and accessories shall be new and unused. The manufacturer's identification shall be distinctly cast upon flanges and fittings. All fittings shall be shipped less accessories unless specifically stated otherwise. Drip tees are a special fabrication for the City for use in service installations and regulator installations.

(b) Fabrication - Drip tees shall be fabricated of steel pipe; forged steel, threaded branch connection; and ring-type steel slip-on flanges. Pipe shall conform to AWWA C200 for 6 inch pipe and larger. The 4 inch pipe shall conform to schedule 80, ASME/ANSI B36.10 for pipe material. Branch connection shall be a Threadolet as manufactured by Bonny Forge Co., P.O. Box 359, Allentown, PA 18105, or approved equal, in the size listed below for 2 inch outlet. Flanges for the assembly shall meet AWWA C207, Class D, 175 psi rating.

(c) Coating - Fabricated assembly shall be coated with a fusion bonded epoxy coating in conformance with AWWA C213.

(d) Special Requirements - Fabricated assembly uses the following components and shall be of overall length as shown. The branch connection (Threadolet, or approved equal) shall be oriented so that the fitting can be at the top or rolled 90° for side outlet use, and centered between the flanges.

Fabricated Assembly	Branch Outlet	Ring-type Slip-on Flanges	Overall Assembly Length
4x4x2	4-3-1/2x2	2-Class D	9 inches
6x6x2	6x2	2-Class D	9 inches
8x8x2	10-8x2	2-Class D	11 inches
12x12x2	18-12x2	2-Class D	11 inches

02475.32 Plain End Fittings - Factory cast plain-end fittings are only allowed as shown.

02475.35 Fittings for Steel Pipe under 6 Inches - Fittings for steel pipe less than 6 inches in diameter shall be malleable iron threaded type with a pressure rating of 150 psi or as specified or indicated. Dimensions shall meet the requirements of ANSI B16.3. Threading shall meet the requirements of ANSI B2.1. Material shall meet the requirements of ASTM A 47/A47M, Grade 22010. Fittings shall be banded and hot-dip galvanized inside and out.

02475.36 Fittings for Concrete Cylinder Pipe - Fittings for concrete cylinder pipe shall conform to AWWA C303 with a minimum cylinder thickness of 3/16 inches and shall have bonding connection points as recommended by the manufacturer.

02475.50 Restrained Joints - Restrain ductile iron pipe, fittings and valves by using a pre-approved system. Provide the restraint system to operate at a working pressure equal to the hydrostatic test pressure required in 01140.51(a) or as shown. No device utilizing round point set screws will be permitted. Provide gaskets and core 10 type or better T-bolts from same manufacturer of the restrained systems or manufacturer's supplier. Loose bound (bulk) gaskets and bolts shall have accompanying documentation from the manufacturer.

02475.60 Bolted, Sleeve-Type Couplings for Plain-End Pipe:

(a) Conformance Requirements - 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, coated and lined to match the steel pipe provided.

(b) Shop Coat Enamel - Ductile iron sleeves and end rings shall have a shop coat enamel finish.

(c) Epoxy Finish - Steel sleeves and end rings shall have fusion bonded epoxy finish suitable for potable water systems meeting NSF 61 regulations.

(d) Bolts - Bolts shall be high strength, low-alloy steel manufactured to ASTM A325 with heavy hexagon nuts manufactured to ASTM A563.

(e) Gaskets - Full gaskets shall be rubber of all new materials compounded to resist oil, acids, alkalis, and water.

02475.70 Acceptance - Acceptance of fittings, restrained joints and couplings will be according to 00160.06, 00165.35 and this Section.

Section 02480 - Potable Water Valve Materials

Description

02480.00 Scope - This Section includes the requirements for gate valves, butterfly valves, ball valves, power actuating devices, valve boxes, valve stem extensions, tapping sleeve and valve assemblies, check valves, hydraulically operated valves, combination air release/air vacuum valves, and backflow prevention devices for potable water systems.

Materials

02480.20 Gate Valves - Gate valves shall meet the requirements of AWWA C509.

(a) Conformance Requirements - The minimum design working pressure shall be 200 psi for valves 2 inches to 12 inches in diameter. Non-rising stems shall be used for buried valves. Sizes not specified in AWWA C509 shall not be allowed for use without approval prior to purchase.

(b) Directional Indicator - Each valve shall open left (counterclockwise) and shall have an arrow showing the direction of opening. Position indicators will not be required.

(c) Component Properties - The valve gate shall be cast gray or ductile iron, with guide bars or channels for controlled movement, and may have an integral 2 inch bronze stem nut. The gate and gate guide bars or channels shall be fully encapsulated by a resilient rubber material bonded to the metal. The gate stem hole, if not also encapsulated, shall be epoxy coated. The method used to provide the rubber-to-metal bond shall be in accordance with the requirements of ASTM D429. The peel strength shall not be less than 75 pounds per inch.

02480.22 Butterfly Valves:

(a) Conformance Requirements - Butterfly valves shall be rubber seated and shall meet the requirements of AWWA C504, Class 150B. Shaft seals shall be standard O-ring seals, designed for replacement under line pressure.

(b) Operating Criteria - Valves shall be bi-directional flow, capable of performing in applications involving throttling service, frequent operation, and operation after long periods of inactivity.

(c) Valve Construction - Valve construction shall meet the following requirements:

(1) Valve shafts - Wrought stainless steel or Monel.

(2) Valve seat mating surface - Stainless steel, Monel or plasma welded nickel-chrome.

(3) Valve coatings - Valves with a complete rubber liner shall not be accepted. Butterfly valves shall have fusion bonded epoxy coating for the exterior valve body.

(4) Thrust Bearing - Two-way type.

(5) Valve Testing – Valves shall be tested in accordance with AWWA C504. Leakage tests shall be performed in both directions.

(d) Large Butterfly Valves - Butterfly valves 30 inches and larger in diameter shall be constructed so that complete seat replacement can be made without valve disassembly, and without removing the valve from the line.

(e) Valve Operators - Valve operators shall be of the traveling nut or worm gear type, sealed, gasketed and permanently lubricated for buried service. Construct valve operators to the standard of the valve manufacturer to withstand all anticipated operating torques, and design to resist submergence in ground water. Operators for buried services shall be equipped with a 2-inch square operating nut. Valves shall close with a clockwise rotation of the nut. Operator nut shall be installed between the water main and the short side to the curb.

(f) Open to Close - Minimum number of turns from fully open to fully closed shall be as follows:

4 inches to 8 inches	16 turns
10 inches to 12 inches	28 turns
14 inches to 18 inches	30 turns
20 inches to 24 inches	44 turns
30 inches	60 turns
36 inches	72 turns
48 inches	96 turns
54 inches and larger	200 turns

02480.23 Ball Valves:

(a) Conformance Requirements - Ball valves shall be double seated, with rubber seat materials mating with metal seating surface, and shall meet the requirements of AWWA C507. The minimum design working pressure shall be 150 psi. Shaft seals shall be standard O-ring seals, designed for replacement under line pressure.

(b) Valve Operators - Valve operators shall be of the traveling nut or worm gear type, sealed, gasketed and permanently lubricated for buried service. Valve operators shall be constructed to the standard of the valve manufacturer to withstand all anticipated operating torques and shall resist submergence in ground water.

02480.24 Power-Actuating Devices - Power-actuating devices for valves shall meet the requirements of AWWA C540. The type of power-actuating devices to be furnished and the operating requirements will be as indicated [and shown](#).

02480.25 Valve Boxes - City will furnish valve boxes and covers (CIV). The 8 inch PVC pipe, ASTM D3034, shall be Contractor-furnished.

02480.26 Valve Operator Extensions - Valves with an operating nut more than 4 feet below the finished grade shall have valve operator extensions installed. Valve operator extensions shall be manufactured per plan. Hot dip galvanize operator extensions after fabrication.

02480.30 Tapping Sleeve and Valve Assemblies:

(a) General - The City shall perform all tapping on the active/live water system unless otherwise specified.

(1) Tapping Sleeves - Tapping sleeves shall be capable of installation on several classes of ductile iron pipe as well as A and C cast iron. Installation shall require no special tools, shims, welding, or caulking.

(2) Tapping Valves - Furnish tapping valves with flanged inlet end connections. The outlet ends shall conform in dimensions to the ASME/ANSI B16.1 for hub or mechanical joint connections, except that the outside of the hub shall have a large flange for attaching a drilling machine.

(3) Associated Equipment - The valves shall be used with a Mueller drilling machine, Model No. CC-25, or approved equal. The seat opening of the valve shall permit a diameter cut no less than 1/2 inch smaller than the valve size.

(4) Conformance Requirements - 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.

(5) Assembly Rating - The installed assembly must be rated by the manufacturer for a minimum working pressure of 175 psi and capable of a minimum test pressure of 125% without leakage or pressure loss.

(b) Steel - Flanged - Tapping Sleeves – Sleeves shall be manufactured from materials per AWWA C200 and be finished with fusion bonded epoxy, minimal 12 mils exterior, NSF 61 approved. Fabrication shall be in accordance with AWWA C200 and C207.

(c) Ductile Iron - Mechanical Joint - Tapping Sleeves – Sleeves shall be manufactured from materials per AWWA C110, C111, C115, C150, and/or C153 as applicable. Sleeves shall be manufactured in accordance with MSS SP111.

(d) Outlet Flanges – Flanges shall be recessed to mate with standard tapping valves per MSS SP60 up through 12 inches in size. Steel flanges shall comply with AWWA C207, Class D with ASME/ANSI B16.5, 150 psi drilling. Ductile iron flanges shall comply with AWWA C110, C115, C150 with ASME/ANSI 16.1, class 125 drilling.

02480.40 Check Valves:

(a) Swing Check Valve - Swing check valves shall meet the requirements of AWWA C508, with rubber seat materials mating with metal seating surfaces. The minimum design working pressure shall be 175 psi for check valves with diameters of 12 inches and smaller, and 150 psi for 14-inch and 16-inch diameters. Check valves shall be nonassisted, unless otherwise indicated.

(b) Spring-Loaded Plug or Disc Check Valves - Spring-loaded plug or disc check valves shall be bronze mounted with bronze, cast or ductile iron body, bronze plug or disc, stainless steel spring, and resilient seating suitable for potable water service. The valves shall provide drop-tight sealing. The plugs or discs shall be easily replaceable. The minimum design working pressure of the valves shall be 150 psi.

(c) Hydraulic Cushion Check Valves - Hydraulic cushion check valves shall be of bronze, cast or ductile iron, with bronze disc and disc faces, seat rings and pivot pins. The valves shall provide droptight sealing. The valves shall be fitted with adjustable speed, integrally mounted, oil dashpot mechanical snubber systems. The minimum design working pressure of the valves shall be 150 psi.

02480.50 Hydraulically Operated Valves:

(a) General - Hydraulically operated valves shall be pilot controlled and diaphragm operated, bronze or stainless steel mounted with bronze, cast or ductile iron body, globe or angle orientation as indicated. Provide valve position indicators. The minimum design working pressure of the valves shall be 175 psi. Pilot controls and piping shall be bronze, designed to operate the main valves as indicated, and shall include stop valves, strainers and adjustable closing speed controls.

(b) Size 2 ½ Inches and Under - Valve shall have cast iron body with female IPT threaded ends and shall be direct acting or pilot operating depending on system requirements. Valve shall have adjustable outlet pressure ranging from 15 to 75 psi.

(c) Size 3 Inches and Above - Valve shall have cast iron body, globe style with flanged ends of either 125 or 250 drilling based on system requirements. Valve shall have adjustable outlet pressures ranging from 15 to 100 psi.

02480.51 Pressure Relief Valves - Valve, ½ to 2 ½ inches in size, shall have bronze body with soft seat design and shall have female IPT ends with inlet ranging from ½ to 2 inches and outlet ranging from ¾ to 2 ½ inches. Orifice sizes range from 0.121 to 1.399 square inches. The valve shall have a temperature range of -20 deg F to 800 deg F and average pressure range of 15 to 500 psig. Valve shall meet ASME Section VIII, designed for high capacity, low pressure applications on assorted media.

02480.60 Combination Air Release/Air Vacuum Valves:

(a) General - Combination air release/air vacuum valves shall 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.

(b) Conformance Requirements - Combination air release/air vacuum valves shall meet the requirements of AWWA C512. The body and cover shall be cast iron conforming to ASTM A 48/A 48M, Class 30. Floats shall be stainless steel conforming to ASTM A 240/A 240M and designed to withstand 1,000 psi. Seats shall be Buna N rubber. Internal parts shall be stainless steel or bronze.

02480.70 Backflow Prevention Devices - Backflow prevention devices shall be capable of withstanding a minimum design working pressure of 150 psi, and shall conform to the following:

(a) Reduced Pressure Principle Backflow Prevention Assembly - Reduced pressure principle backflow prevention assemblies shall consist of a mechanical, independently operating, hydraulically dependent relief valve located between two independently operating, spring loaded check valves that are located between two tightly closing resilient seated shutoff valves, with four resilient seated test cocks, all meeting the requirements of AWWA C511 and the Oregon State Health Division.

(b) Double Check Valve Backflow Prevention Assembly - Double check valve backflow prevention assemblies shall consist of two spring loaded, independently operating check valves, located between two tightly closing resilient seated shutoff valves, with four resilient seated test cocks, all meeting the requirements of AWWA C510 and the Oregon State Health Division.

02480.71 Blowoff Assemblies - Use materials as shown.

02480.80 Acceptance - Acceptance of potable water valve materials will be according to 00160.06, 00165.35 and this Section.

Section 02484 - Pre-cast Concrete Vault Materials

Description

02484.00 Scope - This Section includes the material requirements for precast concrete vaults.

Materials

02484.10 General - Furnish a precast concrete vault complete with floor, roof, grated sump, access door, manhole riser ring(s) and lid, ladder, ladder extension, coal tar epoxy joint sealer, waterproofing surface sealer, incidentals and appurtenances, as shown. Provide vault type and size with the appropriate top to accommodate either an access door or manhole, as specified and shown or as directed. Vault shall be watertight and shall support a minimum of H-20 traffic loading. Vault shall have solid walls 4 inches thick minimum with no knock outs.

02484.20 Concrete Vault Sections - Concrete vault sections shall be designed and manufactured per ACI 318-89, AASHTO 92 and ASTM C913/857, with H-20 loading and 30% impact factor over an 8 inch wide x 20 inch long area. Design loading assumptions are as follows:

Soil Cover (5 foot Maximum)	100 pcf
Fluid Pressure above water table	30 pcf
Fluid Pressure below water table.....	75 pcf

Concrete shall have a minimum 28-day compressive strength of 4500 psi. Details and placement of reinforcing bar shall be in accordance with ASTM A-615. Concrete components shall meet the following standards:

Type II/III Cement	ASTM C-150
3/4" Rock (washed)	ASTM C-33
Sand	ASTM C-33
Plasticizer	ASTM C-494
Water Reducer.....	ASTM C-494
Air Entrainment.....	ASTM C-260
Reinforcing Mesh.....	ASTM A-185
Reinforcing Bar	ASTM A-615 GR 60

Removable lifting eyes shall be provided for each individual section.

02484.25 Pre-cast Vault Roof - Provide precast vault roof with access hatch or manhole and valve box opening of the dimensions and orientation as shown.

02484.27 Joint Sealant - Butyl rubber joint sealant shall be provided for the vault and manhole section joints and for all riser rings.

02484.30 Pipe Penetration Seals - Pipe penetrations through walls or vaults shall be made watertight by the use of a modular mechanical type seal consisting of interlocking

synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening.

02484.35 Access Doors:

(a) General - Access doors where required shall be of spring-assisted diamond plate type with locking latch and angle iron frames cast in one 6 inch minimum concrete riser ring. Doors shall be water-tight, rated for H-20 loading and be constructed of steel, hot dipped galvanized after fabrication; or aluminum, with non-slip surface having a static coefficient of friction between 0.60 and 1.00 as determined by ASTM C1028. Access hatches on inclines greater than 4% shall have a coefficient of 0.80 to 1.00.

(b) Single and Double Doors - Doors shall be a single opening or double opening lid secured with non-removable, penta head bolts. Single doors shall utilize one bolt. Double doors shall have two bolts mounted on the corners of the overlapping door. Each door shall have two 90° 'hold open' arms.

02484.40 Ladder and Ladder Extension - Center/Base vault sections shall include chamber ladder and extension. Use structural steel with a minimum yield strength of 36,000 psi per ASTM A-36. Ladder and all mounting hardware shall be hot dipped galvanized after fabrication, in accordance with ASTM A-123. Nuts and bolts shall be all stainless steel, minimum 1/2 inch in diameter. Length of ladder and mounting details shall be as shown.

02484.45 Grates - Grates shall be hot dipped galvanized after fabrication in accordance with ASTM A-123.

02484.50 Valve Box and Cover (CIV) - Cast iron valve (CIV) boxes and covers for installation into the vault roof as shown will be furnished by the City. Provide non-shrink grout around valve boxes.

02484.55 Paint, Sealers and Coatings - A two coat system, aluminum mastic, with all paint material, shall be Carbo Mastic 15 as manufactured by Carboline, Inc., or approved equal.

02484.60 Bedding Backfill and Cover - The aggregate used for bedding and backfill shall be Class B and conform to Section 02630. Cover material shall be as shown.

02484.65 Filter Fabric - Filter fabric shall be non-woven meeting the requirements of Section 00350.

02484.70 Drain Rock - Drain rock shall be washed round aggregate, with a maximum size of 3 inches with zero percent passing the No. 4 screen.

02484.80 Sump Drain Valve - The sump drain valve shall be model 4FH manufactured by Flood-Guard or approved equal.

02484.85 Acceptance - Precast concrete vault materials will be accepted according to 00160.06, 00165.35, and this Section.

Section 02485 - Hydrants and Appurtenance Materials

Description

02485.00 Scope - This Section includes the requirements for hydrants, hydrant appurtenances and guard posts for potable water systems.

Materials

02485.10 Fire Hydrants:

(a) General - Fire hydrants shall be dry-barrel, conforming to AWWA C502, of standard manufacture and of a pattern approved by the City. Hydrants shall be designed for a minimum working pressure of 150 psi.

(b) Conformance Requirements - All materials in contact with potable water shall conform to ANSI/NSF Standard 61, Drinking Water System Components - Health Effects (NSF 61), or equivalent.

(c) Seals and O-rings - Hydrants shall have O-ring stem and valve seals. Main valve seat ring and seat ring bushing shall be bronze. Removal of main valve assembly including seat ring shall be by a tool that engages the stem either at the breakaway stem coupling or the upper stem section.

(d) Lubricant Fixtures - Operating nut thrust collar and threaded stem drive shall be one piece bronze. Oil filler plug or grease fitting shall be furnished in bonnet to lubricate thrust collar and stem drive. Lubricant reservoir shall be a permanently sealed reservoir. Anti-friction thrust washer shall be Teflon, or equal, fitted on top of thrust collar. Furnish a positive stop to prevent over travel of the stem.

(e) Drain Valves - Furnish two or more bronze bushed drain valves. Drain valve shall close within six turns, at start of opening hydrant.

02485.20 End Connections - End connections shall be mechanical joint conforming to the requirements of AWWA C110 and C111.

02485.30 Hydrant Dimensions and Nozzles:

(a) Configuration - Hydrant connection pipes shall be 6 inches inside diameter with 6 inch auxiliary gate valve. Hydrant length, measured from the bottom of the hydrant to the sidewalk ring shall provide sufficient cover at each installed location. Valve openings shall be 5 inches minimum diameter. Hydrants shall have two 2 1/2-inch hose nozzles and one 4 1/2-inch pumper nozzle.

(b) Nozzles - Nozzle threads shall conform to National Fire Protection Association (NFPA) No. 1963 - Standard Specification for National Fire Hose Coupling Screw Threads. Hydrant nozzle caps shall have inside neoprene gaskets. Do not furnish nozzle cap chains or cable. Hydrant nozzles shall be lug or screw type and shall be brass.

(c) Nozzle Caps - Fit nozzles with cast iron threaded caps with operating nuts of the same design and proportions as the hydrant stem nuts. Operating and nozzle cap nuts shall be pentagon shape, 1 1/4 inches from point to opposite flat at base of nut and 1 3/16 inches from point to opposite flat at top of nut with a tolerance of 1/64 inches for each dimension from flat to opposite point. Thread caps to fit the corresponding nozzles and fit with suitable gaskets to ensure positive water tightness under test pressure. The direction of opening shall be counterclockwise and shall be clearly marked on the operating nut or hydrant top.

02485.40 Hydrant Extensions:

(a) General - Hydrant extensions shall be gray cast iron or ductile iron with an inside diameter of at least 6 inches, 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.

(b) Operating Stem Extensions - Hydrant extensions shall also include the necessary hydrant operating stem extensions.

02485.50 Traffic Flange - Provide hydrants with a traffic flange. Hydrants 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. Also provide, at this point, a safety stem coupling on the operating stem that will shear upon impact. **Aluminum couplings are not acceptable.**

02485.51 Other Materials - Drain rock shall conform to Class D backfill as specified in Section 00405. Geotextile fabric for drain rock shall conform to Type 1 drainage geotextile as specified in Section 02320. Furnish material conforming to Section 00440 for concrete hydrant pads.

02485.52 Out of Service Cover - Provide yellow or orange plastic bag or cover with reflective tape and, if necessary, approved plastic hydrant out-of-service rings.

02485.70 Guard Posts - **If shown**, guard posts for hydrants shall be galvanized steel pipe, 6 inches in diameter, meeting the requirements of ASTM A53/A 53M, Schedule 40, filled with commercial grade concrete, and with the concrete domed at the top.

02485.75 Painting - Hydrants shall be painted in accordance with AWWA C502. Exterior paint shall conform to Federal Specification TT-E-489 G. Furnish the hydrant with standard exterior colors as follows:

<u>Component</u>	<u>Color</u>
Hydrant Barrel	OSHA Safety Orange
Nozzle Caps	Black
Pumper Caps	OSHA Safety Red
Dome or Top	OSHA Safety Orange

02485.80 Acceptance - Acceptance of hydrants and hydrant appurtenances will be according to 00160.06, 00165.35, and this Section.

Section 02490 – Potable Water Service Connection Materials, 2 Inch and Smaller

Description

02490.00 Scope - This Section includes the requirements for materials for potable water service connections 2 inches in diameter and smaller, and sampling stations.

Materials

02490.10 General - Service line materials shall conform to the latest version of AWWA C800 and these specifications. Unless otherwise specified, the minimum working pressure rating of all service line materials shall be 150 psi. In addition, all service line materials provided shall be rated for the test pressures indicated in Section 01140.51. All materials in contact with potable water shall conform to ANSI/NSF Standard 61, Drinking Water System Components - Health Effects (NSF 61).

02490.11 Stops and Valves - All corporation stops, curb stops and meter valves shall be of the ball-valve design with full port opening and have a flow passage area equivalent to the fitting outlet flow area.

02490.12 Padlock Wings - Curb Stops and meter valves shall be provided with padlock wings.

02490.13 Valve Ball - Balls for the corporation and curb valves shall be fabricated from the same material as the body. A Teflon or Nitrile seat or another material proven not to deteriorate when exposed to chemicals such as chloramines shall support the ball.

02490.14 Gaskets - Each compression nut shall be fitted with a gasket and shall contain a groove in its inner surface to locate a stainless steel gripper band. The gasket shall contain a built-in metal conductor spring at one-end to provide electrical continuity between the copper tubing and the coupling.

02490.20 Saddles - Saddles shall be bronze. Saddles used for 1 inch services may be single strap saddles and have AWWA tapered thread outlet. Saddles used for 2 inch services shall be double strap and have AWWA tapered thread outlet.

02490.30 Corporation Stops:

(a) General - Make corporation stops of bronze alloy. Corporation stops for direct tapping shall have AWWA tapered thread inlet and outlet connections compatible with copper tubing.

(b) Threads - Corporation stops used with 1 inch and 2 inch outlet saddles shall have AWWA tapered thread inlets and outlet connections compatible with copper tubing. Thread patterns for the saddle outlet and corporation stop inlet shall be the same.

02490.40 Service Pipe and Fittings:

(a) Copper Pipe & Tubing - Copper tubing shall be in accordance with ASTM B 88. Tubing shall be type K, seamless, and annealed. Sizes 1 inch and below shall be soft drawn design, 0.065 inch wall thickness. Sizes larger than 1 inch shall be hard drawn design, 0.083 inch wall thickness.

(b) Brass Pipe - Brass Pipe shall conform to the standard dimensions, weights, and tolerances for "regular" weight pipe in accordance with ASTM B43. Material composition shall be copper alloy UNS No. C23000. Pipe shall be furnished in the annealed condition to Standard No. "O 61" in accordance with ASTM B601. Pipe shall meet the test requirements of ASTM B43.

(c) Brass and Bronze Service Fittings - Brass and bronze service fittings shall have an alloy composition of copper, tin, lead and zinc in accordance with ASTM B62. The material shall be copper alloy UNS No. 83600. Mechanical services shall have a 100 percent machine finish with no gaps or low spots due to insufficient parent material. All fittings shall either be stamped or embossed with the manufacturer's name.

(d) Brass and Bronze Pipe Nipples - Brass pipe nipples shall be in conformance with ASTM B687. Material, composition and mechanical properties for pipe nipples furnished shall be the same as for Category B copper alloy UNS No. C83600. Threads for pipe nipples will conform to Sections 6 and 11 of AWWA C800, and ASME/ANSI Standard B1.1 as noted in Category B. Standard length and size of nipples shall conform to Section 7 and Table 2 of ASTM B687 for standard and close nipples. All other provisions of ASTM B687 "Brass, Copper and Chromium-Plated Pipe Nipples" shall apply to the materials furnished.

02490.50 Meter Setters:

(a) General - Meter Resetters shall be made of materials as per AWWA C800 specifications and assembled with lead-free solder.

(b) Properties - Resetters shall be made of Type "L" copper tubing and 85-5-5 quality brass and shall have saddle nuts for easy resetting of meters. The length between the saddle nuts will be the same as the brass bar that is threaded and the length of the meter desired.

(c) Resetter Support - Resetter shall have a brass bar to support the front and back side. Resetter shall have the same length of existing meter, with the same threads. Connect before the old existing meter couplings (meter threads).

(d) Configuration - The inlet side shall have a length of copper tubing bent to the size ordered and soldered (lead-free) into the brass bar from the top of the brass bar of 90 deg bend. At the top of the copper tubing, solder (lead-free) an IPT brass bushing with an angle curb stop with a saddle nut shall be attached. The outlet side shall have a length of copper tubing bent to the size ordered and soldered (lead-free) into the brass bar from the top of the brass bar for a 90 deg bend. At the top of the copper tubing, it will be formed to a flat surface of 1/4 inches with a saddle nut for ease in service installation of meter.

(e) 2 Inch Meter Setters - The 2 inch meter setters shall be specially designed and must conform to approved drawings on file.

02490.70 Meter Boxes - Meter boxes will be City-furnished and installed by the Contractor.

02490.80 Sampling Stations - Sampling stations shall have a 3/4 inch inlet with the depth of bury indicated, and a 3/4 inch unthreaded nozzle. Enclose the sampling station in a lockable, non-removable, cast aluminum housing. When opened, the station shall require no key for operation, and the water shall flow in an all-brass waterway. All working parts shall also be of brass and be removable from above ground with no digging. Exterior piping shall be brass. Include at each station a copper vent tube with a ball valve to enable the station to be pumped free of standing water to prevent freezing.

02490.90 Acceptance - Materials for potable water service connections will be accepted according to 00160.06, 00165.35, and this Section.

Section 02510 - Reinforcement

Description

02510.00 Scope - This Section includes the requirements for bars, dowels, and strand reinforcement and tendon ducts.

Materials

02510.10 Deformed Bar Reinforcement - Deformed bar reinforcement shall conform to the requirements of ASTM A 706/A 706M or ASTM A 615/A 615M. Unless otherwise specified or shown, all reinforcing bars shall be Grade 60.

02510.11 Epoxy Coated Reinforcement:

(a) General - Epoxy coated reinforcement shall conform to the requirements of ASTM A 775/A 775M and (b), (c) and (d) below.

(b) Coating Voids - Patch visible voids in the coating, regardless of cause, according to 00530.48.

(c) Handling - All systems for handling coated bars shall have padded contact areas for the bars wherever possible. Pad all bundling bands and lift all bundles with strongbacks, multiple supports or platform bridges so as to prevent bar-to-bar abrasion from sags in the bar bundle.

(d) Coated Reinforcement Ties and Supports - Ties for coated reinforcement shall be nonmetallic coated. Where coated bars are tied to uncoated bars, the ties shall be nonmetallic coated.

(e) Prequalification, Sampling and Testing - Prequalify all epoxy coating and patching/repair material according to ASTM A 775/A 775M. All testing shall be performed by a qualified private testing laboratory. The Department's Materials Laboratory will review all test data to determine whether the material meets the prequalification requirements.

At the time of epoxy coated reinforcing bar shipment, furnish the Engineer a written certification that the coated bars were cleaned, coated and tested according to ASTM A 775/A 775M and according to (b), (c), and (d) above, and that the coating material used on the project is the same as that prequalified.

(f) Plant Certification - Epoxy coated reinforcement shall be produced in a Concrete Reinforcing Steel Institute (CRSI) Certified Epoxy Coating Plant.

02510.20 Mechanical Splices - Mechanical splices for reinforcing bars are systems which connect the bars without raising their temperature above 1,300 °F.

- Provide mechanical splices from the CPL that develop at least 135% of the specified minimum yield strength of the reinforcing bars in tension. Where bars of different sizes or strengths are connected, the governing strength shall be the strength of the smaller or weaker bar.
- The total slip of reinforcing bars within a splice sleeve shall not exceed 0.040 inch, measured between gauge points clear of the splice sleeve, when the reinforcing bars are loaded in tension to 67% of the specified minimum yield strength of the reinforcing bar.

02510.30 Galvanized Reinforcement:

(a) General - Galvanized reinforcement shall conform to the requirements of ASTM A 767/A 767M, Class II, including Supplementary Requirement S3, and ASTM A 143.

(b) Fabrication - The bars may be fabricated before or after galvanizing. If the bars are fabricated after galvanizing, Supplementary Requirements S1 and S2 of ASTM A 767/A 767M shall apply.

(c) Handling - All systems for handling galvanized bars shall be according to 02510.11(c).

(d) Ties and Supports - Tie all mats of galvanized steel bars with galvanized ties. Precast concrete blocks that support galvanized reinforcement shall have galvanized ties.

02510.40 Welded Wire Fabric - Welded wire fabric shall conform to the requirements of ASTM A 185. Deformed welded wire fabric shall comply with ASTM A 497.

02510.50 Dowels - Dowels shall conform to the requirements of ASTM A 615/A 615M, for Grades 40 and 60, or ASTM A 663/A 663M for Grades 70, 75, and 80.

02510.60 Wire Reinforcement - Wire reinforcement shall conform to the requirements of ASTM A 82. Deformed wire shall conform to the requirements of ASTM A 496.

02510.70 Acceptance - Acceptance of reinforcement will be according to 00165.35 and this Section.

Section 02515 - Prestressing Reinforcement

Description

02515.00 Scope - This Section includes the requirements for seven-wire strand, high tensile strength wire, high tensile strength steel alloy bars, tendon duct and couplings.

Materials

02515.10 Seven-Wire Strand - Seven-wire strand, (bright wire) shall conform to the requirements of ASTM A 416/A 416M, Grade 270, supplement 1 (low relaxation strand), minimum ultimate strength, 270,000 psi.

02515.20 Wire, High Tensile Strength - High tensile strength wire shall conform to the requirements of ASTM A 421/A 421M.

02515.30 Bars, High Tensile Strength - High strength steel bars shall conform to the requirements of ASTM A 722/A 722M.

02515.40 Seven-Wire Strand Epoxy Coated Reinforcement - Epoxy coated reinforcement shall conform to the requirements of ASTM A 882/A 882M.

02515.50 Tendon Duct - Provide rigid galvanized steel ducts for post-tensioned structures. Transition couplings connecting rigid ducts in anchoring devices need not be galvanized.

Rigid ducts may be fabricated with either welded or interlocking seams. Galvanizing of the welded seam is not required. Provide ducts with sufficient strength to maintain their correct alignment during placing of concrete and resist denting during construction.

Minimum wall thickness of ducts shall be 26 gage for 2 5/8 inch diameter and smaller ducts, and 24 gage for ducts that are larger than 2 5/8 inch diameter.

02515.60 Couplings - Provide couplings that develop at least 95% of the minimum specified ultimate strength of the prestressing steel without exceeding anticipated set. The coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself.

02515.70 Shipping Protection - Package prestressing steel to protect the steel against physical damage and corrosion. Place a corrosion inhibitor that prevents rust or other results of corrosion in the package, or use a corrosion inhibitor type packaging material, or when permitted, apply directly to the steel. Provide a corrosion inhibitor that has no deleterious effect on the steel or concrete or bond strength of steel to concrete. Immediately replace or restore damaged packaging.

Mark the shipping package with the type of corrosion inhibitor used, and the date packaged.

02515.80 Acceptance - Acceptance of prestressing reinforcement will be according to 00165.35 and this Section.

Section 02520 - Steel and Concrete Piles

Description

02520.00 Scope - This Section includes the requirements for steel pipe, steel H-beams, steel sheets and prestressed concrete used for piling.

Materials

02520.10 Steel Piles:

(a) General - All steel piles, except steel pipe piles, shall meet the requirements for camber and sweep of in ASTM A 6/A 6M.

(b) Steel Pipe Piles - Add the following:

Provide cutting shoes conforming to the following:

ASTM A 27, Grade 65 - 35
 ASTM A 27, Grade 70 - 36
 ASTM A 27, Grade 70 - 40
 ASTM A 148, all grades

(c) Steel H-Piles - Steel H-piles shall be rolled steel pile sections of the size and weight shown. Steel shall conform to the requirements of ASTM A 36/A 36M. The manufacturer's name, brand or trademark may be shown by die stamping in the web at intervals not exceeding 20 feet along the length of the pile.

Reinforce the tips of steel H-piles with approved cast steel points from the CPL. In addition, cast steel points shall meet the following:

The Cast steel points shall conform to the following:

ASTM A 27, Grade 65 - 35
 ASTM A 27, Grade 70 - 36
 ASTM A 27, Grade 70 - 40
 ASTM A 148, all grades

Each cast steel point shall have a weight not less than 30% of the weight of a 1 foot section of the H pile to which it will be attached.

Legibly mark or tag each cast steel point delivered to the Project site with the heat or lot number. If the heat or lot number cannot be read or if the mark or tag is missing, the point will be rejected. Submit certified mill test reports showing the physical and chemical properties of each heat or lot number.

The Engineer may randomly sample from each heat or lot number, at least one pile tip or up to 10% of the tips for larger projects, of the pile tips delivered for incorporation into the Project.

The selected tip(s) shall be non-destructively tested as follows:

- Determine the weight of the tip(s)
- Grind five smooth spots on each randomly selected tip

The Engineer will test each smooth spot on each tip with an ODOT portable hardness tester. The hardness reading of each spot shall be greater than or equal to 74 on the "B" scale.

Three or more spots with a "B" scale reading below 74, will be cause for rejection of the tested tip and may result in rejection of the entire lot. Replace rejected tips with new tips and rejected lots with new lots at Contractor's expense. New tips and new lots may also be tested according to the requirements above.

Install cast steel point according to manufacturer's recommendations but with no less than a 5/16 inch fillet weld full width of each flange.

No other cast steel points will be accepted unless the following conditions are met at the Contractor's expense:

- Install proposed cast steel points on three piles
- Drive the piles to ultimate capacity
- Pull piles and examine the points
- No damage to the cast steel points is discernible

(d) Steel Sheet Piles - Steel sheet piles shall conform to ASTM A 328/A 328M.

02520.20 Prestressed Concrete Piles:

(a) General - Prestressed concrete piles shall be manufactured according to Section 00550 and as shown.

(b) Concrete - Concrete in precast, prestressed piles shall be Class 5000 - 1 or 3/4. Minimum concrete strength at transfer of prestressing force shall be 4,350 psi. Concrete in pile extensions or "build-ups" shall be Class 3600 - 1 1/2, 1, or 3/4.

(c) Prestressing Reinforcement - Prestressing reinforcement steel shall consist of seven-wire, low-relaxation strands conforming to 02515.10.

(d) Mild Steel Reinforcement - Spiral reinforcement shall be plain reinforcing steel meeting the requirements of 02510.10 or cold-drawn wire meeting the requirements of 02510.60. All other mild reinforcing steel shall meet the requirements of ASTM A 615/A 615M, Grade 60.

(e) Forms - The use of steel forms on concrete founded casting beds is required. Forms shall enclose all except the top horizontal surface, and shall be mortar-tight. Forms for piles shall not cause the formation of fins at the intersection of surfaces.

(f) Tolerances - The maximum sweep (deviation of straightness measured along two perpendicular faces of the pile, while not subject to bending forces) shall not exceed 1/8 inch in any 10 feet of length, 3/8 inch in 40 feet, or 3/16 inch x total length in feet/20 feet.

(g) Finish - The tops of concrete castings shall be given a uniformly smooth finish to match the finish surface of the formed sides.

02520.30 Acceptance - Material for piles will be accepted according to 00165.35 and this Section.

Section 02530 - Structural Steel

Description

02530.00 Scope - This Section includes the requirements and Specifications for structural steel used in the fabrication of bridges and non-bridge structures.

Materials

02530.10 Structural Steel for Bridges - Structural steel for bridges shall conform to the following, as shown or specified:

- AASHTO M 270, Grade 36 (ASTM A 709, Grade 36)
- AASHTO M 270, Grade 50 (ASTM A 709, Grade 50)
- AASHTO M 270, Grade 50W (ASTM A 709, Grade 50W)
- AASHTO M 270, Grade HPS 70 (ASTM A 709 Grade HPS 70)
- AASHTO M 270, Grade HPS 70W (ASTM A 709 Grade HPS 70W)

Supplementary Requirement ASTM A 709/A 709M, Supplementary Requirement S83, Non-Fracture-Critical, *T*, Material; Toughness Tests and Marking, is mandatory for all non-fracture critical steel.

Supplementary Requirement S6 (ASTM A 709/A 709M, Supplementary Requirement S84), Fracture-Critical, *F*, Material; Toughness Testing and Marking, is mandatory for all fracture critical steel.

Supplementary Requirements S5 and S6 (S83 and S84) shall apply to all primary load carrying members and secondary members that are welded to primary members, but shall not apply to bearing devices. They shall apply to both temporary and permanent traffic and railroad bridges. Toughness requirements for all areas of Oregon shall be according to Zone 2 requirements.

Supplementary Requirement S9, Limitation on Weld Repair, is mandatory for all fracture critical steel.

Supplementary Requirement S2, Product Analysis, of ASTM A 6/A 6M is mandatory for all steel plate that will be welded. The product analysis shall be on a heat frequency. It shall include all elements listed in Table B of ASTM A 6/A 6M, regardless of the material specification, except that nitrogen need not be reported unless specified in the product specification. The product analysis shall be submitted to the Engineer immediately upon receipt of the steel.

02530.20 Structural Steel for Non-Bridge Structures - Structural steel for metal sign structures and other non-bridge structures shall conform to the following, or as shown or specified:

- ASTM A 709, Grade 36
- ASTM A36
- ASTM A 709, Grade 50
- ASTM A572

Notch toughness of all structural steel members and plates greater than 1/2 inch thick in load carrying members of sign bridges and cantilever sign supports shall conform to Zone 2 requirements of ASTM A 709/A 709M, Supplementary Requirement S83.

02530.21 Structural Steel for Pipe Sign Posts - Use schedule 40 pipe that shall conform to the following, or as shown or specified:

- ASTM A53, Grade B

02530.30 Copper Bearing Steel - When copper bearing steel is specified for increased corrosion resistance, the steel shall contain not less than 0.20% copper by heat analysis.

02530.40 Ultrasonic Inspection of Plate - Ultrasonically inspect flanges for welded plate girders before fabrication according to ASTM A 578/A 578M except as follows:

- Inspect after the flanges have been stripped from the master plate.
- Section 7, Acceptance Standard - Level A, and Section 8, Acceptance Standard - Level B, do not apply. Use Supplementary Requirement S2.1 for acceptance standard.
- Inspection of flanges may be performed in the plant or warehouse where the flanges are stripped.

02530.50 Universal Mill Plate - Universal mill plate shall not be used.

02530.60 Rolled Shapes - With the approval of the Engineer, rolled shapes having equal or greater section properties and meeting minimum flange and web thickness requirements may be substituted for members specified on the plans, at no additional expense to the Department.

02530.70 Galvanizing - Galvanizing shall be by the hot-dip process according to the following, as applicable:

- ASTM A 123/A 123M
- ASTM A 153/A 153M

Steel that will be finished by hot-dip galvanizing for use as sign bridges, illumination poles, traffic signal poles, sign supports, bridge rail and items designated on the plans as "Galvanize - Control Silicon" shall have controlled silicon content. The silicon content shall be in either of the ranges 0 - 0.04% or 0.15% - 0.25%. Before galvanizing, submit mill test certificates verifying silicon content to the Engineer and the galvanizer.

02530.71 Repair of Hot-Dip Galvanizing - Repair damaged hot-dip galvanizing according to ASTM A 780 and ASTM A 123/A 123M.

02530.80 Acceptance - Acceptance of structural steel will be according to 00165.35 and this Section.

Section 02540 - Forgings, Shafting, Castings and Nonferrous Materials

Description

02540.00 Scope - This Section includes the requirements and Specifications for forgings, shafting, castings and nonferrous materials except those used in potable water systems. For potable water system requirements, see Sections 02470, 02475, 02480, and 02490.

Materials

02540.10 Steel Forgings - Steel forgings shall conform to the following:

Carbon steel forgingsASTM A 668/A 668M, Class C
Alloy steel forgingsASTM A 668/A 668M, Class G

02540.20 Steel Shafting - Steel shafting shall be cold-finished and shall conform to ASTM A 108, Grades 1016 - 1030, inclusive.

02540.30 Steel Castings - Steel castings shall conform to the following:

Carbon steel castings..... ASTM A 27/A 27M, Grade 70-36
Alloy steel castings..... ASTM A 743/A 743M, Grade CA-15

Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended. Allowance will be made in dimensions for reasonable pattern draft.

Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect.

Sandblast castings or otherwise effectively clean off scale and sand to present a smooth, clean and uniform surface.

02540.40 Iron Castings - Iron castings shall conform to the following:

- **Gray Iron Castings** - AASHTO M 105, Class 30 with the test bar size, A, B, C or S as appropriate to the dimensions of the casting.
- **Ductile Iron Castings** - ASTM A 536, Grade 60-40-18, or as specified. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, shall be tested for castings weighing over 1,000 pounds.
- **Malleable Iron Castings** - ASTM A 47/A 47M, Grade 32510.

Finish iron castings according to Section 02540.30.

Clean iron castings according to Section 02540.30.

02540.50 Nonferrous Materials - Nonferrous materials shall conform to the following:

Bronze castingsASTM B 22 Copper Alloy UNS No. C91100
Copper alloy platesASTM B 100 Copper Alloy UNS No. C51000

02540.60 Acceptance - Acceptance of forgings, shafting, castings, and nonferrous materials will be according to 00165.35 and this Section.

Section 02560 - Fasteners

Description

02560.00 **Scope** - This Section includes the requirements and Specifications for fasteners.

Materials

02560.10 **Carbon Steel Fasteners:**

(a) Bolts - Carbon steel bolts shall conform to ASTM A 307, Grade A.

(b) Nuts - Nuts for carbon steel bolts shall conform to the requirements of the following, or equivalent:

Plain (Non-coated) Bolts:

- 1/4" - 1 1/2" - ASTM A 563, Grade A, hex
- over 1 1/2" - 4" - ASTM A 563, Grade A, heavy hex

Galvanized Bolts:

- All - ASTM A 563, Grade DH, heavy hex

(c) Washers - Washers for carbon steel bolts shall conform to ASTM F 436.

02560.20 **High-Strength Fasteners:**

(a) Bolts - High-strength bolts shall conform to ASTM A 325, types as specified. High-strength bolts used in noncoated weathering steel connections shall be Type 3.

(b) Nuts - Nuts for high-strength bolts shall conform to the requirements of the following, or equivalent:

Type 1 Plain (Non-coated) Bolts:

- All - ASTM A 563, Grade C, D, or DH, heavy hex

Type 1 Galvanized Bolts:

- All - ASTM A 563, Grade DH, heavy hex

Type 3 Bolts:

- All - ASTM A 563, Grade C3 or DH3, heavy hex

(c) Washers - Washers for high-strength bolts shall conform to ASTM F 436. Use Type 3 washers with Type 3 bolts.

(d) Direct Tension Indicators - Direct tension indicators shall be the compressible-washer type, mechanically galvanized, conforming to ASTM F 959. Adjust bolt lengths to accommodate both direct tension indicators and hardened washers.

(e) Markings - All bolts, nuts, washers and direct tension indicators shall be marked according to the appropriate ASTM specifications and with a symbol identifying the manufacturer.

(f) Lock-Pin and Collar Fasteners - The shank and head of high-strength steel lock-pin and collar fasteners shall meet the requirements of 02560.20(a) and the chemical composition and mechanical property requirements of ASTM A 325 types, as specified. Each fastener shall have the following:

- A solid shank body of sufficient diameter to provide tensile and shear strength equivalent to or greater than the bolt specified
- A cold-forged round head on one end, of type and dimensions as approved
- A shank length suitable for the thickness of the material fastened
- Annular locking grooves
- A breakneck groove (annular)
- Annular pull grooves (all annular grooves) on the opposite end
- A steel locking flange type collar, of proper size for the shank diameter used. The collar shall be cold-swaged into the locking grooves by means of suitable installation tools, approved by the fastener manufacturer, to form a head for the grooved end of the fastener after the pull groove section has been removed. The steel locking collars shall be equipped with tab locks to prevent slippage during installation and shall be a standard product of an approved, established manufacturer of lock-pin and collar fasteners.

Where lock-pin and flange type collar fasteners are used, flat washers will not be required.

Clean the exposed end of the pin, where the pintail breaks away from the pin, with a wire brush and solvent. After cleaning, coat the exposed end with a zinc and micaceous iron oxide-filled single-component moisture-cured urethane primer, followed by micaceous iron oxide-filled single-component top coat colored to match the work. On galvanized fasteners, the exposed end of the pin may also be repaired according to ASTM A 780.

Type 3 fasteners do not require coating.

02560.30 Tie Rods and Anchor Bolts:

(a) Carbon Steel Tie Rods and Anchor Bolts - Carbon steel tie rods and anchor bolts shall conform to: AASHTO M 314, Grade 36 or 55; ASTM F 1554, Grade 36 or 55; or ASTM A 307.

(b) High-Strength Tie Rods and Anchor Bolts - High-strength tie rods and anchor bolts shall conform to: AASHTO M 314, Grade 105; ASTM F 1554, Grade 105; or ASTM A 449, Type 1.

(c) Nuts - Nuts for tie rods and anchor bolts shall conform to the requirements of the following, or equivalent:

Plain Carbon Steel Tie Rods and Anchor Bolts:

- All - ASTM A 563, Grade A, heavy hex

Galvanized Carbon Steel Tie Rods and Anchor Bolts:

- All - ASTM A 563, Grade DH, heavy hex

Plain Or Galvanized High-Strength Tie Rods or Anchor Bolts:

- All - ASTM A 563, Grade DH, heavy hex

(d) Washers - Washers for anchor bolts shall conform to ASTM F 436, Type 1.

02560.40 Galvanizing and Coating of Fasteners, Tie Rods, and Anchor Bolts:

(a) Galvanizing of Fasteners, Tie Rods, and Anchor Bolts - Hot-dip galvanize fasteners, tie rods, anchor bolts, nuts and washers according to ASTM A 123/A 123M or ASTM A 153/A 153M as appropriate to the product.

When specified, mechanically galvanize fasteners according to ASTM B 695, Class 50, Type 1.

Match galvanized bolts, tie rods, and anchor bolts with appropriate galvanized nuts for assembly. Ship nuts in the same container consisting of bolts, tie rods, or anchor bolts.

Overlap nuts for galvanized fasteners, galvanized tie rods, and galvanized anchor bolts according to ASTM A563.

Measure the zinc thickness on the wrench flats or top of bolt head of galvanized bolts and on the wrench flats of galvanized nuts.

(b) Galvanizing of Direct Tension Indicators - All galvanized compressible washer type direct tension indicators shall be mechanically galvanized according to ASTM B 695, Class 50, Type 1, by the manufacturer.

(c) Repair of Hot-Dip Galvanizing - Repair damaged hot-dip galvanizing according to ASTM A 780.

Testing

02560.60 Testing:

(a) Rotational Capacity Test - Test all high-strength fasteners, except anchor bolts and tie rods, according to Method 1 or 2 below, as applicable. Perform the test on coated or galvanized fasteners after coating, galvanizing, oversize tapping and lubricating. Use nuts from those supplied with the bolts for the job. Use washers for this testing. Repeat the rotational capacity test at the job site prior to installation to verify the effectiveness of the lubricant. The rotational capacity test is not required for lock-pin and collar fasteners. Use Method 1 for long bolts and Method 2 for short bolts.

Test each combination of bolt production lot, nut lot and washer lot as an assembly. Assign a rotational capacity lot number to each combination of lots tested. The minimum frequency of testing shall be two assemblies per rotational capacity lot. The test shall meet one of the following requirements:

(1) Method 1:

Place the lubricated fastener, including a washer, in a device capable of indicating direct bolt tension. Use spacers and/or washers with the hole size the same nominal diameter as the hole in the washer for the fastener to be tested. Allow three to five full threads of the bolt to be exposed between the bearing surfaces of the bolt head and the nut. Tighten the nut to a snug-tight condition to produce an initial load in the bolt equal to 10% of the tension required in Table 00560-1 of Section 00560. Mark the nut's position relative to the fixed bolt for this snug-tight position. Tighten the nut using a calibrated torque wrench and record the measured torque with the nut in motion to reach the tension required by Table 00560-1.

The above measured torque to produce the required bolt tensions shall not exceed the torque value calculated by the following equation:

$$T = 0.25 PD$$

Where:

T	=	Torque in foot pounds
P	=	Measured Bolt Tension in pounds
D	=	Nominal Bolt Diameter in feet

Reject assemblies with torque values exceeding the calculated value.

Continue to tighten the nut until the nut has turned twice the rotation shown in Table 00560-3 of Section 00560 from its snug-tight position mark. Record the measured bolt tension. The tension shall not be less than 1.15 times the tension shown in Table 00560-1. Reject assemblies not meeting this tension.

Loosen and remove the nut. Examine the threads on the nut and bolt. Reject assemblies showing evidence of thread shear failure, stripping or torsional failure of the bolt.

(2) Method 2:

Bolts that are too short to be tested in a direct bolt tension indicating device shall be tested in a steel joint.

Place the lubricated fastener including a washer in one or more flat structural steel plates. The total thickness including the washer shall be such that three to five full threads of the bolt are located between the bearing surfaces of the bolt head and the nut. The hole in the joint shall have the same nominal diameter as the hole in the washer. Using a calibrated torque wrench, tighten the nut to a snug-tight condition to produce an initial torque in the bolt equal to approximately 10% of the torque calculated using the equation given in Method 1 above where P shall be the minimum tension in the bolt according to Table 00560-1 of Section 00560. Mark the nut's position relative to the fixed bolt for this snug tight position.

Using the calibrated torque wrench, further tighten the nut until the nut has turned the rotation shown in Table 00560-3 of Section 00560 from its snug-tight position mark. Prevent the bolt head from turning during the tightening process. Record the measured torque with the nut in motion. The measured torque shall not exceed 1.15 times the torque value calculated in the preceding step of Method 2. Reject assemblies with torque values exceeding the calculated value.

Tighten the nut further until the nut has turned twice the rotation shown in Table 00560-3 from its snug-tight position mark. Reject assemblies which fail this rotation either by stripping or fracture.

Loosen and remove the nut. Examine the threads on the nut and bolt. Reject assemblies showing evidence of thread shear failure, stripping or torsional failure of the bolt.

(3) Shipping - Ship bolts, nuts and washers from each rotational capacity test lot in the same container. If there is only one rotational capacity test lot for each size of bolt, the bolts, nuts and washers may be shipped in separate containers. Permanently mark each container with the rotational capacity test lot number to enable identification at any stage before installation.

(b) Other Test Requirements - Proof load testing on all high-strength bolts and nuts is mandatory. Test bolts according to ASTM F 606, Method 1, and nuts according to ASTM F 606, paragraph 4.2, with frequency of tests according to paragraph 9.3 of ASTM A 563. Test galvanized bolts and nuts after galvanizing, overtapping and lubricating. Coated bolts and nuts may be tested before coating.

Wedge test all bolts according to ASTM F 606, paragraph 3.5, with frequency of testing according to ASTM A 325. Test galvanized bolts after galvanizing. Coated bolts may be tested before coating.

Perform other tests called for on the plans.

Provide certified test results for all tests required by these Specifications or the individual product specifications.

Provide one extra tie rod and/or anchor bolt per size per lot for check testing.

02560.70 Lubricating Fasteners - Lubricate all galvanized and coated fasteners with a lubricant containing a visible dye of any color that contrasts with the color of galvanizing or coating so a visual check can be made for the lubricant at the time of field installation. Black fasteners must be "oily" to the touch when installed.

Lubricate galvanized fasteners using commercial wax and coated fasteners using commercial water-soluble wax. Lubricants for galvanized and coated fasteners shall be from the CPL.

Field lubricate galvanized bolts in tapped holes, galvanized anchor rods, and galvanized tie rods with a lubricant from the CPL. Apply lubricant to threads and to bearing surfaces that will turn during installation.

Protect fasteners from dirt and moisture at the job site. Clean, lubricate and retest weathered or rusted fasteners before installing. Do not re-lubricate tension control fasteners designed to automatically provide the tension without consulting with the manufacturer.

The outer surface of the collar in lock-pin and collar fasteners shall be coated with a lubricant as approved by the manufacturer. This lubricant allows the installation tool to swage the collar without removing the corrosion protection from the outer surface.

02560.80 Acceptance - Acceptance of fasteners will be according to 00165.35 and this Section.

Section 02570 - Composite Bearings

Description

02570.00 Scope - This Section includes the material requirements for composite bearings.

Materials

02570.10 General - Provide materials meeting the following requirements:

Structural steel 02530.20
 Stainless steel sliding surfaces ASTM A 240/A 240M, Type 304
 Flat brass rings for pot bearings ASTM B 36/B 36M, half hard
 Cap screws ASTM A 574 or ASTM F 835
 Bolts and nuts ASTM A 325 and Section 02560
 Galvanized bolts, nuts, washers, cap screws,
 sole plates and base plates 02530.70 and 02560.40
 Polytetrafluoroethylene (TFE) Division II, Section 18 of the current AASHTO
 Standard Specifications for Highway Bridges
 Do not use reprocessed material.

Welded Stainless Steel Overlay - Produce welded stainless steel overlay for the convex rotational surface of spherical bearings using Type 309L electrodes.

Elastomer - Elastomer for elastomeric discs of pot bearings shall be 100% virgin natural polyisoprene (natural rubber) or 100% virgin chloroprene (neoprene) meeting the following requirements:

NATURAL POLYISOPRENE:

Physical Properties	ASTM Test Method	Value
Hardness, Durometer D	D 2240	50 ± 5
Tensile strength, minimum, psi	D 412	2,500
Ultimate elongation, minimum, %	D 412	450
Heat Resistance	ASTM Test Method	Value
Change in durometer hardness, maximum points	D 573 70 hour	+10
Change in tensile strength, maximum, %	at 158 °F	-25
Change in ultimate elongation, maximum, %		-25
Compression Set	ASTM Test Method	Value
22 hours at 158 °F, maximum, %	D 395, Method B	25

Ozone	ASTM Test Method	Value
25 pphm ozone in air by volume, 20% strain, 100 °F ± 2 °F 48 hours mounting Procedure D518, Procedure A	D 1149	No Cracks

Adhesion	ASTM Test Method	Value
Bond made during vulcanization, lb/in	D 429, Method B	40
Low Temperature Test	ASTM Test Method	Value
Brittleness at -40 °F	D 746, Procedure B	No Failure

VIRGIN CHLOROPRENE:

Physical Properties	ASTM Test Method	Value
Hardness, Durometer D	D 2240	50 ± 5
Tensile strength, minimum, psi	D 412	2,500
Ultimate elongation, minimum, %	D 412	400

Heat Resistance	ASTM Test Method	Value
Change in durometer hardness, maximum points	D 573, 70 hour	+15
Change in tensile strength, maximum, %	at 212 °F	-15
Change in ultimate elongation, maximum, %		

Compression Set	ASTM Test Method	Value
22 hours at 212 °F, maximum, %	D 395, Method B	35

Ozone	ASTM Test Method	Value
100 pphm ozone in air by volume, 20% strain, 100 °F ± 2 °F 100 hours mounting Procedure D518, Procedure A	D 1149	No Cracks

Adhesion	ASTM Test Method	Value
Bond made during vulcanization, lb/in	D 429, Method B	40
Low Temperature Test	ASTM Test Method	Value
Brittleness at -140 °F	D 746, Procedure B	No Failure

When test specimens are cut from the finished product a 10% variation in physical properties will be allowed.

Polyether Urethane - The properties of polyether urethane for polyether urethane discs of disc bearings shall meet the values of the following tests:

Property	Test Method	Range of Values
Hardness, Durometer D	ASTM D2240	62 $\pm$ 2
Tensile stress, psi		
at 100% elongation	ASTM D412	2,000 min
at 200% elongation		3,700 min
Tensile strength	ASTM D412	5,000 min
Ultimate elongation %	ASTM D412	220 min
Compression set, 22 hrs		
at 158 °F	ASTM D395	40 max

Fabric Pads - Make preformed fabric pads for fabric pad bearings of multiple layers of duck, impregnated and bound with high quality oil resistant synthetic rubber compressed into resilient pads of uniform thickness according to the following:

- Duck shall be highest quality cotton or cotton-polyester 50-50 blend, and weighing a minimum of 8 ounces per square yard.
- Cotton warp and filling yarn shall be two ply.
- Cotton-polyester warp and fill shall be single yarn with a minimum breaking strength by grab method of 150 pounds per inch of width warp, and 140 pounds per inch of width fill.
- The filling count of the duck shall be 40 $\pm$ 2 threads per inch.
- The warp count of the duck shall be 50 $\pm$ 1 thread per inch.
- The number of plies shall produce the specified thickness after compression and vulcanizing.
- The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 psi without any sign of distress after the load is removed. The tested pad shall have a shape factor greater than 2.5. The preformed fabric pad shall have a Shore A hardness of 90 $\pm$ 5.

02570.20 Testing - The manufacturer shall have a typical bearing either tested and certified by an independent testing laboratory, or shall test a typical bearing with the test witnessed and attested to by an independent testing laboratory, for compliance with specified performance requirements as listed below. Tests shall have been performed within five years before Award of the Contract. Provide a test results certificate according to 00165.35 with the submittal of shop drawings.

(a) Friction Test - The coefficient of friction between the sliding surfaces shall not be greater than 0.06 when the maximum working stress for the polytetrafluoroethylene (TFE) surface is 2,000 psi. It shall not be greater than 0.04 when the maximum working stress for the TFE surface is 3,500 psi. Determine the coefficient according to requirements of subsection 18.8.3 of the AASHTO Standard Specifications for Highway Bridges.

(b) Proof Load Test:

(1) Vertical Proof Load Test - Apply a vertical load equal to 150% of the vertical design capacity of the tested bearing for a period of one hour. Place the bearing in a rotated position during the test. Rotation shall be 0.015 radians or the design rotation, whichever is greater. The test bearing shall show no indication of failure or other defects such as weld cracking, plate distortion, extrusion of the elastomer or bearing material, or displacement of the elastomer seal while under load or subsequently upon disassembly and inspection.

The bearing tested for vertical proof load shall have a vertical design capacity no more than 50% greater or no less than 50% smaller than the capacity of the required bearing. The successful test of a bearing with a vertical design capacity of 50 tons or less will be accepted as qualification for all bearings of a similar design with a lesser design capacity.

(2) Horizontal Proof Load Test - A horizontal proof load test is required when the design horizontal capacity exceeds 10% of the design vertical capacity and no engineer's calculations are submitted. Apply a horizontal load equal to 100% of the horizontal design capacity while also applying a vertical load equal to 100% of the dead load for a period of two minutes. The bearing does not need to be in the rotated position. The bearing shall show no indication of failure or other defects such as weld cracking, plate distortion, extrusion of the elastomer or bearing material, or displacement of the elastomer seal while under load or subsequently upon disassembly and inspection.

The bearing tested for horizontal proof load may be either a bearing specified for use on the Project or a similar type bearing with both a vertical design capacity and a horizontal design capacity within 10% of the design capacities of bearings specified for use on the Project.

(c) Acceptance - For each composite bearing used in the structure, provide the manufacturer's quality compliance certificate according to 00165.35 that verifies the bearing has been manufactured according to the design of the tested bearing.

Section 02571 - Elastomeric Bearing Pads

Description

02571.00 Scope - This Section includes the material requirements for plain and laminated elastomeric bearing pads.

Materials

02571.10 Elastomeric Compound - The elastomer portion of the elastomeric compound shall be 100% virgin chloroprene (neoprene) meeting the requirements of the following table:

Table 02571-1

Properties	Test Method	Requirements
Hardness, Durometer D	D 2240	60 ± 5
Tensile strength, min., psi	D 412	2,200
Ultimate elongation, min., %	D 412	350
Heat Resistance:		
Change in durometer hardness max. points after 70 hr. at 212 °F	D 2240	+15
Change in tensile strength, max. % after 70 hr. at 212 °F	D 573	-15
Change in ultimate elongation, max. % after 70 hr. at 212 °F	D 573	-40
Compressive set, max. % after 22 hr. at 212 °F	D 395, Method B	35
Adhesion: Bond made during vulcanization, lb/in	D 429, Method B	40
Tear Resistance, psi	D 624, Die C	180

02571.15 Metal Reinforcement - Metal reinforcement shall be rolled, mild steel sheets 14 gage thick and conforming to ASTM A 1011/A 1011M, Grade 36 Type 1, or ASTM A 1008/A 1008M, Grade 40.

02571.20 Manufacturing Requirements:

(a) Pads - Pads 1/2 inch thick shall be all elastomer. Pads over 1/2 inch thick shall consist of alternate laminations of elastomer and metal.

In metal reinforced pads, the top and bottom layers shall be elastomer 1/4 inch thick, and interior elastomer layers shall be 1/2 inch thick.

(b) Laminations - Laminations of elastomer shall be of uniform thickness and in no case shall the thickness of an individual lamination exceed 5/8 inch. Variations in thickness of an individual elastomer lamination shall not exceed 1/8 inch and the variation in thickness of all elastomer laminations within a pad shall be such that each metal lamination will not vary by more than 1/8 inch from a plane parallel to the top or bottom surface of the pad.

(c) Laminated Pads - Laminated pads shall be molded individually to the sizes required. No shearing to size or drilling of holes will be permitted. Cover all edges of metal laminations with a minimum of 1/8 inch, and a maximum of 1/4 inch, of elastomer except at laminate restraining devices and around holes that will be entirely closed when the pad is in place on the structure.

Clean the exposed edge voids in the pads caused by the steel laminate restraining devices with a solvent. Shop seal with an appropriate caulking material before shipment.

Sandblast and clean the steel laminates of all surface coatings such as grease, oil, rust and mill scale before bonding. Free the laminates of sharp edges and burrs.

Pads 1/2 inch in thickness may be sheared. The shearing shall not heat the material and shall produce a smooth finish to 250 microinches with no tears or jagged areas.

(d) Dimensional Tolerances and Finishes - See Section 18.2.5, Division II of the AASHTO Standard Specifications for Highway Bridges for fabrication tolerances.

Fabricate pads to meet flash tolerance, finish and appearance requirements given in the latest edition of the Rubber Handbook, published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings.

02571.30 Laminated Bearing Pad Tests and Acceptance Criteria:

(a) General - Comply with additional test requirements of this subsection. Non-laminated bearing pads do not require these tests.

Test all completed bearings by compressive visual inspection as described in 02571.30(b).

Obtain an independent testing laboratory and test one standard test specimen of laminated pad as described in ASTM D 429, Method B, from each production lot for peel strength as described in 02571.30(c). Failure of individual bearings to pass the compressive visual inspection will be a cause for rejection of those individual bearings. Failure to pass the peel strength test requirements will be a cause for rejection of all bearings from that production lot. Replace rejected bearings with new acceptable bearings at no cost to the City. The Contractor shall bear the costs of providing the sample pad and all testing herein.

Mark all bearings in indelible ink or flexible paint with job number, lot number and bearing identification number. Place the marking on a side face visible after erection of the bridge.

Clean and free the bearings of any foreign substances such as dust, grit and moisture before testing.

(b) Compressive Visual Inspection - Bring all bearings to a temperature of 73 °F plus or minus 10 °F and proof load individually for a compressive load of 1,500 psi. Maintain the load constant while the bearing is inspected for visual faults. The following will be cause for rejection:

- A bulging pattern or patterns implying lack of bond between the elastomer and the laminate
- Three or more separate surface cracks which are each at least 0.08 inch wide and 0.08 inch deep

(c) Peel Strength Test - The bond between the elastomer and steel laminate shall be not less than 40 pounds per inch when tested according to ASTM D 429, Method B.

(d) Acceptance - Provide a quality compliance certification according to 00165.35 that the bearing pads conform to the requirements for materials, fabrication and testing. Provide a test result certificate according to 00165.35 that includes the manufacturer's and independent testing laboratory test results according to 02571.30(a).

Aggregates

Section 02610 - Special Filter Material

Description

02610.00 Scope - This Section includes the requirements for special filter material for backfilling or filling trenches for perforated drains and other subsurface drains.

Materials

02610.10 Special Filter Materials - Furnish a specially graded filter material of coarse sand, and crushed or uncrushed rock that meets the following requirements:

(a) Grading - Sieve analysis will be determined according to AASHTO T 27. The material shall meet the following requirements:

Sieve Size	Percent Passing (by Weight)
3/8"	100
No. 4	54 - 82
No. 10	34 - 58
No. 40	9 - 17
No. 100	0 - 3

(b) Sand Equivalent - Special filter material will be tested according to AASHTO T 176 and shall have a sand equivalent of not less than 25.

Section 02620 - Bedding and Joint Sand

Description

02620.00 Scope - This Section includes the requirement for bedding and joint sand for pavers.

Materials

02620.10 Bedding Sand - Furnish a specially graded material of coarse sand that meets the following requirements:

(a) Grading for Sidewalk Use - Sieve analysis will be determined according to AASHTO T 27. The bedding sand shall meet the following gradation requirements:

Sieve Size	Percent Passing
3/8"	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 85
No. 30	25 - 60
No. 50	5 - 30
No. 100	0 - 10
No. 200	1

(b) Grading for Street Use - Sieve analysis will be determined according to AASHTO T 27. The material shall be comprised of naturally occurring silica sand. The bedding sand shall meet the following gradation requirements:

Sieve Size	Percent Passing
1/4"	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 75
No. 30	25 - 45
No. 50	0 - 10
No. 100	0 - 2
No. 200	0

(c) Sand Equivalent - Bedding sand will be tested according to AASHTO T 176 and shall have a sand equivalent of not less than 25.

(d) Particle Shape - For street use, the shape of the sand grain shall be cuboid. The particles of sand shall be angular and of approximately cubic shape. The shape shall be verified by a picture from an electron microscope.

(e) Geological Deposits - For street use, the sand shall be from Quarternary deposits. The type of deposit shall be verified in writing by a geologist who has visited the quarry site.

02620.11 Joint Sand - Furnish a specially graded material of coarse sand that meets the following requirements:

(a) Grading for Sidewalk Use - Sieve analysis will be determined according to AASHTO T 27. The joint sand shall meet the following gradation requirements:

Sieve Size	Natural Sand Percent Passing	Manufactured Sand Percent Passing
No. 4	100	100
No. 8	95 - 100	95 - 100
No. 16	70 - 100	70 - 100
No. 30	40 - 75	40 - 100
No. 50	10 - 35	20 - 40
No. 100	2 - 15	10 - 25
No. 200	0 - 1	0 -10

(b) Grading for Street Use - Sieve analysis will be determined according to AASHTO T 27. The material shall be comprised of naturally occurring silica sand. The joint sand shall meet the following gradation requirements:

Sieve Size	Percent Passing
1/4"	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 75
No. 30	25 - 45
No. 50	0 - 10
No. 100	0 - 2
No. 200	0

(c) Sand Equivalent - Joint sand will be tested according to AASHTO T 176 and shall have a sand equivalent of not less than 25.

(d) Particle Shape - For street use, the shape of the sand grain shall be cuboid. The particles of sand shall be angular and of approximately cubic shape. The shape shall be verified by a picture from an electron microscope.

(e) Geological Deposits - For street use, the sand shall be from Quarternary deposits. The type of deposit shall be verified in writing by a geologist who has visited the quarry site.

Section 02630 - Base Aggregate

Description

02630.00 **Scope** - This Section includes the requirements for aggregates in base.

Materials

02630.10 **Dense-Graded Aggregate:**

(a) Grading - Dense-graded base aggregate shall be crushed rock, including sand. Uniformly grade the aggregates from coarse to fine. Sieve analysis will be determined according to AASHTO T 27. The aggregates shall conform to one of the grading requirements of Table 02630-1 as called for in the Special Provisions or indicated by the pay item(s) in the Schedule of Items.

Table 02630-1
Grading Requirements for Dense-Graded Aggregate

Separated Sizes Percent Passing (by Weight)					
Sieve Size	2 1/2" - 0	2" - 0	1 1/2" - 0	1" - 0	3/4" - 0
3"	100				
2 1/2"	95 - 100	100			
2"	—	95 - 100	100		
1 1/2"	—	—	95 - 100	100	
1 1/4"	55 - 75	—	—	—	
1"	—	55 - 75	—	90 - 100	100
3/4"	—	—	55 - 75	—	90 - 100
1/2"	—	—	—	55 - 75	—
3/8"	—	—	—	—	55 - 75
1/4"	30 - 45	30 - 45	35 - 50	40 - 55	40 - 60
No. 10	¹	¹	¹	¹	¹

¹ Of the fraction passing the 1/4 inch sieve, 40% to 60% shall pass the No. 10 sieve

(b) Fracture of Rounded Rock - Fracture of rounded rock will be determined according to AASHTO TP 61. Provide at least one fractured face based on the following percentage of particles retained on the 1/4 inch sieve for the designated size:

Designated Size	Minimum % of Fractured Particles by Weight of Material Retained on 1/4 inch Sieve
1 1/2" - 0 and larger	50
Smaller than 1 1/2" - 0	70

(c) Durability - Dense-graded aggregate shall meet the following durability requirements:

Test	Test Method	Requirements
Abrasion	AASHTO T 96	35.0% maximum
Degradation (Coarse Aggregate)		
Passing No. 20 sieve	ODOT TM 208	30.0% maximum
Sediment Height	ODOT TM 208	3.0" maximum

(d) Sand Equivalent - Dense-graded aggregate will be tested according to AASHTO T 176, and shall have a sand equivalent of not less than 30.

02630.11 Open-Graded Aggregate:

(a) Grading - Open-graded aggregate shall conform to the following grading requirements:

**Table 02630-2
Aggregate Gradation for Open-Graded Aggregate**

Sieve Size	Percent Passing by Weight
1"	100
3/4"	80 - 98
1/2"	60 - 85
3/8"	30 - 65
No. 10	5 - 20
No. 40	0 - 6
No. 100	0 -3 (Dry Sieve)

(b) Fracture of Rounded Rock - Fracture of rounded rock will be determined according to AASHTO TP 61. Open-graded aggregate fracture requirements shall conform to the following:

Percentage of Fracture by Weight	
Material Retained on 3/4", 1/2", and 1/4" Sieves (two fractured faces)	Material Retained on No. 10 Sieve (one fractured face)
90	75

(c) Durability - Open-graded aggregate shall meet the durability requirements of 02630.10(c).

Section 02640 - Shoulder Aggregate

Description

02640.00 Scope - This Section includes the requirements for shoulder aggregate.

Materials

02640.10 Aggregate:

(a) Grading - Shoulder aggregate shall be crushed rock, including sand. Sieve analysis will be determined according to AASHTO T 27. Uniformly grade the aggregates from coarse to fine. The aggregates shall conform to one of the grading requirements of Table 02640-1 as called for in the Special Provisions or indicated by the pay item in the Schedule of Items.

**Table 02640-1
Grading Requirements - Shoulder Aggregates
Separated Sizes**

Sieve Size	1" - 0 Percent Passing (by weight)	3/4" - 0
1 1/2"	100	
1"	90 - 100	100
3/4"	---	90 - 100
1/4"	40 - 55	40 - 60

(b) Fracture of Rounded Rock - Fracture of rounded rock will be determined according to AASHTO TP 61. Provide at least one fractured face based on the following percentage of particles retained on the 1/4 inch sieve for the designated size:

Minimum % of Fractured Particles by Weight of Material

Designated Size	Retained on 1/4" Sieve
1 1/2" - 0 and Larger	50
1 1/2" - 0	50

(c) Durability - The produced aggregates shall meet the following requirements:

Test	Test Method	Requirements
Abrasion	AASHTO T 96	35.0% maximum
Degradation (Coarse Aggregate)		
Passing No. 20 sieve	ODOT TM 208	30.0% maximum
Sediment Height	ODOT TM 208	3.0" maximum

(d) Sand Equivalent - Shoulder aggregate will be tested according to AASHTO T 176, and shall have a sand equivalent of not less than 25.

Section 02690 - PCC Aggregates

Description

02690.00 Scope - This Section includes the requirements for testing the fine and coarse aggregates for portland cement concrete.

Materials

02690.10 General - The Contractor may request approval to produce coarse and fine aggregates in sizes other than those stated in 02690.20 and 02690.30. The request shall be in writing, and shall state the proposed target value and specified tolerances for each of the individual sieve sizes of the materials the Contractor proposes to produce.

02690.20 Coarse Aggregate:

(a) General Requirements - Coarse aggregate shall consist of rock, or other approved inert material of similar characteristics having hard, strong, durable pieces free from adherent coatings. The maximum coarse aggregate size shall be 1 1/2 inch.

(b) Harmful Substances - Harmful substances shall not exceed the following limits:

Test	Test Method		Percent by Weight
	ODOT	AASHTO	
Lightweight pieces		T 113	1.00
Material passing No. 200 sieve		T 11	1.00
Wood particles	TM 225		0.05

¹ For aggregates, if the material finer than the No. 200 sieve consists of fracture dust, essentially free of clay or shale and is non-plastic, the percentage may be increased to 1.5%.

The materials shall be reasonably free from all other deleterious substances.

(c) Soundness - Coarse aggregates for concrete will be tested for soundness using sodium sulfate salt, according to AASHTO T104. The weighted percentage loss shall not exceed 12% by weight.

(d) Durability - Coarse aggregates shall meet the following durability requirements:

	Test Method		Requirements
	ODOT	AASHTO	
Abrasion		T 96	30.0% Maximum
Oregon Air Aggregate Degradation			
Passing No. 20 sieve	TM 208		30.0% Maximum
Sediment Height	TM 208		3.0" Maximum

(e) PCC Paving Aggregate - In addition to requirements above, comply with the following:

(1) Fracture - Provide aggregate with at least two fractured faces on at least 50% of the particles retained on the 3/8 inch, 1/2 inch, 3/4 inch, 1 inch, and 1 1/2 inch sieves, as determined by AASHTO TP 61.

(2) Elongated Pieces - Provide aggregate with elongated pieces not exceeding 10% by weight of the material retained on the No. 4 sieve when tested according to ODOT TM 229 with the proportional caliper device set at a ratio of 5:1.

(f) Grading and Separation by Sizes for Prestressed Concrete - Sampling will be according to AASHTO T 2 and sieve analysis will be determined according to AASHTO T 27/T 11. PCC coarse aggregate shall conform to grading and separated sizes as follows:

(1) Where indicated in Table 02690-1 below, the coarse aggregate shall be separated into two sizes and each separated size shall be measured into the batch in the quantity determined by the mix design.

For each of the indicated maximum sizes of coarse aggregates, the separated sizes thereof shall be as in Table 02690-2:

Table 02690-1

Maximum Nominal Size of Aggregates	Separated Sizes
1"	1" - No. 4
3/4"	3/4" - No. 4
3/4"	3/4" - 1/2" or 1/2" - No. 4
3/4"	3/4" - 3/8" or 3/8" - No. 4

(2) The grading of each of the specified separated sizes of coarse aggregate shall conform to the following:

Table 02690-2

Sieve Size	Separated Sizes					
	1" - No. 4	3/4" - No. 4	3/4" - 1/2"	3/4" - 3/8"	1/2" - No. 4	3/8" - No. 4
Percent Passing (by weight)						
1 1/2"	100					
1"	90 - 100	100	100	100		
3/4"	50 - 80	90 - 100	85 - 100	85 - 100	100	100
1/2"	—	—	0 - 15	—	85 - 100	—
3/8"	15 - 40	20 - 50	—	0 - 15	35 - 65	85 - 100
No. 4	0 - 10	0 - 10	—	—	0 - 15	0 - 15
No. 200	¹	¹	¹	¹	¹	¹

¹ See 02690.20(b)

(g) Grading and Separation by Sizes for Other Concrete - Sampling will be according to AASHTO T 2. Sieve analysis will be according to AASHTO T 27/T 11. Provide aggregates meeting the gradation requirements of Tables 02690-3 and 02690-4 below for structural concrete on projects with more than 100 cubic yards of concrete. Provide a CAgT to perform sampling and testing when required.

**Table 02690-3
Gradation of Coarse Aggregates**

Sieve Size	Combined ¹ Sizes 1 1/2" - No. 4	Separated Sizes 1 1/2" - 3/4"	Separated Sizes 1" - No. 4	Separated Sizes 3/4" - 1/2"
Percent Passing (by Weight)				
2"	100	100		
1 1/2"	95 - 100	90 - 100	100	
1"	—	20 - 55	95 - 100	100
3/4"	35 - 70	0 - 15	—	85 - 100
1/2"	—	—	25 - 60	0 - 15
3/8"	10 - 30	0 - 5	—	—
No. 4	0 - 5	—	0 - 10	—
No. 8	—	—	0 - 5	—

¹ For 1 1/2 inch coarse aggregate use two or more separated sizes which when combined will meet the gradation limits for 1 1/2" - No. 4

**Table 02690-4
Gradation of Coarse Aggregates**

Sieve Size	Separated Sizes 3/4" - 3/8"	Separated or Combined Sizes 3/4" - No. 4	Separated Sizes 1/2" - No. 4	Separated Sizes 3/8" - No. 8
Percent Passing (by Weight)				
1"	100	100		
3/4"	90 - 100	90 - 100	100	
1/2"	20 - 55	—	90 - 100	100
3/8"	0 - 15	20 - 55	40 - 70	85 - 100
No. 4	0 - 5	0 - 10	0 - 15	10 - 30
No. 8	—	0 - 5	0 - 5	0 - 10
No. 16	—	—	—	0 - 5

02690.30 Fine Aggregates-

(a) General Requirements - Fine aggregate shall consist of natural or crushed aggregates or other inert material consisting of hard, strong, durable particles and conforming to a specified grading.

(b) Different Sources - Do not mix fine aggregates from different sources of supply, or store in the same pile. Do not use alternately in the same class of mix, without prior approval.

(c) Harmful Substances - The amount of harmful substances shall not exceed the following limits:

Test	Test Method (AASHTO)	Percent by Weight
Lightweight Pieces	T 113	2.0%
Material Passing No. 200 Sieve ¹	T 11	4.0 % ¹

¹ If this material consists of fracture dust, essentially free of clay and non-plastic, the percentage may be increased to 6.0%.

The material shall also be reasonably free from all other harmful substances, such as shale, alkali, mica, coated grains, and soft and flaky particles.

(d) Soundness - Fine aggregate will be tested for soundness using sodium sulfate salt, according to AASHTO T 104. The weighted percentage loss shall not exceed 10% by weight.

(e) Organic Impurities - All fine aggregate shall meet the requirements of AASHTO M 6 for organic impurities.

(f) Sand Equivalent - Fine aggregate will be tested according to AASHTO T 176 and shall have a sand equivalent of not less than 68.

(g) Sand for Mortar - Sand for mortar shall conform to the requirements of this Section.

(h) Grading - Sampling will be according to AASHTO T 2. Sieve analysis will be determined according to AASHTO T 27/T 11. Provide aggregates meeting the gradation requirements of Table 02690-5 below for structural concrete on projects with more than 100 cubic yards of concrete, and all prestressed concrete. Provide a CAgT to perform sampling and testing when required.

Table 02690-5
Gradation of Fine Aggregate ¹

Sieve Size	Percent Passing by Weight
3/8"	100
No. 4	90 - 100
No. 8	70 - 100
No. 16	50 - 85
No. 30	25 - 60
No. 50	5 - 30
No. 100	0 - 10
No. 200	0 - 4 ²

- ¹ Determine the fineness modulus according to AASHTO T 27/T 11. Maintain the fine aggregate fineness modulus within plus or minus 0.20 from the fineness modulus used in the Contractor's mix design. Fine aggregates in which the fineness modulus varies by more than 0.20 from the mix design target shall be rejected unless an adjustment in the aggregate proportions is performed by a CCT according to the provisions of ACI 211.
- ² For manufactured sand, where the material passing No. 200 is non-plastic rock dust crusher fines, the specification limits may be increased to 6%.

Railing and Guidance Devices

Section 02810 - Bridge Rail

Description

02810.00 Scope - This Section includes the requirements for the steel in railings for bridges.

Materials

02810.10 Shapes, Plates and Bars - Shapes, plates and bars shall comply with ASTM A 36/A 36M.

The silicon content of all exposed shapes, plates and bars that are called out on drawings as "Galvanize - Control Silicon", shall be in the range of 0 - 0.04% or 0.15% - 0.25%.

02810.20 Structural Steel Tubing - Structural steel rail members shall comply with ASTM A 500, Grade B, or ASTM A 501. Steel conforming to ASTM A 513 or ASTM A 618 may be substituted for ASTM A 500 tubing subject to the following limitations:

- Provide chemical and tensile properties test results.
- Silicon content shall be in the range of 0 - 0.04% or 0.15% - 0.25%.
- Strength and elongation requirements of ASTM A 513 tubing shall meet the requirements of ASTM A 500 tubing.

02810.30 Steel Pipe - Metal parapet rail members shall be standard steel pipe complying with ASTM A 53, Grade B or ASTM A 500, Grade B.

02810.40 Cast Steel Posts - Cast steel posts shall be carbon steel castings complying with ASTM A 27/A 27M, Grade 65-35.

02810.50 Metal Thrie Beam Rail - Form metal thrie beam rail from galvanized steel. Galvanized steel beam shall conform to the requirements of AASHTO M 180, for Class A rail. The zinc coating shall conform to the requirements for Type II, AASHTO M 180, applied after fabrication and subject to the single spot test. Backup plates will be accepted with un-galvanized edges and bolt holes, provided these areas are field-coated with an approved galvanizing substitute. Metal posts and hardware shall meet the requirements of 02820.20 and 02820.30.

02810.60 Incidentals - Plates, caps and miscellaneous pieces necessary to complete the rail shall be as shown or specified.

02810.70 Acceptance - Bridge rail materials will be accepted according to 00165.35 and this Section.

Section 02820 - Metal Guardrail

Description

02820.00 Scope - This Section includes the test requirements, Specifications and tolerances for forming galvanized steel sheets into metal beam rail, and the manufacture of guardrail hardware.

Materials

02820.10 Metal Beam Rail - Form metal beam rail from galvanized steel. Galvanized steel beam rail shall conform to the requirements of AASHTO M 180, Class A. The zinc coating shall conform to the requirements of AASHTO M 180, Type II, applied after fabrication and subject to the single spot test. Backup plates will be accepted with ungalvanized edges and boltholes, provided these areas are field-coated with an approved galvanizing substitute.

02820.20 Metal Guardrail and Median Barrier Posts - Metal posts shall be of structural steel conforming to the requirements of ASTM A 36/A 36M and galvanized according to ASTM A 123/A 123M.

02820.30 Guardrail Hardware:

(a) General - All bolts, nuts, washers and other fittings for beam-type guardrail shall be galvanized steel meeting the requirements of AASHTO M 180.

All bolts, nuts and washers shall be as detailed, with nuts tapped oversize not to exceed 1/32 inch.

02820.40 Guardrail Anchor Hardware - Provide cable and fittings for guardrail anchors that conform to the requirements of AASHTO M 30, Class C, for Type II cable. Galvanize all fittings according to ASTM A 123/A 123M.

For steel anchors, the steel tubing shall meet the requirements of ASTM A 500, Grade B, ASTM A 501 or ASTM A 618. The soil plate shall meet the requirements of ASTM A 36/A 36M. After fabrication galvanize tubing and plate according to ASTM A 123/A 123M.

02820.50 Acceptance of Materials - If feasible, manufacturing plants will be inspected periodically for compliance with specified manufacturing methods, and material samples obtained for laboratory testing for compliance with materials quality requirements. This may be the basis for acceptance of manufacturing lots as to quality.

Acceptance of metal guardrail materials will be according to Section 00165.35 and this Section.

Section 02830 - Handrail

Description

02830.00 Scope - This Section includes the requirements for the steel in handrail for bridges and stairways.

Materials

02830.10 Shapes, Plates and Bars - Shapes, plates and bars shall comply with ASTM A 36/A 36M.

The silicon content of all exposed shapes, plates and bars that are called out on drawings as "Galvanize - Control Silicon", shall be in the range of 0 - 0.04% or 0.15% - 0.25%.

02830.20 Steel Pipe - Steel pipe used for handrail members shall comply with ASTM A 53/A 53M or ASTM A 500.

02830.30 Incidentals - Plates, caps and miscellaneous pieces necessary to complete the rail shall be as shown.

02830.40 Acceptance - Acceptance of handrail materials will be according to 00165.35 and this Section.

Section 02840 - Pavement Marking Materials

Description

02840.00 Scope - This Section includes the requirements for striping paint, reflective beads, primers, adhesive and materials for thermoplastic pavement markings and pavement markers.

02840.01 Definitions:

(a) Entrance Angle - The angle in the horizontal plane between a ray from the light source to the marker and the normal to the leading edge of the marker face.

(b) Observation Angle - The angle between a ray from the light source to the marker and the returned ray from the marker to the measuring receptor.

Materials

02840.10 Striping Paint - Use striping paint from the CPL.

02840.20 Reflective Beads - Use traffic paint beads from the CPL or as recommended by the manufacturer of the material in which they will be used.

02840.50 Primers - The primer used over concrete or asphalt pavements shall be compatible for use with the pavement and marking material, and shall increase the bond of the marking material to the pavement. Use a primer approved by the manufacturer of the striping material being used.

02840.60 Pavement Markers:

(a) Type I Reflectorized - Provide reflectorized markers from the CPL, with one or two reflective faces as required to reflect incident light from the specified directions.

Markers provided for installation as recessed markers shall not be more than 4 inches wide in the dimension perpendicular to the direction of traffic.

(b) Type II Nonreflectorized - Use nonreflectorized markers from the CPL.

02840.61 Adhesive:

(a) Epoxy Adhesive - Use Type I or Type II adhesive from the CPL or that conforms to the requirements of AASHTO M 237, except that the viscosity of the individual components at 77 °F plus or minus 2 °F shall be 1,000 to 5,000 poise.

The methods of testing epoxy shall comply with AASHTO T 237 and the following field test:

Into an unwaxed 8 ounce paper cup discharge 8 ounce of mixed epoxy as prepared for application to the traffic marker. Permit the epoxy to thoroughly harden without any additional mixing. Split open the cast resin with a cold chisel and hammer. If the exposed face is of uniform color the epoxy is adequately mixed. If streaks of white or black epoxy are evident, the epoxy is inadequately mixed. Correct mixing equipment deficiencies before further use.

(b) Bituminous Adhesive:

(1) General - Use bituminous adhesives from the CPL and meeting the following requirements:

The bituminous adhesive shall be an asphaltic material with a homogeneously mixed mineral filler and shall be suitable for bonding markers to portland cement concrete, asphaltic concrete, and chip sealed road surfaces. Apply when road surface and marker temperatures are in the range of 40 °F to 160 °F. The adhesive properties shall not deteriorate when heated to and applied at temperatures up to 425 °F using either air- or oil-jacketed meters. The material shall not contain rubber polymers.

(2) Packaging and Labeling - Package the adhesive in silicone lined cardboard containers that will stack properly. The label shall show the product name, lot or batch number and manufacturer's name and address. Print "Bituminous Adhesive for Pavement Marker" in bold lettering on the label.

02840.70 Acceptance - Acceptance of pavement marking materials and adhesive will be according to 00165.35 and this Section.

Section 02850 - Delineators

Description

02850.00 Scope - This Section includes the requirements for support posts, target members, and flexible posts for delineators.

Materials

02850.10 Galvanized Support Posts:

(a) General - Fabricate the support member from hot-rolled steel sections meeting either of the requirements given in Table 02850-10.

**Table 02850-10
Metal Properties**

Grade	Minimum Yield Strength, psi	Minimum Ultimate Strength, psi
Hot-rolled carbon steel - min. carbon content 0.32%	40,000	70,000
Hot-rolled rail steel ¹	50,000	80,000

¹ As defined in U.S. Department of Commerce Commercial Standard CS 150-48, rail steel products shall be rolled from standard tee-section steel rails. No other materials, such as those known by the terms "re-rolled", "rail steel equivalent", and "rail steel quality", shall be substituted.

The support posts shall be of channel section and of the nominal dimensions and weight per foot shown on the plans, subject to the manufacturer's tolerances in dimensions, and a tolerance in weight of 3.5% in any one shipment and 5% under for any one post, and a tolerance in length of 1 inch under and 2 inches over. The members shall be straight and free of sharp corners and rough or burred edges or surfaces.

(b) Multiple Punching - Support posts with holes in addition to those called for on the plans will be acceptable provided that the critical net width of the section measured on the frontal plane projection of the post is not less than 2 1/2 inches.

(c) Galvanizing - Galvanize support posts after fabrication according to ASTM A 123/A 123M.

(d) Acceptance - Acceptance of support posts will be according to 00165.35, 02850.10, and the following:

(1) Pretested Stock - A supplier may qualify an identified lot of support posts for use by the City by complying with the requirements of 02850.10. This lot may then be subdivided for shipment to several projects. Such sublots may be accepted on the basis of certification by the supplier that the identified lot of support posts had been qualified by the City's Materials Laboratory.

(2) Galvanized Support Posts - If galvanized support posts are not from a qualified lot, furnish one post per 1000 posts, or any fraction thereof, for testing.

02850.20 Target Members:

(a) General - The target members shall be of aluminum alloy conforming to the requirements of ASTM B 209/B 209M, "3xxx" or "5xxx" series with "Hxx" approximately half-hard temper, suitable for enameling by continuous roller or other acceptable method. The aluminum sheet from which targets are fabricated shall have a nominal thickness of 0.050 inch, subject to standard manufacturers' tolerances. Provide well finished targets, free of burrs, irregularities and turned edges. When resting on a plane surface, the targets shall not show warp, twist or variation from the surface in excess of 1/4 inch.

(b) Surface Preparation and Enameling - Clean and prepare each surface of each target member for enameling according to one of the following procedures:

(1) Cleaning - Type A Solvent Cleaning or Type B, Method 1 Alkaline Cleaner Chemical Treatment, ASTM D 1730, with water rinsing. During rinsing, as evidence of proper cleaning, the cleaned surface shall retain a continuous film of water.

(2) Chemical Treating - Type B, or Methods 5, 6, or 7 chemical conversion coating, or Method 8 Acid-Bound Resinous Treatment, ASTM D 1730.

(3) Anodic Treating - Type C, Method 1 Sulfuric Acid Anodic or Method 2 Chromium Trioxide Anodic, ASTM D 1730.

(4) Enameling - Give each surface of each target member that has been cleaned and treated as specified above, and is ready for enameling either:

- Two coats of enamel of the kind given in (c) below, each coat being properly baked and with the final coat baked to hard finish, or
- A first coat of an inhibitive and compatible primer having a dry film thickness of about 0.3 mil, followed with one heavy coat of specified enamel baked to a hard finish. The baked enamel shall be uniform in color, commercially smooth and free from flow lines, streaks, blisters or other surface imperfections.

(c) Enamel - Enamel for the surface finish of the prepared aluminum target members shall be Class B baking enamel conforming to the requirements of Federal Specification TT-E-489, or equivalent.

The baked enamel finish is to be white or standard interstate yellow as applicable. The 3 1/2" x 13 3/4" target member may be furnished with a white finish on one side and a yellow finish on the other side, if the Contractor so elects.

(d) Testing Baked Enamel:

(1) Adhesion Test - The adhesion test shall conform to ASTM D 3359, Method B. The enamel shall meet or exceed "4B" adhesion rating. One test is to be made on each face of each test specimen.

(2) Pencil Hardness Test - The pencil hardness test shall conform to ASTM D 3363. The enamel shall have a gouge hardness rating of not less than "H". One test is to be made on each face of each test specimen.

(e) Acceptance - Acceptance of target members will be according to 00165.35, 02850.20 and the following:

(1) Pre-tested Stock - Target members may be qualified according to the method used in 02850.10(d), if the lot of target members comply with the requirements of 02850.20(a) through (d).

(2) Target Members - If target members are not from a qualified lot, furnish target members for testing as follows:

- For acceptance testing, a lot shall consist of target members of the same color from a single production run.
- Test specimens will be sampled at random by the Engineer as follows:

Lot Size	Number of Target Test Specimens
Up to 1000	1 per 100 or fraction of 100
1000 - 10,000	10 plus 1 per 500 or fraction of 500
More than 10,000	30 plus 1 per 1000 or fraction of 1000

- Allow the Engineer to sample the target members for test specimens, at no additional cost to the City for the specimens.
- If a test specimen fails any test, the lot will be re-sampled for the same number of test specimens and retested. If a specimen of the second sample fails any test, the lot will be rejected.
- Accompany each shipment of target members with a quality compliance certificate, as described in 00165.35, verifying that the materials furnished are represented by a lot that has been sampled and tested by ODOT and met the Contract requirements. The certification shall include the ODOT inspection report number.

02850.30 Flexible Delineators:

(a) General - Material for the above-ground portion of flexible delineators shall:

- Be flexible, durable plastic; resistant to impact, ultraviolet light, ozone, hydrocarbons and other effects of atmospheric weathering
- Exhibit good workmanship and be free of burns, discoloration, contamination and other objectionable marks or defects that affect appearances or serviceability

Material for the portion of Type 2 or Type 3 delineators to be installed below ground level shall either be the same as the portion above ground or other durable material suitable for firmly anchoring the post in the ground. If the portion installed in the ground is either iron or steel, galvanize it according to ASTM A 153/A 153M, Class B-2.

(b) Design Prequalification - All flexible delineators shall be from the CPL.

(c) Flexible Delineator Requirements:

(1) Marking - Mark the top of the post on the side away from traffic with the manufacturer's name, symbol or brand and the month and year of fabrication. The legend shall be at least 1/4 inch in height and shall be either die stamped or legibly stamped with permanent ink.

(2) Dimensions - The post shall have a width of 3 inches plus or minus 1 inch, facing traffic and long enough to provide the required height above the pavement surface while providing the required anchoring specified under (3) below.

The top 12 inches of Type 2 delineator posts shall have a uniformly smooth, flat surface at least 3 inches x 12 inches in size on which to mount the reflective material. The 3 inch x 12 inch surface may be slightly rounded provided the minimum brightness value is not significantly reduced.

The top 12 inches of Type 3 delineator posts shall be round in shape to provide for 360° reflectance.

(3) Base Anchoring - When permanently installed, the delineator post shall resist overturning, twisting and displacement from wind and impact forces, and be able to pass the impact resistance requirements of 02850.30(c)(8).

(4) Color - The delineator posts shall be either yellow in color or opaque white as designated. The yellowness index of the white posts shall not exceed 12 when tested according to ASTM E 313. The daylight 45°, 0° luminous directional reflectance shall be a minimum of 70 when tested according to ASTM E 1347. Yellow posts shall meet the requirements for Highway Color Tolerance Chart Color No. 13538 of Federal Standard 595.

(5) Heat Resistance - Condition one delineator post a minimum of two hours in an oven at 140 °F plus or minus 3 °F. Firmly grasp the heat-conditioned post at one end and hold vertically. Bring down the free end to make a tight 180° bend in the middle of the post with the viewing face on the outside of the bend. When released, the post shall straighten itself to within 1 inch of its original straightness within 30 seconds. Repeat the bend test three more times within three minutes of removal from the oven or return the post to the oven for one hour before completing the test.

(6) Cold Resistance - Condition two delineator posts a minimum of two hours at -5 °F plus or minus 3 °F in an environmentally controlled test chamber or cold box. If possible, perform testing in the environmental chamber.

a. Bending - Subject one cold conditioned post to a tight 90° bend at its midpoint four times with the viewing face on the outside of the bend. The post shall not be adversely affected and shall be capable of straightening itself after each bend to within 1 inch of original straightness within 60 seconds after being released. If the test is performed outside of an environmental chamber the first two bends shall be made within three minutes of removal from the cold box. Return the specimen to the cold box for one hour before making the last two bends, which shall also be made within three minutes of removal from the cold box.

b. Impact - Test one cold conditioned post, other than the one used in the test described in the previous paragraph, as follows:

Place the post in a horizontal position with the traffic face up and supported on cylindrical bearings approximately 6 inches in diameter, spaced 36 inches apart. Subject the post to five impact tests, concentrated at the midpoint of the post, by dropping a 1 inch diameter tup (weight approximately 2.37 pounds) a distance of 5 feet through a virtually frictionless vertical guide to impact the surface of the post. Cracking or splitting of the post constitutes failure. If a cold box is used, complete the test within two minutes of removal from the cold box or return the post to the cold box for one hour before completing the test.

(7) Weatherometer - Expose the delineator post material for 1000 hours in a weatherometer conforming to ASTM G 26, (Method 1, standard cam, 50 to 60% relative humidity, 145 °F black-panel temperature). Significant yellowing or darkening of the white posts, change of color of the yellow posts, or significant loss of pliability will be cause for failure.

(8) Impact Resistance - Manufacture delineator posts from impact-resistant material, and design so that an installed post is capable of self-erecting, remaining in position and serviceable after being subjected to a series of straddle hits by a typical sedan. The impacting vehicle shall suffer little or no damage during the impact test series.

Use five delineator posts in the impact tests, which shall be conducted when the temperature is 40 °F or above. The posts to be tested shall be complete with attached reflective material proposed for use and shall be installed according to the manufacturer's recommendations. The five posts shall withstand a series of 10 impacts head-on (90°) into the traffic face of the post at 35 mph and a series of five impacts at an angle of 75° to the traffic face of the post at 55 mph. Four of the posts must pass the test.

(d) Acceptance - Acceptance of flexible delineators will be according to 00165.35, 02850.30 and the following:

(1) Pre-tested Stock - Flexible delineators may be qualified according to the method used in 02850.10(d), if the lot of flexible delineators comply with the requirements of 02850.30.

(2) Flexible Delineators - If flexible delineators are not from a qualified lot, furnish two samples per 1000 posts, or any fraction thereof, for testing.

02850.40 Reflective Sheeting - Reflective sheeting shall have the following minimum coefficient of retroreflection values:

Entrance Angle	Observation Angle	Coefficient of Retroreflection ¹ (cd/lx·m ²)	
		White	Yellow
-4°	0.2°	250	170
+30°	0.2°	150	100

¹ Average cd/lx·m² according to Federal Standard 370

Mount the reflective sheeting on the posts as detailed on the plans by an approved positive means that has adequate strength to prevent loss of the reflective material during the life of the post.

Section 02910 - Sign Materials

Description

02910.00 Scope - This Section includes the requirements for backing, sheeting, legend, reflectors and hardware for sign installations.

Fabricate wood sign posts according to the requirements of 02110.40.

Materials

Backing

02910.10 Aluminum - The aluminum materials shall conform to the following requirements:

Extruded aluminum shapes	ASTM B 221/B 221M
Rolled or extruded structural shapes	ASTM B 308/B 308M
Aluminum sheet	ASTM B 209/B 209M
Aluminum bars or rods	ASTM B 211/B 211M
Aluminum sand castings	ASTM B 26/B 26M

Aluminum to be color coated shall be of an alloy which is compatible with the coating and the application process. The color-coated aluminum shall have a temper that, after coating and aging, provides an ultimate strength of 30,000 psi and a yield strength of 25,000 psi.

Fabricate sheet aluminum signs from aluminum alloy 6061-T6, 5052-H38, 5154-H38, or approved equal, and give a chromate treatment conforming to ASTM B 449, Class 2. Provide certified test reports for all heats of aluminum products furnished to the City. Signs shall be of the thickness shown on Table 02910-1 below unless otherwise indicated.

Table 02910-1

Sign Width (Horizontal Measure)	Sheet Aluminum Thickness
Less than 20"	0.063"
20" through 30"	0.080"
31" through 48"	0.100"
Over 48"	0.125"

02910.11 Plywood:

(a) General - Construct all plywood signs from 3/4 inch high-density overlay plywood or medium-density overlay plywood. Plywood shall be Douglas fir plywood, Grade B-B exterior or better, conforming to "Product Standard PS-1 for Douglas Fir Plywood" published by the U. S. Department of Commerce.

(b) Overlay - High-density and medium-density overlay shall be black or buff unless otherwise shown or specified. High-density and medium-density overlay shall conform to "Product Standard PS-1 for Douglas Fir Plywood".

(c) Plywood Sealer - Fill any voids in top or sides of panel with caulking compound after cutting plywood to size. Apply an approved plywood edge sealer tinted to match the color of the panel overlay material. The sealer shall be a medium oil alkyd primer.

Sheeting

02910.20 Reflective and Retroreflective Sheeting :

(a) General - Use reflective sheeting Type 1 and retroreflective sheeting Type III, Type IV, Type VII, Type VIII, Type 1X, and Type X from the CPL and the following:

(1) Perforation - If required for application, the sheeting may be pre-perforated with holes not greater than 0.02 inch in diameter. The perforations shall be approximately 0.4 inch apart in rows approximately 1.5 inches apart.

(2) Surface - The sheeting and adhesive shall be compatible with non-reflective permanent cut-out legend.

(b) Acceptance - Provide quality compliance certification according to 00165.10(b).

02910.21 Nonreflective Sheeting for Sign Background:

(a) General - The nonreflective sheeting shall be durable, weather resistant, gloss plastic film, and shall have a protected, precoated adhesive backing.

(b) Color - Color of the nonreflective sheeting shall conform to 00940.01. Submit for testing a 4 inch by 4 inch sample of the background color for each color of nonreflective sheeting shown.

(c) Adhesive - Adhere the nonreflective sheeting by a mildew and vandal resistant precoated adhesive that has no staining effect on the sheeting.

(d) Film:

(1) General - The nonreflective sheeting shall be flexible and easily cut to shape. The minimum tensile strength of the sheeting shall be 5 pounds per inch width.

(2) Surface - The sheeting surface shall be smooth and flat, to facilitate cleaning and wet performance. The sheeting surface shall be readily processed and compatible with recommended transparent and opaque process inks.

The sheeting shall permit cutting and color processing at minimum temperatures of 60 °F. The sheeting shall be heat resistant and shall permit force curing of applied sheeting at temperatures up to 150 °F. The sheeting surface shall be solvent resistant. Clean according to the manufacturer's recommendations.

(e) Durability - Process and apply according to the manufacturer's recommendations. The material shall be weather resistant, and following cleaning shall show no discoloration, cracking, crazing, blistering or dimensional change.

The sheeting surface shall be capable of being readily refurbished when cleaned and clear over-coated according to the manufacturer's recommendations.

(f) Finish - The finishing clear coat applied to sign faces shall be compatible with the sheeting and shall conform to the requirements of the sheeting manufacturer.

(g) Acceptance - Furnish a quality compliance certificate according to 00165.10, certifying that the nonreflective sheeting furnished meets all the above requirements.

02910.31 Retroreflective Sheeting (Wide-Angle, Prismatic):

(a) General - The retroreflective sheeting for sign faces/finished signs shall have a smooth surface with distinctive interlocking diamond seal pattern and orientation marks visible from the face. Precoat the sheeting with a pressure-sensitive adhesive backing protected by a removable liner. The retroreflective sheeting (wide angle, prismatic) shall be one of the following types as shown or specified.

(1) Type A - Type A sheeting is a wide-angle retroreflective sheeting with optimized performance over a broad range of observation angles. Normal use is for surface mounted signs.

(2) Type B - Type B sheeting is a wide-angle retroreflective sheeting with optimized performance at narrow observation angles and with extended entrance angle performance. Normal use is for overhead mounted signs.

(b) Acceptance Sampling and Testing - The following documents of the issue in effect on the date the Project is advertised form a part of this Specification to the extent specified as follows:

(1) ASTM Standards:

- B-117 Method of salt spray (fog) testing.
- B-209/B 209M Specification for Aluminum and Aluminum Alloy Sheet Plates.
- D-523 Standard Method for Test for Specular Gloss.
- E-284 Standard Definitions of Terms Relating to Appearance of Materials.
- E-308 Computing the Colors of Objects by Using the CIE System.
- E-810 Standard Test Method for Coefficient of Retroreflection (R_A) of Retroreflective sheeting.
- E-1164 Standard Practice for Obtaining Spectrophotometric Data for Object Color Evaluation.

(2) CIE Publications - CIE Publication Number 39-2, Recommendations for Surface Colors for Visual Signaling:

The adhesive shall require no heat for proper bonding when applied according to the manufacturer's recommendations to substrates 18 °C (65 °F) or above.

(3) Test Methods:

a. Test Conditions - Unless otherwise specified all applied and unapplied test samples and specimens shall be conditioned at the standard conditions of:

- 73 °F ± 3 °F, and
- 50% ± 5% relative humidity for 24 hours before testing

b. Test Panels - Unless otherwise specified when tests are to be performed using test panels, apply the specimens of retroreflective material to smooth aluminum cut from ASTM B-209/B 209M, alloy 5052-H36, 5052-H38, 5154-H38, or 6061-T6 sheets in the following thickness:

- 0.020 inch
- 0.040 inch
- 0.063 inch

Degrease and lightly acid etch the aluminum before the specimens are applied. Apply the specimens to the panels according to the retroreflective sheeting manufacturer's recommendations.

(c) Photometric - The retroreflective sheeting shall have the following daytime color specification limits *:

Table 02910-4

Color	1		2	
	X	Y	X	Y
White	0.305	0.305	0.355	0.355
Yellow	0.487	0.423	0.545	0.454
Red	0.690	0.310	0.595	0.315
Blue	0.078	0.171	0.150	0.220
Green	0.030	0.398	0.166	0.364
Orange (new or weathered)	0.583	0.416	0.523	0.397

Color	3		4	
	X	Y	X	Y
White	0.335	0.375	0.285	0.325
Yellow	0.465	0.534	0.427	0.483
Red	0.569	0.341	0.655	0.345
Blue	0.210	0.160	0.137	0.038
Green	0.286	0.446	0.201	0.794
Orange (new or weathered)	0.560	0.360	0.631	0.369

NOTE: Type A sheeting may not be available in red.

Reflectance Limit Y (%)		
Color	Minimum	Maximum
White	40	—
Yellow	24	45
Red	3	15
Blue	1	10
Green	3	9
Orange (new)	30	—
Orange (weathered)	20	45

* The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

Maximum Spectral Radiance Factor

New	110%, min.
Weathered	60%, min.

(1) Color Test - Determine conformance to color requirements by instrumental method according to ASTM E 1164 on sheeting applied to test panels and conditioned as in 4.1. Do the computations according to ASTM E 308 for the 2° observer.

(2) Coefficient of Retroreflection (R_A) - The coefficients of retroreflection (R_A) shall not be less than the minimum values specified in Table 02910-5 (Type A Sheeting), Table 02910-6 and Table 02910-6A (Type B Sheeting). Perform testing according to ASTM E 810 except that Table 02910-5 and Table 02910-6 values shall be met at 0° and at 90° orientation without averaging and the Table 02910-6A values shall be met using only the 45° orientation.

- Coefficients of retroreflection (R_A) shall be specified in units of candelas per lux per meter squared.
- The observation angles shall be 0.2° and 0.5°. Type A shall also be measured at 0.33° and 1.0° observation.
- For measurement, the datum mark (orientation arrow) shall be positioned horizontally for the 0° orientation and vertically for the 90° (preferred) orientation.

- For screen printed transparent color areas on white sheeting, the ratios of the R_A for the white to the R_A for color, when measured at 0.2° observation, -4° entrance, and 0° orientation, shall be 5:1 to 15:1 for Red and not less than 5:1 for Green and Blue when processed according to the sheeting manufacturer's recommendations.

Table 02910-5

Type A Sheeting
Minimum Coefficient of Retroreflection (R_A)
($\text{cd/lx}\cdot\text{m}^2$)
(0° and 90° Orientation)

Observation Angle ($^\circ$)	Entrance Angle ($^\circ$)	White	Yellow	Green	Blue
0.20	-4	430	350	45	20
0.20	+30	235	190	24	11
0.20	+40*	150	125	15	6
0.33	-4	300	250	33	15
0.33	+30	150	130	18	7
0.33	+40*	85	75	8	4
0.50	-4	250	200	25	10
0.50	+30	170	140	19	7
0.50	+40*	35	30	3.5	1.5
1.00	-4	80	65	10	4
1.00	+30	50	40	5	2.5
1.00	+40*	20	17	2.0	0.7

* Measure the 40° entrance angle at the 90° orientation only.

Table 02910-6

Type B Sheeting
Minimum Coefficient of Retroreflection (R_A)
($\text{cd/lx}\cdot\text{m}^2$)
(0° and 90° Orientation)

Observation Angle ($^\circ$)	Entrance Angle ($^\circ$)	White	Yellow	Red	Green	Blue	Fluorescent Orange
0.2	-4	800	660	215	80	43	200
0.2	+30	400	340	100	35	20	120
0.2	+45	145	85	25	12	7.6	—
0.2	+50	—	—	—	—	—	50
0.2	+60 *	35	23	6.6	2.0	1.0	—

Table 02910-6

Type B Sheeting
Minimum Coefficient of Retroreflection (R_A)
($\text{cd/lx}\cdot\text{m}^2$)
(0° and 90° Orientation)

Observation Angle ($^\circ$)	Entrance Angle ($^\circ$)	White	Yellow	Red	Green	Blue	Fluorescent Orange
0.5	-4	200	160	45	20	9.8	80
0.5	+30	100	85	26	10	5.0	50
0.5	+45	75	60	18	6.0	2.8	—
0.5	+50	—	—	—	—	—	20
0.5	+60	*	30	20	6.4	2.0	2.0
—							

* Measure the 60° entrance angle at the 90° orientation only.

Table 02910-6A

Minimum Coefficient of Retroreflection (R_A)
($\text{cd/lx}\cdot\text{m}^2$)
(45° Orientation)

Observation Angle ($^\circ$)	Entrance Angle ($^\circ$)	Yellow
0.2	-4	550
0.2	+30	130
0.5	-4	145
0.5	+30	70

(3) Gloss Retention - The retroreflective sheeting shall have an 85° specular gloss of not less than 50 when tested according to ASTM D 523.

(4) Color Processing - The retroreflective sheeting shall permit cutting and color processing with compatible transparent opaque process colors according to the sheeting manufacturer's recommendations at temperatures of 60°F to 100°F and relative humidities of 20% to 80%.

The sheeting shall be heat resistant and shall permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.

(d) Adhesive - Remove the protective liner attached to the adhesive by peeling without soaking in water or other solutions, and without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for four hours at 160 °F under a load of 2.5 pounds per square inch. The adhesive backing of the retroreflective sheeting shall produce a bond to support a 1.75 pound weight for five minutes without the bond peeling for a distance of more than 2 inches when applied to a test panel prepared as in 02910.31(b)(3)(b). Apply 4 inches of a 1 inch by 6 inch specimen to a test panel. Condition and then position the panel face down horizontally. Suspend the weight from the free end of the sample, and allow it to hang free at an angle of 90° to the panel surface for five minutes.

(e) Durability:

(1) Flexibility - The retroreflective sheeting, with the liner removed and conditioned as in 02910.31(b)(3)(a), shall be flexible and show no cracking when slowly bent, in one second's time, around a 1/8 inch mandrel, with the adhesive contacting the mandrel, at test conditions. Spread talcum powder on the adhesive to prevent sticking to the mandrel.

(2) Impact Resistance - The retroreflective sheeting, applied according to the sheeting manufacturer's recommendations to a test panel of aluminum alloy 6061-T6, 0.040" x 3" x 5" and conditioned as in 02901.31(b)(3)(a), shall show no cracking outside the impact area when the face of the panel is subjected to the impact of a 4 pound weight, with a 5/8 inch diameter rounded tip, dropped from a height necessary to generate an impact of 10 in·lb, at test temperatures of 32 °F and 72 °F.

(3) Resistance to Accelerated Outdoor Weathering - The retroreflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after two years of unprotected outdoor exposure, facing the equator and inclined 45° from the vertical. Following weather exposure, wash the panels in a 5% hydrochloric acid solution for 45° seconds, rinse thoroughly with clean water, blot with a soft clean cloth and bring to equilibrium at standard conditions. After cleaning, the coefficient of retroreflection shall not be less than the values in Table 02910-7 (Type A Sheeting) and in Table 02910-8 (Type B Sheeting) when measured at 0° rotation, and the colors shall conform to the requirements of Table 02910-4. The sample shall:

- Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch shrinkage or expansion.
- Where more than one panel of a color is measured, the coefficient of retroreflection (R_A) shall be the average of all determinations.
- For Type A Sheeting, be measured only at angles of: 0.2° observation, -4° entrance, and 0° rotation; and 1.0° observation, -4° entrance, and 0° rotation.
- For Type B Sheeting, be measured only at angles of 0.2° observation, -4° entrance, and 0° rotation.

Table 02910-7

Type A Sheeting
Minimum Coefficient of Retroreflection (R_A)
After Accelerated Outdoor Weathering
($\text{cd/lx}\cdot\text{m}^2$)

Color	Observation Angle (°)	Entrance Angle (°)	$\text{cd/lx}\cdot\text{m}^2$
White	0.2	-4	250
	1.0	-4	45
Yellow	0.2	-4	200
	1.0	-4	35
Blue	0.2	-4	11
	1.0	-4	1.3
Green	0.2	-4	25
	1.0	-4	3

Table 02910-8

Type B Sheeting
Minimum Coefficient of Retroreflection (R_A)
After Accelerated Outdoor Weathering
($\text{cd/lx}\cdot\text{m}^2$)

Color	Observation Angle (°)	Entrance Angle (°)	$\text{cd/lx}\cdot\text{m}^2$
White	0.2	-4	400
Yellow	0.2	-4	330
Red	0.2	-4	107
Green	0.2	-4	38
Blue	0.2	-4	22

(4) Resistance to Heat - Apply the retroreflective sheeting to a test panel and condition as in 02910.31(b)(3)(a); measure according to 02910.31(c)(2) at 0.2° observation and -4° entrance angles at 0° orientation and exposed to 170 °F plus or minus 5 °F for 24 hours in a circulating-air oven. After heat exposure, the sheeting shall retain a minimum of 70% of the original coefficient of retroreflection at each orientation when measured at room temperature.

(5) Resistance to Corrosion - The retroreflective sheeting, applied to a test panel and conditioned as in 02910.31(b)(3)(a), shall show no loss of adhesion, appreciable discoloration or corrosion, and after cleaning shall retain a minimum of 80% of the original coefficient of retroreflection when measured at 0.2° observation, -4° entrance and 0° rotation angles, after 1000 hours exposure to a 5% concentration salt spray at 95 °F when tested according to ASTM B 117.

(f) Warranty - The reflective sheeting shall carry a manufacturer's warranty for a minimum of seven years from the date of fabrication. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that:

- (1)** The sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision, or
- (2)** The coefficient of retroreflection, after cleaning, is less than the minimums specified in Table 02910-7 (Type A Sheeting) or Table 02910-8 (Type B Sheeting). Make all measurements after sign cleaning.

The Agency will date all signs at the time of application. That date constitutes the start of the field performance obligation period.

Where it can be shown that performance requirements of the sheeting supplied and used according to manufacturer's recommendations have not been met, the manufacturer shall bear the cost as follows for sheeting shown to be unsatisfactory during the:

- First five years, the manufacturer shall bear the cost of restoring the sign panel to its original effectiveness at no cost to the Agency for materials or labor, including removal and reinstallation if necessary.
- For the remaining two years, from the 61st to the 84th month, from the date of fabrication, the manufacturer shall furnish replacement sheeting required to restore the sign panel to its original effectiveness.

02910.32 ReflectORIZED Removable Legend-

(a) General - The letter and numeral design shall be the "E" modified version of the FHWA's standard rounded upper case, lower case, and capital letter alphabet.

Provide mounting holes within the frames to permit the use of the mounting hardware specified herein. Provide a sufficient number of mounting holes to ensure a firm attachment of the frames to the sign and meet the requirements of 00940.45(b). This requires a minimum of four mounting holes at each joint in the border.

(b) Retroreflective Sheeting Legend - The silver-white or white letters, numerals, symbols and borders shall be of adhesive-coated retroreflective sheeting permanently adhered to a flat aluminum frame. The white retroreflective sheeting shall consist of Type VII or Type 1X sheeting conforming to 02910.20. The silver-white retroreflective sheeting shall consist of Type III or Type IV sheeting conforming to 02910.20.

Letters, numerals, symbols and borders shall be a minimum of 0.032 inch thick aluminum conforming to ASTM B 209/B 209M, alloy 3003-H14. Degrease and etch the aluminum, or treat with a light, tight amorphous chromate type coating.

Apply the reflective sheeting to the prepared aluminum according to the sheeting manufacturer's recommendations.

The finished letters, numerals, symbols and borders shall be clean-cut and sharp, and shall have a nearly plane surface.

(c) Sampling and Testing - Sample and test removable legend according to the following:

(1) Sampling - Submit sample letters of each size of removable legend used on the Project to the Engineer for testing. The number of samples submitted shall equal 5% of the letters of each size with a minimum of two letters of each size of removable legend submitted. Submit two samples of each size border material used on the Project. The letters submitted shall be letters used on the signs for the Project.

(2) Testing - Substitute sample letters for actual letters used on the Project signs. The Engineer will test the letters removed from the sign according to 02910.32(b). Failure of one letter or border sample will result in the rejection of the sign from which it came. If a sign is rejected, the Engineer may require the testing of all the remaining signs on the Project that contain removable legend. If additional testing is required, the Engineer will specify the letter to be tested from each sign. No more than two letters of each size of removable legend will be tested from each sign. Furnish the additional letters to the City at the Contractor's expense.

02910.33 Permanent Legends:

(a) General - Permanent legends consist of silver-white reflectorized screened, red reflectorized screened, black screened or cut-out silver reflective sheeting. The letters and numerals of all permanent legends shall conform to the design of the FHWA "Standard Rounded Capital Letter Alphabets".

(b) Reflectorized White Screened Legend - The transparent paste materials used for the reverse screening of reflectorized white legends and for the screening of reflectorized red legends shall conform to the recommendations of the manufacturer of the reflective sheeting.

(c) Retroreflectorized Silver Cut-out Legend - The material used for retroreflective cut-out legend shall conform to the requirements of 02910.20.

(d) Non-reflectorized Black Screened or Cut-out Legend - The screen process ink for non-reflectorized legends shall be Naz-Dar 811 Black Screen Process Ink (Naz-Dar Company), Sherwin Williams Kem Screen Process, color D22-B2 (Sherwin Williams Company), or approved equal.

(e) Non-reflectorized Black Cut-out Legend - The material used for non-reflectorized cut-out legend shall conform to 02910.20.

02910.40 Hardware - The bolts, nuts, and washers used to fabricate and erect signs shall be aluminum alloy, stainless steel, or galvanized steel. Aluminum for bolts and nuts shall conform to ASTM B 211/B 211M, alloys 2024-T4 or 6061-T6 as the Contractor elects. Aluminum washers shall conform to ASTM B 209/B 209M, alloy Alclad 2024-T4. Stainless steel shall be Type 316. Galvanized steel bolts, nuts, and washers shall be medium carbon steel. Galvanize steel hardware according to ASTM A 153/A 153M.

Use nylon washers supplied by the sheeting manufacturer as shown or directed.

All mounting hardware shall be of the design and type shown, or if not shown shall be of such sizes and kinds as approved by the Engineer.

Blind rivets shall be 1/8 inch diameter, 1/4 inch head diameter, domed head, aluminum alloy conforming to ASTM B 316/B 316M. Aluminum alloys 5052 and 5056 are acceptable alloys. Blind rivets used to attach sign panels to closure strips or wind beams shall be anodized the same color as the sign background.

02910.60 Electronically Cuttable Films for Use on Retroreflective Sheeting:

(a) General - Electronically cuttable films shall consist of durable, transparent, colored films coated with a transparent pressure sensitive adhesive protected by a removable liner. The films shall be designed to be cut on knife-over-roll (sprocket fed or friction fed) and flat bed electronic cutting machines. The films shall be available in standard traffic colors, be dimensionally stable, and be designed to optimally cut, weed, lift and transfer. Use of electronic cuttable film shall not require the release of any volatile organic compounds.

(b) Acceptance Sampling and Testing - The following documents, of the issue in effect on the date the Project is advertised, form a part of this Specification to the extent specified as follows:

(1) ASTM Standards:

- B-209/B 209M Specification for Aluminum and Aluminum Alloy Sheet and Plate.
- D-523 Standard Method for Test for Specular Gloss.
- D-4956 Standard Specification for Retroreflective Sheeting for Traffic Control.
- E-284 Standard Definition of Terms Relating to Appearance of Materials.
- E-308 Computing the Colors of Objects by Using the CIE System.
- E-810 Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting.
- E-1164 Standard Practice for Obtaining Spectrophotometric Data for Object Color Evaluation.

(2) CIE Publications - CIE Publication Number 39-2 Recommendations for Surface Colors for Visual Signaling.

(3) Federal Standard Specifications - Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects.

(4) Test Methods:

a. Test Conditions - Unless otherwise specified all applied and unapplied test samples and specimens shall be conditioned at the standard conditions of:

- 73 °F ± 3 °F, and
- 50%, ± 5%, relative humidity for 24 hours prior to testing

b. Test Panel - Unless otherwise specified, when tests are to be performed using test panels the specimens of retroreflective and/or overlay film material shall be applied to smooth aluminum cut from ASTM B-209/B 209M Alloy 5952-H36, 5052-H38, 5154-H38, or 6061-T6 sheets in the following thicknesses:

- 0.020 inch
- 0.040 inch
- 0.063 inch

Degrease and lightly acid etch the aluminum before the specimens are applied. Apply the specimens to the panels according to the reflective sheeting and electronic cuttable film manufacturer's recommendations.

(c) Photometric - When electronically cuttable film is applied to retroreflective sheeting, the resulting color of the composite sheeting shall conform to Federal Specification FP-92, Section 718.01 and ASTM D 4956 for the appropriate retroreflective sheeting to which it is applied.

(1) Color Test - Determine conformance to color requirements by instrumental method according to ASTM E 1164 on sheeting applied to aluminum test panels. Perform the computations according to ASTM E 308 for the 2° observer.

(2) Coefficient of Retroreflection (R_A) - When electronically cuttable film is applied to retroreflective sheeting, the composite shall conform to the percentage retained of the minimum coefficient of retro-reflection specified by the [City](#) and the manufacturer for the retroreflective sheeting when the retroreflective sheeting is screen processed. The coefficient of retroreflection shall be determined in accordance with ASTM E 810.

- Coefficients of retro-reflection (R_A) shall be specified in units of candelas per lux per square meter.
- The observation angles shall be 0.2° and 0.5° unless otherwise specified.
- The entrance angles shall be -4° and 30° unless otherwise specified.

Retroreflective sheeting with datum marks shall be tested in the orientation specified by the manufacturer. If no datum mark is supplied, the sheeting shall be rotated to determine the minimum R_A , which shall be reported without averaging.

(3) Gloss Retention - The electronic cuttable film shall have an 85° specular gloss of not less than 50 when tested in accordance with ASTM D 523.

(4) Color Processing - The electronic cuttable film shall permit cutting, weeding, masking with transfer tape, lifting, and application to retroreflective sheeting when used in accordance with manufacturer's recommendations at temperatures between 65°F and 95°F and relative humidities between 30% and 70%. The film shall lay flat with minimal edge curl and be dimensionally stable.

(d) Adhesive - Remove the protective liner attached to the adhesive by peeling without soaking in water or other solution, and without breaking, tearing or removing any adhesive from the electronic cuttable film. The liner shall have a controlled release from the adhesive coated film sufficient to allow cutting without the film popping off from the liner while still allowing the liner to easily be peeled from the film.

Film with punched edges for use on sprocket fed knife over roll cutters shall be edge scored and weeded to remove film in the punched area as a means of eliminating adhesive build up on the sprockets.

(e) Resistance to Accelerated Outdoor Weathering - When electronic cuttable film is applied to retroreflective sheeting, the surface of the film shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after two years unprotected outdoor exposure, facing the equator and inclined 45° from the vertical. Following weather exposure, wash the panels in a 5% HCL solution for 45 seconds, rinse thoroughly with clean water, blot dry with a soft clean cloth and bring to equilibrium at standard conditions. After cleaning, the coefficient of retro-reflection shall not be less than the value specified by the City for the retroreflective sheeting when the retroreflective sheeting is screen processed. The sample shall:

- Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch shrinkage or expansion
- Show "Good" color fastness or better when tested as in 02910.60(f)

Retained reflectivity shall be the same as the City Specification for screen processed retroreflective sheeting of the type being tested.

The electronic cuttable film shall not be removable from the retroreflective sheeting without damage.

Retroreflective performance measurements made after weather exposure shall be made only at angles of 0.2° observation and -4° entrance. Where more than one panel of a color is measured, the coefficient of retro-reflection shall be the average of all determinations.

(f) Colorfastness - Wet out one specimen, exposed and prepared as specified in 02910.60(e), with a mild detergent and water solution. Compare with a similarly treated unexposed specimen under natural (North sky) daylight or artificial daylight having a color temperature of 7600 °K. Evaluate the colorfastness as follows:

Excellent	-	No perceptible change in color
Good	-	Perceptible but no appreciable change in color
Fair	-	Appreciable change in color

Appreciable change in color means a change that is immediately noticeable in comparing the exposed specimen with the original comparison specimen. If closer inspection, or a change of angle of light, is required to make apparent a slight change in color, the change is not appreciable.

(g) Acceptance - If requested, furnish with each lot or shipment a quality compliance certificate according to 00165.10, certifying that the material supplied will meet all the requirements listed.

02910.75 Manufacturer's Warranty - Furnish a Warranty, for Warranty periods stated below, from the Manufacturer and signed by a Manufacturer's Representative, conforming to the following requirements:

For retroreflective Type III, Type IV, and Type VII sheeting, provide a Warranty, for a Warranty period of 10 years, for restoring sign panels and replacing sheeting if the sheeting has failed as defined below.

For retroreflective type IX sheeting, provide a Warranty, for a Warranty period of 12 years, for restoring sign panels and replacing sheeting if the sheeting has failed as defined below.

For electronic cuttable films used with Type III, Type IV, and Type VII sheeting, provide a Warranty, for a Warranty period of 10 years, for restoring sign and panels and replacing sheeting cuttable film if the composite sheeting and cuttable film has failed as defined below.

For electronic cuttable films used with Type IX, sheeting, provide a Warranty, for a Warranty period of 12 years, for restoring sign panels and replacing sheeting with cuttable film if the composite sheeting and cuttable film has failed as defined below.

For purposes of the Warranty, the retroreflective sheeting will be deemed to have failed if it has deteriorated due to natural weathering or defects in materials or workmanship to the extent that:

- The sign shows discoloration, cracking, de-lamination, loss of adhesion, or
- The coefficient of retro-reflection is less than the following:
- 80% of minimum coefficient of retro-reflection for designated sheeting or cuttable film according to ASTM D 4956 for the first 7 years of the Warranty period
- 70% of minimum coefficient of retro-reflection for designated sheeting or cuttable film according to ASTM D 4956 for the remaining 3 years of the Warranty period for Type III, Type IV, and Type VII sheeting and remaining 5 years of the Warranty period for Type 1X sheeting.

All coefficient of retro-reflection measurements will be made after signs are cleaned.

The Warranty shall recite that, upon written notification by the City that the supplied sheeting or supplied sheeting with applied cuttable film, used according to the Manufacturer's recommendations, has failed, the Manufacturer shall repair or replace the sheeting, or sheeting with applied electronic cuttable film, within 6 months of the written notification according to the following:

- During the first seven years, the Manufacturer shall restore the sign panel to its original effectiveness at no cost to the City, including removal and re-installation if necessary
- For the remaining three years, (five years for Type IX sheeting) the manufacturer shall furnish replacement sheeting required to restore the sign panel to its original effectiveness at no cost to the City

When the City makes written notification to the Manufacturer of sheeting failure, the Warranty period will stop for the affected signs until required repairs or replacements are made and accepted.

All repaired or replaced signs and sheeting shall meet current sheeting specifications and be warranted for the remaining Warranty period.

The City will date all approved signs at the time of inspection at the City material laboratory. That date is the start of the Warranty period.

Section 02920 - Traffic Signal Materials

Description

02920.00 Scope - This Section includes the requirements for materials used in construction of traffic signal installations [with or without incidental street lighting](#).

Materials

02920.01 General - All materials shall conform to the standards and workmanship of 00960.01 and this Section. Where shown or specified, hardware shall be furnished and installed with hot-dip galvanized or Type 304 or 316 stainless steel screws, bolts, nuts and washers. Bolts and screws shall have square or hex heads. Allen head fasteners will not be allowed.

02920.02 Powder Coating - Powder coat materials according to the following:

(a) Galvanized Steel - After galvanizing light brush blast according to SSPC-SP-7 that removes surface contaminants and provides a profile but does not destroy the integrity of the galvanizing. Hand sand and debur as needed to remove rough areas. Preheat galvanized steel before powder coating to eliminate off gassing during curing. Electrostatically apply and oven cure a TGIC Polyester powder according to manufacture specifications to achieve a 50 micron minimum dry film thickness. The time from brush blasting to curing shall take no longer than eight hours to reduce surface oxidation. Coated galvanized steel shall have a salt spray resistance of 1,000 hours using ASTM B117 without loss of adhesion. Retap threads as required.

(b) Aluminum - Solvent clean according to SSPC-SP-1 followed by a light brush blast according to SSPC-SP-7. Preheat aluminum before powder coating to eliminate off gassing during curing. Electrostatically apply and oven cure a TGIC Polyester powder according to manufacture specifications to achieve a 50 micron minimum dry film thickness. The time from solvent cleaning to curing shall take no longer than eight hours to reduce surface contamination. Coated aluminum shall have a salt spray resistance of 1,000 hours using ASTM B117 without loss of adhesion. Retap threads as required.

Conduit and Junction Boxes

02920.10 Metal Conduit - Furnish metal conduit conforming to the following:

(a) Rigid Metal Conduit - Metal conduit and fittings shall be galvanized rigid metal manufactured of mild steel conforming to UL 6, Rigid Metal Electrical Conduit.

(b) Liquid-Tight Flexible Metal Conduit - Flexible conduits shall have a liquid-tight, nonmetallic, sunlight resistant outer jacket over an inner flexible metal core. Conduit shall conform to UL 360 Liquid-Tight Flexible Steel Electrical Conduit.

02920.11 Nonmetallic Conduit - Furnish nonmetallic conduit conforming to the following:

(a) Rigid Nonmetallic Conduit - Nonmetallic conduit shall be heavy wall, extruded, rigid polyvinyl chloride (PVC) conforming to UL 651, Schedule 80 Rigid PVC Conduit as shown, for 194 °F wire rated conduit.

(b) Liquid-Tight Flexible Nonmetallic Conduit - Liquid-tight, flexible nonmetallic conduit shall meet the requirements of Article 351 of the NEC and shall be UL listed.

02920.12 Conduit Fittings:

(a) Expansion Fittings - Expansion fittings shall be weatherproof, malleable iron expansion head and body with a hot-dip galvanized finish. Where the plans do not specify an equipment ground wire in the conduit run, furnish fittings with external bonding jumpers.

(b) Expansion-Deflection Fittings - For rigid metallic conduit furnish water-tight expansion-deflection fittings according to NEMA 4, with an integral bonding jumper.

(c) Condulets - Condulets shall be malleable iron conduit body hot dip galvanized with cover and moistureproof gasket.

02920.13 Junction Boxes:

(a) General - Junction box covers in vehicle traffic areas shall be rated for AASHTO H-20 highway loading. Surface-mounted boxes shall have overlapping covers.

Junction box covers shall have the [appropriate](#) legend [either](#) "SIGNALS" [or](#) "STREET LIGHTING" stamped or embossed on the cover. Letter size shall be no smaller than 1/16 of the box width.

[Cover shall be recessed non-slip material with a static coefficient of friction of between 0.8 and 1.0 as determined by ASTM Designation C 1028-89 and verified by an independent testing laboratory.](#)

(b) Metal Junction Boxes - Construct metallic junction boxes of cast iron or 1/8 inch nominal welded sheet steel. Make covers from reinforced non-slip steel plate. Use commercial quality steel. Hot-dip galvanize metallic boxes and covers after fabrication according to ASTM A 153/A 153M. Each box shall have a cover gasket that will, with cover in place, form a NEMA 4 watertight fit. Provide covers with stainless steel hex-head cap screws. Recess screw heads in the cover.

Drill conduit entrances into junction boxes and tap a minimum of three and one-half full threads for the size conduit used. Provide bosses where wall thickness is not sufficient for the minimum number of threads.

Flush-mounted boxes shall be outside-flanged with recessed, checkered steel covers.

(c) Concrete Junction Boxes - Concrete junction boxes shall be precast concrete, water meter type. Covers shall be capable of withstanding a load of 15,000 pounds over a 10 inch by 10 inch square surface. Covers shall have a skid-resistant surface with a static coefficient of friction of at least 0.8 as determined by ASTM Designation C 1028-89 verified by an independent testing laboratory, and bolt to the junction box with recessed stainless steel hex-head bolts. All covers for concrete junction boxes shall be recessed.

Steel lids shall be galvanized and bonded. The following junction box lids have been approved for City of Portland projects:

- Christy galvanized steel with “SlipNOT Grip Plate” Grade 1 finish (COF = 0.95)
- Christy galvanized steel with “SlipNOT Grip Plate” Grade 2 finish (COF = 0.98)
- Christy “Synertech” polymer 20K cover (COF = 0.88)

Recessed covers shall fit the box so that when the cover is set in the box, the top of the cover shall be even with the top of the box, with not more than a 1/8 inch gap between any part of the top edge of the cover and the inside lip edge of the box.

02920.20 Cable and Wire - Unless otherwise noted, all electrical conductors shall be approved stranded copper conforming to ASTM B 3 and ASTM B 8, Class B or C. Insulation shall be 600 V plasticized polyvinyl chloride, polyethylene, or chemically cross-linked polyethylene, conforming to ASTM D 2220, ASTM D 1351, ASTM D 2655, and ASTM D 2656. Do not use polyethylene compounds where exposed to sunlight.

Use aluminum conductors as an option to copper only in overhead service drops and overhead illumination circuits where shown or specified; otherwise conductors shall be copper conforming to this section.

Place the number and size of conductors shown to service the electrical device. Unless otherwise shown, the conductors shall be sized according to requirements of the NEC.

02920.21 Color Coding:

(a) General - Apply wire color coding mechanically, with striping clearly visible the entire length. Colored tape may be used where striping is worn from handling.

(b) Illumination Circuits - Color coding of illumination circuits will be required for three-phase systems only. Color coding of each phase conductor shall remain consistent throughout the entire electrical system.

(c) Traffic Signal Circuits - Color coding of traffic signal circuits shall conform to the wiring color code shown or specified.

02920.22 Cable:

(a) Messenger Cable - All messenger cable, unless otherwise specified, shall be 3/8 inch, seven-wire, conforming to ASTM A 475 utility grade, Class A coating, rated at 11,500 pounds. Where "figure eight" cable is permitted, such messenger cable shall be 1/4 inch seven-wire, Class A galvanized.

(b) Tether and Stabilizer Cable - Provide 1/4 inch common grade, or better, seven-wire stranded tether and stabilizer cable with Class A coating conforming to ASTM A 475.

(c) Loop Feeder Cable - Construct loop feeder circuits of two-conductor No. 14 AWG twisted pair shielded cable conforming with IMSA Specification No. 50-2.

When shown for traffic signal loop replacements, four-conductor loop feeder cable may be used, consisting of two twisted pairs of No. 16 or 18 AWG stranded wire, with polyethylene insulation and jacket, filled cable, and overall aluminum/mylar shield. When shown, construct loop feeder circuits of two-conductor No. 18 AWG twisted pair shielded cable conforming with IMSA Specification No. 50-2.

(d) Interconnect Cable - The interconnect cable shall:

- Comply with REA Specification PE-38 or PE-39
- Contain the number of wire pairs shown, and the individual conductors shall be No. 22 AWG solid and sequential length markings shall be included on the outer jacket.
- Be lashed to 3/8 inch messenger cable type for overhead installation
- Be PE-39 cable in underground installations
- Not be spliced
- Terminate on telephone style punch down blocks.
- Have an outer jacket that easily separates from the shield when stripped with a razor knife

(e) Power Service Cable - Power service conductors located on traffic signal spans shall be control cable or USE type RR wire.

(f) Control Cable - Provide control cable meeting IMSA Specifications 19-1 and 20-1. Outside jacket insulation shall be black in color.

Unless otherwise specified on the plans, individual conductors in control cables shall be No.14 AWG stranded copper wire. The control cable shall comply with all requirements of IMSA Specification 20-1 for span wire applications or applications exposed to sunlight and with all requirements of IMSA Specification 19-1 for cable which is not exposed to sunlight.

The straps used to attach control cable to messenger cable shall be heavy-duty UV resistant black plastic self-locking straps. The straps shall be approximately 5/16 inch in width. The straps shall have serrated gripping surfaces through a binding buckle, and when affixed shall remain securely tightened. The strap shall have a minimum tensile strength of 45 pounds when tested by a straight-line axial pull across the buckle. Test specimens shall be conditioned at 73.4 °F plus or minus 3.6 °F for at least four hours. Speed of testing shall be 1 inch per minute. The strength shall be the average of five test specimens. [The following strap has been prequalified by the City and are considered acceptable straps:](#)

- | • [Tyton MS 3367-3](#)

[\(g\) Unshielded 4 Conductor Detection Cable](#) -Unshielded 4-conductor detection cable shall have four No.18 AWG stranded copper wire conductors with an outer jacket of black high-density polyethylene. Individual conductors shall be insulated with high-density polyethylene. The following cable has been approved for City projects:

- | • [Belden Model 603425 "Vehicle Detection Cable"](#)

02920.23 Wire:

(a) THHN/THWN Wire - THHN and THWN wires shall be flame-retardant, moisture and heat-resistant thermoplastic insulated copper wire, with outer nylon jacket cover. Provide THHN wire rated for 194 °F operation in dry locations and THWN wire rated for 167 °F operation in wet or dry locations. Wires shall be UL labeled as THHN or THWN wire according to the NEC.

(b) XHHW Wire - XHHW wire shall be flame-retardant, cross-linked synthetic polymer insulated copper wire. Wire shall be rated for 194 °F dry and 167 °F wet locations and be UL labeled as XHHW wire according to the NEC. Wire used for traffic signal loops shall be No. 14 AWG XHHW wire conforming to IMSA Specification No. 51-3.

(c) Ground and Bond Wire - All ground or bond wire shall be stranded copper wire conforming to the NEC. Ground wire circuits shall be THWN green in color when installed in conduit. Minimum size shall be No. 6 AWG or as shown.

02920.24 Eyebolts - 3/4 inch diameter eyebolts shall meet the requirements of ASTM A 307.

02920.25 Electrical Splice Materials - Electrical wire splices and taps for illumination circuits shall be made using a silicon bronze split bolt connector to securely join the wires both mechanically and electrically. Splices located in junction boxes, pole bases or other similar locations shall be made moisture proof by using either a heat-shrink tubing with internal sealant or electrical insulating rubber tape over-wrapped with electrical vinyl plastic tape.

[Splices that may be submersed in water shall be made using heat shrink tubing with internal sealant or other approved method.](#)

Connections to factory equipment or luminaires shall be made according to the manufacturer's recommendations.

Heat-shrink tubing shall be a surface-irradiated tube listed UL 486, 194 °F, with 600 V inner melting wall or liner to provide a void-free encapsulated insulation. Tubing shall be flexible, abrasion resistant and nonflammable. An insulating rubber type tape shall be used when necessary to ensure the connection is void-free.

Insulating rubber tape shall be either an electrical grade, nondrying, rubber based, elastic-type putty for molding around the spliced connector or a rubber insulating tape conforming to ASTM D 4388.

Vinyl plastic tape shall be a minimum of 8.5 mil thick, flame-retardant, hot and cold weather resistant from 0 °F to 220 °F, and resistant to ultraviolet rays, moisture, abrasion, alkalis, acids and corrosion. Plastic tape shall conform to the requirements of ASTM D 3005, Type II and UL 510, Insulating Tape.

02920.26 In-Line Fuseholder:

(a) Slip Base Poles - The in-line fuseholder rated for 30 A at 600 V shall be designed to hold a 13/32 inch by 1 1/2 inch KTK type fuse. The case shall be rigid plastic with a threaded coupling for joining the two halves. When threaded together, the two halves shall completely enclose the fuse and exert pressure against a neoprene "O" ring to provide a waterproof seal. The load side holder shall hold the fuse securely in place, so when the two halves are disconnected, the load side holder will retain the fuse. The line side contact point shall be spring-loaded to provide pressure between the fuse and the contact points.

Wire terminals shall be set screw type for copper wire. Insulate terminal ends using either heat shrink tubing or electrical insulating rubber tape over-wrapped with electrical vinyl plastic tape as specified.

(b) Fixed Base Poles - Each in-line fuse connector shall be supplied with a 10 A fuse. In-line fuse connectors to be used on two-phase lighting circuits shall be designed for two-pole fusing so both poles disconnect simultaneously from both phases of the line side. The connector shall have no exposed metal parts, except that the head of a stainless steel assembly screw may be exposed. Recess the head of the metal assembly screw a minimum of 5/16 inch below the top of a plastic boss surrounding the head. The connector shall be designed for compression connection to the line and luminaire conductors. Screw connection will not be allowed. The body of the connector shall be of substantial thickness and strength to resist breakage.

02920.28 Wye Connector - Each wye connector shall contain three terminal lugs, a bolt and a stop nut. Each lug shall provide a mounting hole by which the lugs shall be fastened together with the bolt and nut.

The tap housing and the Y housing shall be made of water-resistant synthetic rubber suitable for burial in the ground or for installation in the sunlight. The tap housing shall provide a section to form a watertight seal around a cable and a section to provide a watertight seal between itself and the Y housing at the point of disassembly. The Y housing shall provide sections to form a watertight seal for the tap housing. Each unit shall be supplied with sufficient silicone compound to lubricate the rubber housings for easy assembly.

Make all connector ends at the cable entrance moisture proof using either heat-shrink tubing or vinyl plastic tape.

Poles and Towers

02920.30 Wood Poles - All wood poles shall conform to the requirements on 02120.10 except that 40 to 45 foot Class 4 poles shall be used for street light only poles, 25 foot Class 5 poles shall be used for beacon only poles and 35 foot Class 3 poles shall be used for traffic signal wood strain poles.

02920.31 Illumination Poles:

(a) General - The design, fabrication and installation of metal strain poles and mast arm poles shall comply with all applicable portions of the "2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals" and shall conform to the requirements set forth in the plans. Design wind shall be 90 mph.

The design, fabrication and installation of metal standards shall conform to the requirements of the plans, Section 00960, 02530.20, and this Section.

The type of poles shown on the plans is for illustrative purposes only and is not representative of any manufacturer.

Identify all poles, arms and anchor bolts by pole number, catalog number, and contract number. Before poles are ordered, submit to the Engineer, catalog cuts of approved drawings of poles, including anchor bolt and bolt circle information.

All illumination poles with a resulting mounting height of 24' or more shall have a reinforced hand hole with a minimum overall dimension of 4 inches x 6 inches. All illumination poles with a resulting mounting height of less than 24' shall have a hand hole with a minimum overall dimension of 3 inches x 5 inches. The bottom of the hand hole shall be approximately 18 inches above the bottom of the pole base. The hand hole shall be positioned 90° to the bracket arm, faced away from approaching traffic in the adjacent roadway lane. A cover that matches the pole shall be provided for the hand hole. The cover shall be secured to the pole with stainless steel allen-head screws.

The interior of the pole at the top of the shaft shall have an open-on-top hook attached at 90° to the mast arm opening.

Each pole shall be equipped with a removable metal ornamental pole cap secured to the shaft with stainless steel screws, and nut covers or full base covers finished to match the pole shaft. Cover shall be attached to the shaft with stainless steel allen-head screws.

Each pole shaft shall have an internal lug nut, or 5/8 inch hole for the purpose of attaching a grounding conductor.

All nuts, bolts, and washers shall be made from passivated stainless steel except for anchorage hardware.

(b) Aluminum Illumination Poles:

(1) General - Fabricate aluminum poles from one piece of seamless aluminum alloy tapered tubing conforming to ASTM B 241M, Alloy 6061-T6 or 6063-T6.

The base flange for the attachment of the shaft to the foundation shall be one-piece cast socket of aluminum Alloy 356-T6. The flange shall be joined to the shaft by means of complete circumferential welds, externally at the top of the flange, and internally at the bottom of the shaft tube. Anchor bolt covers shall be made of aluminum Alloy 43.

The surface finish shall be natural "satin" or anodized (Dark Bronze) aluminum, as specified.

(2) Aluminum-Concrete Contact - Felt used between aluminum and concrete contact surfaces shall conform to ASTM D 226, except that testing shall be limited to weight requirements (minimum 26 pounds per 100 square feet) only. Acceptance of felt will according to 00165.35.

(c) Steel Illumination Poles - Steel sheet for poles and arms shall conform to ASTM A 595, Grades A or B, or approved equal. All other steel sheet and plate shall conform to AASHTO M 270M/M 270, Grade 50, or approved equal. ASTM A 6/A 6M, supplement S18 regarding maximum tensile strength shall apply. The silicon content for steel, except base plates and small incidental and hidden pieces, shall be 0 - 0.04% or 0.15% - 0.25%. Prior to galvanizing, the pole manufacturers shall submit mill certificates verifying silica content to Engineer and the galvanizer.

Galvanize steel poles, mast arms, luminaire arms, fittings, bolts, nuts, miscellaneous hardware and appurtenances after fabrication according to ASTM A 123/A 123M or ASTM 153/A 153M, as appropriate.

Fabricate all pole and arm entrance fittings, including handholes, before galvanizing. All poles and arm entrance fittings shall be of the type shown or specified and shall be welded into the pole and/or arm. Grind all exposed butt-welds flush with the base metal before poles are galvanized.

The fabricator shall inspect welds as specified on Standard Drawings, which shall take precedence over the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

If requested, additional weld inspection may be required upon arrival of the material at the job site. If defects are found by this additional inspection, the fabricator shall be responsible for the additional testing and repair costs. If no defects are found, the Engineer will be responsible for the additional inspection costs.

The poles installed shall be as specified on the plan set or in the Special Provisions.

(d) Ornamental Poles - Ornamental poles and castings shall conform to the *City of Portland Specifications and Standard Drawings for Ornamental Light Poles*. Materials which are received that do not conform to these specifications will be rejected.

02920.32 Traffic Signal Poles:

(a) General - The design, fabrication and installation of metal strain poles and mast arm poles shall comply with all applicable portions of the "2001 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" and shall conform to the requirements set forth in the plans. Design shall be for 100 mph 3 second gust, gust factor 1.14, 50-year recurrence interval, and fatigue category II, no galloping and truck speed of 55 mph.

All poles shall be 8-sided in cross section unless otherwise specified by the Engineer. Alternative cross section shapes shall be considered special design poles and require submission of pole design calculations per the above criteria. All poles shall have a hand hole with a minimum overall dimension of 4 inches x 6 1/2 inches. The reinforcing frame shall be as shown on the base plate detail drawings. The bottom of the hand hole shall be not more than 7 inches above the bottom of the pole base.

Aluminum standards will not be allowed. The silicon content for steel, except small incidental pieces, shall be in the range of 0 to 0.04%. All steel used in the metal pole assemblies including base plates, flange plates and gusset plates shall have a yield strength of 50ksi. All materials shall be of domestic origin. Submit mill certificates to the Project Manager verifying silicon content, materials origin and prefabrication strength.

Four standard anchor bolts each fitted with two hex nuts shall be furnished with each pole.

Pole assembly dimensions and thickness shall be as shown in the plans. All tube thicknesses shall consist of a single ply of steel, no multi-ply shafts shall be utilized. No alternate sizes will be accepted. The height of strain poles and mast arm poles and the length of mast arms shall be as indicated on the plans. All pole assemblies shall be galvanized. Where the specifications call for painting the poles, the poles shall be painted as described in 00960.48 of these special specifications.

Submit detail drawings of poles for approval prior to fabrications.

(b) Design:

Strain Poles - All strain poles shall be furnished with pole tops.

Type 1 Strain Poles - Type 1 strain poles shall be tapered 8 or 12 sided faceted and shall, as a minimum, be fabricated of 5/16 inch weldable plate or coil steel. The pole diameter shall not be less than 12 1/2 inches and shall be tapered at 0.14 in/ft. The pole base plate shall be 2 inches thick and 18 1/2 inches square.

Type 1 strain poles shall be mounted on the footing shown on Standard Drawing D-200. This footing utilizes (4) 2 1/4 inches x 48 inches ASTM A307C anchor bolts on a 18" bolt circle. The base plate on the Type 1 strain pole shall be able to accommodate this bolt pattern as well as the "old standard," 1 3/4 inches diameter bolts on a 16 1/2 inches bolt circle. See D-103 for base plate detail.

Type 2 Strain Poles - Type 2 strain poles shall be tapered 8 or 12 sided faceted and shall, as a minimum, be fabricated of 3/8 inch weldable plate or coil steel. Pole diameter at the base shall not be less than 14 inches and shall be tapered at 0.14 in/ft. The pole base plate shall be 2 1/2 inches thick and 21 1/2 inches square.

Type 2 strain poles shall be mounted on the footing shown on Standard Drawing D-201. This footing utilizes (4) 2 3/4 inches x 60 inches ASTM A307C anchor bolts on a 20 inches bolt circle.

Mast Arm Poles - Mast arm poles shall be tapered 8 sided faceted unless otherwise indicated on the plans and shall be fabricated of weldable plate or coil steel of the minimum size shown on the drawings.

The length of the mast arm pole shaft from the base plate to the center of the mast arm shall be indicated as the dimension (RISER) on the mast arm clearance calculations shown on the plans.

There are three types of mast arm poles; Type 1, Type 2 and Type 3. Each type may have a single street light luminaire arm.

Type 1 mast arm poles shall be mounted on the footing shown on Standard Drawing D-200 and D-202. This footing utilizes (4) 2 1/4 inches x 48 inches ASTM A307C anchor bolts on a 18 inches bolt circle. See Standard Drawing D-103 for base plate detail.

Type 2 mast arm poles shall be mounted on the footing shown on Standard Drawing D-201 and D-205 (Type 2). This footing utilizes (4) 2 3/4 inches x 60 inches ASTM A307C anchor bolts on a 20 inches bolt circle.

Type 3 mast arm poles shall be mounted on the footing shown on Standard Drawing D-201 and D-205 (Type 3). This footing utilizes (4) 2 3/4 inches x 60 inches ASTM A307C anchor bolts on a 22 1/2 inches bolt circle.

All mast arms up to 40' in length shall attach to the pole riser shaft using a flange plate connection as shown in detail on Standard Drawing D-102. All mast arms greater than 40' in length shall attach to the pole riser shaft using a flange plate connection with reinforcing rings as shown in detail on Standard Drawing D-102A. The mast arm shall be inserted into the mast arm flange plate and shall be circumferentially welded inside and outside. The mast arm flange plate shall be perpendicular to the centerline of the mast arm. The pole flange plate shall be welded to the pole at the designated angle using 5/16 inches thick gusset plates for single mast arms, and 3/8 inch thick gusset plates for dual arm poles with equal riser heights. The gusset plates shall form a water tight "box" after welding is completed. Vent holes shall be cut into the pole inside the gusset "box" to allow proper ventilation for galvanizing. A 3 inches STD pipe wire guide shall be welded into the center of the pole flange and shall protrude into the pole.

All mast arms greater than 45 feet in length shall have an arm taper of 0.16 inch per foot in order to limit pole vibration.

(c) Mast Arm - Mast arm shall match the pole style. When attached to the mast arm riser pole at the flange plate joint, the mast arm and the straight stub tube will form a geometric figure composed of three segments. Starting from the mast arm riser pole, the first segment will be an angled straight section. The second section is a curved section of constant radius tangent to the first and third sections. The third section is a straight section that is a maximum of 4° above horizontal when the mast arm is unloaded and a minimum of 1° above horizontal when fully loaded.

When the mast arm assemblies are installed and all the cabling, signals and signs are in place, the elevation difference between the top of the foundation and the end of the arm will be at a minimum the value shown on the plans in the Mast Arm Clearance Calculations. This value may be higher by up to 3% of the mast arm length but not less than the value given.

A pipe tenon shall be installed by the manufacturer for each signal and sign, as shown on the plans. The placement of the tenon on the arm shall be on the side of the arm facing the approaching traffic as described in the pole schedule. Holes installed in the tenons for the required through bolts shall be field drilled.

Field installed pipe tenons shall be Pelco AB-3008 Clamp Kits or approved equals. The placement of the tenon shall be on the side of the arm facing the approaching traffic as shown on the plans. Field drill and tap a 1 inch hole for the wiring entrance and install a short nipple and bushing prior to installing the tenon clamp kit. Field drill holes in the tenon for through bolts that connect the plumbizer.

02920.33 Frangible Bases:

(a) General – Bolts, nuts and washers shall conform to 02560.20 and shall be galvanized according to 02560.40.

(b) Vehicle Signal Pedestals - Frangible transformer bases for vehicle signal pedestals shall be used only when shown or specified. Transformer bases shall be constructed to bolt to shaft flanges. Bases shall be square with rounded corners, tapered from the base to the top and approximately 20 inches in height. They shall be made of cast aluminum and shall conform to the City's Standard Drawings.

(c) Pedestrian Signal Pedestals - Pedestrian signal pedestal bases shall be a raised, frangible type and shall be constructed of cast aluminum. Bases shall include a removable access plate and a threaded connection for a 4-inch standard steel pipe pedestal.

02920.34 Anchor Bolts - Anchor bolts shall conform to 02560.30 and to the types and sizes shown.

Cabinets and Control Devices

02920.40 Cabinets:

(a) Illumination - Construct all cabinets 14 gauge, 304 stainless steel. Cabinets shall be weatherproof, rated as NEMA Type 3R, and be constructed as shown. A 14 gauge stainless steel nameplate shall be attached to the door with a minimum of six stainless steel tamperproof fasteners. The nameplate shall be inscribed "Street Lighting" in letters approximately 3/8 inch high.

Construction of pedestal-type cabinets to be open-bottom with a bottom frame that can be employed to bolt the unit to a concrete pad at a minimum of four points. All working hardware shall be stainless steel. All metal and non-hardware metal parts shall have all slag, burrs, and rough spots cleaned and ground smooth. The service enclosures shall be delivered to the site complete with all equipment installed and wired for correct operation. Arrangement of equipment and wiring shall be in general conformance with the plans and details. All work on the construction of the service cabinets and panels shall be at a UL listed facility and the services enclosures shall carry a UL label of approval for use as "service entrance equipment".

All switch gear, relays clocks, etc., shall be mounted on a mounting pen, and the enclosure is to be fitted with a dead front panel. No equipment or devices are to be attached to the dead front panel. Dimensions of the service enclosures shall be as specified on the plans and details. These dimensions are minimum and nominal. The dead front panels and mounting pans shall be 14-gauge stainless steel.

Panels controlling two or more circuits shall have schedule affixed to the interior of the cabinet which shall clearly indicate the pole number each pole that is connected to each circuit breaker. Each circuit breaker shall be numbered or otherwise identified.

(b) Traffic Signal - Construct all cabinets, except signal controller cabinets, from 12 gauge Type 304 stainless steel, or 10 gauge sheet steel and hot-dip galvanize after fabrication according to 2530.70, or 8 gage 5052 - H32 powder-coated aluminum. Cabinet shall be weatherproof, rated as NEMA type 3R, and constructed as shown. Pole-mounted controller cabinets shall be provided with solid bottoms or covers for openings provided for foundation mounting and only the appropriate openings for a conduit connection.

The internal wiring of cabinets shall be done by a UL listed facility. Cabinets shall conform to one or more of the following standards where appropriate: UL 50, Cabinets and Boxes; UL 67, Panelboards; and UL 869A, Service Equipment.

Use a welded conduit hub to make conduit entrances into cabinets. Hubs shall be of the size required and shall be securely welded to the cabinet before galvanizing. Malleable iron screw-on hubs may be used as approved. Conduit entrances into poles from cabinets may be from the bottom of the cabinet through an LB conduit and conduit nipple.

The service cabinet shall be raintight and fabricated from 14-gauge stainless steel with all joints spot welded. A 1 inch stainless steel hub shall be welded to the top of the cabinet and centered near the back. A 1/4 inch stainless steel padlock hasp shall be spot welded to the bottom of the cabinet in such a manner that the hasp will protrude through the front cover when the cover is closed.

Where the plans call for the service cabinet to be mounted on a steel pole, the cabinet shall have a 1 1/4 inch hole drilled in the center of the back near the bottom of the cabinet. A 1/8 inch stainless steel bracket shall be welded to the back near the top of the cabinet for use in banding the cabinet to the pole.

The cabinet shall be 10 inches x 7 inches x 4 inches and shall contain one 40 amp. and one 15 amp. SPST circuit breaker. Space shall be provided for one additional breaker. A blank cover shall be secured to the faceplate to cover the opening for the additional breaker.

02920.41 Circuit Control Devices:

(a) General - Install circuit breakers, the copper neutral block, and contactors as shown.

(b) Circuit Breakers - Circuit breakers for illumination shall be GE type TEB for all 150 amp breakers or smaller; GE type TED shall be used for all breakers greater than 150 amps.

Circuit breakers shall be of the rating shown or specified. Circuit breakers shall be of the unenclosed, molded case bolt-on type with end conductor terminals, suitable for surface mounting in the cabinet on a false back or bracket.

Circuit breakers shall conform to Federal Specification W-C-375B. All 100 A frame breakers shall be Class 13a for single pole breakers, and Class 18a for multiple pole breakers. 225 A frame breakers shall be Class 20a, 400 A frame breakers shall be Class 21a, and 800 A frame breakers shall be Class 23a.

Install overcurrent protection and relay equipment, as shown or specified, according to the best common practice, with materials and installation conforming to the NEC.

(c) Multiple Light Contactors - For illumination projects, the contactor shall be model Square D 8903, or approved equal.

(d) Test Switch - Furnish and install a 277 V AC rated test switch in the control cabinets if shown. The test switch shall be a heavy-duty single-pole switch or circuit breaker rated at 15 A and shall be installed in the control cabinet as a roadway lighting test switch. The switch shall be wired to shunt the photoelectric relay power contactor and energize the lighting circuit contactors.

(e) Photocontrol Electronic Relay - The photocontrol electronic relay shall attach to a three-pole locking receptacle by a twisting motion.

The unit shall have a built-in surge protective device for protection from induced high voltage and follow-through currents. The relay shall meet or exceed the requirements of ANSI C136.10. Factory set turn-on lights shall be 1.4 foot-candle plus or minus 0.2 foot-candle at 120 V AC. When operated at 240 V AC, turn-on shall not change more than plus or minus 0.3 foot-candle from the 120 V value. Maximum off-to-on ratio shall be 1.5:1.

The photocell shall be a cadmium-sulfide photocell encapsulated for humidity protection, or a silicon junction-type photo-transistor.

Normal operation shall be designed for dual voltage operation of 105 V - 285 V, 60 Hz.

Power consumption shall be less than 1 W. At the designated voltage, the photoelectric control shall be capable of controlling a minimum mercury vapor, fluorescent or incandescent lamp load of 1000 W. Minimum operating temperature range shall be from -40 °F to 150 °F.

A time-delay control circuit shall prevent false turn-offs by transient light conditions. Provide a fail-safe circuit for the lighting load to remain on or become energized if any functional failure of the photoelectric control circuit occurs.

02920.42 Traffic Signal Control Devices:

(a) Signal Controllers - The traffic signal controllers and related equipment shall conform to requirements of the current edition of ODOT's Standard Specifications for Microcomputer Signal Controller, except as supplemented and/or modified by the Special Provisions.

(b) Flasher Mechanism (Remote from Controller Cabinet) - The remotely located flasher mechanism shall be a model 204 flasher.

02920.45 Vehicle Detection Devices:

(a) Inductive Loop Detector Amplifier for Model 170 Controller - The inductive loop-type detector unit shall be as specified in the current edition of ODOT's Standard Specifications for Microcomputer Signal Controller, except as supplemented and/or modified by the Special Provisions.

Lamps, Ballasts and Luminaires

02920.50 Illumination Lamps - All mercury vapor, high-pressure sodium and metal halide lamps shall conform to ANSI Standards. All lamps of the same size and type, on a single Project, shall be from the same manufacturer's lot number.

All lamp bases shall have a brass mogul base mounting with dating system.

Lamps shall have an average minimum initial lumen rating (after 100 burning hours) and an average minimum lamp life (based on 10 hours per start) as follows:

Lamp Watts	ANSI Code	Minimum Initial Vertical	Lamp Lumens Horizontal	Minimum Average Lamp Life
High-Pressure Sodium - Clear				
50	S68MS-50	4 000	4 000	24 000
70	S62ME-70	6 300	6 300	24 000
100	S54SB-100	9 500	9 500	24 000
150	S55SC-150	16 000	16 000	24 000
200	S66MN-200	22 000	22 000	24 000
250	S50VA-250/S	29 000	29 000	24 000
310	S67MR-310	37 000	37 000	24 000
400	S51WA-400	50 000	50 000	24 000

02920.51 Traffic Signal Lamps - Vehicular signal lamps shall be rated for 130 V AC operation, and shall have a rated life of at least 8000 hours.

The light distribution and candle power intensity from the combination of lamp, reflector, and lens for signal heads shall conform to the current ITE Standards for Adjustable Face Vehicle Traffic Control Signal Heads.

The signal lamps shall be rated in either watts or lumens. The following are recommended signal lamp ratings. Certification of compliance with ITE standards shall be submitted on lamps rated for other than the recommended values.

Indication Color	8 Inch Lens		12 Inch Lens	
	watts	lumens	watts	lumens
Red	See 02920.51(a)		See 02920.51(a)	
Yellow	67 - 69	665	100 - 116	1260
Green	See 02920.51(a)		See 02920.51(a)	

Light center length for 12 inch signal lenses shall be 3 inches and for 8 inch signal, lenses shall be 2 7/16 inches or as recommended by the manufacturer. Lamps shall be designed to withstand vibration and intended for use in traffic signal heads. Each lamp receptacle shall be equipped with heat and moisture-resistant, thermoplastic-insulated, color-coded or marked leads of stranded wire of sufficient length to allow full movement of the hinged reflector without breaking the lighting circuits. Lamp sockets shall be of weatherproof molded construction and capable of withstanding, without deterioration, the temperatures encountered during operation. Design the sockets so the lamps will not become loose due to vibration.

(a) Traffic Signal Light Emitting Diode (LED) Modules - Traffic signal LED modules shall comply with current ITE specifications. Submittals shall include a report from an independent test laboratory that certifies full compliance of LED signal modules to the ITE specifications across the temperature range of -35° Fahrenheit to +165° Fahrenheit. All modules must conform to the City of Portland's requirements for wiring and termination.

Ball signal modules shall comply with the ITE VTCSH LED Circular Supplement specifications. Typical or nominal wattage shall not exceed 6 watts for the 12 inches Red Ball, 19 watts for the 12 inches Yellow Ball, and 9 watts for the 12 inches Green Ball.

Arrow signal modules shall comply with to the ITE VTCSH Part 3 LED Vehicle Arrow Traffic Signal Modules specifications. Combined nominal wattage for the Red Arrow, Yellow Arrow and Green Arrow shall not exceed 23 watts.

Pedestrian signal modules shall comply with the ITE PTCSI Part 2; LED Pedestrian Traffic Signal Modules specifications. Combined nominal wattage for the Hand/Person Countdown pedestrian signal shall not exceed 19 watts. Combined nominal wattage for the Hand/Person pedestrian signal shall not exceed 15 watts.

02920.52 Ballasts - Unless otherwise specified on plans, the luminaire ballasts shall be normal power factor reactor type for 150 watt or smaller. Ballasts for 200 watt and larger shall be magnetic regulator type.

If remote-mounted ballasts are shown or specified, mount the ballasts in weatherproof ballast enclosures of corrosion-free aluminum or fiberglass reinforced polyester. A 1-inch threaded nipple shall be molded into the cover. Provide a minimum of 10 inch color-coded and identified leads.

Ballasts directly exposed to rain or water shall have enclosures completely filled with epoxy resin or other suitable material to lock capacitors, core, and coils firmly in place and maintain a watertight seal. Mount starting-aid circuits for high-pressure sodium lamps in the luminaire.

Provide a manufacturer's nameplate on the ballast housing. The nameplate shall have the manufacturer's name, model number, serial number, hook-up diagram, power supply data, lamp type and operating wattage.

The ballast shall operate the lamp within the limits specified below throughout the rated life of the lamp:

- The lamp wattage shall not vary more than plus or minus 5% of nominal when the lamp is at its rated nominal voltage (high-pressure sodium lamps only).
- The ballast shall not allow the lamp arc to extinguish when a line voltage dip as shown below occurs for several seconds.
- The ballast shall start and operate the lamp in ambient temperatures down to -20 °F.

- The lamp current crest factor shall not exceed 1.8 for line voltage variation shown below.
- The ballast shall conform to all ANSI Standards.

Unless otherwise shown or specified, operate ballasts on 240 V or 480 V. When 120 V operation is specified, the ballast shall be a multi-voltage type with taps to allow the ballast to be connected to 120 V, 208 V, 240 V, or 277 V.

02920.53 High-Intensity Discharge Luminaires:

(a) General - Furnish conventional roadway luminaires for horizontal slipfitter end mounting.

Luminaires shall have a cast-aluminum housing and shall attach to 2 inch pipe tenons on mast arms. The luminaire attachment fitting shall provide for a minimum of plus or minus 3° adjustment of the luminaire in the vertical direction. The reflector of all luminaires shall be of a snap-on or easily removed design manufactured of polished aluminum or molded from prismatically formed borosilicate glass. The refractor shall be mounted in a door frame assembly hinged to the luminaire and secured in the closed position by means of an automatic latch or a draw latch. The refractor and doorframe assembly, when closed, shall exert pressure against a gasket. Gaskets shall be composed of material capable of withstanding the temperatures encountered and shall be securely held in place. Glassware shall be of the refractor type with prisms.

Reflectors and refractors provided with the luminaire shall be stamped or labeled with a part number. The luminaire photometric submittal (isocandela diagrams) shall indicate the reflector and refractor part number used.

All luminaires shall have their components secured to the luminaire frame with corrosion-resistant mounting hardware. The housing, complete with integral ballast, shall be weathertight.

If sand-cast, the aluminum housing shall be left in its natural finish. If die-cast, the housing shall be given a coat of aluminum paint.

Refractors shall be formed from heat-resistant, high-impact, molded borosilicate glass.

Lamp sockets shall be adjustable to obtain the light distribution shown or specified.

Socket opening shall be sealed with a heat-resistant filter or filtering gasket to prevent the entry of dirt, insects or moisture into the optical system.

The socket mounting mechanism shall be sufficiently rigid that upon application of a 2 pound load in any direction on the light source center, the light source center will not deflect more than 1/16 inch.

(b) Classification of Luminaire Light Distribution - Furnish the following distribution types as shown or specified.

(1) Vertical Light Distributions - Divide vertical light distributions into three groups: short (S), medium (M), and long (L). Classification of the three groups depends on the maximum candle power point within a grid area according to the ANSI/IES RP-8 (1990) publication for Roadway Lighting.

(2) Lateral Light Distributions - Lateral light distribution patterns shall have the following designations:

Type I
Type II
Type III
Type IV
Type V

The type designations listed above shall conform to ANSI definitions.

(3) Distribution above Maximum Candle Power - This classification shall be used to control the candle power in the upper portion of the beam above the maximum candle power. The following three classifications shall be used:

Cutoff
Semicutoff
Noncutoff

The classifications listed above shall conform to ANSI definitions.

(c) Standard Luminaires - The luminaire shall be as specified on the plan set. All exposed hardware shall be made of stainless steel. The fixture provided shall be as specified for the project, or an approved equivalent.

Signal Indication and Sign Material

02920.60 Signal Indication Material - The housings, including doors and hoods, shall have a smooth homogeneous finish. Construct the pedestrian and vehicle signal housings and doors of die-cast aluminum alloy. All parts shall be clean, smooth, and free from flaws, cracks, blow holes, and other imperfections. Parts shall be finished inside and out according to 00990.48. All fasteners not specifically noted as hot-dip galvanized shall be Type 304 or 316 stainless steel installed with anti-seize compound.

Except for brass terminal screws, all hardware on pedestrian and vehicle signal heads shall be Type 304 or 316 stainless steel. The stainless steel latching device shall utilize a wing nut or a positive fastener to hold the door securely in place. The reflector retaining rings shall be stainless steel, black powder-coated aluminum, or polycarbonate. All lamp sockets shall be brass with a phosphor bronze center contact. Aluminum sockets are not acceptable.

02920.61 Illuminated Signs:**(a) Part-Time Restriction Signs - Use LED part-time restriction sign:**

(1) Cabinet - Furnish a cabinet having a frame constructed of extruded aluminum alloy. The back panel shall be polycarbonate plastic, ABS plastic or sheet aluminum. All panels and frame members shall be of sufficient strength and thickness to prevent warping and bowing. Aluminum frame members shall be 6063-T5 and aluminum panels shall be hot-dip galvanized or Type 304 or 316 stainless steel. Provide easy access to the components of the sign for maintenance. Wash exposed exterior aluminum with a cleaning solvent and when dry, apply two coats of flat black paint.

(2) Visor - Attach to the sign frame a visor that projects over the sign face and sides. Projection over the sign face shall be approximately 5 inches at the top of the sign and approximately 2 inches at the bottom of the sign. Construct the visor of sheet aluminum of sufficient strength and thickness to prevent warping and bowing. Attach the visor to the sign frame with stainless steel screws and paint as specified in paragraph (a)(1) above.

(3) Legend - The legend shall be clearly legible in bright sunlight within 250 feet of the sign. The face of the sign shall be black and the legend shall not be visible even in direct sunlight when the sign is off. The color of the legend shall be as shown on the plans. Obtain the Engineer's approval of the layout and letters prior to construction.

(4) Lighting - The legend shall be made up of strings of LEDs. The LEDs have a minimum viewing angle of 22° and a maximum viewing angle of 30°. The LEDs shall be energized from at least two circuits, to maintain visibility in the event of an LED failure.

(5) Physical - The minimum size of the sign face shall be 30 inches wide by 36 inches high, and may vary with the approved legend. The sign shall be capable of continuous operation over a temperature range of -35 °F to 165 °F.

(6) Mounting - Mount the sign using mounting hubs. Tether signs installed on messenger cables. Use a minimum of two hubs and two letters, installed as shown.

02920.62 Signal and Sign Mounting Hardware - Use cast bronze to construct elevator plumbizers, standard plumbizers, and span wire hangers. Paint the mounting hardware with two coats of zinc-rich aluminum paint. All fasteners not specifically noted as hot-dip galvanized shall be Type 304 or 316 stainless steel, including all hardware and fasteners on tri-stud adapters, spanwire hangers, and plumbizers. The fasteners shall have either square or hex heads. Allen head fasteners are not allowed. Use nylon insert lock nuts on tri-stud adapters and for mounting signal sections together.

Furnish tri-stud adapters with two backing washers and omit the neoprene washer/gasket. Use silicon to seal between the tri-stud and the signal head. The 1/8 inch reinforced plate for the 30 inch by 36 inch interior illuminated signs shall have a minimum 24 square inch bearing surface.

Use silicon to seal between the tri-stud and the signal head. Use an adjustable bracket for vehicle signal assemblies that incorporate four or more sections (lenses). The 1/8 inch reinforced plate for the 30 inch by 36 inch interior illuminated signs shall have a minimum 24 square inch bearing surface.

On span wire hangers, use hot-dip galvanized or stainless steel U-bolts in the messenger cable clamp.

02920.64 Signal Heads - Each housing shall be of the one-section expandable type. Each section shall be of one-piece construction. The design shall be such that at any time and without the use of other than simple tools, it shall be possible to convert any housing into a one-, two-, three-, four- or five-section housing by the addition or subtraction of housing sections. The entire housing shall be made dustproof and waterproof. Vehicle signal heads shall have the screw hole plug installed and shall have a 1/4 inch drain hole drilled in the bottom of the casting or in the plug.

The following make and model of vehicle signals have been prequalified by the City and are considered acceptable for signals which are not programmed visibility signals:

1. Traffic Control Technologies (TCT) Die-Cast Aluminum
2. Automatic Signal/Eagle Signal Die-Cast Aluminum with phenolic shell and brass socket
3. McCain Traffic Supply Die-Cast Aluminum
4. Peek Traffic Die-Cast Aluminum with aluminum frame for reflector support

If the head(s) that the Contractor proposes to supply on this project is not listed above, submit an actual sample of the head to the City for approval prior to installation.

Color code all leads inside vehicle signal heads red, yellow, green, and white.

(a) Lenses - Vehicular signal lenses shall conform to ITE Specifications and shall be:

- Glass with a minimum light transmittance of 92%
- Free of bubbles, flaws and other imperfections
- Circular with a nominal diameter as shown or specified. All arrow indications shall have a nominal diameter of 12 inches.
- Mounted in a separate door hinged to the signal housing
- Mounted in an endless composition rubber gasket that completely encompasses the edge of the lens and provides a cushion and positive seal between the lens and the door. Use at least four lens clips to secure the lens and gasket to the door.

- Designed so the lens, when illuminated, is clearly visible to the traffic controlled by the signal face at all distances up to 1,000 feet under all light and atmospheric conditions, except dense fog
- Designed so the sun's rays do not reflect and produce any appreciable sun phantom effect, even with the sun shining directly into the lens face

(b) Doors - Gasket each door to provide moisture-proof construction, so when closed it fits snugly against the reflector. Doors shall open and close easily with one hand.

(c) Reflectors - Illuminate each lens independently of any other lens and provide with a parabolic Alzak[®]-finished aluminum reflector. Hinge reflector frames to either the door or the housing, so access to the rear of the reflector is allowed without breaking the light circuit. Use suitable clips to hold each reflector firmly to its frame so lamp socket inspection is permitted without removing the reflector.

Removal of the reflector shall not be necessary to replace the lamps on either vehicle or pedestrian signals.

(d) Visors - Construct visors of sheet aluminum alloy ASTM B 209/B 209M, nominal thickness 16 gage. Visors shall be of one-piece construction and attach to the signal housing doors with Type 304 or 316 stainless steel screws. Provide 8 inch lenses with a 7 inch visor and 12 inch lenses with a 9 1/2 inch visor.

Signal housing doors, with visors attached, shall be capable of being opened a minimum of 90°. Use tunnel visors with the bottom portion open, so the signal is visible directly in front of and below the signal head, on all vehicular signal indications.

(e) Backboards - Construct backboards of sheet aluminum alloy ASTM B 209/B 209M, 14 gage nominal thickness. All backboards shall be louvered. Provide all vehicular signal heads with backboards and include all of the necessary mounting hardware for completing the installation. Backboard dimensions shall fit the signal head housings used, with no gap between backboard and housing. Backboards shall conform to the general design shown. Backboards shall have a minimum border width of 5 inches and a maximum border width of 5 1/2 inches. Powder-coat backboards according to 00990.48(b)

Attach backboards with stainless steel screws and washers. Use washers at least 3/8 inch in diameter.

02920.65 Pedestrian Signal Heads - All pedestrian signal heads shall be single-section and shall comply with the following:

(a) Signal Heads - All pedestrian signal indications shall be LED countdown pedestrian signals. The light source shall be:

- 16 inch by 18 inch module
- LED overlaid filled countdown style. Overlaid filled hand/man on the left with countdown on the right.
- Meet ITE standards for color and luminous intensity
- Countdown only in the flashing don't walk phase
- Compatible with all other controller equipment

The message module shall consist of LEDs protected by a housing of rugged plastic and a polycarbonate plastic prismatic lens. The message module shall be equipped with two circuits, one for each of the "HAND" and "WALKING PERSON" symbol messages. Each of the solid state circuit shall energize the appropriate message when powered up from 120 volt 60 Hz source. Energy requirements for each message shall not exceed 13 watts per message.

Pedestrian signals shall be equipped with Z-crate type visors made of polycarbonate plastic having a depth of an inch and a half with members placed in such a manner as to permit optimum view of the signal message. Cables feeding pedestrian signals on steel poles shall run inside the pole from the entrance fitting, terminal cabinet or pole base directly into the clamshell mounting bracket.

The City has prequalified the following makes and models of countdown pedestrian signals:

1. Gelcore - Countdown Pedestrian Signal (PS7-CFF1-01A)
2. Dialite - Countdown Pedestrian Signal (430-6479-001)
3. Quixote - Countdown Pedestrian Signal (LEDP-HMC-001P)

If the head(s) that the Contractor proposes to supply on this project is not listed above, submit an actual sample of the head to the Engineer for approval prior to installation.

(b) Pedestrian Push Button - All push buttons shall be the "H" bracket style push buttons within an extruded aluminum bracket with signs placed directly on both sides of the extrusion.

The City has prequalified the following makes and models of push buttons:

1. Polara Bulldog Model RBDLM2-B
2. Dick Campbell Company Model 120-4EVR

If the push button(s) that the Contractor proposes to supply on this project is not listed above, submit an actual sample to the Engineer for approval prior to installation.