3501
Basic Requirements For Ready-Mixed Paints and Enamels

3501.1 SCOPE

This Specification covers the requirements for paints to be used for construction and maintenance purposes.

For the purposes of this Specification, the term "paint" shall be construed to include enamels.

3501.2 REQUIREMENTS

A General Requirements

A1 Proportions

All proportions as specified are by mass. The proportions of pigment and vehicle and composition of pigment and vehicle shall be within 97 to 103 percent of the quantities specified.

A2 Package Stability

Within a period of 6 months from time of delivery, the paints shall not cake, liver, thicken, curdle, gel, or show any other objectionable properties that cannot be readily corrected by stirring.

A3 Colors

All paints shall be matched to Federal Standard 595 colors or the Department's standard shades, unless otherwise specified.

A4 Manufacturing and Packaging

The paint shall be manufactured by an approved process. All pigments shall be thoroughly ground in the vehicle before reduction. The equipment for mixing and grinding shall be clean, modern and in good condition and subject to the approval of the Department. As containers are being filled the paints shall be screened to remove any coarse particles, skins, etc.

The paint shall be packaged in new containers which shall bear the name of the manufacturer, name of contents, Specification number, date, and manufacturer's batch number.

Quantities of paint supplied shall be based upon the volume or unit mass at 25ºC (**77ºF)**.

A5 Drying Time

Drying time of the paints, for the specified degree of hardness, shall be determined by latest ASTM test method.

B Properties of Finished Paint

Paints shall comply with Section 3.5, Qualitative Requirements, of Federal Specification TT-E-489, latest publication, as applicable.

Unless otherwise specified, finished paints shall be free of toxic metals and shall meet latest Federal VOC regulation. Toxic metals shall include lead, arsenic, selenium, mercury, barium, hexavalent, chromium, and cadmium.

C Specific Requirements

The formulation and other specific requirements for each paint shall be as stated in the detailed Specification for that paint, or in accordance with the referenced Federal Specification.

3501.3 REQUIREMENTS FOR PIGMENTS

All pigments shall conform to the ASTM Specifications except as otherwise stated in the detailed Specification for each paint.

3501.4 REQUIREMENTS FOR VEHICLE COMPONENTS

A General Requirements

All vehicle components for use in the manufacture of paints and enamels shall meet the ASTM Specification except as otherwise stated herein.

3501.5 INSPECTION, SAMPLING AND TESTING

A Inspection and Sampling

All paints, unless otherwise specifically provided shall not be shipped until tested and approved by the State Materials Engineer. The manufacturer shall allow adequate time for testing the paint.

B General Testing

All tests shall be conducted in accordance with the latest appropriate ASTM test methods except as otherwise stated herein.

The density and viscosity of all paints and varnishes shall be determined at 25ºC (**77ºF**).

C Specific Tests

C1 Water Resistance

A film shall be flowed out on a clean tin plate and dried for 72 hours and immersed in distilled water for 24 hours at room temperature, following which it shall be immediately immersed for 5 hours in distilled water at 93 to 99ºC (**200 to 210ºF**). One hour recovery period at room temperature shall be allowed before judging.

C2 Alkali Resistance

A test tube 150 by 25 mm (**6 inches x 1 inch**) shall be dipped in the varnish and allowed to drain with rounded end uppermost, and dried for 72 hours. The rounded end shall be immersed 50 mm (**20 inches**) below the surface of a 3 percent solution of sodium hydroxide in distilled water for 7 hours at a temperature of 20 to 21ºC (**68 to 70ºF**).

D Approval Process

Unless the selection of the paint is covered by a state contract, is addressed in a project proposal or appears on a Approved Products

List, approval must be obtained by State Materials Engineer prior to use. Paint Approved Product lists are on file at the Chemical Laboratory.

3507
Primer, Steel (Free of Lead and Chromate Pigments)

3507.1 SCOPE

This Specification covers a fast-drying, low VOC,red iron oxide, alkyd primer for steel. This primer is free of lead and chromate pigments. It is intended for use on hand- or blast-cleaned surfaces.

3507.2 REQUIREMENTS

A Basic Requirements..... 3501

3507.3 INSPECTION, SAMPLING, AND TESTING..... 3501

3508
Primer, Steel, Zinc Hydroxy Phosphite (Free of toxic pigments)

3508.1 SCOPE

This specification covers a heavy duty linseed oil/alkyd anti-corrosion primer for steel.

3508.2 REQUIREMENTS

A. General Requirements..... 3501

The primer shall be free of lead, chromium, and other toxic metals and shall meet latest Federal VOC regulations.

B. Composition of Paint

Total Pigment ..... 53 - 55 %
Total Vehicle ..... 45 - 47 %

C. Composition of Pigment

Zinc Hydroxy Phosphite (ASTM D 4462)..... 73 %
Red Iron Oxide (ASTM D 3721) ..... 25 %
Organo Montmorillonite .....1 %

D. Vehicle Composition

Alkyd Resin Solids (TT-R-266) ..... 44 %
Linseed Oil (ASTM D 234) ..... 22 %
Thinners, Driers, and Additives ..... 34 %
(Lead driers not allowed)

E. Properties of Finished Paint

Density, minimum..... 1550 g/L (**12.5 lbs./ gal.**)
Viscosity, (Krebs Units).....67 - 77
Dry Set to Touch, maximum..... 6 hours
Dry Through, maximum ..... 24 hours
Grind, Hegman, minimum 4.5

3508.3 INSPECTION, SAMPLING, AND TESTING 3501

3511
Primer, Equipment, Brown

3511.1 SCOPE

This Specification covers a corrosion inhibiting primer for use as a prime coat on metal parts of equipment, and for similar purposes.

3511.2 REQUIREMENTS

A General Requirements..... 3501

3511.3 INSPECTION, SAMPLING AND TESTING..... 3501

3514
Primer, Metal Sign (Air Dry, Commercial) Yellow

3514.1 SCOPE

This Specification covers a corrosion inhibiting primer for use on metal signs. This primer is to be used by commercial sign manufacturers.

3514.2 REQUIREMENTS

A General Requirements..... 3501

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

3514.3 INSPECTION, SAMPLING AND TESTING..... 3501

3518
Water-Based Inorganic Zinc-Rich Primer

3518.1 SCOPE

This Specification covers two types (A and B) of water-based inorganic zinc-rich primers for use on blast cleaned steel. Products meeting the requirements of this Specification and approved by the Mn/DOT State Materials Engineer will be placed on the Mn/DOT Approved Product List (APL).

The paint shall be part of the manufacturer's regular line of industrial coatings and not specially formulated to meet the requirements of this Specification.

This primer is intended for application with or without top-coats. Top-coats, when specified, shall be by the same manufacturer as the primer.

3518.2 REQUIREMENTS

The Contractor shall select a primer from the Mn/DOT APL that is on file at the Mn/DOT Chemical Laboratory.

A Primer

A1 General 3501

The inorganic zinc-rich primer shall be a two-component water based self-curing alkali silicate system capable of being spray applied to the specified dry film thickness in one coat without sagging or mud-cracking. After mixing, the paint shall be smooth and uniform without lumps or coarse particles. The primer shall be formulated to produce a distinct contrast from both the blast cleaned steel and the top-coat.

The primer shall be a water-based system containing essentially no VOC's (Volatile Organic Compounds).

A2. Pigment

The pigment shall consist primarily of metallic zinc powder meeting the requirements of ASTM D 520. Other materials added to the pigment for tinting shall be inert and shall not exceed 3 percent by mass.

A3 Finished Primer

When applied at 25ºC (**77^0 F**) and 50 percent relative humidity, the primer shall be water and solvent resistant within 2 hours. The finished primer shall meet the following requirements:

	Type A	**Type B**
Density at 25ºC (77^0 F), minimum	2040 g/L **17 lbs/ gal**	2040 g/L **17 lbs/ gal**
Total solids, % by mass , minimum	72	72
Zinc portion, % of total solids, minimum	75	75
Pot life at 25ºC (77^0 F), hours, minimum	4	4
$Si0_2$:K_20 ratio	—	5.3:1

A4 Properties of Cured Primer

A4a Test Panels

Steel test panels meeting the requirements of ASTM D 609, having minimum dimensions of 50 x 125 x 1.58 mm (**2 x 5 x 0.062 inches**), shall be prepared by cleaning all surfaces to a near white finish (SSPC SP-10) with a 38 to 63 µm (**1.5 to 2.5 mils**) anchor profile. A 75 to 100 µm (**3.0 to 4.0 mils**) dry-film thickness shall be applied to the test panels in accordance with manufacturer's directions. The coating shall then be cured as recommended by the manufacturer. When tested

according to the procedures listed below, the test panels shall meet or exceed the following requirements.

A4b Weather Resistance

Panels shall be tested in accordance with ASTM G 23 Type D or ASTM G 53. The panels shall be placed on the test at the beginning of the wet cycle. After 4000 hours of continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.

A4c Moisture Resistance

A4c1 Fresh Water Resistance

Panels shall be scribed with an X, of at least 50 mm (**2 inch**) legs, down to base metal, and shall be immersed in fresh tap water between 22 and 28ºC (**72 and 82ºF**). The panels shall show no rusting, blistering, or softening when examined after 30 days.

A4c2 Salt Water Resistance

Panels shall be scribed with an X, of at least 50 mm (**2 inch**) legs, down to base metal and shall be immersed in 5 percent sodium chloride between 22 and 28ºC (**72 and 82ºF**) and examined at intervals of 7, 14, and 30 days. The sodium chloride solution shall be replaced with fresh solution after each examination. The panels shall show no rusting, blistering, or softening when examined after 30 days.

A4c3 Weather and Salt Fog Resistance

The panels shall be tested in the weatherometer, as stated above in Weather Resistance, for 300 hours. After this period the panels shall be scribed with an X of at least 50-mm (**2 inch**) legs down to the base metal. The panels shall be then tested in accordance with ASTM B 117. After 5000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 2 mm (**0.08 inch**) from the center of the scribe mark.

A4c4 Resistance to Elevated Temperature and Thermal Shock

Panels shall be exposed to a temperature of 260ºC (**500^0 F**) for 1 hour and then quenched immediately in 15 to 21ºC (**59 to 70^0 F**) water. Panels shall show no blistering or flaking of the coating.

A4d Adhesion..... 3520

A4e Mud Cracking Resistance..... 3520

B Qualification Requirements

To be listed on the Approved Product List by the Mn/DOT Materials Engineer, the paint manufacturer shall submit the following information:

(1) Certified independent laboratory tests showing that the primer meets the requirements of this Specification.

(2) Written evidence of satisfactory performance history in a heavy salt spray environment on bridges in cold temperature climates or similar applications.

(3) Ten steel panels, as described in 3518.2A4, coated with primer at the required dry-film thickness.

(4) Samples (0.47 L (**1 pint**)) of each paint component.

A qualified manufacturers' technical representative shall be available for assistance during application.

Any changes in formulation will require requalification of the system.

C Packaging and Labeling 3520

3518.3 INSPECTION, SAMPLING, AND TESTING 3520

3520
Epoxy Zinc-Rich Paint System

3520.1 SCOPE

This Specification covers a three-coat, low VOC (Volatile Organic Compounds), paint system consisting of an epoxy zinc-rich primer, a polyamide epoxy intermediate coat, and an aliphatic polyurethane finish coat. This paint system is intended for spray application on blast cleaned steel. Products meeting the requirements of this Specification and approved by the Mn/DOT Materials Engineer will be placed on the Mn/DOT Approved Product List (APL).

Paints approved under this Specification shall be from a manufacturer's regular line of industrial products and not specially formulated to meet the requirements of this Specification.

3520.2 REQUIREMENTS

The Contractor shall select a paint system from the Mn/DOT APL that is on file at the Mn/DOT Materials Laboratory.

A Epoxy-Rich Primer

A1 General 3501

The epoxy zinc-rich primer shall be a multi-component solvent based chemically curing polyamide epoxy system capable of being spray applied to the specified dry-film thickness in one coat without sagging or mud-cracking. After mixing, the paint shall be smooth and uniform, without lumps or coarse particles. The primer shall be formulated to produce a distinct contrast with blast cleaned steel and with the subsequent intermediate coat.

A2 Pigment

The pigment shall consist primarily of metallic zinc powder meeting the requirements of ASTM D 520. Other materials added to the pigment for tinting shall be inert, shall be in minimal quantities, and shall not reduce the effectiveness of galvanic protection.

A3 Finished Primer

The finished primer shall meet the following requirements:

Zinc portion, percent of total solids..... 75.0 min

Pot life at 25ºC (**77ºF**). ..... 4 min hours

Density of VOC, max. ..... 420 g/L (**3.5 lbs./ gal.**)

Slip coefficient of cured primer..... not less than 0.33

Cure Time for Recoating, (Note 1)..... 24 max hours

Note 1 - When applied at 75 µm (**3 mils**) dry-film thickness at 25ºC (**77ºF**) and 50 percent RH.

A4 Properties of Cured Primer

A4a Test Panels

Steel test panels meeting the requirements of ASTM D 609, having minimum dimensions of 50 x 125 x 1.58 mm (**2 x 5 x 0.06 inches**), shall be prepared by cleaning all surfaces to a near white finish (SSPC SP-10) with a 38 µm to 63 µm (**1.5 to 2.5 mils**) anchor profile. A 75 µm to 100 µm (**3 to 4 mils**) dry-film thickness shall be applied to the test panels in accordance with manufacturer's directions. The coating shall then be cured as recommended by the manufacturer. When tested according to the procedures listed below, the test panels shall meet or exceed the following requirements.

A4b Weathering Resistance

Panels shall be tested in accordance with ASTM G 23 Type D or ASTM G 53. Test exposure shall begin with the wet cycle. After 1000 hours continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.

A4c Salt Fog Resistance

The panels shall be scribed with an X, of at least 50 mm (**2 inches**) legs, down to the base metal. The panels shall then be tested in accordance with ASTM B 117. After 1000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 2 mm (**0.08 inches**) from the center of the scribe mark.

A4d Adhesion

Panels shall be tested in accordance with ASTM D 3359, Method B, and shall attain a rating of 4B or better.

A4e Mud-Cracking Resistance

Tee coating when applied to test panels, as specified above, to a 150 µm (**6 mils**) dry-film thickness shall show no mud-cracking when viewed under 10 x magnification.

B Intermediate Coat

The intermediate coat shall be a two-component chemically curing polyamide epoxy meeting the requirements of Federal Specification Mil-P-24441 or an approved equal. After mixing, the paint shall be smooth and uniform and shall be completely suitable for spray application to the recommended dry-film thickness. The mixed paint shall have a VOC content of less than 420 g per liter The color of the epoxy intermediate coat shall present a distinct contrast from both the epoxy zinc primer and the polyurethane top-coat. The epoxy paint shall be by the same manufacturer as the epoxy zinc primer.

C Finish Coat

The finish coat shall be a two-component chemically curing aliphatic polyurethane. After mixing, the paint shall be smooth and uniform and shall be completely suitable for spray application to the recommended dry-film thickness. The mixed paint shall have a VOC content of less than 420 g per liter (**3.5 pounds per gallon**). The polyurethane finish coat shall be by the same manufacturer as the zinc rich primer and the epoxy intermediate coat.

The finish coat colors shall be chosen from the Federal Standard 595B colors and have a semi-gloss finish. Finish coat color or colors shall be specified in the Special Provisions of the specifications.

D Resistance Tests on Full Three-Coat System

When applied to steel panels described in A4 above, at the manufacturer's recommended dry-film thicknesses, the full three-coat system shall meet the requirements of weathering resistance, salt fog resistance, and adhesion tests described above.

E Blank

F Qualification Requirements

To be listed on the Approved Product List by the Mn/DOT Materials Engineer, the paint manufacturer shall submit the following information:

(1) Certified independent laboratory tests showing that the primer and the full system meet the requirements of this Specification.

(2) Written evidence of satisfactory performance history in a heavy salt spray environment on bridges in cold temperature climates or similar applications.

(3) Ten steel panels, as described in 3520.2A4, coated with the full three-coat system at the required dry-film thickness.

(4) Samples (0.5 L (**one pint**)) of each paint component. (Unused portions of paint samples will be returned to the manufacturer.)

Any changes in formulation will require requalification of the system.

G Packaging and Labeling

Multi-component paints shall be packaged in separate containers or kits to provide proper mixing proportions when the entire container is used.

Manufacturer shall supply a materials safety data sheet with each shipment of paint.

3520.3 INSPECTION, SAMPLING, AND TESTING 3501

When requested, manufacturer shall submit certified samples of paints to be used on the Department projects. Sample size shall be 0.5 L (**one pint**).

Testing shall be carried out according to appropriate Mn/DOT, ASTM, and Federal test methods.

3526
Bridge and Guardrail Paint, Black Finish Coat

3526.1 SCOPE

This Specification covers black paint for use as a finish coat on bridges, guardrails and for similar purposes.

3526.2 REQUIREMENTS

A General Requirements 3501

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Composition of Paint

Total Pigment	26-28%
Total Vehicle	72-74%

C Composition of Pigment

Iron Oxide, Black Synthetic	80.0%
Carbon Black	8.0%

Magnesium Silicate 12.0%

D Color to match number 17038 of Federal Standard 595.

3526.3 INSPECTION, SAMPLING, AND TESTING..... 3501

3528
Bridge Paint, Ready-Mixed Aluminum, Finish Coat

3528.1 SCOPE

This Specification covers aluminum paint for use as a finish coat on bridges, sign posts, and for similar purposes.

3528.2 REQUIREMENTS

A General Requirements 3501

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Stability

A sample of the paint kept at room temperature for 30 days in a full, tightly closed container, shall show no apparent loss in leafing properties, when compared to a freshly mixed sample made with the same varnish and aluminum paste.

3528.3 INSPECTION, SAMPLING AND TESTING..... 3501

3531
General Purpose Exterior Paint, White

3531.1 SCOPE

This Specification covers a white paint for general use, including guardrails.

3531.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals.

B Specific Requirements

The paint shall conform to the latest publication of Federal Specification TT-P-102, Type II.

3531.3 INSPECTION, SAMPLING AND TESTING 3501

3534
Exterior Paint, Light Stone

3534.1 SCOPE

This Specification covers a paint for use on buildings and for similar purposes.

3534.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

The paint shall conform to the latest publication of Federal Specification TT-P-102, Type III. Color shall match number 13523 of Federal Standard 595.

3534.3 INSPECTION, SAMPLING AND TESTING 3501

3535
Silicone Alkyd Finish Paint

3535.1 SCOPE

This specification covers the requirements for a high durability silicone modified alkyd for use as a finish coat over oil, alkyd, and other compatible primers.

3535.2 REQUIREMENTS

A General Requirements 3501

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations..

B Specific Requirements

This paint shall conform to the requirements of Steel Structures Paint Council (SSPC) Paint Specification No. 21.

Type I..... High Gloss
Type II ..... Semi-Gloss

C Drying Time

Dry to Touch, maximum..... 2 hours
Dry Hard, maximum ..... 8 hours

D Colors

Color shall match the specified color from Federal Specification 595.

3535.3 INSPECTION, SAMPLING, AND TESTING 3501

3537
Alkyd Semi-Gloss Finish Paint

3537.1 SCOPE

This specification covers the requirements for a semi-gloss alkyd for use as a finish coat over oil, alkyd, and other compatible primers.

3537.2 REQUIREMENTS

A General Requirements 3501

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

This paint shall conform to the requirements of Federal Specification TT-E-529 Type I air drying.

C Drying Time

Dry to Touch, maximum..... 2 hours
Dry Hard, maximum ..... 8 hours

D Colors

Color shall match the specified color from Federal Specification 595.

3537.3 INSPECTION, SAMPLING, AND TESTING 3501

3541
Interior Shop Paint, Gray

3541.1 SCOPE

This Specification covers a gray enamel type paint for use in shops and for similar purposes.

3541.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

The paint shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A and quantitive requirements of Federal Standards No. 595, Color 16251. Color to match number 16251 of Federal Standard 595.

3541.3 INSPECTION, SAMPLING AND TESTING 3501

3551
General Purpose Enamel, Black

3551.1 SCOPE

This Specification covers a black enamel for general use on interior and exterior surfaces.

3551.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

The enamel shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A, and Color 17038 of Federal Standard 595.

3551.3 INSPECTION, SAMPLING AND TESTING 3501

3552
Exterior Enamel, Dark Green

3552.1 SCOPE

This Specification covers a dark green enamel for use on light standards and handrails, and for similar purposes.

3552.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

This enamel shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A, and quantitative requirements of Color 14062, Federal Standard No. 595. Color to match Department Standard.

3552.3 INSPECTION, SAMPLING AND TESTING..... 3501

3553
Exterior Enamel, Light Green

3553.1 SCOPE

This Specification covers a light green enamel for use on light standards and handrails, and for similar purposes.

3553.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

This enamel shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A, with the following modification. Pigment shall be Chrome Oxide Green. The enamel shall conform to the quantitative requirements of Color 14159, Federal Standard No. 595. Color to match number 14110 of Federal Standard 595.

3553.3 INSPECTION, SAMPLING AND TESTING..... 3501

3561
Equipment Enamel, Orange

3561.1 SCOPE

This Specification covers enamel for use on equipment.

3561.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

This enamel shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A and requirements of Color 12246 of Federal Standard No. 595.

3561.3 INSPECTION, SAMPLING AND TESTING..... 3501

3571
Sign Enamel, White (Baking and Air Dry)

3571.1 SCOPE

This Specification covers white baking and air drying enamels for use on signs and markers.

3571.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

The enamels shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A and Class B, and Color 17875 of Federal Standard 595.

3571.3 INSPECTION, SAMPLING AND TESTING..... 3501

3572
Sign Enamel, Yellow (Baking and Air Dry)

3572.1 SCOPE

This Specification covers yellow baking and air drying enamels for use on signs and markers.

3572.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

This enamel shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class A and Class B, and Color 13538 of Federal Standard No. 595.

3572.3 INSPECTION, SAMPLING AND TESTING..... 3501

3573
Sign Enamel, Black, Low Gloss (Baking and Air Dry)

3573.1 SCOPE

This Specification covers black enamel for use as a background coating on signs, when a low gloss finish is desired.

3573.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

This enamel shall conform to the latest publication of Federal Specification TT-E-529, Type I and Type II and Color 27038 of Federal Standard 595.

3573.3 INSPECTION, SAMPLING AND TESTING..... 3501

3574
Sign Enamel, Interstate Green (Baking)

3574.1 SCOPE

This Specification covers green baking enamel for use on metal signs.

3574.2 REQUIREMENTS

A General Requirements 3501.2

Paint shall be free of toxic metals and shall meet latest Federal VOC regualtions.

B Specific Requirements

The enamel shall conform to the latest publication of Federal Specification TT-E-489, Type I, Class B, quantitative requirements of Color 15045, with the following modification. Pigments used shall be Copper Phthalocyanine Green (as approved by the Department), Chrome Yellow (ASTM D 211 Type I) and Titanium Dioxide (ASTM D 476 Type II). Color shall match Department Standards.

3574.3 INSPECTION, SAMPLING AND TESTING..... 3501

3584
Exterior Masonry Acrylic Emulsion Paint

3584.1 SCOPE

This Specification covers an acrylic latex paint for coating exterior masonry such as concrete noise attenuator walls.

3584.2 REQUIREMENTS

A General Requirements 3501

Paint shall be free of toxic metals and shall meet latest Federal VOC regulations.

B Specific Requirements

The paint shall conform to Federal Specification TT-P-19. In addition, the vehicle shall be 100 percent straight acrylic polymer.

Color shall be as specified and shall match the appropriate color chip of Federal Standard No. 595 unless otherwise specified. Only light fast colorants shall be used.

3584.3 INSPECTION, SAMPLING, AND TESTING..... 3501

3601
Riprap Material

3601.1 SCOPE

This Specification covers stone and filter layer material for use in random, hand-placed, or quarry-run riprap; gabion; and revet mattress (3602) construction.

3601.2 REQUIREMENTS

A Stones

A1 Quality

The Contractor shall furnish only durable, field or quarried, stone of the quality approved by the Department and meeting the following requirements:

(a) The individual pieces of stone are free of defects such as seams or cracks that will cause rapid or excessive deterioration or degradation during service.

(b) The riprap is free of soil or other debris before placement.

(c) The placed riprap contain less than 10 percent of undesirable material by mass. Undesirable material is defined as:

  (1) Individual pieces of stone with defects that are visually differentiated from acceptable pieces.

  (2) Stone that is slabby or elongated (having width or thickness less than 30 percent of the length).

To determine suitable quality of any stone, the Department may consider the results of laboratory tests, the behavior of the stone under natural exposure conditions, the behavior of the riprap from the same or similar geological formations or deposits, or other tests or criteria. The Contractor shall not use recycled concrete as riprap unless allowed by the Contract.

A2 Type

A2a Random Riprap.....Table 3601-1

A2b Hand-Placed Riprap

The Contractor shall furnish individual stones with a minimum mass of 22 kg (**50 pounds**). Smaller stones required for chinking do not have a minimum mass.

A2c Quarry-Run Riprap

The Contractor shall furnish quarried stone, including spalls, well graded (full range and even distribution of sizes) from the maximum size shown in the Plans to not more than 15 percent by mass smaller than the 2.00 mm (**#10**) sieve.

A2d Gabions and Revet Mattresses

The Contractor shall furnish stones for filling the baskets that are well graded, ranging in size from 100 to 200 mm (**4 to 8 inches**) for gabions and 75 to 150 mm (**3 to 6 inches**) for revet mattresses.

TABLE 3601-1
RANDOM RIPRAP REQUIREMENTS

Mass kilogram **(pounds)**	**Size** mm **(inch)** *(A)*	**Approx. % of Total Mass** Smaller than Given Mass				
		Class of Riprap				
		I	**II**	**III**	**IV**	**V**
900 (**2000**)	750 (**30**)	--	--	--	--	100
450 (**1000**)	600 (**24**)	--	--	--	100	--
300 (**650**)	525 (**21**)	--	--	--	--	75
180 (**400**)	450 (**18**)	--	--	100	--	--
113 (**250**)	375 (**15**)	--	--	--	75	50
55 (**120**)	300 (**12**)	--	100	75	50	--
22 (**50**)	225 (**9**)	--	75	50	--	--
7 (**15**)	150 (**6**)	100	50	--	--	10
2 (**5**)	100 (**4**)	--	--	--	10	--
1 (**2**)	75 (**3**)	50	--	10	--	--
--	50 (**2**)	--	10	--	--	--
--	25 (**1**)	10	--	--	--	

(A) Mass to approximate size conversion based on a specific gravity of 2.60 and a volume average between a sphere and a cube.

B Filter Material

B1 Granular Filter

Granular filter material shall conform to 3149 and the following gradations.

B1a Under Class I Random Riprap 3149.2G
B1b Under Other Riprap, Gabion, and Revet Mattress
.....Table 3601-2

TABLE 3601-2
GRANULAR FILTER MATERIAL

Sieve Size	**Percent Passing by Mass**
150 mm (**6 inches**)	100
75 mm (**3 inches**)	75-95
25 mm (**1 inch**)	35-75
4.75 mm (**#4**)	10-40
2.00 mm (**#10**)	5-25
425 µm (**#40**)	0-10
75 µm (**#200**)	0-5

B2 Geotextile Filter..... 3733

3601.3 SAMPLING AND TESTING

The Department will inspect the material for compliance with the foregoing requirements for quality, mass, and gradation. The Contractor shall obtain the Engineer's approval of the quality of the stone before the stone is delivered to the Project. The Engineer will inspect for compliance to the gradation requirements at the Project.

The Engineer will visually check riprap gradations. In case of disagreement, the Engineer will test gradation based on mass. For random riprap, compliance shall be within 10 percent of the percentages indicated.

When the quantity of riprap for any class exceeds 30 m^3 (**40 cubic yards**), the Engineer may require, that size and quality compliance be referenced to a control unit consisting of approximately 3 m^3 (**4 cubic yards**) of riprap constructed at the source or construction site. When the Engineer requires and approves a control unit for reference, the control unit shall remain intact during the course of riprap construction until being incorporated as the last stones placed. The Contractor shall use production stone equivalent in all respects to the stone placed in the approved control unit.

3602
Gabions and Revet Mattresses Materials

3602.1 SCOPE

This Specification covers the material and the construction of baskets for gabions and revet mattresses.

The baskets are rectangular, variable in size, and manufactured either from double-twisted metallic-coated wire mesh or from metallic-coated welded wire fabric.

A Gabion ..... Rectangular Basket

B Revet Mattress ..... Thin Flat Rectangular Basket

3602.2 REQUIREMENTS

Gabions and revet mattresses shall conform to ASTM A 974 (welded wire fabric) or ASTM A 975 (double-twisted wire). Unless otherwise specified the double-twisted wire gabions and revet mattresses shall have a Style 1 coating, and the welded wire fabric gabions and revet mattresses shall have a Style 2 coating. The Contractor shall furnish the Engineer a manufacturer's Certificate of Compliance, in accordance with 1603, that the material conforms to these requirements.

3602.3 SAMPLING AND TESTING

Wire and basket construction for gabions and revet mattresses shall be certified by the manufacturer in accordance with 1603.

3608
Concrete Armor Units

3608.1 SCOPE

This specification covers manufactured concrete armor units for use in streambank, riverbank, and lakeshore stabilization; and soil bioengineering construction.

3608.2 REQUIREMENTS

Concrete armor units shall consist of interlocking concrete cross shaped units. Each unit shall consist of 2 individual and symmetrical interlocking halves. When assembled, the two individual halves shall form a three dimensional cross with six symmetrical legs. Each unit shall be identical so that multiple units can be placed into a continuous and flexible interlocking matrix. When interlocked into a matrix, there shall be approximately 40 percent void space to allow ample space for soil filling and planting. Concrete used in the units shall meet 2461 Type 3 with a minimum of 27.6 MPa **(4000 psi)** compressive strength and a maximum water absorption of 160 Kg per cubic meter **(10 pound/cubic foot**). Physical requirements shall be as indicated in Table 3608-1:

Table 3608-1*

Designation	A-24	A-36
Overall dimension (Outside of leg to outside of leg)	610 mm **(24 inches)**	910 mm **(36 inches)**
Thickness of each side of leg	93 mm **(3.6 inches)**	142 mm **(5.5 inches)**
Kerf corner reinforcement	46 mm **(1.8 inches)**	92 mm **(2.7 inches)**
Overall weight of assembled unit	35 kg **(78 pounds)**	119 kg **(265 pounds)**

* Dimensions in Table 3608-1 are nominal dimensions with a 10% tolerance.

3608.3 SAMPLING AND TESTING

Samples for testing shall be of such size and numbers as requested by the Engineer.

3612
Sewer Brick (Clay)

3612.1 SCOPE

This Specification covers brick made from clay or shale and burned, and which are to be used in drainage structures for the conveyance of sewage, industrial wastes, or storm water.

3612.2 REQUIREMENTS

Sewer brick shall conform to AASHTO M 91 for the grade specified. If no grade is specified, Grade MM or better shall be furnished.

3612.3 SAMPLING AND TESTING

A Compressive Strength and Absorption ...AASHTO T 32

B Freezing and Thawing.....AASHTO T 32

C Bricks for testing shall be selected by the Engineer.

The manufacturer or seller shall furnish test specimens without charge.

3613
Building Brick (Clay or Shale)

Building brick (clay or shale) shall conform to AASHTO M 114. Three grades of brick are covered; SW, MW, and NW. The grade required will be specified in the Contract.

3614
Building Brick (Sand-Lime)

Building brick (sand-lime) shall conform to ASTM C 73. Unless otherwise specified the grade required shall be MW.

3615
Building Brick (Concrete)

Building brick (concrete) shall conform to ASTM C 55. Unless otherwise specified the grade required shall be S-II.

3616
Sewer Brick (Concrete)

3616.1 SCOPE

This Specification covers concrete brick for use in the construction of catch basin and manholes.

3616.2 REQUIREMENTS

The units shall conform in quality to ASTM C 139, except that:

(a) At the time of delivery to the site of the work, the minimum compressive strength requirements shall be 28 Mpa (**4100 psi**) for any individual unit, and 31 MPa (**4500 psi**) for the average of three units.

(b) The concrete units shall be cured by the steam or water curing methods, unless the use of a sealing membrane or other curing methods are authorized by the Engineer. When steam curing is used, atmospheric temperature in the curing chamber shall not exceed 70ºC (**158^0 F**). The concrete units shall be protected against freezing until the curing is completed. Curing shall continue for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less.

The dimensions of the brick may be any standard size that will produce the required dimensions in the completed structure.

3616.3 SAMPLING AND TESTING .....ASTM C 140

The Materials Engineer is the Engineer with authority regarding this Specification. The manufacturer shall notify the Engineer before starting production, in sufficient time to permit the required testing and inspection during manufacturing.

3621
Concrete Masonry Units

3621.1 SCOPE

This Specification covers solid, precast, segmental concrete masonry units for use in the construction of catch basins and manholes.

3621.2 REQUIREMENTS

The units shall conform to 3616.2, except as modified below:

The dimensions of the units shall be such that the catch basins or manholes will have the dimensions shown in the Plans, within a tolerance of 10 mm (**3/8 inch**) in the 200 mm (**8 inches**) wall thickness.

3621.3 SAMPLING AND TESTING 3616

3622

Sectional Concrete Manhole/Catch Basin Units

3622.1 SCOPE

This Specification covers precast, reinforced concrete manhole/catch basin units consisting of riser sections and appurtenances such as grade rings, base slabs, tops and special sections to be used in constructing sewer or water works.

3622.2 REQUIREMENTS

Reinforced concrete manhole/catch basin units furnished under this Specification shall conform to AASHTO M 199 and 3236, together with the additional requirements and modifications set forth herein.

The manufacturer shall notify the Engineer prior to starting production, in sufficient time to permit the required testing and inspection during manufacturing.

A Calcium Chloride 3911

Calcium chloride may be added to the mixture to accelerate hardening, at the rate of not more than 1.0 kg (**2.2 pounds**.) of Type 1 (flakes) or 0.8 kg (**1.8 pounds**.) of Type 2 (pellets) per 50 kg (**110 pounds**.) of cement. Admixtures other than calcium chloride and air-entraining agents shall not be used without approval of the Engineer.

B Physical Properties

Dimensions, shape, wall thickness, and the type and quantity of reinforcement shall be in conformance with the Plans.

Manufacturers may produce the alternative spigot-up joint. Manufacturers may also produce the alternative offset joint. This type of offset joint is to be used with the profile or pre-lubricated pipe seal system.

The concrete shall develop a compressive strength of not less than 21 Mpa (**3100 psi**) at 14 days. Cores taken from the finished units shall have a compressive strength of not less than 28 MPa (**4200 psi**) at 28 days. However, all manhole sections including Structural Manhole Covers, Standard Plate 4020, shall attain full design strength prior to shipment.

C Manufacture

The units shall be true to shape and their surfaces shall be smooth, dense and uniform in appearance. Minor surface cavities or irregularities that do not impair the service value of the unit and that can

be corrected without marring the appearance shall be filled with mortar as soon as the forms are removed. Forms shall remain in place until they can be removed without damage to the unit.

When the manufacturer provides blockouts or cuts holes in manhole units, additional steel shall be provided in the remaining unit to prevent cracking. If the unit is cracked, the cracked portion shall be removed and replaced with mortar.

3630
Precast Concrete Median Barriers

3630.1 SCOPE

This Specification covers the construction of precast concrete median barriers at a precasting plant that has been granted "plant pre-approval for acceptance of precast concrete products" by the Materials Engineer..

B Concrete Finish

The Fabricator shall sandblast the precast barrier units and fill the surface imperfections with a grout containing an approved bonding agent as described in 2401.3, Finish of Concrete. The sandblasting and grouting operations shall commence as soon as possible after the forms are stripped, while the concrete barriers are still warm.

3661
Reinforced Concrete Cribbing

3661.1 SCOPE

This Specification covers precast reinforced concrete units for use in the construction of cribwalls.

3661.2 REQUIREMENTS

The manufacturer shall notify the Engineer prior to starting production, in sufficient time to permit the required testing and inspection during manufacturing.

The class and gradation of the coarse aggregate shall be optional with the manufacturer.

A2 Fine Aggregate 3126

A3 Portland Cement 3101

A4 Calcium Chloride 3911

A5 Reinforcement 3301

B Concrete Production

The reinforced concrete shall consist of a mixture of Portland cement, mineral aggregates, and water, in which steel has been embedded in such a manner that the steel and concrete act together.

The aggregates shall be so sized and so graded and proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that standard test cylinders will develop a compressive strength of not less than 21 Mpa (**3100 psi**) at 14 days. In no case, however, shall the quantity of cement be less than 330 kg per cubic meter (**610 pounds per cubic yard**) of concrete.

The concrete shall be air-entrained by using either an air-entraining Portland cement or by using standard Portland cement plus an approved air-entraining admixture. The air content of the concrete shall be maintained within the approximate range of 5 to 8 percent.

Calcium chloride may be added to the mixture to accelerate hardening, at the rate of not more than 1.0 kg (**2.2 pounds**) of Type 1 (flakes) or 0.8 kg (**1.8 pounds**) of Type 2 (pellets) per 50 kg (**110 pounds**) of cement. Admixtures other than calcium chloride and air-entraining agents shall not be used without approval of the Engineer.

C Design Details..... 3238

The finished units shall conform to the dimensions shown in the Plans, to such a degree that they can be assembled in the field without chipping or using mortar.

D Manufacture

The units shall be cast in horizontal position in mortar-tight forms. The concrete in each unit shall be placed without interruption, and shall be consolidated with a vibrator, supplemented by hand tamping, as may be necessary to force the concrete into the corners of the form and prevent the formation of stone pockets or cleavage planes.

The forms shall remain in place until they can be removed without damage to the units.

The units shall be cured for a sufficient length of time as will develop the specified compressive strength. The units shall be protected from freezing, after being cast and until curing is completed.

The units shall be cured by the steam or water curing methods, as described in AASHTO M 199, unless the use of a sealing membrane or

other effective methods are specifically approved by the Engineer. When steam curing is used, atmospheric temperature in the curing chamber shall not exceed 70ºC (**158^0 F**)

E Workmanship and Finish

The finished units shall be true to shape and their surfaces shall be smooth, dense and uniform in appearance. All surfaces that will be exposed to view in the completed structure shall have a finish equivalent to that obtained by rubbing with a carborundum brick. Minor surface cavities or irregularities that do not impair the service value of the unit and that can be corrected without marring the appearance may be pointed with mortar as soon as the forms are removed.

F Identification Marks

Each unit shall bear the name or trademark of the manufacturer and the date it was cast, stenciled or otherwise placed thereon in a manner as to remain in evidence for at least 1 year.

Units containing special reinforcement shall be marked as specified in the Plans.

G Physical Tests

Sampling and testing of materials shall be in accordance with the methods and requirements prescribed in the Specifications listed for the individual materials.

Compression tests for satisfying the minimum concrete strength requirement may be made on either standard rodded cylinders cast in accordance with AASHTO T 23 or on cylinders cast and cured in a like manner as the cribbing units.

Three cylinders shall be cast in the presence of and under the supervision of the Engineer for each 100 units, or major fraction thereof, manufactured, but in no case shall the number of test cylinders required under a given contract be less than five.

Compression tests will be made on the cylinders in accordance with AASHTO T 22. The average compression strength of all cylinders tested shall be equal to or greater than the specified strength of the concrete. At least 90 percent of the cylinders tested shall meet the specified strength, and in no case shall any cylinder tested fall below 80 percent of the specified strength.

3667
Precast Concrete Monuments

3667.1 SCOPE

This Specification covers precast concrete units for use as bench marks, right of way markers, section corners, and elsewhere where a permanent monument is required.

3667.2 REQUIREMENTS

A Materials

A1 Concrete

Concrete shall be produced as provided in 2461 subject to the specific requirements and limitations as follows:

(a) The maximum size of the aggregate (Light Weight Aggregate) shall be 25 mm (**1 inch**).

(b) The minimum cement content shall be 335 kg per cubic meter (**565 pounds per cubic yard**) of concrete.

(c) The concrete shall develop a compressive strength of not less than 21 Mpa (**3100 psi**) in 28 days.

(d) The air content of the concrete shall be between the limits of 5.5 to 10 percent.

(e) Maximum density of the concrete shall be 1840 kg/m^3 (**205 pounds per cubic yard**).

(f) Calcium chloride may be added to the mixture to accelerate hardening, at the rate of not more than 1.0 kg (**2.2 pounds**) maximum of commercial product per 50 kg (**110 pounds**) of cement.

A2 Reinforcement

The reinforcement may be bars conforming to 3301, held in place by wire hoops, or it may be steel fabric conforming to 3303 and providing the same strength as the specified number of bars.

B Manufacture

The units shall be cast to the dimensions shown on the Standard Plate to which reference is made in the Contract.

Any metal disks or caps that are required will be furnished to the manufacturer by the Department, in such quantities as may be required from time to time.

The concrete shall be thoroughly consolidated by hand-tamping or by vibrating.

Curing shall be in accordance with 3661.2D.

3667.3 SAMPLING AND TESTING

The Materials Engineer is the Engineer with authority regarding this Specification.

A Compressive Strength Tests

Three standard cylinders, for use in testing the compressive strength of the concrete, shall be cast in the presence of and under the supervision of the Engineer in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22 for each 100 monuments or fraction thereof in any one order.

3702
Preformed Joint Fillers

Preformed filler material for joints in concrete construction shall conform to AASHTO M 153 or M 213 for the type specified. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise authorized by the Engineer. For pavement construction, the filler shall be furnished in lengths equal to the width of the pavement lanes, and where dowel bars are required, the filler shall have clean-cut punched holes of the require size and spacing to admit the dowel bars.

Unless another type is specified, or is permitted by approval of the Engineer, the filler material furnished shall be the bituminous bound type (fiber or granulated cork) conforming to AASHTO M 213.

3719
Joint and Crack Sealer
(Hot-Poured, Crumb Rubber Type)

3719.1 SCOPE

This specification covers joint and crack sealant of the hot poured, crumb rubber type for sealing cracks in concrete and bituminous pavements and miscellaneous structures.

3719.2 REQUIREMENTS

A General Requirements

The sealant material shall consist of asphalt and crumb rubber blended together either by the manufacturer to produce a homogeneous mixture. Only material from certified sources is allowed for use. A list of certified sources is on file at the Chemical Laboratory.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B Physical Requirements

The sealant shall conform to the following physical property requirements:

(1) Recycled rubber, mass, % of asphaltic components, minimum . 18

(2) Cone Penetration, 25 ^{o} C (**77 ^{o}F**), maximum..... 90

(3) Bond Test, 50% extension, @-18 ^{o}C (**0 ^{o}F**) ..... Pass 5 cycles

(4) Flow, 60 ^{o}C (**140 ^{o}F**), mm, maximum..... 5

(5) Resilience, 25 ^{o}C (**77 ^{o}F**), minimum 40

(6) Softening Point, ^{o}C, minimum 82

The sealant shall meet the above requirements after one cycle of heating to application temperature, cooling and reheating to the recommended application temperature.

C Packaging and Marking

The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 23 kg (**50 pound**) weight, clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, and pouring temperature recommended by the manufacturer.

3719.3 SAMPLING AND TESTING

A Sampling

Inspection and sampling usually done at source. Contact Chemical Laboratory for list of approved lots. If lot has not been preapproved submit a 23 kg (**50 pound**) sample to the Chemical Laboratory for testing.

B Methods of Test

Testing shall be according to the appropriate test methods reference on ASTM D 1190 except that the bond test shall be performed using mortar blocks prepared according to The Mn/DOT Method.

B1 Softening Point..... ASTM D 36

B2 Cement Mortar Blocks (Mn/DOT Method).

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 50 mm (2 inch) cube specimens). After curing one day in moist air and six days in water at 23 ± 1.7 ^{o}C, the blocks shall be cut into in to 25 x 50 x 75 mm (**1 by 2 by 3**) inch test blocks using a diamond saw blade. Discard the 25 mm (**1 inch**) strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth of blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 0.50 ± 0.01 inch apart enclosing a reservoir of 2 inch by 2inch by 0.50 inch.

3720
Joint and Crack Sealer
(Hot-Poured, Low Modulus, Elastic Type)

3720.1 SCOPE

This specification covers joint and crack sealer of the hot-poured, low modulus, elastic type, for sealing joints and cracks in concrete and bituminous pavements, bridges, and other structures.

3720.2 REQUIREMENTS

A General Requirements

The sealant shall be composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound. Only material from certified sources is allowed for use. A list of certified sources is on file at the Chemical Laboratory.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B Physical Requirements

The sealant shall conform to ASTM D 3405 except for the following modifications:

(1) Cone penetration, dmm at 25 ^{o}C (**77 ^{o}F**) , 150 g, 5 s,..... 90-150

(2) Bond at -29 ^{o}C (**-20 ^{o}F**), 3 cycles, 200% extension.....Passes

(3) Resilience at 25 ^{o}C (**77 ^{o}F**) , minimum, %..... 60

(4) The sealant material shall weigh not less than

1.08 kg/L (**9.01 pounds/gallon**) nor more than 1.12 kg/L (**9.35 pounds/gallon**).

The sealant material may be subjected to any or all of the above tests after prolonged heating of the material for 6 hours with constant mixing in a laboratory melter at the manufacturers recommended

pouring temperature. After such heating, the material shall meet the above specified requirements.

C Packaging and Marking

The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 23 kg (**50 pound**) weight, clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, and pouring temperature recommended by the manufacturer.

3720.3 SAMPLING AND TESTING

A Sampling

Inspection and sampling usually done at source. Contact Chemical Laboratory for list of approved lots. If lot has not been preapproved submit a 23 kg (**50 pound**) sample to the Chemical Laboratory for testing.

B Methods of Test

B1 Testing shall be according to ASTM D 3405 except the bond test will be run using sawed cement mortar blocks prepared by the Mn/DOT method.

B2 Cement Mortar Blocks (Mn/DOT Method).

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 50 mm (**2 inch**) cube specimens). After curing one day in moist air and six days in water at 23 ^{o}C ± 1.7 ^{o} the blocks shall be cut into 25 x 50 x 75 mm (**1 x 2 x 3 inch**) test blocks using a diamond saw blade. Discard the one inch strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth of blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 12.5 ± .25 mm (**0.50 ± 0.01 inch**) apart enclosing a reservoir of 50 x 50 x 12.5 mm (**2 x 2 x 0.50 inch**).

3721
Preformed Elastomeric Compression Joint Seals for Concrete

3721.1 SCOPE

This Specification covers preformed elastic joint seals of the open-cell compression type, intended for use in sealing joints in concrete pavements, bridges and other structures. It also covers the lubricant-adhesive used when installing the seals.

3721.2 REQUIREMENTS

A Requirements for Seals

A1 Composition and Manufacture

The seals shall be preformed and manufactured from vulcanized elastomeric compound using polymerized chloroprene as the only polymer.

A2 Size and Shape

The size, shape and dimensional tolerances of the seals shall be as shown in the Plans or otherwise specified. Alternate shapes may be used upon approval of the Engineer.

A3 Physical Properties

The material shall conform to the physical properties prescribed below.

Property	Requirements	Test Method
Tensile strength, Using Die D,		
Before Aging, min.	14 Mpa (**2000 psi**)	ASTM D 412
After oven aging, 70 hours.		
@ 100EC (**212EF**), loss, %	30 max.	ASTM D 573
Elongation at Break,		
Before aging, %	250 min.	ASTM D 412
After oven aging,		
70 hrs. @ 100EC (**212EF**)		
loss, %	40 max.	ASTM D 573
Permanent set at Break, %	10 max.	ASTM D 412
Hardness, Type A Durometer,		
Before aging	55 ∀ 5	ASTM D 2240
After oven aging,		
70 hours @ 100EC (**212EF**),		
points change	0 to + 10	ASTM D 2240
After 70 hours @ -10EC (**14EF**),		
points change	0 to + 15	ASTM D 2240
Ozone Resistance,		
After 70 hours @ 40EC (**104EF**),		

under 20 % strain,		
303 mPa (**300 pphm**) in air	No Cracks	ASTM D 1149 *(A)*
Mass Change in Oil,		
After 22 hours in Oil No. 3		
(ASTM D 471), mass change, 45% max.		Mn/DOT Method *(C)*
Compression-Deflection		
Characteristics		
20 mm (**13/16 inch**) Seal:		
Force @ 16.5 mm,	0.70 N/mm min	Mn/DOT Method *(C)*
Force @ 0.65 inch pounds/linear inch.	(**4 min**)	Mn/DOT Method *(C)*
Force @ 10.5 mm,	3.50 N/mm max.	Mn/DOT Method *(C)*
Force @ 0.41 inch pounds/linear inch.	(**20 max**)	Mn/DOT Method *(C)*
32 mm (**1-1/4 inch**) Seal:		
Force @25 mm (**1 inch**),	0.90 N/mm min.	Mn/DOT Method *(C)*
Force @ 1.00 inch pounds/linear inch.	(**5 min.**)	Mn/DOT Method *(C)*
50 mm (**2 inch**) Seal:		
Force @ 41 mm,	0.90 N/mm min.	Mn/DOT Method *(C)*
.Force @ 1.62 inch pounds/linear inch.	(**5 min.**)	Mn/DOT Method *(C)*
65 mm (**2-1/2 inch**) Seal:		
Force @ 54 mm,	0.90 N/mm min.	Mn/DOT Method *(C)*
Force @ 2.13 inch pounds/linear inch	(**5 min.**)	Mn/DOT Method *(C)*
75 mm (3 inch) Seal:		
Force @ 65 mm,	0.90 N/mm min.	
Force @ 2.50 inch pounds/linear inch	(**5 min.**)	Mn/DOT Method *(C)*
90 mm (3-1/2 inch) Seal:		
Force @ 75 mm,	0.90 N/mm min.	Mn/DOT Method *(C)*
Force @ 3.00 inch pounds/linear inch.	(**5 min.**)	Mn/DOT Method *(C)*
Recovery Under Deflection of 50 % of the Nominal Seal Width		
After 70 hours @ 100EC (**212E F**) ,	85 % min. *(B)*	Mn/DOT Method *(C)*
After 72 hours @ -10EC (**14EF**),	88 % min. *(B)*	Mn/DOT Method *(C)*
After 22 hours @ -29EC (**-20EF**),	83 % min. *(B)*	Mn/DOT Method *(C)*

Notes: *(A)* Specimens, wiped with toluene before test to remove surface contamination.

(B) Recovery value is the average of test results on the two specimens run at the same time. The average of the two tests shall meet the requirement, and the lowest test result shall not be more than 3 percentage points below the specified minimum. Any adhesion between any of the webs or any cracking of a specimen caused by the recovery test at 100°C (212°F) shall mean the specimen has failed the test.

(C) Refer to 3721.3C of this Specification for the Test Method.

A4 Identification and Marking

The seals shall be marked with the name or a suitable trademark of the manufacturer, lot number, and the date of production, at intervals of not more than 1.2 m (**4 feet**). In addition, for multiple die extrusion machines, the marking shall identify the seal produced from each extrusion die as an individual sublot, e.g., a suffix number or letter to the lot number. Individual lot numbers or sublot numbers shall be limited to one every 8-hour shift or 1800 m (**6000 linear feet**), whichever results in the smallest lot size. Also, on the top surface of the seal, a mark shall be placed at every 300 mm (**1 foot**) interval, sufficiently clear and durable to enable making length measurements on each seal after installation.

The containers in which the seals are packaged for shipment shall be clearly marked with the name of the manufacturer, lot number or sublot number, and the date of manufacture of the material contained herein.

B Requirements for Lubricant-Adhesive

For installing seals less than 25 mm (**1 inch**) in nominal width, the lubricant-adhesive shall meet ASTM D 2835.

For installing seals 25 mm (**1 inch**) or more in nominal width, the lubricant-adhesive shall be a one-component moisture curing polyurethane and hydrocarbon solvent mixture that is compatible with both the seals and the concrete, being relatively unaffected by the normal moisture in the concrete, and having a suitable consistency at the temperatures at which the seals are installed.

The lubricant-adhesive shall have the following physical properties:

Average density ..... 1 kg/L (**8.0 pounds/gallon)** ± 10%

Solids content ..... 72 to 74 %, by mass (**weight**)

Adhesive to remain fluid from ..... -15°C (**5°F**) to 50EC (**120°F**)

Film strength, ASTM D 412 ..... 8250 kPa (**1200 psi**)

Elongation 350%

The lubricant-adhesive shall be delivered in containers plainly marked with the manufacturer's name or trademark, lot number and date of manufacture.

3721.3 SAMPLING AND TESTING

The Department reserves the right to sample and test joint seals and lubricant-adhesive materials at any time prior to or after delivery.

One failure in the test results for a lot or sublot will be cause for rejection of that entire lot or sublot.

A Sampling

When required by the Engineer, the Contractor shall furnish, without charge, a 2 m (**6 foot**) test sample for each 900 m (**3000 linear foot**) of seals, or fraction thereof, of each lot or sublot.

A 0.5 L (**1 pint**) sample from each lot of lubricant-adhesive shall be furnished upon request of the Engineer.

B Sample Preparation

All test specimens shall be prepared in accordance with ASTM D 2240 and D 412 from samples taken of the joint seals as delivered to the Project.

Specimens for low-temperature and high-temperature recovery tests shall be approximately 125 mm (**5 inches**) long and shall be taken at random from the sample representing the lot or shipment under test.

Specimens for low-temperature recovery tests shall be lightly dusted with talc on both the internal and outside surfaces to prevent adhesion between all internal surfaces and between the outside surface and the metal compression plates.

Specimens for the high-temperature recovery test shall be tested as received except that the outside surfaces only shall be dusted lightly with talc.

Specimens for test of mass (**weight**) change in oil shall be approximately 75 mm (**3 inch**) long and shall be taken at random from the samples representing the lot or shipment under test.

Specimens for the compression-deflection test will be either 100 to 150 mm (**4 to 6 inches**) long, depending on the test requirements for the seal.

C Methods of Test

Testing shall be in accordance with the methods prescribed in the referenced ASTM Specifications and the following:

C1 Recovery Tests

All recovery tests shall be run on two specimens at the same time, as a pair. The procedure shall be as follows:

(a) Take a width measurement in the center of the 125 mm (**5 inch**) length specimens, using a dial gauge graduated in micrometers (**thousandths of an inch**) and having a 5 mm (**1/4 inch**) diameter foot. The width measurement should be made with the top longitudinal edge of the specimen at the center of the foot. Carefully mark the foot position on the specimen before the first gauge reading is made.

(b) Deflect the specimens between parallel plates to 50 percent of the nominal width of the specimen, using the Method B compression clamp assembly described in ASTM D 395; or using a vise having parallel plates or jaws; or using any other basic device by which uniform compression can be applied to the specimen. Prior to compression, place the specimen in a horizontal position such that the plane through both edges of the surface of the joint seal is perpendicular to the compression plates. As the specimen is being compressed, fold the top surface of the seal inward toward the center of the specimen.

(c) For the high-temperature recovery test, place a clamped assembly containing the compressed specimens in a circulating oven maintained at 100°C (**212°F**), with a tolerance of 1°C (**2°F**), for 70 hours. Do not preheat the clamp assembly. After the oven aging, remove specimens from clamp assembly and allow to cool at 23°C (**73°F**), with a tolerance of 1°C (**2°F**), on a wooden surface for 1 hour. Measure the recovered width at the same location as the original width measurement and examine the specimens for adhesion or cracks.

(d) For the low-temperature recovery test at -10°C (**14°F**), place a clamp assembly containing the compressed specimens in a refrigerated box maintained at -10°C (**14°F**), with a tolerance of 1°C (**2°F**), for 72 hours. After the cold aging, unclamp the assembly and remove the upper plate, and allow the specimens to recover in a free state for 1 hour at -10°C (**14°F**), with a tolerance of 1°C (**2°F**). Before removing the specimens from the box, measure the recovered width at the same location as the original width measurement.

(e) For the low-temperature recovery test at -29°C (**-20°F**), proceed as described in (d) above, except that the specimens are to be cold aged for 22 hours at -29°C (**-20°F**), with a tolerance of 1°C (**2°F**), and allowed to recover for 1 hour at -29°C (**-20°F**), with a tolerance of 1°C (**2°F**).

(f) Calculate the recovery, expressed as a percentage of the original width, as follows:

$$\% \text{ recovery} = \frac{\text{recovered width} \times 100}{\text{original width}}$$

C2 Oil Test to Determine the Change in Mass (**Weight**)

Two specimens shall be tested in accordance with the following procedure:

(a) Weigh each specimen to the nearest tenth of a gram (**W1**) and place in a Pyrex beaker containing sufficient test oil to fully cover the samples throughout the test period. The two specimens may be placed in the same beaker, but they must be separated by large glass balls or beads. Cover the beaker loosely with aluminum foil.

(b) Place the beaker assembly in a circulating air oven maintained at 100°C (**212°F**), with a tolerance of 1°C (**2°F**), for 22 hours. After the immersion period is completed, remove the test specimens from the hot oil and cool to room temperature by transferring them to a cool, clean portion of the test oil for 30 to 60 minutes. Then dip the specimens quickly into acetone to remove surface test oil, blot lightly with filter paper, and immediately determine the mass (**W2**) of each specimen.

(c) Calculate the change in mass as follows:

$$\% \text{ Change in Mass} = \frac{(W2 - W1) \times 100}{W1}$$

Where: W1 = Initial mass of specimen in grams.

W2 = Final mass of specimen in grams, after immersion.

C3 Compression-Deflection Test

Compression-deflection tests shall be run on two specimens in accordance with the following procedure:

TABLE 3721-1

SPECIFIED SPECIMEN SIZE AND TEST DEFLECTIONS

Nominal Width of Seal mm **(inches)**	**Column A Specimen Length** ∀ 5 mm **(∀ 0.2 inch)**	**Column B Test Width for Min. Pressure** mm **(inches)**	**Column C Test Width for Max. Pressure** mm **(inches)**
20 mm (**13/16 inch**)	100 mm (**4 inch**)	16.5mm (**0.65 inch**)	10 mm (**0.41 inch**)
32 mm (**1-1/4 inch**)	100 mm (**4 inch**)	25.0 mm (**1.00 inch**)	11 mm (**0.44 inch**)
50 mm (**2 inch**)	150 mm (**6 inch**)	41.0 mm (**1.62 inch**)	17 mm (**0.69 inch**)
90 mm (**3-1/2 inch**)	150 mm (**6 inch**)	75.0 mm (**3.00 inch**)	35 mm (**1.38 inch**)

(a) The machine for compressing the test specimens shall be a standard compression testing machine conforming to the Methods of Verification Testing Machines (ASTM E 4) and having a speed of approximately 12 mm (**0.5 inches**)) per minute, or any other type of machine that will meet these requirements. The machine shall be equipped to: provide determination of the load to cause deflection to the specified width to the nearest 0.2 kg (**0.5 lb.**); and to determine when the specified compressed width of the specimen, to the nearest 0.25 mm (**0.01 inch**), has been reached.

(b) The test temperature shall be 23ºC (**73ºF**), with a tolerance of 2ºC (**5ºF**). The specimens to be tested shall be kept at this temperature at least 30 minutes prior to testing.

(c) The test specimen shall be measured to the nearest 2 mm (**0.1 inch**) and the length recorded. The specimen shall then be placed between the platens of the testing machine in such a manner that the load will be applied to the sides of the specimen. The top, bottom and the ends of the specimen shall be free to deform unrestricted during the loading cycle. Sheets of sandpaper (waterproof, 400 Grit) slightly larger than the specimen shall be placed between the rubber surfaces and the testing machine platens to resist slippage of the rubber at the contact surfaces.

(d) The load shall be applied at the rate of approximately 12 mm (**0.5 inches**) per minute until the test-width for minimum pressure (Table 3721-1, Column B) is reached, after which the load shall be immediately released at the same rate. This loading cycle shall be repeated a second time. Then the load shall be applied as before until the specified width (Column B) is reached. The loading shall then be read and recorded. The loading shall then be continued until the test-width for maximum pressure (Column C) is reached and after a period of 30 seconds at this width the load shall be read and recorded.

(e) Calculate the compression-deflection force as follows:

$$P = \frac{F}{L}$$

Where: P = Force required to deflect specimen the specified width.

F = Observed load on specimen at specified width.

L = Length of specimen.

(f) The value of "P" shall be rounded to the nearest whole unit in accordance with paragraph 3(d) of ASTM E 29, Designating ignificant Places in Specified Limiting Values.

3723
Joint and Crack Sealer
(Hot-Poured Elastic Type)

3723.1 SCOPE

This specification covers joint and crack sealer of the hot-poured elastic type, for sealing joints and cracks in concrete and bituminous pavements, bridges, and other structures. On concrete structures requiring less than 23 kg (**50 pounds**) of material, the contractor may substitute an approved silicone or polyurethane sealer.

3723.2 REQUIREMENTS

A General Requirements

The sealant shall be composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound. Only material from certified sources is allowed for use. A list of certified sources is on file at the Chemical Laboratory.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B Physical Requirements

The sealant shall conform to ASTM D 3405 except for the following modifications:

(1) Cone penetration at 25 ^{o}C (**77 ^{o}F**), 150 g, 5 s, ...60 - 90

(2) Bond at -29 ^{o}C (**-20 ^{o}F**), 3 cycles, 100% extension .....Passes

(3) Mandrel bend test at -34 ^{o}C (**-29 ^{o}F**), 25 mm (**1 inch**) mandrel .....No cracking

(4) Resilience at 25 ^{o}C (**77 ^{o}F**), minimum, %..... 40

C Packaging and Marking

The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 23 kg (**50 pound)** weight, clearly marked with the name of the material, the name of the manufacturer, brand name, weight, batch number, and pouring temperature recommended by the manufacturer.

3723.3 SAMPLING AND TESTING

A Sampling

Inspection and sampling usually done at source. Contact Chemical Laboratory for list of approved lots. If lot has not been preapproved submit a 23 kg (**50 pound**) sample to the Chemical Laboratory for testing.

B Methods of Test

B1 Testing shall be according to ASTM D 3405 except the bond test will be run using sawed cement mortar blocks prepared by the Mn/DOT method.

B2 Mandrel bend test ..... ASTM D 522 Method B

Test at -34 °**C (-29 °F)** using 25 mm (**1 inch**) mandrel, 180 degree bend over five seconds. Test specimen prepared according to ASTM D3405, Flow Test, and conditioned at -34 °**C (-29 °F)** for a minimum of 4 hours.

B3 Cement Mortar Blocks (Mn/DOT Method).

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ∀ 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 50 mm (**2 inch**) cube specimens). After curing one day in moist air and six days in

water at 23 ∀ 1.7 EC, the blocks shall be cut into 25 x 50 x 75mm (**1 x 2 x 3**) inch test blocks using a diamond saw blade. Discard the one inch strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth of blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks **12.5∀ .25mm** (**0.50 ∀ 0.01 inch**) apart enclosing a reservoir of 50 x 50 x12.5mm (**2 x 2 x 0.50 inch**).

3724
Sewer Joint Sealing Compound
(Hot-Poured)

The sealer shall conform to Federal Specification SS-S-169 for Class 1 compounds.

3725
Joint and Crack Sealer
(Hot-Poured, Extra Low Modulus, Elastic Type)

3725.1 SCOPE

This specification covers joint and crack sealer of the hot-poured, extra low modulus, elastic type, for sealing joints and cracks in concrete and bituminous pavements, bridges, and other structures.

3725.2 REQUIREMENTS

A General Requirements

The sealant shall be composed of a combination of polymeric materials, fully reacted chemically to form a homogeneous compound. Only material from certified sources is allowed for use. A list of certified sources is on file at the Chemical Laboratory.

The sealant must be melted in a double boiler, oil jacketed melter-applicator equipped with a mechanical agitator, pump, gas pressure gauges, separate temperature thermometers for the oil bath and melted material with accessible control valves and gauges. Follow melting procedures recommended by supplier.

The sealant, when melted, shall be free of any dispersed or settling component and be of a uniform consistency suitable for filling joints and cracks without inclusion of large air holes or discontinuities.

B Physical Requirements

The sealant shall conform to the following properties when heated in accordance with ASTM D5167:

(1) Cone penetration, **25 ^{o}C (77 ^{o}F)**, dmm (ASTM D5329) ..... 100 - 150

(2) Cone penetration,-18 ^{o}**C (0 ^{o}F)**, dmm (ASTM D5329 modified) ..... 25 min.

(3) Flow, 60^{o}C (**140 ^{o}F)**, 5h (ASTM D5329) ..... 10 mm max.

(4) Resilience (ASTM D5329) ..... 30 - 60 %

(2) Bond,**-29 ^{o}C (-20 ^{o}F)**, 200% extension (ASTM D5329) ..... Pass3 cycles

(3) Asphalt Compatibility (ASTM D5329) ..... Pass

The sealant material may be subjected to any or all of the above tests after prolonged heating of the material for 6 hours with constant mixing in a laboratory melter at the manufacturer's recommended pouring temperature. After such heating, the material shall meet the above specified requirements.

C Packaging and Marking

The sealant material shall be packaged and shipped in suitable commercial boxes, of no more than 23 kg mass (**50 pounds**), clearly marked with the name of the material, the name of the manufacturer, brand name, mass, batch number, and pouring temperature recommended by the manufacturer.

3725.3 SAMPLING AND TESTING

A Sampling

Inspection and sampling usually done at source. Contact Chemical Laboratory for list of approved lots. If lot has not been preapproved submit a 23 kg (**50 pound**) sample to the Chemical Laboratory for testing.

B Methods of Test

B1 Testing shall be according to ASTM D5329 except the bond test will be run using sawed cement mortar blocks prepared by the Mn/DOT method.

B2 Cement Mortar Blocks (Mn/DOT Method).

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 50 mm (**2 inch**) cube specimens). After curing one day in moist air and six days in water at 23 ± 1.7 °C, the blocks shall be cut into 25.4 by 50.8 by 76.2 mm (**1 x 2 x 3 inch**) test blocks using a diamond saw blade. Discard the 25.4-mm (**1 inch**) strips in contact with the vertical sides of the mold.

Immerse the mortar blocks in lime saturated water for not less than two days prior to use. To prepare specimens, remove from lime water and scrub the block faces with a stiff bristle brush holding the block under running water. Blot the washed blocks with absorbent lint-free cloth of blotting paper. Allow the blocks to air-dry for one hour before assembling and filling. Assemble the blocks 12.7 ± 0.25 mm (**1 inch ± 0.1 inch**) apart enclosing a reservoir of 50.8 by 50.8 by 12.7 mm (**1 x 2 x 3 inches**).

3726

Preformed Gasket Seals For Concrete Pipe

Preformed gasket type seals for effecting flexible watertight joints in concrete pipe shall conform to AASHTO M 198 for Type A (rubber) or Type B (plastic) as required for the specific joint design of the pipe furnished.

3728

Bituminous Mastic Joint Sealer for Pipe

This Specification covers a cold applied, mineral filled, joint sealing compound for joints of bell and spigot or tongue and groove, concrete or clay culvert, sewer, or drain pipe.

The material shall be a refined petroleum asphalt or a refined coal tar, dissolved in a suitable solvent and stiffened with a suitable mineral filler.

The material shall be a smooth, uniform mixture, not thickened or livered, and it shall show no separation which cannot be easily overcome by stirring. It shall be of such consistency and proportions that it can be readily applied with a trowel, putty knife, or caulking gun without pulling or drawing.

The material shall exhibit good adhesive and cohesive properties when applied to metal, concrete or vitrified clay surfaces. It shall not flow, crack, or become brittle when exposed to the atmosphere, nor shall it be damaged by exposure to freezing temperatures.

When the material is applied in a layer 2 to 3 mm (**1/16 to 1/8 inch**) thick on a tinned metal panel and cured at room temperature for 24 hours, it shall set to a tough, plastic coating, free of blisters.

The bituminous mastic sealer shall meet the following test requirements:

(1) Grease cone penetration (unworked), 150 g, 25°C (**77°F**),
5 s, ASTM D 217, ... 17.5 to 30.0 mm

(2) Density ..... 1.0 g/L (**8.75 pounds/gallon**) min.

(3) Non-volatile, 10 g, 105 to 110°C, 24 hours, min.....65 %

(4) Ash, by ignition, ...25 to 45 %

Material furnished under the Specification shall be covered by a Certificate of Compliance supplied by the manufacturer in accordance with 1603.

3731

Caulking Compound

Caulking compound shall conform to Federal Specification TT-C 598, for the grade specified in the Contract.

Two grades of caulking compound are covered as follows:

Grade 1 - For gun applications; soft consistency, for hand gun use at temperatures above 4°C (**40°F**).

Grade 2 - For knife application; consistency about that of glazing putty.

Unless otherwise specified, Grade 1 shall be furnished. The color shall be near white, light gray or buff.

3733
Geotextiles

3733.1 SCOPE

This Specification covers geotextiles (permeable fabrics) for use in a variety of typical construction applications. Types of geotextile are classified by typical use as follows:

Type I - For use in wrapping subsurface drain pipe or for other specified drainage applications.

Type II - For use in wrapping joints of concrete pipe culvert and as a cover over drain field aggregate.

Type III - For use under Classes I and II random riprap, gabions, and revet mattresses.

Type IV - For use under Classes III and IV random riprap, hand-placed riprap, and quarry-run riprap.

Type V - For use in separating materials (stabilization).

Type VI - For use in earth reinforcement and Class V random riprap.

3733.2 REQUIREMENTS

A General

Geotextile shall be a woven, nonwoven, or knit fabric of polymeric filaments or yarns such as polypropylene, polyethylene, polyester, or polyamide formed into a stable network such that the filaments/yarns retain their relative position to each other. Knit fabric will only be allowed for use as perforated pipe wrap. The geotextile shall be inert to commonly encountered chemicals and shall be free of any chemical treatment or coating that might significantly reduce porosity or permeability.

Geotextile shall be uniform in texture, thickness and appearance, and be free of defects, flaws or tears that would significantly alter its strength or filtering properties. All authorized repairs shall be completed to the satisfaction of the Engineer.

All rolls of geotextile or geotextile-wrapped perforated pipe shall be delivered to the Project with an opaque plastic covering to prevent degradation due to ultraviolet rays of the sun or contamination with mud, dirt, dust or debris. Rolled geotextile shall be identified by manufacturer, product name, and roll number, both on the outside wrap and inside the core, as well as other requirements of ASTM D 4873 (Identification, Storage, and Handling). Geotextile shall not be left exposed to the sun for a period in excess of 7 days without being covered by the appropriate protective soil or rock layer. The Engineer may require replacement of any geotextile exposed to the sun for periods longer than 7 days or if the geotextile is contaminated with foreign matter.

When geotextiles are used for stabilization (Type V) or earth reinforcement (Type VI), the Contractor shall produce sewn seams meeting the strength requirements of Table 3733-1.

B Physical Properties

Geotextile shall conform to the requirements of Table 3733-1:

TABLE 3733-1
Geotextile Property Requirements

Geo-textile Property	Test Method (ASTM)	Type *(A)*						
		I		II	III	IV	V	VI
	Units	Fabric	Knit Sock *(B)*					
B1 Grab Tensile Strength minimum, each principal direction	D4632 kN (**pounds**)	0.45 (**100**)	--	0.45 (**100**)	0.45 (**100**)	0.90 (**200**)	0.90 (**200**)	*(C)*
B2 Elongation minimum, each principal direction	D4632 percent	--	--	--	15	15	--	*(C)*
B3 Seam Breaking Strength minimum *(D)*	D4632 kN (**pounds**)	0.40 (**90**)	--	0.40 (**90**)	0.40 (**90**)	0.80 (**180**)	0.80 (**180**)	*(C)*
B4 Apparent Opening Size (AOS) maximum opening size or range *(E)*	D4751 mm (**U.S. Std. sieve size**)	0.125-0.425 (**40 - 120**)	0.125-0.425 (**40 - 120**) as applied	0.30 (**50**)	0.30 (**50**)	0.30 (**50**)	0.60 (**30**)	0.85 (**20**) *(G)*
B5 Permittivity minimum *(F)*	D4491 falling head (per sec)	0.7	1.0 relaxed	0.5	0.3	0.3	0.05	0.05 *(G)*
B6 Mass (weight) minimum	D3776 g/m^2 (**oz/yd^2**)	--	115 (**3.5**) as applied	--	--	--	--	--
B7 Bursting Strength minimum	D3786-87 kPa (psi)	--	930 (**135**)	--	--	--	--	--
B8 Wide Width Strip Tensile Strength min. ea. principal direction	D4595 kN/m (**pounds/ft**)	--	--	--	--	--	--	*(C)*

(A) Minimum average roll values (MARV=s) based on average of at least three tests per swatch (sample). (Manufacturers MARV=s shall meet or exceed these requirements.)

(B) Sock shall be knit of 150 denier (minimum) polyester yarn, exhibit minimum snag or Arun@ potential, be factory-applied so as to maintain uniform installed mass, and conform to the outside diameter of the tubing with a snug fit throughout.

(C) Requirements are site specific and shall be as specified in the Contract. In no case shall these values or the properties be less than shown for Type V.

(D) This shall apply when seaming is specified or permitted in the Contract. Strength Specifications shall apply to both factory and field seams. Minimum thread strength for sewing shall be 110N (**25 pounds**). All seams shall be sewn with a Federal Type 401 stitch (two spool sewing machine) and shall be installed facing upward.

(E) Where maximun opening size is shown. For U.S. sieve sizes, AOS Number must be equal to or larger than the Number specified.

(F) Permittivity : P = K/L per second, where K = fabric permeability and L = fabric thickness.

(G) When used for Class V random riprap, maximum AOS size shall be 0.3 mm **(#50)** sieve and minimum permittivity shall be 0.3 per second (same as for Type IV geotextiles).

C Quality Control

The geotextile manufacturer is responsible for establishing and maintaining a quality control program so as to ensure compliance with this Specification.

3733.3 CERTIFICATION, SAMPLING AND TESTING

A Certificate of Compliance

Along with each shipment of geotextile, a Certificate of Compliance shall be furnished by the supplier in accordance with 1603. This certificate shall be accompanied by a document stating the manufacturer's minimum average roll values (MARVs) for the geotextile. (MARVs are two standard deviations below the mean value of all rolls tested.) In addition, the manufacturer shall maintain test records and make them available to the Engineer upon request. A copy of the Certificate of Compliance must accompany each geotextile sample sent to the Materials Laboratory for testing.

B Sampling and Testing

Geotextiles must be sampled and tested prior to use, except in special circumstances with the Project Engineers approval. In the presence of the Engineer, sampling shall be by random selection in the

field at the rate of one swatch (sample) per ten rolls or fraction thereof, or one swatch per 15 000 m (**50,000 feet**) of perforated pipe or fraction thereof. Swatches shall be full roll width and at least 1 m (**yard**) long (discard first 1 m (**3 feet**) of fabric from outside of roll) or 3 m (**10 feet**) long for pipe wrap. Samples shall be available for testing at least 21 days prior to intended use. Seam samples shall be at least 2 m (**6 feet**) long, in addition to the regular sample, and be joined in a manner and with a machine the same or equal to that to be used on the Project.

3741
Elastomeric Bearing Pads

3741.1 SCOPE

This Specification covers elastomeric bearing pads for use in bridges and other structures.

3741.2 REQUIREMENTS

A General

The elastomeric portion of the bearing pads shall be 100 percent virgin chloroprene. Pads shall be cast in molds under pressure and heat to the required Plan thickness.

Bearing pads 13 mm (**½ inch**) or less in thickness shall be all elastomer. Pads over 13 mm (**½ inch**) in thickness shall be of laminated construction.

Laminated pads shall consist of alternate layers of elastomer and metal reinforcement integrally bonded together. Laminated pads shall have reinforcement spaced as shown in the Plans. The reinforcement shall be parallel to the top and bottom surfaces of the pad. In no case shall the finished laminated pad be exposed to instantaneous temperatures greater than 205ºC (**400^0 F**).

Each laminated bearing pad shall have the manufacturer's name or trademark molded into the edge of the pad, as will provide positive identification of the manufacturer.

Pads of all elastomer may be cut from larger sheets of the material that have been cast to the required thickness. Cutting shall be performed in such a manner as to avoid heating of the material and not cause any material damage. The cutting shall produce edges at least as smooth as ANSI 250 finish.

Edges of metal reinforcement shall be covered with 6 mm (**1/4 inch**) of elastomer.

Tolerances for dimensions and configurations shall be in accordance with Section 18.2.5, Division II of the AASHTO Standard Specifications for Highway Bridges, except that the elastomer cover over the top and bottom steel plates shall have a thickness of 6 mm plus 3 or minus 2 mm (**½ inch+1/4 -1/16 inch**).

B Physical Properties

B1 Elastomer

The elastomer, as determined from test specimens, shall conform to the following:

TEST	ASTM Designation	Requirements
Hardness (Type A)	D 2240 w/2 kg.	55 ± 5
Tensile Strength,	D 412	17 Mpa (**2500 psi)** Min.
Elongation at Break, %	D 412	400, Min.
Compression Set, 22 hours at 70ºC (**158^0 F**), %	D 395	(**Method B**)25 Max.
Tear Strength,	D 624 (**Die C**)	32 kN/mm (**180 pounds/inch**) Min.
Ozone Resistance, 20% strain, 100 hours at 38º± 1ºC (**100^0 ± 2^0 F**)	D 1149 *(A)*	No cracks
Low Temperature Stiffness, Young's Modulus at -34ºC (**-30^0 F**)	D 797	34 Mpa (**5000 psi**) Max.
Low Temperature Brittleness, 5 hours at -40ºC (**-40^0 F**)	D 746	Passed

(A) Except 100 ± 20 parts per 100,000,000

After accelerated aging in accordance with ASTM D 573 for 70 hours at 100ºC (**212^0 F**) , the elastomer shall not show deterioration changes in excess of the following:

Tensile Strength, %	-15
Hardness, points,	+ 10
Elongation at Break, %	-40*

* (but not less than 300 % total elongation of the material.)

Specimens taken by the Department for acceptance testing of the physical properties of the vulcanized elastomeric material will be taken from the finished product. When test specimens are cut from the finished product, a 10 percent variation in physical properties will be allowed.

B2 Metal Reinforcement

Metal reinforcement shall be mild steel plates 3 mm (**1/8 inch**) minimum in thickness.

B3 Complete Pad

When a full size pad is tested in compression in accordance with the procedures on file in the Materials Laboratory, the compressive strain shall not exceed the following values:

	APPLIED LOAD	
SHAPE FACTOR	5.5 Mpa (**800 psi**)	8.3 Mpa (**1200 psi**)
6	6 %	8.5 %
7	5 %	7 %
8	4 %	5.5 %
9	3.5 %	5 %

For shape factors other than those specified above, the allowable compressive strain percentage will be extrapolated from an appropriate curve that defines the above specified data.

When tested with an applied load of 10 Mpa (**1500 psi**) the pad shall not crack or bulge nonuniformly.

C Certification

The Contractor shall furnish a Certificate of Compliance as provided for in 1603.

3741.3 SAMPLING AND TESTING

A Sampling

One bearing pad from each lot of material furnished will be selected by the Engineer for compliance testing at least 30 days in advance of the scheduled erection of beams. After removal of the test specimens, the bearing pad will be returned to the supplier within 30 days of receipt. The sample pad may be incorporated in the work if the test results are acceptable. Bearing pads laminated with steel plates shall have the edge covering restored to the satisfaction of the Engineer before being incorporated in the work.

B Testing

Testing shall be in accordance with the above referenced methods. Test specimens will be prepared in accordance with ASTM D 2240 and D 412.

3751

Burlap Curing Blankets

This Specification covers the requirements for burlap cloth to be used as a curing cover on Portland cement concrete. The burlap material shall conform to AASHTO M 182 for Class 3, except that samples for testing shall be furnished in the size and number directed by the Engineer.

3752
Waterproof Curing Paper

This Specification covers the requirements for waterproof paper to be used as a curing cover on Portland cement concrete. The waterproof paper shall conform to AASHTO M 171 for White Waterproof Paper. Samples for testing shall be furnished in the size and number directed by the Engineer.

3754
Membrane Curing Compound

This Specification covers liquid membrane-forming compounds suitable for spray application on Portland cement concrete surfaces to retard the loss of water during the early hardening period. The material shall conform to ASTM C 309 for the type specified in the Contract. Unless other types are specified or permitted, the material to be furnished shall be Type 2, Class B.

This material shall be tested at an application rate of 5 m^2 per liter (**1 gallon per 200 square feet**).

3755
Extreme Service Membrane Curing Compound

3755.1 SCOPE

This Specification covers extreme service white pigmented, heavy bodied linseed oil emulsion for application as a membrane cure and sealer.

3755.2 REQUIREMENTS

A General Requirements

The membrane cure/sealer emulsion shall be composed of a blend of boiled linseed oil and high viscosity, heavy bodied linseed oil emulsified in a water solution meeting AASHTO M 148, Type 2 requirements. The drying time requirement shall be waived.

B Chemical Requirements (volumes are exclusive of added pigment)

Oilphase (50 ± 4% by volume)	**Percent by Mass (weight)**
Boiled Linseed Oil	80
Z-8 Viscosity Linseed Oil	20
Waterphase (50 ± 4% by volume)	100

C Physical Requirements

The compound shall be sprayable above 4ºC (**40ºF**). Also, this compound must be protected from freezing prior to application.

3756
Plastic Curing Blankets

This Specification covers white polyethylene sheeting to be used as a curing cover on Portland cement concrete. The material shall conform to AASHTO M 171 for White Opaque Polyethylene Film. Samples for testing shall be furnished in the size and number directed by the Engineer.

3760
Insulation Board (Polystyrene)

Extruded polystyrene insulation board used for highway insulation applications shall conform to AASHTO M 230, except that the requirement of flammability shall not apply. Sampling shall be as directed by the Engineer.

3801
Rigid Steel Conduit

3801.1 Scope

This Specification covers rigid steel conduit and fittings for electrical systems.

3801.2 Requirements

Rigid steel conduit and fittings shall conform to the Federal Specification No. WW-C-581 (Class 1).

All rigid steel conduit and fittings shall be hot-dip galvanized on both the inside and outside surfaces.

3801.3 Inspection and Testing

Each length of conduit shall bear the Underwriters' Laboratories Inc. (UL) label.

The Department reserves the right to sample, test, inspect, and accept or reject conduit or fittings based on its own tests.

3802
Intermediate Metal Conduit

3802.1 Scope

This Specification covers intermediate metal conduit and fittings for electrical systems.

3802.2 Requirements

Intermediate metal conduit and fittings shall conform to the Federal Specification No. WW-C-581 (Class 2).

All intermediate metal conduit and fittings shall be hot-dip galvanized on both the inside and outside surfaces.

3802.3 Inspection and Testing 3801

3803
Non-Metallic Conduit

3803.1 Scope

This Specification covers non-metallic conduit and fittings for electrical systems.

3803.2 Requirements

Non-metallic conduit and fittings shall conform to the Federal Specification No. W-C-1094.

If the Contract fails to specify the type of conduit to be furnished, heavy-wall rigid PVC Schedule 40 plastic conduit and fittings shall be furnished, except all conduit runs under roadway surfaces shall be

heavy -wall rigid PVC Schedule 80 plastic conduit and conduit fittings.

3810
Lighting Luminaires

3810.1 SCOPE

This Specification covers lighting luminaires and fixtures with their associated components.

3810.2 REQUIREMENTS

A General

The Contractor shall furnish a complete and operational lighting luminaire or fixture. The luminaire or fixture and its components shall be as specified in the Contract as to type and capacity, and shall be in accordance with roadway lighting luminaire industry standard specifications.

Luminaires furnished must have a minimum of five (5) years warranty.

All luminaires must have the date of installation (month and year) marked with permanent marker inside the luminaire housing.

All lamps supplied must have the date of installation (month and year) etched or marked with permanent marker on the lamp socket base.

B Roadway Lighting Luminaire

The luminaire shall be a complete lighting device, including an aluminum housing, lamp, support clamp, reflector, refractor, mogul base, socket, terminal block, terminal block, plug-in igniter, and integral ballast unless a separate ballast is specified. Luminaires for High Pressure Sodium lamps shall also contain starting aids that are either encapsulated or conformal coated. The complete mounted assembly shall be weatherproof and have the internal parts readily accessible.

Pole-bracket-arm mounted luminaires shall have provisions for a slip fitter type mounting that allows engagement with at least 153 mm **(6 inches)** of the bracket arm and permits any necessary adjustment to orient the luminaire with the roadway for proper light distribution.

Luminaires shall be multivolt and wired to operate at 120/240 or 240/480 VAC, as specified in the Contract, and operate the specified lamp in a completely sealed optical system.

If specified in the Contract, the luminaires shall include an EEI/NEMA standard 3-terminal twist-lock type photoelectric control

mounting receptacle and photoelectric control. The photoelectric control shall be in accordance with 3812.

Unless otherwise specified in the Contract, luminaires shall be high pressure sodium and standard horizontal-burning type.

C Sign Lighting Fixture

The fixture (including a fixture housing and a door) shall be shaped as shown in the Contract and meet the following requirements:

(1) Maximum dimensions: width - 450 mm **(18 inches)**, length - 500 mm **(20 inches)**, height - 250 mm **(10 inches)**.

(2) Heavy duty (NEMA-EBHD), UL listed (suitable for wet locations) two piece die cast aluminum construction with a baked gray powder coat painted inside and out (hot dip process).

(3) Any holes in the base, other than weep holes, shall be filled with stainless steel screws. Each weep hole shall be screened with an activated carbon filter.

(4) Exterior components and fasteners (nuts and bolts) shall be stainless steel, except that the hinge support and the latch may be fastened to the door (cover) with self tapping galvanized or stainless steel screws, as appropriate.

(5) Door easily removed from the fixture housing without tools and attached to the fixture housing by one of the following methods:

  (a) Cast aluminum hinge (rear) and stainless steel latch (front). A galvanized steel brace shall be attached to the door and fixture housing to hold door in an open position during maintenance.

  (b) Stainless steel latches front and rear. A hinge type mechanism shall be attached to the door and fixture housing, in each back corner, to allow the door to rest in an open position during maintenance.

(6) Gasketing (sponge or neoprene) shall be provided between the door and fixture housing to provide a fixture that is weather resistant and dust tight, except for the weep holes and mounting holes.

(7) The clear, heat, and shock resistant lens shall be hermetically sealed into the door frame and be clear, tempered flat glass or convex molded prismatic glass.

(8) The fixture shall house the following:

  (a) A single piece die-form aluminum reflector made from high purity aluminum and shall have a finish of chemically bonded lightweight non-breakable glass (Alglas) on both the inside and outside surfaces of the reflector.

  (b) A heavy duty mogul base porcelain lamp socket

(c) A 175 W (H39KC-175/DX) or a 250 W (H37KC-250/DX) lamp with a deluxe white mogul base mercury vapor unit designed for horizontal operation. The lamp wattage shall be as specified in the Contract.

(d) A ballast that is "seated" to prevent movement during shipment or other vibrations.

(e) Electrical conductors within the fixture housing sized and installed in accordance with National Electrical Code.

(f) Electrical components within the fixture housing shielded in accordance with UL requirements.

(g) An outdoor, cold weather start, high power factor, constant wattage ballast for a 175 W or 250 W mercury vapor lamp as specified in the Contract. The ballast shall provide regulation within a 2 percent variation in lamp watts and with a 13 percent variation in primary volts and have adequate means of heat dissipation.

High impact resistant polycarbonate shields shall be provided for the fixtures installed on bridge mounted bridge mounted overhead signs.

D Underpass Lighting Fixture

The underpass lighting fixture shall be a complete lighting device, including an aluminum housing, lamp, reflector, refractor, mogul base, socket, terminal block, plug-in igniter, and an integral constant wattage ballast unless a separate ballast is specified. Fixtures for High Pressure Sodium lamps shall contain starting aids that are either encapsulated or conformal coated. The fixture shall be designed for wall mounting, and shall have an IES Type IV short non-cutoff light distribution. An insulated bushing shall be provided to protect the conductors entering the fixture. A gasket shall be provided to ensure a good seal between the fixture and the wall to the satisfaction of the Engineer.

The underpass fixture shall include a rear die-cast back housing that encloses the ballast, starter board, lamp socket, reflector, and a refractor frame assembly. The back housing shall be finished with a black polyester powder paint coating. The refractor frame shall be anodized etched aluminum, painted gray. The back housing assembly shall mount against the wall and the refractor frame assembly shall fasten to it by means of concealed hinges and a single point, positive acting latch. Gasketing material shall be of the molded T-type attached to the refractor frame assembly. Stainless steel retaining cables shall be provided between the refractor frame assembly and the back housing. Overall dimensions shall be approximately 406 mm **(16 inches)** square x 295 mm **(11 ½ inches)** deep.

All insulation shall be UL listed Class H; the ballast and starter board shall be positioned for maximum heat dissipation; the supply wires into the unit are to be of the proper temperature rating.

The optical unit shall include the lamp, fluted specular aluminum reflector and molded prismatic borosilicate thermal-shock-resistant glass refractor. The dimensions of the refractor shall be approximately 406 mm **(16 inches)** square x 101 mm **(4 inches)** deep and the refractor shall have internal splitting prisms and external dispersing prisms.

The underpass fixture shall have a main beam between 70 and 76 degrees vertically and between 20 and 25 degrees laterally.

E Lamps (High Pressure Sodium)

The high pressure sodium lamp shall have a mogul base, a 24 000 average rated life hours (at 10 hours per start), and a lamp burning position as required by the luminaire and lamp manufacturers. The lamps are as follows:

(1) 150 W High Pressure Sodium according to ANSI Code No. S55 clear 150 W.

(2) 200 W High Pressure Sodium according to ANSI Code No. S66 clear 200 W.

(3) 250 W High Pressure Sodium according to ANSI Code No. S50 clear 250 W.

(4) 400 W High Pressure Sodium according to ANSI Code No. S51 clear 400 W.

3810.3 INSPECTION

The lighting and electrical materials are subject to final inspection and acceptance at the project site. Such inspection will include but is not limited to the identification of the item, type, size and manufacturer's marking, and documentation of these data. When required by the Engineer, random samples will be selected from the material delivered to the Project site or at the source before delivery.

The Contractor shall submit to the Engineer, for approval by the Department's Lighting or Signing Engineer, five complete sets of manufacturer's drawings and Specifications for the lighting luminaires, or fixtures proposed for installation in accordance with 2471.3B1 and 2471.3B3. The drawings shall be distributed, after approval, to the following:

(a) Contractor

(b) Contractor's Fabricator

(c) Engineer

(d) Department's Lighting or Signing Engineer

(e) District or Division Traffic Engineer

All luminaires or fixtures shall be approved before installation.

3811
Light Standards

3811.1 SCOPE

This Specification covers the design and fabrication of light standards including pole, mast arm and base anchorage.

3811.2 REQUIREMENTS

A General

The Contractor shall furnish a complete light standard and all miscellaneous hardware required for a complete light standard installation. The light standard and its components shall be as specified in the Contract. The design of the light standard shall meet the "Standard Specifications of Structural Supports for Highway Signs, Luminaires, and Traffic Signals" as published by AASHTO.

The design shall use a wind velocity of 130 km/h **(80 mi/h)** with a 1.3 gust factor. Design service life shall not be less than 20 years.

B Light Standard

Within 30 days after Contract Award, the Contractor shall submit data, as listed below, for the Engineer's approval. The submittal shall constitute the basis of testing and acceptance of the units and shall include the following:

(1) Material Specifications with chemical compositions and mechanical properties to be used for all components of the lighting standard and anchorage assembly.

(2) Dimensioned drawings of the standard including details of components.

(3) Data as to method of manufacture and assembly of the standard and components thereof.

(4) Complete data supporting breakaway design features of the standard.

(5) Anchor bolt test specimen representative of the designs to be supplied.

(6) Complete structural design computations for the lighting standard and components thereof to include, but not limited to, the design criteria, allowable stresses including fatigue stresses for the materials proposed, loading, as designed unit stresses, etc.

(7) A certification on the part of a registered professional engineer competent in structural design, certifying as to the structural adequacy of the lighting standard proposed to be furnished under the Contract.

Preceding requirements 3, 4, 6, and 7 can be satisfied if the Department has previously approved the manufacturer's design (to these same Specifications) for other lighting projects and the manufacturer certifies in writing that the material, design, structural

analysis, manufacturing procedure, and workmanship are the same as that for previously furnished standards on the stated lighting project.

Each standard shall be designed for a luminaire with a mass of 34 kg **(75 pounds)** and a projected area of 0.3 m^2 **(3.2 square feet)**, except that in the case of twin mast arm standards these figures shall apply to each mast arm.

The top of shaft for truss arm type standards shall be enclosed with a removable, rainproof ornamental cap and a smooth opening shall be provided in the shaft for cable entrance in the mast arm. Mast arms shall be fabricated from pipe or tubing, without intermediate splices or couplings, and shall conform to the general design indicated in the Plans. The mast arm to shaft bracket shall provide a watertight connection.

Unless otherwise specified, standards shall be of the transformer base type. The base shall be so designed and constructed as to provide internal space for any required transformer, fuses, and ballast, and for which a waterproof frame and mount shall be provided. An access hole, providing an opening of at least 0.06 m^2 **(100 square inches)** shall be provided on one side of the base, and this opening shall be provided with a waterproof cover having positive closure. The access hole shall be placed 180 degrees from the mast arm or as otherwise specified in the Contract.

All exposed edges and corners of the light standard base assembly shall be finished smooth, with rounded corners and no burrs remaining. Workmanship and finish shall be equal to the best general practice of metal fabrication shops.

Each light standard shall be provided with an electrical grounding lug or nut. The complete light standard shall provide electrical continuity to the grounding lug. Such electrical continuity shall be provided in the design and fabrication of the light standard.

Each standard shall be designed to stand plumb with the design dead loads in place under a no wind condition.

Light standards shall be furnished in compliance with the following material types. Minimum shell thicknesses and shaft diameters shall be as specified in the Plans or required by the design analysis.

C Coated Steel Standards

The shaft and transformer base shall be fabricated from steel meeting 3309, unless galvanized coating is specified, in which case the Engineer may approve the use of other weldable steel having a minimum yield point of 276 Mpa **(40,000 psi)** after fabrication. Unless otherwise permitted, the shafts shall have only one longitudinal seam.

Mast arms shall be made of Schedule 40 pipe meeting ASTM A 53, Grade A.

All component parts of the standard, including hardware and fittings, shall be painted or galvanized as required by the Plans. Cleaning, painting, and galvanizing shall be performed in accordance with 2471.3L and 2476.

D Aluminum Alloy Standards

The shaft shall be fabricated from seamless 6063-T6 or 6061 T6 aluminum alloy tapered tubing. Mast arms shall be made of 6063-T6 or 6061-T6 seamless tubing.

The transformer base for breakaway designs shall be cast aluminum alloy 356-T6.

All screws, nuts, bolts, washers, and other miscellaneous hardware, except for the anchor rod assemblies, shall be made of stainless steel meeting ASTM A 276, for Type 303, 304, 305 or 316, Condition A or B.

The aluminum alloy standards shall have a nonspecular, natural or sand belted (satin) finish, which shall be free of injurious and disfiguring defects.

E Stainless Steel Standards

The shaft, mast arm, transformer base, and base slipfitter shall be fabricated from material conforming to ASTM A 240, UNS Designation S20103 or an approved equal except that the minimum yield strength shall be 345 Mpa **(50,000 psi)**. The slipfitter accommodating the luminaire shall be fabricated from material conforming to ASTM A 511, Grade MT 304L, MT 316L, or an approved equal. Failure of materials to conform to these requirements shall be cause for rejection of the light standards.

The transformer base shall be attached to the shaft by means of a slip fitter having a minimum length of one and one-half times the major shaft diameter. The fitter shall be accurately sized to fit properly. The stainless steel base plate shall be riveted to the transformer base. The design of the light standard shall provide that the base to slip fitter circumferential weld and heat affected zone are visible after assembly of shaft and slipfitter.

The number and size of the base plate rivets shall be approved by the Engineer before fabrication. Rivets shall be annealed and waxed Type 316 or equal.

The complete stainless steel standard shall have a nonreflective frost finish. The complete standard shall be thoroughly cleaned with an approved cleaning agent such as a detergent that will not damage the original mill finish.

3811.3 INSPECTION AND TESTING

The light standards are subject to final inspection and acceptance at the project site. Such inspection will include but is not limited to the identification of the item, type, size and manufacturer's marking,

and documentation of these data. When required by the Engineer, random samples will be selected from the material delivered to the Project site or at the source before delivery.

The Contractor shall submit to the Engineer, for approval by the Department's Lighting Engineer, five complete sets of shop detail drawings of the light standards and anchor rods, in accordance with 2471.3B1 and 2471.3B3. For high mast lighting installations, the Contractor shall submit final reproducible drawings in accordance with 2471.3B. The drawings shall be distributed, after approval, to the following:

(a) Contractor
(b) Contractor's Fabricator
(c) Engineer
(d) Department's Lighting Engineer
(e) District or Division Traffic Engineer

All light standards shall be approved before installation.

3812
Photoelectric Control

3812.1 SCOPE

This Specification covers photoelectric control devices for turning "ON" and "OFF" roadway luminaires, sign lights, sign downlights, or dimming flasher beacons.

3812.2 REQUIREMENTS

The photoelectric control device shall conform to the following requirements:

(a) The device shall be a solid state crystal sensing type with an inverted turn-on and turn-off design and shall meet the design and quality requirements specified in ANSI C136.10.
(b) The device shall have surge protection conforming to ANSI standard requirements.
(c) The device shall have a 2 to 3 s time delay to eliminate false operation due to lightning or stray passing lights.
(d) The device shall provide fail-safe operation (the light supply shall remain "ON" if the control circuit fails).
(e) The device shall have an arrester for built-in transient/surge protection.
(f) The voltage rating of the photoelectric control device shall be multi -voltage, operating properly over the input voltage range of 105 to 285 V, 50-60 Hz, alternating current with no change in the turn-on and turn-off foot candle values.
(g) The device shall be rated at 1800 VA, 15 A for all HID lamps.

(h) The device shall have a "TURN ON" level of 32 lx **(3.0fc)**, with a tolerance of 0.6 lx **(0.05fc)**, at the appropriate voltage. The "TURN OFF" level of the control device shall be 50 to 60 percent of the turn-on value.

(i) The device shall have a non-metallic housing and shall twist-lock mount to a EEI/NEMA three-terminal, polarized, twist-lock type receptacle. The printed circuit board shall be coated to prevent corrosion and the control device window shall be acrylic with the UV stabilizers that prevent discoloration.

3812.3 INSPECTION AND TESTING

The photoelectric control devices are subject to final inspection and acceptance at the project site. Such inspection will include but is not limited to the identification of the item, type, size and manufacturer's marking, and documentation of these data. When required by the Engineer, a sample will be selected from the material delivered to the Project site or at the source before delivery.

The Contractor shall submit to the Engineer, for approval by the Department's Lighting Engineer, five complete sets of shop detail drawings of the photoelectric control devices, in accordance with 2471.3B1 and 2471.3B3. the drawings shall be distributed, after approval, to the following:

(a) Contractor

(b) Contractor's Fabricator

(c) Engineer

(d) Department's Lighting Engineer

(e) District or Division Traffic Engineer

All photoelectric control devices shall be approved before installation.

3814
Emergency Vehicle Pre-Emption (EVP) Equipment

3814.1 SCOPE

This specification covers emergency vehicle pre-emption (EVP) equipment for use in traffic control signal systems.

3814.2 REQUIREMENTS

The Contractor shall furnish optical energy one-way or two-way EVP detectors and indicator light(s) mounted on traffic signal mast arms as indicated in the Contract. All mounting hardware and attachment to mast arms shall be in accordance with the Contract and to the satisfaction of the Engineer.

A EVP Detectors

The Contractor shall furnish EVP detectors that are:

(1) -- One-way or two-way as required by the Plans.

(2) -- Firm rigid construction.

(3) -- Solid-state.

(4) -- Mounted in combination with EVP indicator light(s) as required and a conduit outlet body with proper fittings for attaching to the mast arm.

(5) -- Operate over an ambient temperature range of from minus 40 to 85ºC (**minus 40 to 185^0 F**).

(6) -- Impervious to moisture with internal circuitry encapsulated in a semi-flexible compound.

(7) -- Capable of a reception angle providing wide coverage and a reception range variable up to approximately 520 m (**1700 feet**).

(8) -- Responsive to the optical energy impulses generated by a pulsed Xenon source generating a pulse energy density of 0.8 μJ/m^2 (**0.7 μJ/foot^2**) at the detector from a distance of 550 m (**1800 feet**) , a rise time less than 1 μs, and a half power point pulse width of not less than 0.30 μs.

B EVP Indicator Lights

Each EVP indicator light shall mount within an outdoor type flood lamp housing and shall provide a solid white indication visible at a distance of at least 150 m (**500 feet**).

3814.3 INSPECTION AND TESTING

The emergency vehicle pre-emption (EVP) equipment shall be approved by the Engineer prior to installation.

3815
Electrical Cables and Conductors

3815.1 SCOPE

This Specification covers electrical cables and individual conductors for use in traffic control signal systems, roadway lighting systems, traffic management systems, sign control systems, automatic traffic recorder systems, and other electrical systems.

3815.2 REQUIREMENTS

A General

The following standards shall govern for electrical cables and conductors unless otherwise stated:

(1) Electrical conductors shall be single conductor, 600 V, stranded copper conductors in conformance with the American National Standards Institute (ANSI) and the National Electrical Code (NEC). All conductors shall be listed and marked as required by

Underwriters' Laboratories, Inc. (UL), and shall bear the UL label.

(2) Electrical cable shall be in conformance with ANSI, NEC, ASTM and ICEA/NEMA Standards Publications.

(3) Wire sizes for all electrical conductors shall be based on the American Wire Gauge (AWG).

B Individual Electrical Conductors

B1 Power Conductors

Power conductors (1/c No. 12, 10, 8, 6, 4, 2, 1/0, etc., indicated in the Contract) shall be Type THW, Type THWN, or Type XHHW insulation.

B2 Roadway Loop Detector Conductors

(a) Roadway loop detector conductors in non-metallic conduit (NMC) shall be No. 14, stranded copper, insulated with filled chemically cross-linked thermosetting polyethylene (XLPE), or XHHW insulation per UL 44. Roadway loop detector conductors shall have "XLPE", "XLP" or "XHHW" marked on the conductor.

(b) Conductors for roadway embedded saw-cut loop detectors shall be No. 14, stranded copper, insulated with filled chemically cross-linked thermosetting polyethylene (XLPE), or XHHW insulation per UL 44. In addition, the conductor shall have a black polyethylene tubing that has a nominal outside diameter of 6.35 mm (**1/4 inch**), and a nominal wall thickness of 1 mm (**40 mils**). Roadway loop detector conductors shall have "XLPE", "XLP" or "XHHW" marked on the conductor.

B3 Bridge Deck Loop Detector Conductors

Conductors for bridge deck embedded saw-cut loop detectors shall be No. 16, stranded nickel or silver plated copper conductors, insulated with a minimum of 0.25 mm (**0.010 inch**) extruded Teflon conforming to the Federal Specification MIL-W-16878D (Type E).

B4 Signal Conductors

Conductors from terminal blocks in mast arm pole transformer bases, traffic signal pedestal bases, junction boxes on wood poles, advance warning flasher cabinets mounted on pedestal shafts, etc., to the terminal blocks in vehicle signal faces, pedestrian signal faces, advance warning flasher signal indications, pedestrian push buttons, emergency vehicle pre-emption indicator lights, photoelectric controls, etc., shall be No. 14, Type THW, Type THWN, Type THHN, or Type XHHW insulation. All signal conductors from an individual terminal block shall have a separate color code, except all neutrals shall be white.

B5 Grounding Conductors

Each equipment grounding conductor or grounding electrode conductor (1/C No. 6 GROUND or 1/C No. 6 GR. indicated in the Contract) that is installed as an individual conductor in conduit together with other conductors shall be Type THW, Type THWN, or Type XHHW green-colored insulated wire, No. 6, stranded (7 strands, Class B Stranding), and shall conform to ASTM B 8 for stranded wires.

Each equipment grounding conductor or grounding electrode conductor (1/C No. 6 BARE GROUND or 1/C No. 6 BR.GR. indicated in the Contract) that is not installed in conduit together with other conductors shall be a bare uninsulated solid copper wire, No. 6, and shall conform to ASTM B 1 or ASTM B 2 for solid wires.

C Electrical Cables

C1 Armored Underground Cables

This section covers multiple conductor, chemically filled cross-linked thermosetting polyethylene (XLPE) insulated underground direct buried cables for electrical systems.

The armored underground cables shall be in conformance with one of the following:

(a) ICEA/NEMA Standard Publication for "Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy" (ICEA publication No. S-19-81, NEMA publication No. WC3).

(b) ICEA/NEMA Standard Publication for "Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy" (ICEA publication No. S-61-402, NEMA publication No. WC5).

(c) ICEA/NEMA Standard Publication for "Cross-linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy". (ICEA publication No. S-66-524, NEMA publication No. WC7).

The armor shall be a single thickness bronze tape meeting ASTM B 130 with a minimum thickness of 254 µm (**0.001 inch**) and a spiral overlap of not less than 6.35 mm (**0.25 inch**).

The 600 V armored multiple conductor cable shall have three conductors, each covered with chemically cross-linked thermosetting polyethylene insulation, circuit identification, conductors cabled, filler, binder, armor, and common overall jacket of PVC which when assembled shall produce a completed cable of circular cross-section. All fillers shall be of a moisture resistant material, not of paper or jute.

C2 Overhead Light Cable

This section covers quadplex cables for the overhead distribution circuits of electrical systems.

The cable shall be a thermoplastic-insulated 4 conductor No. 4, self supporting aluminum cable with ACSR (aluminum conductor, steel reinforced) equipment ground messenger in accordance with the ICEA/NEMA Specification for "Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy" (ICEA publication No. S-61-402, NEMA publication No. WC5).

C3 Signal Control Cable

The multiple conductor control cables for traffic control signals shall meet the following requirements:

(a) Signal control cable shall conform to the ICEA/NEM Standards Publication for "Thermoplastic-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy," (ICEA Publication No. S-61-402, NEMA publication No. WC5), and shall be Type B in conformance with Part 7.4 of this Standard Publication.

(b) Conductors shall be Class B or Class C stranded copper conductors in accordance with ASTM B 8.

(c) All fillers shall be of a moisture resistant material, not of paper or jute.

(d) Circuit identification shall be in accordance with Appendix K, Method 1, Table K-1, of the above mentioned ICEA/NEMA Standard Publication, and the cable shall be marked as specified in the NEC.

(e) The size of the conductor shall be No. 12.

(f) Conductor insulation materials and thickness shall be 508 μm (**20 mils**) of polyethylene plus 254 μm (**10 mils**) of PVC.

(g) The outer jacket shall be PVC.

C4 Loop Detector Lead-in Cable

This section covers loop detector lead-in cable for use in traffic control signal systems and Traffic Management Systems.

Loop detector lead-in cable shall conform to one of the following:

(a) A twisted two-conductor shielded cable with a ground drain wire. Each conductor shall be a 750 V, Class C stranded (19x27) tinned copper conductor, insulated with 0.81 mm (**32 mils**) thick polyethylene. One conductor shall be color coded black and the other white or clear. The conductors shall have a longitudinally or spirally applied aluminum-polyester or aluminum-mylar tape shield. A single conductor, stranded (19x29) tinned copper ground drain wire shall be twisted around the conductors or the conductor shield in such a manner as to be in continuous contact with the aluminum part of the shield. The conductor assembly shall be covered with a continuous layer of black jacketing grade,

high molecular weight, low density polyethylene material having a minimum average thickness of .76 mm (**30 mils**).

The jacketing material shall meet the requirements of ASTM D 1248, Type I, Class C, Grade 5, J-3. The nominal capacitance measured between conductors shall be 78.7 pF per meter (24 pF per foot), and the nominal capacitance measured between one conductor and the other

conductor connected to the shield shall be 154.2 pF per meter (47 pF per foot). The cable shall be UL recognized, Style 2106, 600 V.

(b) International Municipal Signal Association, Inc. Specification No. 50-2 - Polyethylene insulated, Polyethylene Jacketed Loop Detector Lead-in Cable.

C5 Emergency Vehicle Pre-emption (EVP) Detector Cable

This section covers emergency vehicle pre-emption (EVP) detector cable for conduit and mast arm pull, direct burial, and exposed overhead installation in traffic control signal systems.

EVP detector cable shall be a twisted three-conductor shielded cable with a ground drain wire in accordance with the following:

(a) Conductors -	3/C No. 20 (7x28) stranded, individually tinned copper, insulation rating 75ºC (**167ºF**), 600 V, colored coded yellow, blue, orange.
(b) Ground Drain Wire - tinned copper.	No. 20 (7x28) stranded, individually
(c) Shield -	Aluminized polyester shield with 20 percent overlap.
(d) Jacket -	Black PVC jacket. 1 mm nominal wall thickness. 80ºC (**175ºF**) insulation rating. 600 V rating.
(e) Cable Outside Diameter -	Nominal 7.62 mm (**0.3 inch**).
(f) Drain and Conductor DC Resistance -	Not to exceed 36 Ω per kilometer (**11.0 Ohms/1000 feet**).
(g) Capacitance -	From one conductor to other two and shield shall not exceed 157.5 pF per meter (**48 pF per foot**).

C6 Telephone Cables

This section covers voice grade telephone cable for indoor installation, for outdoor installation in conduit, for outdoor direct buried installation, and for telephone drop wire.

C6a Indoor Installation

Telephone cable installed indoors in conduit or cable trays shall utilize No. 22 conductors and shall conform REA PE-71, "REA SPECIFICATION FOR INSIDE WIRING".

C6b Outdoor Installation in Conduit

Telephone cable for outdoor installation in conduit shall utilize No. 19 conductors and shall conform to RUS 1755.390 -39, "RUS SPECIFICATION FOR FILLED TELEPHONE CABLES" -Standard Cable.

C6c Outdoor Direct Buried Installation

Telephone cable for direct buried installation not in conduit shall be a gopher resistant grease-filled telephone cable; shall utilize No. 19 conductors; and shall conform to RUS 1755.390, "RUS SPECIFICATION FOR FILLED TELEPHONE CABLES", except that plastic-coated aluminum-shielded cable with plastic-coated steel-armor (CACSP) is not acceptable.

The cable shielding shall be one of the following:

(1) Fully annealed solid copper.

(2) Fully annealed copper-clad stainless steel.

(3) Alloy 194.

C6d Telephone Drop Wire

Telephone drop wire from the traffic signal cabinet or other type cabinet to the point of connection with the servicing telephone company conductors shall be a two-conductor parallel-type drop wire for use on telephone systems. The telephone drop wire shall conform to REA PE-7, "REA SPECIFICATION FOR PARALLEL CONDUCTOR DROP WIRE" and shall be approved by the local telephone company.

C7 Video Cables

This section covers the video cables (RG-__U) used in closed circuit television (CCTV) systems. RG-11/U shall be used between a camera and communications device when the distance between is greater than 50 feet and RG-59/U shall be used between communications and camera/display devices when distances are less than 50 feet.

C7a Video Cable (RG-__/U)

The cable shall bear the nomenclature and the manufacturer's name, in 6.35 to 12.7 mm (**0.25 to .05 inches**) characters, every 152 mm (**6 inches**). The center conductor shall be insulated with a cellular polyethylene dielectric to permit 78 percent velocity of

propagation. The cable shall be completely shielded from interference with dielectric foil. The impedance of the cable shall be 75 Ω. The capacitance shall be 56.8 pF/100m (**17.3 pF/100 foot**).

C7b Outdoor Video Cable (RG-11/U)

The cable shall be triaxial with a 1/C No. 14 solid copper center conductor and a 12 mm (outside diameter) extruded jacket of noncontaminating black polyethylene. The nominal attenuation of the cable at 200 MHz, shall be 77.2 dB per 100 m (**2.2 dB/100foot**).

C7c Indoor Video Cable (RG-59/U)

The cable shall be triaxial with a 1/C No. 20, solid copper center conductor and a 8 mm (**one-third inch**) (outside diameter) jacket of extruded noncontaminating black polyethylene. The nominal attenuation at 200 MHz, shall be 12.5 dB/100 m (**3.8 dB/100foot**).

C8 Camera Control Cable

This section covers the cable used to control the pan and tilt unit and the camera functions in closed circuit television (CCTV) installations.

The camera control cable shall be 27/C No. 18, 7x26 stranded, tinned copper per Type B of MIL-W-16878D. The 600 V, vinyl insulation shall meet the MIL-W-16878D requirements. The conductors and filler shall be wrapped with a mylar tape. The overall, braided, tinned copper shield shall provide 80 percent coverage. The black vinyl jacket shall be flexible from 105ºC to -40ºC. The conductors shall be color coded or numbered at 300 mm (**12 inch**) intervals.

The capacitance between adjacent conductors shall be less than 134.4 pF (**41 pF/foot**) per meter.

C9 Radio Frequency Transmission Cables

This section covers the trunk radio frequency (RF) transmission cable (coax in the Plan) used to transmit an RF modulated signal to a demodulator.

The RF transmission cable shall be a low loss cable intended for direct burial in a high saline environment. The cable shall have the manufacturer's name labelled on the outer jacket at 1.5 m (**60 inches**) intervals. The direction shall not be changed in a handhole.

The center conductor shall be 4.12 to 4.29 mm (**162 mils-169 mils**) diameter, soft or annealed copper clad aluminum wire that conforms to ASTM B 556, inside a dielectric of foam polyethylene.

The center conductor and dielectric shall be sheathed in a seamless aluminum tube that conforms with ASTM B 221, Type 1060F. The inside diameter of the sheath shall be 17.4 mm (**0.685 inch**) and the outside diameter shall be 19 mm (**0.75 inch**). The sheath shall be coated with flooding compound..

The cable shall have a helically applied, continuous, stainless steel tape armor that is 0.25 mm **(0.1 inch)** thick by 12.7 mm **(12.7 inch)** wide. The wraps of armor shall have a f (3.2) mm gap. The armor shall be coated with flooding compound and the assembly shall be contained inside an extruded, black noncontaminating polyethylene outer jacket 22.9 **(0.9 inch)** to 25.4mm **(1 inch)** thick 22.9 mm to 25.4 mm thick.

The cable properties shall be as follow:

(a) The characteristic impedance shall be 73 to 77 Ω.

(b) The velocity of propagation shall be 78 to 84 percent.

(c) The DC resistance of the inner conductor shall be 24.7 to 32.8 Ω per kilometer **(0.752 to 1.00Ω/100feet)** at 15ºC.

(d) The capacitance shall be 55.1 pF per 100 m **(1.0 to 16.8 pF/100 feet)** with a tolerance of 3.3 pF per 100 m.

(e) The attenuation at 20ºC shall be less than 3.1 dB per 100 m **(0.93 dB/100feet)** at 216 MHz and 3.5 dB per 100 m **(1.05 dB/100 feet)** at 250 MHz.

(f) The allowable bending radius shall be less than 381 mm **(15 inches)**.

(g) The allowable pulling tension shall be 1.9 kN **(425 pounds).**

C13 Fiber Optic Cables

This section covers the configurations of singlemode (SM) and multimode (MM) fiberoptic cables used to transmit data and video from field devices to central control.

The configurations are: MM pig tails; SM pigtails; SM patchcord; MM patchcord; armored pigtail (MM and SM fibers as indicated in the Plan); and trunk cables that have a varying number of MM fibers and/or SM fibers.

One company shall assemble the entire cable.

The label of each cable reel shall list the following:

(a) Customer.

(b) Order number.

(c) Reel number.

(d) Shipping date.

(e) Destination.

(f) Date of manufacture.

(g) Manufacturer.

(h) Cable code.

(i) Blank

(j) Reel length.

The Department will accept larger fiber count when supplied at no extra cost. The manufacturer shall certify that each reel of each cable meets these minimum Specifications.

C13a Trunk Cable

The direct burial singlemode and multimode fiberoptic cables shall be filled, rodent proof, armored, cable with inner and outer jackets and comply with the following additions:

The trunk cable assemblies:

(1) Have up to 24 tubes of six single mode fibers each;

(2) have dielectric strength member and color coded thermoplastic buffer tubes;

(3) buffer tubes are filled per USDA RUS,7 CFR1755.900 (former REA PE 90) for direct bury cable;

(4) buffer tubes are stranded around the dielectric central strength member using the reverse oscillation stranding process;

(5) water blocking yarns are applied longitudinally along the central member during stranding;

(6) have two non hygroscopic, non-wicking, dielectric polyester yarn binders applied contra-helically with sufficient tension to secure the buffer tubes to the central strength member without crushing the tubes;

(7) have a water blocking tape applied longitudinally around the outside of the stranded tubes/fillers;

(8) armored cables have an inner sheath of medium density, polyethylene (MDPE) of 1 mm thickness;

(9) inner sheath is applied directly over tensile strength members and water blocking tape;

(10) have armor of plastic-coated, corrugated-steel tape over a second layer of water-blocking tape;

(11) have a 1.4 mm thick MDPE outer jacket containing carbon black;

(12) have two ripcords (approximately 180º apart), one ripcord under the armor and one ripcord under the inner jacket;

(13) the cable outside diameter is < 18 mm;

(14) have a minimum loaded bend radius of 250 mm and minimum installed bend radius of 200 mm;

(15) have a nominal weight of less than 250 kg/km

(16) are not deformed but are round after installation;

(17) attenuation requirements are for cabled fiber measured along the cable axis;

(18) have **indented** markings showing the fiber count and length in meters.

C13b Multimode Properties

The multimode (MM) optical fibers shall conform to EIA/TIA-492AAAA and shall have the following optical and physical characteristics:

(1) has a UV acrylate (or equal) coating;

(2) can be mechanically stripped;

(3) the core diameter is within 3 µm of 62.5 µm;

(4) the cladding diameter is within 2 µm of 125 µm;

(5) the numerical aperture is within 0.015 of 0.275;

(6) the attenuation coefficient is 3.5 dB/km or less at 850 nm and 1.0 dB/km or less at 1300 nm;

(7) attenuation at the water peak (1383 nm < 2.1 dB/km);

(8) The ITC of the cable is > or equal to 160 MHZ/km at 850 nm and 600 MHZ/km at 1300 nm;

(9) Mn/DOT does not allow factory fusion splices.

C13c Singlemode Properties

The EIA Class IVa singlemode fibers in cables comply with the following:

(1) the core diameter is typically 8.3 µm;

(2) the diameter of the cladding is within 1µm of 125 µm;

(3) the coating diameter is within 5 µm of 245 µm;

(4) The coating is a dual layer acrylate coating in physical contact with the cladding surface;

(5) ZDW: 1301.5 to 1321.5 nm;

(6) cutoff wavelength: < 1260 nm;

(7) maximum attenuation at 1310 nm is 0.35 dB/km and 0.25 dB or less/km at 1550 nm;

(8) the mode field diameter is within 0.4 µm of 9.20 µm at 1310 nm and 1.00 µm of 10.50 µm at 1550 nm ;

(9) the maximum dispersion is 3.2 ps/nm•km from 1285 to 1330 nm and < 18 ps/nm•km at 1550 nm;

(10) Core-to-cladding offset (Core/cladding concentricity) is ≤ 0.5µm;

(11) Mn/DOT does not allow factory fusion splices in the optical fibers; and

(12) Mn/DOT does not allow splices in the armor of cables of length less than 1 kilometer.

C13d Patchcords and Pigtails

The fibers for MM and SM patchcords and pigtails shall meet the trunk cable fiber requirements. The patchcord and pigtails shall withstand a short term tensile load of 2.65 kPa and shall have factory installed connectors on both ends. The length of the patchcord shall be the distance from the splice enclosure, splice panel, or fiber distribution frame (FDF), to the communications equipment.

Patchcords and Indoor Pigtails shall be incidental to the fiberoptic system.

C13e Connectors

The MM fibers normally shall have an ST connector with less than 0.9 dB loss. The SM fibers normally shall have an FC-PC connector with less than 0.4 dB loss. The connector loss after 1000 matings, shall be less than 0.2 dB. The connector return loss shall be greater than 45 dB for SM and greater than 35 dB for MM.

C13f Indoor Pigtails

The optical pigtails shall be manufactured in pairs by installing connectors to both ends of a patch cord then cutting it to length. The pigtails shall be tested by measuring the insertion loss of the patchcord before cutting. The loss shall be equal to the connector loss.

C13g Armored Pigtail

The armored pigtail fibers, armor, and filler shall be equal to those of the trunk cables. The 6 multimode and 4 singlemode fibers shall be in individual polyethylene or polyurethane jackets. The color code of the sub-jackets shall comply with REA PE-90.

The cable length shall be determined by measuring the distance from the splice vault to the communications equipment.

The fiber number shall be labeled at the connector end of the pigtails.

The fibers shall be tested by measuring the insertion loss of the patchcord. The armored pigtail shall be spliced to the trunk cable in splice vaults.

The armored pigtail shall be measured separately.

C13h Label Terminations

The patchcord and pigtail terminations shall be labeled with the origin, destination, and function.

3815.3 INSPECTION AND TESTING

The Department reserves the right to sample, test, inspect and accept or reject all electrical conductors and cables covered in these Specifications based in its own tests.

A Armored Underground Cables

The testing and inspections of underground armored cable shall be in accordance with the following:

(1) All cable shall be subject to the Physical Properties, Aging Requirements, and Electrical Tests, except that the electrical requirement test shall be 5.7 KVAC for 5 minutes.

(2) The moisture absorption test shall not be required.

(3) The manufacturer shall submit certified test reports covering the above physical and electrical properties to the Engineer before the cable is shipped to the job site. A certificate of compliance will not be acceptable.

B Signal Control Cable

The Department may required certified test reports covering the physical and electrical properties of the signal control cable.

C Video Cables

The manufacturer shall sweep test the video cable 100 percent. The test shall be performed using the structural return loss method. The Contractor shall furnish the test certifications to the Engineer and obtain approval before installing the cable.

D Camera Control Cables

The Contractor shall furnish the test certification of the properties and construction of the camera control cable and obtain approval from the Engineer before delivering the cable.

E Radio Frequency Transmission Cable

The manufacturer shall sweep test the radio frequency transmission cable 100 percent, using the structural return loss method, through the range of 5 to 300 MHz. The loss determined shall not be less than 26 dB down from the incident wave. The Contractor shall furnish the test certification to the Engineer and obtain approval before installing the cable.

F Data Interface Cables, Data Interface Cross Cables, DS-1 Cables, and Fiber Optic Cables

The testings and inspections of the data interface cable, data interface crossover cable, DS-1 cable and fiber optic cable shall be in conformance with 2550.

THIS
PAGE
WAS
INTENTIONALLY
LEFT
BLANK.

3831
Mast Arm Pole Standards and Luminaires

3831.1 SCOPE

This Specification covers mast arm pole standards for supporting mast arm mounted and pole mounted vehicle and pedestrian signal heads, and for supporting luminaires, as part of a traffic signal system.

3831.2 REQUIREMENTS

A General

Each mast arm pole standard shall consist of a transformer base, a vertical pole shaft, a traffic signal mast arm, and, if specified in the Contract, a luminaire vertical pole shaft extension with a luminaire mast arm and luminaire.

The type of mast arm pole standard will be specified in the Contract.

The mast arm pole standard shall be designed and constructed in accordance with the "Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals" as published by AASHTO.

B Transformer Base

The transformer base shall be of the square transformer type complete with access hole. The access hole shall provide an opening of at least 0.06 m^2 on one side of the base and shall be provided with a cover having positive closure. The locking mechanism shall be an integral part of the door.

C Mast Arm

A 19 mm (**3/4 inch**) half-coupling and plug shall be furnished on the top side of the traffic signal mast arm at approximately 600 mm (**2 feet**) and 1200 mm (**4 feet**) from the end of the mast arm (flange).

Attachment of the traffic signal mast arm to the vertical pole shaft shall be by high strength galvanized bolts and nuts.

If required by the Contract, swing-away hinges shall be furnished in conjunction with the traffic signal mast arm. The swing away hinges shall be approved by the Engineer before installation. The swing-away hinges shall be installed in such a manner that the traffic signal mast arm shall swing away from the intersection.

C1 One-way Mast Arm Signal Mounts

One-way vehicle signal heads shall be mounted on the extended end of traffic signal mast arms utilizing high strength cast aluminum one-way mounts.

If required by the Contract, one-way vehicle signal heads shall be mid-arm mounted on traffic signal mast arms utilizing one-way mounts as specified above.

C2 Two-way Mast Arm Signal Mounts

Two-way vehicle signal heads required to be mounted on the extended end of traffic signal mast arms shall utilize high strength cast aluminum two-way mounts.

D Luminaires on Mast Arm Pole Standards

Luminaires shall be furnished atop mast arm pole standards where required by the Contract.

D1 Mast Arm and Pole Extension

The mast arm and pole extension for luminaires atop mast arm pole standards shall be as required by the Contract. The slipfitter on the extended end of the luminaire mast arm shall be nominal 50 mm (**2 inch**) diameter.

D2 Luminaires

Luminaires shall be standard horizontal-burning roadway type luminaires in accordance with the applicable provisions of 3810 and as specified herein. Luminaires shall be either 150 W high pressure sodium, 200 W high pressure sodium, 250 W high pressure sodium, or 400 W high pressure sodium. Luminaires shall be IES Type II medium semi cutoff light distribution pattern.

Luminaires shall be designed to operate at 120 VAC; shall have an integral constant wattage ballast pre-wired at factory with a terminal block for field connections; and shall have reflector, refractor, gaskets, luminaire housing and finish, and hardware in accordance with roadway lighting luminaire industry standard Specifications and materials. The luminaire housing shall be adaptable to the nominal 50 mm diameter slipfitter on the end of luminaire mast arm.

If required by the Contract, the luminaire shall include a photoelectric control mounting receptacle and photoelectric control. The photoelectric control shall be in accordance with 3812.

D3 Luminaire Wiring

Two No. 12 conductors shall be provided from the luminaire to the pole base with a 10 A cartridge type fuse mounted in an inline watertight fuse connector. The No. 12 conductors shall be as specified under 3807.2, Power Conductors. The conductors shall be supported near their connection point to the luminaire.

D4 Manual Check Switch

A manual check switch shall be furnished on each mast arm pole standard that has a luminaire utilizing a photoelectric control to facilitate a daytime check of the luminaire. The check switch shall be an outdoor switch complete with 10 A, 120 V single pole switch and one 13 mm (**1/2 inch**) hub on top. The check switch shall mount to a 13 mm (**1/2 inch**) Iron Pipe Size (IPS) conduit elbow with male threads on both ends. The check switch shall be mounted below the

conduit elbow. Two No. 12 conductors shall be connected from the check switch to the luminaire photoelectric control AC+ and AC+ (SW) terminals. The No. 12 conductors shall be in accordance with 3807.2B.

The check switch shall be mounted approximately 3 m above the concrete foundation and shall be mounted so as to be easily accessible from the side of the pole away from the roadway.

3831.3 INSPECTION AND TESTING

The Contractor shall furnish to the Engineer, for approval, six complete sets of shop detail drawings of the mast arm pole standard, anchor rods, luminaires and photoelectric control, in accordance with 2471.3B1 and 2471.3B3. The drawings shall be distributed, after approval, to the following:

(a) Contractor
(b) Contractor's Fabricator
(c) Engineer
(d) Blank
(e) Blank
(f) Department Traffic Engineer
(g) Spare or District Traffic Engineer

3832
Traffic Signal Pedestal

3832.1 SCOPE

This Specification covers the 100 mm diameter traffic signal pedestals that support vehicle signal faces, pedestrian signal faces, and warning flashers.

3832.2 REQUIREMENTS

A General

Submit shop drawings of the pedestal to the Engineer for approval, before procurement. The traffic signal pedestal consists of a shaft and a base.

B Pedestal Shaft

The pedestal shaft is welded 3.18 mm steel tubing and a threaded 6 mm x 100 mm diameter, standard steel pipe nipple. Electric weld the nipple to an end of the steel tubing. The welding shall meet American Welding Society standards.

The overall length of the steel tubing and the nipple is:

(1) 800 mm for a 1 m pedestal shaft and base.
(2) 1.9 m for an 2.4 m pedestal shaft and base.

(3) 2.5 m for a 3 m pedestal shaft and base.

(4) 3 m for a 3.9 m pedestal shaft and base.

(5) 4 m for a 4.6 m pedestal shaft and base.

(6) Within 6 mm of the specified measurement.

Clean the pedestal shaft on both the inner and outer surfaces. Blast clean the outer surface.

Shop paint the pedestal shaft on the inner and outer surfaces with 2 coats of prime paint, the first conforms to 3507, the last to 3511. The total dried primer thickness is 76 µm. Finish paint the outside of the shaft with two coats of yellow paint that conforms to 3572. The total thickness of the dried primer and finish coats is at least 140 µm. Scratches or other damages to the paint render the shaft unacceptable for installation.

C Pedestal Base

The pedestal base is a square transformer base with a standard 100 mm top.

C1 Access Door

The access door has a locking mechanism on the inside top and a fixed catch on the inside bottom. The locking mechanism includes a 6.4 mm diameter x 40 mm stainless steel allen-head cap screw and is part of the door. The cap screw goes through the door, through a U shaped bracket, and is held in place by two hex-head locknuts.

C2 Ground Connector

Use a bolt to mount one UL Inc listed ground wire connector 80 mm in from the door and 200 mm above the base bottom of each sidewall.

A crosslot head screw secures the ground wire to the connector. The connector accommodates a No. 6 bare copper wire. Install the connectors with the connector down. Make every device in the pedestal base from compatible materials.

C3 Anchor rods

Install four new 20 mm anchor rods, washers, and nuts with each pedestal base.

C4 Painting

Shop paint the pedestal base on the inner and outer surfaces with 2 coats of prime paint, the first conforming to 3507, the last to 3511. The dried primer is 76 µm thick. Finish paint the outside with two coats of green paint that conforms to 3552. The combined depth of

the primer and finish coats is 140 µm. Scratches or other damage to the paint render the base unacceptable for installation.

3833
Pedestrian Push Buttons and Signs

3833.1 SCOPE

This Specification covers pedestrian push buttons and signs for detecting the presence of pedestrians and giving pedestrians instructions as part of a traffic control signal system.

3833.2 REQUIREMENTS

A Pedestrian Push Buttons

Pedestrian push buttons shall be furnished where required by the Contract on vertical mast arm pole shafts, vertical light standard shafts, traffic signal pedestal shafts, or the like, or be a separate mounting.

Each pedestrian push button shall consist of a push button housing (without conduit entrance) with a cover attached by stainless steel screws and an enclosed weatherproof switching unit where the switch and actuator are a hermetically sealed unit. The cover shall have a visor type hood projecting more than the switch actuator button. The switching unit shall be rated for operation compatible with the traffic signal control equipment and shall be so constructed that it shall be impossible to receive an electrical shock under any weather condition. The push button housing shall be fabricated of a non-corrosive material designed for shaft mounting to permit internal wiring within the shaft. A saddle shall be furnished if necessary to secure a rigid installation.

The installation of each push button shall be as waterproof as possible with a neoprene or cork gasket between the push button housing and cover and a rubber gasket on the mounting screws between the push button housing and the pedestal or pole shaft. A rubber grommet shall be furnished in the wire entrance of the push button housing.

Each pedestrian push button shall be located to allow easy access for the pedestrian.

B Pedestrian Instruction Signs

A pedestrian instruction sign shall be furnished with each pedestrian push button installation. The sign shall be furnished with suitable brackets for shaft mounting directly above the push button or shall be mounted as directed by the Engineer. Each sign shall be fabricated of galvanized sheet steel in accordance with 3352.2A1a, shall utilize a white non-reflectorized background, and shall have black painted legend, border, and arrow in accordance with 3352.2B4. The arrow shall be R (Right), DH (Doublehead), or L (Left) as required.

B1 Signs for use with Pedestrian Signal Faces

Each pedestrian instruction sign shall be in accordance with Standard Sign Drawing Sign No. R10-4b [PUSH BUTTON FOR (PICTURE OF PERSON WALKING)] of the FHWA Standard Highway Signs Manual and with the applicable provisions of 3352.

B2 Signs for use without Pedestrian Signal Faces

Each pedestrian instruction sign shall be in accordance with Standard Sign Drawing Sign No. R10-3b (PUSH BUTTON FOR GREEN LIGHT) of the Mn/DOT Standard Signs Manual and with the applicable provisions of 3352.

3833.3 INSPECTION AND TESTING

The Contractor shall obtain the Engineer's approval before installation of this material.

3834
Vehicle Signal Faces

3834.1 SCOPE

This Specification covers standard and optically programmed traffic signal faces to control vehicle movements as part of a traffic control signal system or freeway ramp control signal.

3834.2 REQUIREMENTS

A Standard ITE Vehicle Signal Faces

A1 General

Standard ITE vehicle signal faces shall be furnished unless Special Signal Faces are specified in the Contract. Standard ITE vehicle signal faces shall be constructed in accordance with the ITE standard for Vehicle Traffic Control Signal Heads and as required by these Specifications.

The electrical and optical system of each vehicle signal indication shall be designed for operation on a nominal 120 VAC, single phase power supply.

Each vehicle signal face shall be of the adjustable type permitting rotation of 360 degrees about a vertical axis.

Each vehicle signal face shall be made up of three or more separate vehicle signal indications. Each vehicle signal indication shall consist of a housing, housing door, visor, glass lens, optical unit, and wiring.

Vehicle signal indications for traffic control signal systems shall be of the nominal size as indicated in the Contract.

Arrangement of vehicle signal indications in a vehicle signal face shall be in accordance with Part IV, "SIGNALS", of the MMUTCD.

All standard ITE vehicle signal faces to be furnished at one intersection shall be of the same manufacturer.

Each vehicle signal face shall be installed at the location and mounted in the manner as shown in the Contract.

Each vehicle signal face shall have provisions for easily attaching a background shield even though a background shield may not be specified in the Contract.

A2 Housing

The vehicle signal face shall be of unitized sectional construction and shall consist of as many sections as there are vehicle signal indications. All sections shall be rigidly and securely fastened together into one weatherproof vehicle signal face.

The housing material of each vehicle signal indication shall be a one-piece, corrosion-resistant, aluminum alloy die casting with all sides, top and bottom integrally cast.

All parts of the housing shall be clean, smooth and free from cracks and other imperfections.

The top and bottom exterior of the housing shall be of ribbed construction designed to ensure proper alignment of assembled sections.

The top of each section shall have 72 evenly spaced, integrally cast, protruding serrations around the pipe opening. The bottom of each section shall have 72 evenly spaced, integrally cast, recessed serrations around the pipe opening.

Individual signal sections shall be fastened together, one above the other, by means of a noncorrosive 3 bolt mounting assembly. The complete vehicle signal face, when used with serrated pipe fittings or span-wire fittings, shall provide positive locking of the vehicle signal face in any 5 degree increment about the vertical axis to eliminate rotation, twisting, or misalignment of the vehicle signal indications.

A3 Housing Door

The housing door of each vehicle signal indication shall be a one-piece, corrosion-resistant, aluminum alloy die casting (same material as the housing).

The door shall be suitably hinged and shall be forced tightly against the housing by stainless steel locking devices. All hardware including hinge pins and lens clips shall be of stainless steel.

The door shall be designed to be easily removed from the housing without the use of tools.

The lens opening in the door shall be circular and shall provide a visible diameter of not less than 185 mm (**7-1/4 inches**) nor more than 200 mm (**8 inches**) for a nominal 200 mm (**8 inches**) circular lens and a visible diameter of not less than 280 mm (**11 inches**) nor

more than 290 mm (**11.5 inches**) for a nominal 300 mm 300 mm (**12 inches**) circular lens.

The outer face of the door shall have four tapped holes equally spaced about the circumference of the lens opening to accommodate four screws for securing the signal indication visor.

A4 Gasketing

Neoprene gasketing shall be provided between the body of the housing and housing door, between the lens and the housing door, and between the lens and the reflector to exclude dust and moisture and ensure a weather-tight enclosure.

A5 Visor

Each vehicle signal indication of each vehicle signal face shall have a removable visor. The visor shall be fabricated from sheet aluminum. The visor shall be designed to fit tightly against the housing door to prevent any perceptible filtration of light between the visor and the housing door. The visor shall be mounted with twist-on slots and stainless steel screws positioned for either vertical or horizontal mounting of the vehicle signal face, and shall have a minimum downward tilt of 3.5 degrees. The length of the visor shall be a minimum of 240 mm for a nominal 300 mm vehicle signal indication and a minimum of 180 mm for a nominal 200 mm vehicle signal indication.

For traffic control signal system indications, the visor shall be the tunnel type that encloses approximately 80 percent of the lens circumference.

A6 Optical Unit

The optical unit of each vehicle signal indication shall consist of a lens, reflector, lamp receptacle, and traffic signal lamp. The lens of each vehicle signal indication shall be made of glass and shall becircular in shape with a visible nominal diameter of 200 or 300 mm as specified in the Contract. The lens shall be of the color specified in the Contract (Red, Yellow, Green, Red Arrow, Yellow Arrow, or Green Arrow). The lens shall be true to color and shall conform to the ITE standard. Each lens shall fit into a specifically designed slotted circular neoprene lens gasket designed to fit the housing door in such a manner so as to exclude moisture, dust and road film. The lens and gasket shall be secured to the door with four stainless steel lens clips. The lens gasket shall be of substantial thickness and wide enough to engage the rim of the reflector holder when the door is closed, to provide a dust tight seal of the optical unit.

A6a Circular Lens

Each nominal 300 mm (**12 inch**) diameter lens used in standard 300 mm (**12 inch**) vehicle signal indications shall conform to ITE for

a standard (wide) type lens, shall be properly marked as required by ITE, and shall be capable of being used with a 75 mm (**3 inch**) light center length traffic signal lamp of the type indicated elsewhere in these Specifications.

Each nominal 200 mm (**8 inch**) diameter lens used in standard 200 mm (**8 inch**) vehicle signal indications shall conform to ITE, shall be properly marked as required by ITE, and shall be capable of being used with a 60 mm (**7/16 inch**) light center length traffic signal lamp of the type indicated elsewhere in these Specifications.

The lens manufacturer shall place on each lens a label that shall indicate that the lens meets the ITE standard.

A6b Arrow Lens

Each arrow lens shall provide for an arrow indication within a standard size nominal 300 mm (**12 inch**) diameter signal lens for use in directing vehicle traffic in a certain direction during a specific interval, shall have the configuration and dimensions shown in the ITE standard under "Arrow Lenses", shall be of the color specified in the Contract, and shall have the arrow as the only illuminated portion of the lens.

The lens manufacturer shall place on each lens a label that shall indicate that the lens meets the ITE standard.

A6c Reflector

The reflector of each vehicle signal indication shall be made of specular Alzak finished aluminum. The reflector shall be mounted in a cast aluminum reflector support attached to the housing or shall be an integral reflector and support of formed sheet aluminum. The reflector assembly shall be hinged to the housing with stainless steel hinge pins and shall be designed so that it can be easily removed or swung out for access without the use of tools or disconnecting any wires. The method of mounting and fastening the reflector shall be sufficiently rigid to secure proper alignment between the lens and reflector when the housing door is closed. The reflector shall have an opening in the back for the lamp receptacle.

A6d Lamp Receptacle

The lamp receptacle shall be of heat resistant molded phenolic material designed to properly position a medium screw base traffic signal lamp with means to accommodate a lamp having a 60 mm (**7/16 inch**) light center length for a nominal 200 mm (**8 inch**) diameter vehicle signal indication or a lamp having a 75 mm (**3 inch**) light center length for a nominal 300 mm (**12 inch**) diameter vehicle signal indication. The lamp receptacle shall be designed to automatically position the filament of the lamp at the exact focal point of the reflector so that an accurate focus will always be

obtained. The lamp receptacle shall be designed so that it can be easily rotated and positively positioned without the use of tools and shall provide proper lamp filament orientation without affecting the lamp focus. The lamp receptacle shall have a lamp grip to prevent the lamp from working loose due to vibration. The metal portion of the lamp receptacle shall be compatible with brass or copper and the screw shell shall be metal. A neoprene gasket shall be provided between the lamp receptacle and the reflector for a cushion and positive seal.

A6e Traffic Signal Lamps

Traffic signal lamps for standard ITE vehicle signal indications shall be nominal 130 V clear traffic signal lamps with a rated average life of minimum 6000 hours. Traffic signal lamps shall be in accordance with the ITE standard for traffic signal lamps. Each lamp shall have a base made of brass and shall be the standard medium screw-type. The glass envelope shall be clear and shall be indelibly marked to show the manufacturer's identification, the rated voltage, the rated lumens, the rated average life, and the orientation of lamp for proper burning position.

Traffic signal lamps for vehicle signal indications shall be as listed in Table 3834-1

TABLE 3834-1
TRAFFIC SIGNAL LAMPS FOR VEHICLE SIGNAL INDICATIONS

Indication	Size (Diameter)	Wattage	Initial Lumens	Light Center Length
CIRCULAR RED	300 mm **(12 inches)**	150	1950	76 mm **(3 inches)**
CIRCULAR YELLOW	300 mm **(12 inches)**	69	675	62 mm **(2-7/16 inches)**
CIRCULAR GREEN	300 mm **(12 inches)**	150	1950	76 mm **(3 inches)**
ARROW	300 mm **(12 inches)**	150	1950	76 mm **(3 inches)**
CIRCULAR RED	200 mm **(8 inches)**	116	1280	62 mm **(2-7/16 inches)**
CIRCULAR YELLOW	200 mm **(8 inches)**	69	675	62 mm **(2-7/16 inches)**
CIRCULAR GREEN	200 mm **(8 inches)**	116	1280	62 mm **(2-7/16 inches)**

NOTE: 1. All lamps shall burn base down to horizontal.

2. 69 W LAMP: A single piece lamp receptacle adapter provided with each 300 mm (**12 inch**) circular yellow standard vehicle signal indication shall be compatible with the 62 mm (**2-7/16 inch**) light center length lamp for proper focusing.

A6f Light Distribution

The lighted vehicle signal indication shall appear to be illuminated uniformly over its entire surface when viewed from the usual angles encountered in service. The resultant light distribution and candlepower intensity and the relative luminous transmittance and chromaticity of an assembled vehicle signal face with colored lenses shall be in accordance with the ITE standard. The optical unit shall be so designed that each lens of a vehicle signal face is illuminated separately and assembled so that no light can escape from one indication to another. The optical unit, including lens, reflector, lamp, and visor shall be designed to minimize the return through the lens of outside light entering the lens at low sun angles, to prevent the effect termed "Sun Phantom".

A7 Wiring

Each lamp receptacle of a vehicle signal face shall be provided with two color coded copper conductors. The conductors shall be equal to or better than No. 18, 600 V, fixture wire with 105ºC (**220ºF**) rating thermoplastic conductor insulation. The conductors shall be securely fastened to the lamp receptacle and with sufficient length to reach the terminal block with the reflector fully open. The thermoplastic insulation shall, at minus 36ºC (**minus 34º F**), be capable of being bent six times around a 25 mm (**1 inch**) mandrel without damage to its insulating properties at rated voltage. A terminal block shall be provided and securely fastened to the inside of one of the housings of a vehicle signal face for connection of the conductors from each vehicle signal indication lamp receptacle and the field conductors. The conductors from each lamp receptacle of a vehicle signal face shall be run independently to the terminal block and shall not be bound together into a cable.

A8 Painting

All surfaces of the housing, housing door, and visor of each vehicle signal indication shall be treated with a metal primer suitable for the material.

All surfaces of the housing shall be finish painted highway yellow.

All surfaces of the housing door and visor shall be finish painted dull non-reflective black.

A9 Background Shield

A background shield (or backplate) shall be furnished and attached to vehicle signal faces unless otherwise specified in the Contract.

Background shields shall be fabricated from sheet aluminum. The shield shall extend not less than 125 mm (**5 inches**) on each side of the vehicle signal face and not less than 100 mm (**4 inches**) at the top and bottom.

The bottom of a background shield attached to a vehicle signal face mounted directly above a pedestrian signal face shall not be cut. When this case exists, a sufficient length pipe nipple threaded on both ends shall be furnished above the pedestrian signal face to permit the separate rotation of the vehicle signal face and the pedestrian signal face.

Background shields shall be constructed and attached to vehicle signal faces so that no background light shows between the shield and the vehicle signal face.

Background shields shall be finish painted dull nonreflective black.

B Optically Programmed Vehicle Signal Faces (Special Signal Faces)

If specified in the Contract, an optically programmed vehicle signal face (Special Signal Face) shall be furnished in lieu of a standard ITE vehicle signal face.

Optically programmed signal faces (Special Signal Faces) and the installation thereof shall conform to the applicable provisions for standard ITE vehicle signal faces.

B1 General

The special signal face shall permit the visibility zone of each signal indication to be determined optically and shall require no hoods or louvers. The projected signal indication may be selectively visible or veiled anywhere within 15 degrees of the optical axis. No signal indication shall result from external illumination nor shall one light unit illuminate a second light unit. Each signal indication of the special signal face shall provide a nominal 300 mm (**6 inch**) circular vehicle signal indication.

B2 Optical System

The optical system of the special signal face shall consist of a lamp, lamp collar, optical limiter-diffuser, and an objective lens.

The lamp for each signal indication shall be a nominal 150 W, 120 VAC, three prong, sealed beam type having an integral reflector with stippled cover and an average rated life of at least 6000 hours. The lamp shall be coupled to the diffusing element with a collar

including a specular inner surface. The diffusing element may be discrete or integral with the convex surface of the optical limiter.

The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 275 to 365 m (**900 to 1200 feet**) distant and permit an effective veiling mask to be variously applied as determined by the desired visibility zone. The optical limiter shall be provided with positive indexing means and composed of heat resistant glass.

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

The optical system shall accommodate projection of different selected indications to separate portions of the roadway such that only one signal indication is simultaneously apparent to any viewer. The projected signal indication shall conform to ITE transmittance and chromaticity standards.

B3 Construction

Each signal housing shall be constructed of die-cast aluminum conforming to ITE alloy and tensile requirements and shall have a chromate preparatory treatment. The exterior of the signal housing, lamp housing and mounting flanges shall be finished with a baked enamel prime and finish painted highway yellow. The lens holder and interior of the signal housing shall be flat black.

Each signal housing and lens holder shall be predrilled for a background shield and visor. Hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather-resistant rubber gaskets.

Each signal indication of the special signal face shall have a cutaway type visor and each special signal face shall have a background shield. Each visor and background shield shall be fabricated from sheet aluminum with all surfaces treated with a metal primer suitable for the material and finish painted dull non-reflective black.

B4 Mounting

The special signal face shall mount to standard 38 mm (**1-1/2 inch**) signal brackets and pipe fittings as a single section, as a multiple section signal face, or in combination with other vehicle signal faces. Each signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connection shall permit external adjustment

about the mounting axis in 5 degree increments. The special signal face shall be installed with ordinary tools and serviced with no tools.

Attachments such as visors, background shields or adapters shall conform and readily fasten to existing connection between the case and lamp housing shall be accomplished with an interlock assembly that disconnects the lamp housing when opened. Each signal section shall include a covered terminal block for screw attachment of lead wires. Concealed No. 18, Type AWM insulation, stranded, color coded, copper wires shall interconnect all signal sections to permit field connection within any signal section.

B6 Photocontrol

Each signal section shall include an integral means for regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 10 764 lx (**1000 foot candles**) and shall reduce to 15 percent plus or minus 2 percent of maximum at less than 10.764 lx (**1000 foot candles**) over the applied voltage and ambient temperature range. Response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 10 764 lx and damped for any decrease from 10 764 lx (**1000 foot candles**).

The intensity controller shall consist of an integrated, directional light sensing and regulating device interposed between lamp and field wires. The device shall be responsive over an applied voltage of 95 to 130 VAC, temperature range from minus 40ºC to plus 77ºC (**minus 40 to plus 165ºF**) and may provide phase controlled output voltage but shall have a nominal open circuit terminal impedance of at least 1000 Ω.

B7 Installation

Each special signal face shall be installed, directed, and veiled (masked) in accordance with published instructions and the Engineer's visibility requirements. Each signal indication of the special signal face shall be masked with prescribed materials (tape) in an acceptable manner.

C Signal Brackets and Pipe Fittings

All signal brackets and pipe fittings for mounting vehicle and pedestrian signal faces shall utilize nominal 40 mm (**1-1/2 inch**) diameter standard steel pipe signal brackets and malleable iron pipe fittings.

Signal brackets shall be of sufficient length to provide proper vehicle and pedestrian signal face alignment, to permit programming of optically programmed vehicle signal faces, or of a length as directed by the Engineer.

3834.2

All locknuts, nipples, locknipples, gaskets, washers, and all other hardware, used to fasten vehicle and pedestrian signal faces to signal bracketing and pipe fittings and to signal head mounts shall not be fabricated of aluminum and shall be traffic signal industry standard signal hardware.

All signal brackets and pipe fittings shall be mounted plumb or level, symmetrically arranged, and securely assembled. Construction shall be such as to permit all traffic signal conductors to be concealed and shall be watertight and free of sharp edges or protrusions that might damage the traffic signal conductor insulation.

3834.3 INSPECTION AND TESTING 3833

3835
Pedestrian Signal Faces

3835.1 SCOPE

This Specification covers pedestrian signal faces to direct pedestrian movements as part of a traffic control signal system.

3835.2 REQUIREMENTS

A General

Pedestrian signal faces shall be furnished where specified in the Contract. Pedestrian signal faces shall be constructed in accordance with the ITE Pedestrian Traffic Control Signal Indication standard.

Pedestrian signal faces shall be incandescent type consisting of two pedestrian signal indications per pedestrian signal face.

The electrical and optical system of each pedestrian signal indication shall be designed for operation on a nominal 120 VAC, single phase power supply.

Each pedestrian signal indication shall consist of a housing, housing door, visor, lens, optical unit, and wiring.

Each pedestrian signal face shall transmit an illuminated lunar white symbol of a "WALKING PERSON" (symbolizing WALK) and an illuminated portland orange symbol of a "UPRAISED HAND" (symbolizing DONT WALK).

Each pedestrian signal face shall be of the adjustable type permitting rotation of 360 degrees about a vertical axis.

Arrangement of pedestrian signal indications in a pedestrian signal face shall be in accordance with Part IV, "SIGNALS", of the MMUTCD.

Pedestrian signal indication size shall be nominal 230 x 230 mm (**9 x 9 inches**) or nominal 300 x 300 mm (**12 x12 inches**). If the Contract does not specify the size, nominal 300 x 300 mm (**12 x 12 inches**) size pedestrian signal indications shall be furnished.

Pedestrian signal faces shall be installed at the locations and mounted in the manner as required by the Contract.

B Housing

The housing material of each pedestrian signal indication shall be a one-piece, corrosion-resistant, aluminum alloy die casting with all sides, top, and bottom integrally cast.

The housing shall be of unitized sectional construction and shall consist of two separate identical sections. The sections shall be rigidly and securely fastened together into one weatherproof pedestrian signal face.

The top and bottom exterior of the housing shall be rigid and of ribbed construction designed to ensure perfect alignment of assembled sections.

The top of each section shall have 72 evenly spaced, integrally cast, protruding serrations around the pipe opening. The bottom of each section shall have 72 evenly spaced, integrally cast, recessed serrations around the pipe opening.

Individual signal sections shall be fastened together, one above the other, by means of a noncorrosive three-bolt mounting assembly in such a manner that any section may be rotated about a vertical axis and oriented at any angle with respect to an adjacent section. The complete pedestrian signal face, when used with serrated pipe fittings, shall provide positive locking of the pedestrian signal face in any 5 degree increment about the vertical axis to eliminate rotation, twisting, or misalignment of the pedestrian signal indications or pedestrian signal face.

C Housing Door

The housing door of each pedestrian signal indication shall be a one-piece, corrosion-resistant, aluminum alloy die casting, or shall be a one-piece polycarbonate molding.

The door shall be suitably hinged and shall be forced tightly against the housing by stainless steel locking devices. All other door hardware such as hinge pins and lens clips shall be of stainless steel material.

The door shall be designed to be easily removed from the housing without the use of tools.

The housing door shall accommodate the pedestrian signal indication lens.

The outer face of the housing door shall have four tapped holes equally spaced about the lens opening to accommodate four screws for securing the pedestrian signal indication visor.

D Gasketing

Neoprene gasketing shall be provided between the body of the housing and the housing door and between the lens and the reflector to exclude dust and moisture and ensure a weather-tight enclosure.

E Visor

Each pedestrian signal indication of each pedestrian signal face shall have a removable visor a minimum of 175 mm (**7 inches**) in length for a nominal 230 x 230 mm (**9 x 9 inches**) pedestrian signal indication and a minimum of 280 mm (**11 inches**) in length for a nominal 300 x 300 mm (**12 x 12 inches**) pedestrian signal indication. All sides of the visor shall be approximately the same length.

The visor shall be fabricated from either sheet aluminum for pedestrian signal indications with aluminum doors, or ultraviolet stabilized polycarbonate for pedestrian signal indications with polycarbonate doors.

The visor shall encompass the entire top and sides (bottom open) of the pedestrian signal indication and shall be designed to fit tightly

against the door so as to prevent any perceptible filtration of light between the door and the visor. The top of the visor shall have a minimum downward tilt of 3.5 degrees. The visor shall be secured to the housing door by stainless steel screws.

F Optical Unit

The optical unit of each pedestrian signal indication shall consist of a lens, reflector, lamp receptacle, and traffic signal lamp.

F1 Lens

The lens of each pedestrian signal indication shall be approximately 230 mm (**9 inches**) square for a nominal 230 x 230 mm (**9 x 9 inches**) pedestrian signal indication or approximately 300 mm (**12 inches**) square for a nominal 300 x 300 mm (**12 x 12 inches**) pedestrian signal indication.

The symbol "WALKING PERSON" and symbol "UPRAISED HAND" lenses shall conform to ITE and the MMUTCD. The symbols shall be at least 226 mm (**8.9 inches**) high on the nominal 300 mm (**12 inches**) square lens and at least 152 mm (**6 inches**) on the nominal 230 mm (**9 inches**) square lens.

The lens shall fit into a specifically designed slotted neoprene lens gasket designed to fit the housing door in such a manner so as to exclude moisture, dust, and road film. The lens and gasket shall be secured to the door with four stainless steel clips. The lens gasket shall be of substantial thickness and wide enough to engage the rim of the reflector holder when the door is closed, to provide a dust tight seal of the optical unit.

F2 Reflector

The reflector of each pedestrian signal indication shall be specular Alzak finished aluminum. The reflector shall be mounted in a cast aluminum reflector support attached to the housing or shall be an integral reflector and support of formed sheet aluminum. The reflector assembly shall be hinged to the housing with stainless steel hinge pins and shall be designed so that it can be easily removed or swung out for access without the use of tools or disconnecting any wires. The method of mounting and fastening the reflector shall be sufficiently rigid to secure proper alignment between the lens and reflector when the housing door is closed. The reflector shall have an opening in the back for the lamp receptacle.

F3 Lamp Receptacle

The lamp receptacle shall be of heat resistant molded phenolic material designed to properly position a standard medium screw base traffic signal lamp with means to accommodate a lamp having a 60 mm (**2-7/16 inch**) light center length. The lamp receptacle shall be designed to automatically position the filament of the lamp at the exact focal point of the reflector so that an accurate focus will always be obtained.

The lamp receptacle shall be designed so that it can be easily rotated and positively positioned without the use of tools and shall provide proper lamp filament orientation without affecting the lamp focus. The lamp receptacle shall have a lamp grip to prevent the lamp from working loose due to vibration. The metal portion of the lamp receptacle shall be compatible with brass or copper and the screw shell shall be metal. A neoprene gasket shall be provided between the lamp receptacle and the reflector for a cushion and positive seal.

F4 Traffic Signal Lamps

Traffic signal lamps for standard ITE pedestrian signal indications shall be nominal 130 V clear traffic signal lamps with a rated average life of minimum 6000 hours. Traffic signal lamps shall be in accordance with the ITE standard for traffic signal lamps. Each lamp shall have a base made of brass and shall be the standard medium screw-type. The glass envelope shall be clear and shall be indelibly marked to show the manufacturer's identification, the rated voltage, the rated lumens, the rated average life, and the orientation of lamp for proper burning position.

Traffic signal lamps for pedestrian signal indications shall be as follows:

(a) A 116 W lamp shall be installed in all nominal 300 x 300 mm (**12 x 12 inches**) standard ITE pedestrian signal indications. The lamp shall have a 62 mm (**2-7/16 inch**) light center length, approximate initial lumens of 1280 and shall burn base down to horizontal. A single piece lamp socket or lamp socket adaptor compatible with the 62 mm (**2-7/16 inch**) light center length may be required with each nominal 300 x 300 mm (**12 x 12 inch**) pedestrian signal indication for proper focusing.

(b) A 69 W lamp shall be installed in all nominal 230 x 230 mm (**9 x 9 inch**) standard ITE pedestrian signal indications. The lamp shall have a 62 mm (**2-7/16 inch**) light center length, approximate initial lumens of 675 and shall burn base down to horizontal.

F5 Light Distribution

The lighted pedestrian signal indication shall be uniformly illuminated over the entire message surface when viewed from usual angles encountered in service. The "WALKING PERSON" or "UPRAISED HAND" symbols shall be the only illuminated portions of the lens or pedestrian signal face.

The pedestrian signal indications shall attract the attention of and be readable to the pedestrian both day and night at all distances from 3 m (**10 feet**) to the full width of the area to be crossed. When not illuminated, the "WALKING PERSON" and "UPRAISED HAND" symbols shall not appear to be illuminated by external light sources when viewed from the far end of the crosswalk.

The luminous transmittance and chromaticity of an assembled pedestrian signal face with lenses shall be in accordance with the ITE

standard. The optical unit shall be so designed that each lens of a pedestrian signal face is illuminated separately and assembled so that no light can escape from one indication to another. The optical unit, including lens, reflector, lamp, and visor shall be designed to minimize the return through the lens of outside light entering the lens at low sun angles, to prevent the effect termed "Sun Phantom".

G Wiring

Each lamp receptacle of a pedestrian signal face shall be provided with two color coded copper conductors. The conductors shall be equal to or better than No. 18, 600 V, fixture wire with 105ºC thermoplastic conductor insulation rating. The conductors shall be securely fastened to the lamp receptacle and with sufficient length to reach the terminal block with the reflector fully open. A terminal block shall be provided and securely fastened to the inside of one of the housings of a pedestrian signal face for connection of the conductors from each pedestrian signal indication lamp receptacle and the field conductors. The conductors from each lamp receptacle of a pedestrian signal face shall be run independently to the terminal block and shall not be bound together into a cable.

H Painting

All surfaces of the housing, aluminum housing door, and aluminum visor of each pedestrian signal indication shall be treated with a metal primer suitable for the material.

All surfaces of the housing shall be finish painted highway yellow.

All surfaces of the aluminum housing door and aluminum visor shall be finish painted dull non-reflective black.

Polycarbonate housing doors and visors shall have the ultraviolet stabilized color permanently impregnated within the material.

I Blank

J Signal Brackets and Pipe Fittings..... 3834.2C

3835.3 INSPECTION AND TESTING 3833

3837
Electrical Service Equipment

3837.1 SCOPE

This Specification covers electrical service equipment for controlling and distributing electrical power, providing over-current protection, and providing a means to cut off power to items of electrical equipment, as part of a traffic control signal system, roadway lighting system, automatic traffic recorder system, or other electrical system.

3837.2 REQUIREMENTS

A Service Equipment

A1 General

The Contractor shall furnish and install a meter socket, disconnecting means, ground rod, grounding and bonding materials, conduit, conduit fittings, power conductors, and, for installations on wood poles, conduit risers and weatherhead, for electrical service for the traffic control signal system, roadway lighting system, automatic traffic recorder system, or other electrical system, where required by Contract.

For installation on a wood pole, the power conductors above the disconnecting means, through the meter socket to the weatherhead, shall be sized appropriately for the rating of the service disconnect, shall meet the requirements of the power company, and shall extend beyond the weatherhead for connection to the power conductors from the source of power; which connection will be made by others at no cost to the Contractor.

All parts of the service equipment shall utilize copper wire and shall have connections that are UL listed for use with copper wire.

A2 Meter Socket

The meter socket shall contain a positive bypass mechanism, shall have lugs that will allow the power conductors to be stripped and laid into the lugs without being cut, and shall be approved by the power company. The meter will be furnished and installed by others.

A3 Circuit Breaker Load Center

Unless otherwise indicated in the Contract, the disconnecting means shall be a 3-wire, solid neutral, 100 A, 120/240 VAC, NEMA 3R rain-tight enclosure for outdoor use, circuit breaker load center, UL listed for use as service equipment.

The load center shall have a front cover and inner dead front cover. The front cover shall be hinged at the top (with a slip hinge arrangement that permits leaving the cover in an open position) and snap closes at the bottom. Both covers shall be easily removable for installation, maintenance, and wiring.

Any lugs that are required for power conductor connections in the load center shall be UL listed for use with copper wire, shall be

solderless (set screw type), and shall be the appropriate size for the conductors with which they are used.

The circuit breaker load center shall be provided with an isolated, bondable neutral bar with capacity to accept the number and size of neutral and grounding conductors as indicated in the Contract or required by the NEC. Bonding of the neutral shall be in accordance with the NEC.

Unless otherwise specified in the Contract, the Contractor shall furnish and install circuit breakers in the load center as follows:

(a) -one 2-pole, 100 A main circuit breaker.

(b) -one 1-pole, 60 A circuit breaker for signal system.

(c) -two 1-pole, 15 A circuit breakers for roadway lighting.

Circuit breakers shall be 120/240 VAC, and shall be clearly marked with the "ON" and "OFF" positions and identified with the load that it is carrying, such as "SIGNALS" or "LIGHTING". The circuit breakers and the load center enclosure shall be of the same manufacturer.

A4 General Duty Safety Switch

When specified in the Contract, the disconnecting means shall be a 3-wire, fusible, 2-pole, solid neutral, single throw, 60 A, 120/240 VAC, NEMA 3R (rain-tight enclosure for outdoor use), general duty safety switch, UL listed as suitable for use as service equipment. Any lugs contained in the safety switch shall be appropriate for the material and size of the conductors with which they are used. The Contractor shall furnish the required fuses.

The general duty safety switch shall be provided with an isolated, bondable neutral bar with capacity to accept the number and size of neutral and grounding conductors as indicated in the Contract or required by the NEC. Bonding of the neutral shall be in accordance with the NEC.

A5 Heavy Duty Safety Switch

The safety switch shall be provided to turn off power to the sign lights. The safety switch shall be:

1. A NEMA 3R rain tight enclosure for outdoor use.
2. 30 ampere, heavy duty, single throw, fusible with an insulated solid neutral.
3. Rated 240 volts AC for a 120/240 volt sign lighting system and 600 volts AC for a 240/480 volt sign lighting system.
4. Provided with two 20 ampere catridge type fuses, and
5. 3-wire, 2-pole. For the 600 volt AC switch, 4 wire, 3 pole is acceptable.

The rain tight enclosure shall be fabricated from sheet metal, zinc coated and have a grey finish coat.

The safety switch shall be installed in a vertical upright position.

A6 Enclosed Circuit Breaker

When specified in the Contract, an enclosed circuit breaker shall be furnished and installed where indicated in the Plans for cutting power to the electrical system or systems.

The circuit breaker shall be mounted in a NEMA 3R rain-tight enclosure for outdoor use. The circuit breaker shall be a 2-pole, 100 A, 120/240 VAC, thermo-magnetic breaker, UL listed as suitable for use as service equipment, and shall be clearly marked with "ON" and "OFF" positions and identified with the load it is carrying, such as EQUIPMENT PAD. If lugs are required for power conductor connections to the breaker, they shall be UL listed for use with copper wire and shall be solderless (set screw type). The rain-tight enclosure shall have provisions for a padlock (furnished by others).

B Transformer and Circuit Breaker Assembly

B1 Transformer

The transformer shall be an outdoor, general purpose, dry type transformer. Transformer Specifications shall be as follows:

(a) Primary - 480 V, two 5-percent taps below 480 V.

(b) Secondary- 120/240 VAC.

(c) Rating - 7.5 KVA, single phase

(d) Size - Approximately 400 mm (**16 inches**) high, 300 mm (**12 inches**) wide, and 270 mm (**10-1/2 inches**) deep.

The transformer and related wiring compartment shall be UL listed for indoor-outdoor applications and shall meet applicable NEMA and IEEE standards. The transformer shall be mounted on the equipment pad as detailed in the Contract to the satisfaction of the Engineer.

B2 Enclosed Circuit Breaker

The transformer shall be protected by a circuit breaker mounted in a NEMA 3R rain-tight enclosure for outdoor use. The circuit breaker shall be a 2-pole, 20 A, 480 VAC, thermo-magnetic breaker. If lugs are required for power conductor connections to the breaker, they shall be UL listed for use with copper wire and shall be solderless (set screw type). The rain-tight enclosure shall have provisions for a padlock (furnished by others). The circuit breaker enclosure shall be mounted as detailed in the Contract to the satisfaction of the Engineer.

3837.3 INSPECTION AND TESTING

The Contractor shall submit to the Engineer, for approval, six sets of manufacturer's drawings and specifications for the transformer and circuit breaker assembly proposed for installation.

The drawings shall be distributed, after approval, to the following:

(a) Contractor

(b) Contractor's Fabricator

(c) Engineer

(d) Department Traffic Engineer

(e) Spare or District Traffic Engineer

(f) Traffic Signal Cabinet or other pad mount cabinet

All items of electrical service equipment shall be approved before installation.

3838
Electrical Junction Boxes

3838.1 SCOPE

This Specification covers junction boxes for providing access to electrical wiring, facilitating the installation of electrical wiring, and for changing from field cable wiring to individual conductors as part of a traffic control signal system, freeway ramp control signal, automatic traffic recorder system, roadway lighting system, or other electrical system.

3838.2 REQUIREMENTS

A Metal Junction Boxes Attached to a Bridge

Metal junction boxes required to be mounted to a bridge shall be NEMA Type 4X galvanized cast iron boxes with covers.

The junction boxes shall have four mounting lugs and shall be equipped with drain and breather fittings.

Junction boxes shall be adequately sized to permit easy installation of all electrical cables and conductors routed through the junction box. The cover shall be of the same material as the box, fastened with stainless steel hex-head screws or bolts and nuts, and equipped with a neoprene gasket around the entire perimeter of the cover.

Each conduit entrance shall accommodate the nominal outside diameter of the conduit specified and shall be bossed and threaded to provide five full threads.

Junction boxes shall be attached using two unit threaded bolt anchorages conforming to the Contract or, if not specified, approved by the Engineer, with the required hardware to permit removal of the junction box.

B Metal Junction Boxes on Wood Poles

The Contractor shall furnish and install a metal junction box with terminal blocks whenever installing temporary traffic control signal systems; flashing beacon systems; advance warning flashers; or vehicle, pedestrian signal faces, or flashing signal indications on wood poles.

Each metal junction box shall conform to NEC requirements, shall be NEMA Type 3R, shall be at least 300 mm (**12 inches**) square by 150 mm (**6 inches**) deep with a 6 mm (**1/4 inch**) drain hole on the bottom side, and shall have a cover with a gasket around the entire perimeter of the cover. The cover shall be attached by stainless steel screws.

Each metal junction box shall have terminal blocks for terminating field conductors and traffic signal conductors. Terminal blocks shall be as described in 2565.3J, shall be firmly attached to the back of the junction box in such a manner that the terminal screws of the terminal block face the box opening, and shall be covered with an electrical insulating coating after all conductor terminations on the terminal block.

Liquid-tight flexible metal conduit and conduit fittings as required shall be furnished and installed between the metal junction box and each type wood pole mounted signal bracketing.

C Junction Boxes in Non-Metallic (NMC) Conduit Runs Attached to a Bridge

Junction boxes required to be mounted to the bridge shall be NMC junction boxes with a cover attached by stainless steel screws. Each NMC junction box shall be sized at least 150 mm (**6 inches**) square by 150 mm (**6 inches**) deep and shall be attached to the bridge in a manner approved by the Engineer.

D Blank

E Junction Boxes for Roadway Lighting Systems

Junction boxes specified for roadway lighting systems shall be NEMA Type 4X, hot dip galvanized cast iron with interchangeable cover and side hub plates, brass cap screws, gaskets for cover and hub plates, suitable for use with rigid steel conduit.

The junction box shall have inside dimensions of 216 x 216 x 100 mm (**8-1/2 x 8-1/2 x 4 inches**) unless otherwise specified in the Contract. The junction boxes shall have four mounting lugs and be equipped with drain and breather fittings.

The cover shall be of the same material as the box, fastened with stainless steel hex-head screws or bolts and nuts, and equipped with a neoprene gasket around the perimeter of the cover.

Each conduit entrance shall accommodate the nominal outside diameter of the conduit specified and shall be bossed and threaded to provide five full threads.

Junction boxes shall be attached to concrete using masonry anchorages or power activated studs with the required hardware to permit removal of the junction box.

3838.3 INSPECTION AND TESTING

Three sets of shop drawings of the metal junction boxes and mounting details that the Contractor proposes to install shall be submitted to the Engineer for approval.

3839
Conduit Expansion Fittings

3839.1 SCOPE

This Specification covers conduit expansion fittings for use in conduit runs attached to bridges.

3839.2 REQUIREMENTS

Each expansion fitting shall be a weatherproof manufactured unit providing for conduit movement as specified in the Contract. A fitting providing for a minimum movement of 25 mm (**1 inch**) may be furnished if no movement is specified in the Contract.

Expansion fittings for use with RMC or IMC shall be iron or steel protected by galvanizing or plating and shall be UL listed.

Expansion fittings for use with NMC shall be intended for use with the particular type of conduit.

3839.3 INSPECTION AND TESTING

The expansion fittings shall be approved by the Engineer before installation.

3840
Wood Poles

3840.1 SCOPE

This Specification covers wood poles for use in traffic control signal systems, electric lighting systems, and mounting service equipment.

3840.2 REQUIREMENTS

The Contractor shall furnish wood poles:

(a) Conforming to the American Standard Specifications and Dimensions for Wood Poles (ANSI 2051).

(b) Of the length specified in the Plans.

(c) Of Class II unless otherwise specified.

(d) Of the species in Table 3491-1.

(e) Treated with preservative in accordance with 3491, lighting poles. Creosote shall not be used.

3840.3 INSPECTION AND TESTING 3491

3850
Lighting Service Cabinet

3850.1 SCOPE

This Specification covers electrical service cabinets used for distributing electrical power, providing overcurrent protection and providing a means to cut off power to all or part of a roadway lighting system.

3850.2 REQUIREMENTS

A General

The Contractor shall furnish a complete and operational lighting service cabinet as specified in the Contract. The lighting service cabinet shall be a single phase, 3 wire, weatherproof cabinet, and shall contain circuit breakers, lighting contactor(s), photoelectric control with test switch(es), power distribution blocks when specified, and neutral/ground bonding bar(s).

The cabinet shall be located such that the door is orientated 90 to 180 degrees to the roadway, away from traffic.

The cabinet and its contents shall comply with the requirements of the Underwriters Laboratory Inc. (UL) standards UL-508 and UL-508A. The enclosure shall have a NEMA 3R rating.

B Electrical Equipment and Wiring

B1 Circuit Breakers

Circuit breakers shall be thermo-magnetic type. Main circuit breakers shall be located on the line side of the lighting contactor(s).

The lighting contactor(s) shall be located on the line side of the branch circuit breakers. Each branch circuit breaker shall be bolted onto a copper bus and shall be labeled indicating the lighting poles that it serves. Labels shall be pressure sensitive vinyl embossed label-maker tape 9.5 mm **(3/8 inch)** high with 3.7 mm **(0.144 inch)** high letters. Spacers shall cover empty circuit breaker spaces for circuits that are not used.

The branch circuit breakers shall be sized to accomodate a No. 4 AWG wire without splitting.

B2 Lighting Contactors

The lighting contactor(s) shall be 2-pole, normally open, electrically held, open type, and shall be rated for tungsten filament and ballast lighting loads. The control coil shall be actuated by a photocell and protected by a 15 A circuit breaker on the line side of the photocell and test switch.

The lighting contactor shall be General Electric 360L, Allen Bradley Bulletin 100L, or Westinghouse Type A202.

B3 Test Switches

The test switch shall be a heavy duty, single pole, double throw, two position, rotary switch. One switch position shall be labeled "AUTOMATIC" and the other switch position shall be labeled "TEST". In the "AUTOMATIC" position, the test switch shall connect the coil of the lighting contactor to the AC+ (SWITCHED) from the photoelectric control, providing photoelectric control of the lighting circuit. In the "TEST" position, the test switch shall connect the coil of the lighting contactor to the AC+ (UNSWITCHED) from the photoelectric control, providing power to the lighting circuit regardless of the state of the photoelectric control.

B4 Component Arrangement

The main circuit breaker, lighting contactor, photoelectric control with test switch, power distribution blocks when specified, and branch circuit breakers shall be arranged and wired as indicated in the Contract.

The main breaker, lighting contactor(s), power distribution blocks, and branch circuit breaker(s) shall be mounted on a removable panel. A separate dead front shall cover the panel and shall be hinged on one side and held in place with quick release captive fasteners.

All neutral/ground bonding bars and bus bars shall be copper.

All terminals/connectors shall be UL listed for copper wire.

All wiring inside the cabinet shall be sufficient length to allow for contraction.

Three single conductors in accordance with 3807.2B shall be provided from the cabinet to the source of power and shall be the size indicated in the Contract.

C Photoelectric Control

A photoelectric control mounting receptacle (EEI/NEMA standard 3-terminal twist-lock type), photoelectric control, and photoelectric control shield when specified shall be mounted within the cabinet near the two lexan windows or 3 m **(10 feet)** above the ground on top of a rigid steel conduit rising vertically and entering the side of the cabinet. When specified, the conduit shall be 41 mm **(1 ½ inch)** nominal diameter for a pad mounted cabinet and 21 mm **(3/4 inch)** nominal diameter for a pole mounted cabinet. The wires to the photoelectric control mounting receptacle shall be single conductor No. 14 stranded copper conductors in accordance with 3815. The photoelectric control shall be in accordance with 3812.

D Type L1 and L2 Service Cabinet

In addition to meeting the general requirements above, the Type L1 and Type L2 lighting service cabinet shall meet the following requirements:

D1 Cabinet Enclosure Construction

The lighting service cabinet shall be constructed from a minimum 3 mm **(0.125 inch)** thick aluminum conforming to the requirements of

ASTM B 209 for 5052-H32 aluminum sheet. The Aluminum cabinet shall be anodized to match the Duranodic finish #311 after all machining has been completed.

The cabinet shall be pad mounted with dimensions of 1525 mm **(60 inches)** high, 835 mm **(33 inches)** wide and 355 mm **(14 inches)** deep. The cabinet shall be secured to a concrete pad by four 19 mm **(3/4 inch)** diameter, 150 mm **(6 inch)** long, high strength anchor bolts in a 660 mm x 280 mm **(26 inch x 11 inch)** center to center rectangular bolt pattern.

The cabinet flanges shall have slotted holes for mounting the cabinet to anchor rods. The holes shall be reinforced on the top side of the flange with a piece of 3 mm **(0.125 inch)** aluminum 150 mm **(6 inches)** long and same width as the mounting flange.

A gasket shall be provided for mounting the cabinet on a concrete pad. The gasket shall consist of a one piece 13 mm **(1/2 inch)** thick x 64 mm **(2 1/2 inch)** wide solid butyl rubber gasket with drilled holes, shaped to match the mounting flange and slots on the bottom of the cabinet.

The cabinet shall have two compartments. The right compartment shall be 1525 mm **(60 inches)** high, 685 mm **(27 inches)** wide and 355 mm **(14 inches)** deep, providing space for the lighting service panel and the photoelectric control circuit. The service panel shall be installed 150 mm **(6 inches)** from the bottom of the cabinet to provide access to the anchor bolts when mounting the cabinet. The cabinet shall have an enclosed left compartment to provide space for the 50 mm **(2 inch)** conduit containing the power conductors to the meter. This compartment shall be 760 mm **(30 inches)** high,150 mm **(6 inches)** deep and 355 mm **(14 inches)** wide. An opening and a hub shall be provided on the top of this compartment to facilitate wiring to the meter socket. The edge of the opening shall be properly protected. This compartment shall have a 610 mm x 355 mm **(24 inch x 14 inch)** removable front panel 180 mm **(7 inches)** from the bottom of the cabinet. The panel fasteners shall be of stainless steel or other non-corroding material.

The cabinet shall have a weathertight hinged door opening to the right (righthanded door). The door shall be equipped with a three-point locking mechanism that operates from a single easy-turning handle. The upper and lower locking points of the locking mechanism shall each have a pair of nylon rollers. The shaft size of the handle shall be a minimum of 16 mm **(5/8 inch**) diameter or 13 mm **(1/2 inch)** square. The cabinet door shall lock with a standard police lock and key (1 key shall be furnished).

The hinges, hinge pins, locks and lock covers shall be of stainless steel or other non-corroding material. Hinges may be welded on or fastened with stainless steel tamperproof bolts.

The cabinet door shall have two sets of 100 mm x 255 mm **(4 inch x 10 inch)** louvered vents, with screening or perforated metal, installed

approximately 255 mm **(10 inches)** from the bottom. The two sets of vents shall be separated by approximately 50 mm **(2 inches)**.

Two circular windows shall be at the right upper back corner of the cabinet for the photocell. One window shall be on the back cabinet wall and the other shall be on the right cabinet wall. The windows shall have a diameter of 90 mm **(3.5 inches)**.

The windows shall be of 3 mm **(0.125 inch)** thick lexan and be installed in a manner that does not sacrifice the weather-tightness or the security of the cabinet.

The cabinet top shall be crowned or slanted to the rear to prevent standing water, and shall provide a 50 mm **(2 inch)** overhang above the door beyond the front of the cabinet. The overhang shall provide venting for the entire cabinet.

The cabinet lifting provisions shall meet the UL requirements for the NEMA 3R. The lifting provisions shall consist of two aluminum lifting ears mounted to the enclosure, allowing a bar or hooks to be inserted through both ears for lifting the cabinet.

The lifting ears shall have a lifting capacity equal to the weight of the completely wired cabinet plus 25 percent, a 23 kg **(500 pound)** capacity minimum. Each lifting ear shall have a 25 mm **(1 inch)** hole, the bottom of which shall be flush with the top of the cabinet or within 3 mm **(1/8 inch)** of the cabinet. The top of the lifting ears shall be between 50 mm **(2 inches)** and 55 mm **(2 1/8 inches)** above the cabinet. The lifting ears shall be secured to the cabinet by corrosion resistant bolts.

The cabinet enclosure shall be of good workmanship. All seams and joints shall be smooth and even, without cracks or pinholes. There shall be no sharp corners or jagged edges.

The exterior seams for cabinet and doors shall be continuously welded or sealed with silicon sealant. All exterior welds shall be ground smooth. All sharp edges shall be filed.

D2 Electrical Equipment and Wiring

A self contained meter socket, rated for 200 Ampere, 480 volts, commercial type with a lever actuated positive bypass mechanism in accordance with Mn/DOT 3837.2A2 shall be mounted to the left cabinet wall facing to the left. The meter socket shall be listed as approved for commercial use by the power company. The top of the meter socket shall be right under the left lifting ear. A chase nipple (minimum 50.8mm **(minimum 2 inches)**)shall be installed at the bottom of the meter socket to provide connection to the left compartment of the cabinet.

For metered feed points, meters will be furnished and installed by others.

For unmetered feed points, a meter jumper shall be furnished and installed by the Contractor.

The lighting service cabinet shall have two copper power distribution blocks to provide tapping from the primary feeds to the 100 amp circuit breaker. The power distribution block shall have lugs suitable for use with 75º C **(167ºF**) conductors; shall be rated for 600 volt; and shall have a flammability rating of UL 94V-0.

The Type L1 lighting service cabinet shall have one 2-pole 100 amp circuit breaker; one 2-pole 100 amp lighting contactor; and eight 1-pole 20 amp branch circuit breakers (two breakers for each three-wire lighting branch circuit).

The Type L2 lighting service cabinet shall have two 2-pole 100 amp circuit breaker; two 2-pole 100 amp lighting contactor; and sixteen 1-pole 20 amp branch circuit breakers (two breakers for each three-wire lighting branch circuit).

E Type T1 and T2 Service Cabinet

In addition to meeting the general requirements above, the Type T1 and Type T2 lighting service cabinet shall meet the following requirements:

E1 Cabinet Enclosure Construction

The lighting service cabinet shall be constructed of 2.78 mm thick **(12 gauge)** steel and shall be a dead-front type with a hinged door for access to the contractor(s). The cabinet shall have a weather-tight door capable of being securely latched at three points and released by an easy-turning handle. The handle and three-point locking mechanism shall lock with a standard police lock and key (1 key shall be furnished). Hinges shall be fabricated from stainless steel. Hinges may be welded on or fastened with stainless steel tamper-proof bolts.

All surfaces of the cabinet shall be painted in accordance with 2476 using two prime shop coats of iron oxide primer in accordance with 3507. The metal surface shall be properly prepared before the primer is applied.

The Type T1 lighting service cabinet shall be a pad-mounted cabinet with approximate dimensions 1422 mm **(56 inches)** high, 660 mm **(26 inches)** wide, and 355 mm **(14 inches)** deep. The cabinet shall have provisions for being secured to the concrete pad by means of four 19 mm **(3/4 inch)** diameter anchor bolts, located on a 610 x 305 mm **(24 inch x 12 inch)** center to center rectangular bolt pattern.

The Type T2 lighting service cabinet shall be a pad-mounted cabinet with approximate dimensions 1422 mm **(56 inches)** high, 762 mm **(30 inches)** wide, and 355 mm **(14 inches)** deep. The cabinet shall have provisions for being secured to the concrete pad by means of four 19-mm **(3/4 inch)** diameter anchor bolts, located on a 711 x 305 mm **(28 inch x 12 inch)** center to center rectangular bolt pattern.

E2 Electrical Equipment and Wiring

The Type T1 lighting service cabinet shall be provided with one 2-pole, 100 A main circuit breaker; one 2-pole, 100 A lighting contactor; two 20-A single pole branch circuit breakers for each three-wire

lighting branch circuit indicated in the Contract; and capacity for a total of eight single pole branch circuit breakers.

Each Type T1-S-120 lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 120/240 VAC. The lighting contactor coil shall be rated for 120 VAC.

Each Type T1-S-240 lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 240/480 VAC. The lighting contactor coil shall be rated for 240 VAC.

The Type T2 lighting service cabinet shall be provided with one 2-pole, 200 A main circuit breaker; two 2-pole, 100 A circuit breakers; two 2-pole, 100 A lighting Contractors; two 20-A single pole branch circuit breakers for each three-wire lighting branch circuit indicated in the Plans or Special Provisions; and capacity for a total of sixteen single pole branch circuit breakers.

Each Type T2-D-120 lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 120/240 VAC. The lighting contactor coil shall be rated for 240 VAC.

Each Type T2-D-240 lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 240/480 VAC. The lighting contactor coil shall be rated for 240 VAC.

G Type A Service Cabinet

In addition to meeting the general requirements above, the Type A lighting service cabinet shall meet the following requirements:

G1 Cabinet Enclosure Construction

The Type A lighting service cabinet shall be a wood pole mounted cabinet with approximate dimensions 1270 mm **(50 inches)** high, 419 mm **(16 ½ inches)** wide, and 203 mm **(8 inches)** deep. The cabinet shall have provisions for being secured to the wood pole by means of two iron straps and two 13 mm **(½ inch)** diameter by 153 mm **(6 inch)** long lag screws.

G2 Electrical Equipment and Wiring

The cabinet shall be provided with one 2-pole, 100 A main circuit breaker; one 2-pole, 100 A lighting contactor; two 20-A single pole branch circuit breakers for each three-wire lighting branch circuit indicated in the Plans or Special Provisions; and capacity for a total of eight single pole branch circuit breakers.

For lighting circuits serving luminaires rated at 120 V, each Type A lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 120/240 VAC. The lighting contactor coil shall be rated for 120 VAC.

For lighting circuits serving luminaires rated at 240 V, each Type A lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 240/480 VAC. The lighting contactor coil shall be rated for 240 VAC.

The Contractor shall furnish and install a 53 mm **(2 inch)** RSC riser and weatherhead above the Type A lighting service cabinet to a point 600 mm **(2 feet)** below the secondary terminal taps of the feed point transformer, or to a point designated by the power company. The service entrance conductors above the cabinet shall be No. 2 in accordance with 3815. The conductors shall extend up the conduit riser, through the weatherhead, and terminate a minimum of 1525 mm **(5 feet)** beyond the weatherhead for connection to the power conductors from the source of power; which connection will be made by others at no cost to the Contractor.

A 53 mm **(2 inch)** RSC stubout with insulating bushing shall be provided below the cabinet to a point a minimum of 610 mm **(24 inches)** below the ground line for the each armored cable entering the cabinet.

H Type B Service Cabinet

In addition to meeting the general requirements above, the Type B lighting service cabinet shall meet the following requirements.

H1 Cabinet Enclosure Construction

The Type B lighting service cabinet shall be a wood pole mounted cabinet with approximate dimensions 762 mm **(30 inches)** high, 610 mm **(24 inches)** wide, and 203 mm **(8 inches)** deep. The cabinet shall have provisions for being secured to the wood pole by means of two iron straps and two 13 mm **(½ inch)** diameter by 153 mm **(6 inch)** long lag screws.

H2 Electrical Equipment and Wiring

The cabinet shall be provided with one 2-pole, 30 A main circuit breaker; two single pole, 30 A branch circuit breakers; and one 2-pole, 30 A lighting contractor.

For lighting circuits serving luminaires rated at 120 V, each Type B lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 120/240 VAC. The lighting contactor coil shall be rated for 120 VAC.

For lighting circuits serving luminaires rated at 240 V, each Type B lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 240/480 VAC. The lighting contactor coil shall be rated for 240 VAC.

The Contractor shall furnish and install a 53 mm **(2 inch)** RSC riser and weatherhead above the Type B lighting service cabinet to a point 600 mm **(2 feet)** below the secondary terminal taps of the feed point transformer, or to a point designated by the power company. The service entrance conductors above the cabinet shall be No. 6, in accordance with 3815. The conductors shall extend up the conduit riser, through the weatherhead, and terminate a minimum of 1525 mm **(5 feet)** beyond the weatherhead for connection to the power conductors from the source of power; which connection will be made by others at no cost to the Contractor.

A 53 mm **(2 inch)** RSC stubout with insulating bushing shall be provided below the cabinet to a point a minimum of 610 mm **(24 inches)** below the ground line for the each armored cable entering the cabinet.

3850.3 INSPECTION AND TESTING

The lighting service cabinets are subject to final inspection and acceptance at the project site. Such inspection will include but is not limited to the identification of the item, type, size and manufacturer's marking, and documentation of these data. When required by the Engineer, random samples will be selected from the material delivered to the Project site or at the source before delivery.

The Contractor shall submit to the Engineer, for approval by the Department's Lighting Engineer, five complete sets of shop detail drawings of the lighting service cabinets and anchor rods, in accordance with 2471.3B1 and 2471.3B3. The drawings shall be distributed, after approval, to the following:

(a) Contractor

(b) Contractor's Fabricator

(c) Engineer

(d) Department's Lighting Engineer

(e) District or Division Traffic Engineer

All light service cabinets shall be approved before installation.