

### 3501

#### Basic Requirements for Paints

##### 3501.1 SCOPE

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

##### 3501.2 REQUIREMENTS

###### A General Requirements

###### A1 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.

###### A2 Colors

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

###### A3 Toxic Metals and Volatile Organic Compounds (VOC)

Paints shall be free of toxic metals and shall meet latest Federal and MPCA VOC regulation.

###### A4 Manufacturing and Packaging

The paint shall be manufactured by an approved process. 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 25°C (77°F).

###### A5 Drying Time

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

##### 3501.3 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 the Chemical Laboratory prior to use. Approved Product Lists can be accessed on the Office of Materials website.

##### 3501.4 INSPECTION, SAMPLING AND TESTING

###### A Inspection and Sampling

All paints, unless otherwise specifically provided shall not be shipped until tested and approved by the Chemical Laboratory. The manufacturer shall allow adequate time for testing the paint. When requested, manufacturer shall submit certified samples of paints to be used on the Department projects. Sample size shall be 0.5 L (**1 pint**). Follow Schedule for Materials Control for sampling instructions.

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**B General Testing**

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

**C Color**

Color "Draw Down" samples shall be submitted to the Chemical Laboratory for verification of the finish coat color when appropriate.

**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**

**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**

**3520**

**Zinc-Rich Paint Systems**

**3520.1 SCOPE**

This Specification covers paint systems consisting of a zinc-rich primer, an intermediate coat and an aliphatic polyurethane finish coat.

**3520.2 REQUIREMENTS**

**A Zinc-Rich Primer**

**A1 General**

The zinc-rich primer shall be a multi-component primer capable of being spray applied in accordance with the manufacturer's instructions and applications guide. After thorough mixing the primer shall be strained through a 30-60 mesh screen or a double layer of cheesecloth so that there are no un-dispersed agglomerates of zinc remaining after mixing. The primer shall be formulated to produce a distinct contrast with blast cleaned steel and with the subsequent intermediate coat.

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**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 25°C (77°F). ..... 4 min hours
- Density of VOC, max. ....420 g/L (**3.5 pounds per gallon**)
- 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 25°C (77°F) and 50 percent RH.

**3520.3 APPROVED EPOXY ZINC-RICH SYSTEMS**

Only Mn/DOT Approved Zinc-Rich Paint systems shall be used. The 3520 Approved Products List, Acceptance Criteria and Qualification Procedure can be accessed on the Office of Materials website.

**A Epoxy Zinc-Rich System**

The epoxy zinc-rich system shall consist of a epoxy zinc-rich primer, an epoxy or urethane intermediate coat and an aliphatic urethane finish coat.

**B Inorganic Zinc-Rich System**

The Inorganic Zinc-Rich System shall consist of solvent-based inorganic zinc-rich primer, an epoxy or urethane intermediate coat and an aliphatic urethane finish coat.

**C Moisture-Cure Zinc-Rich System**

The Moisture -Cure Zinc-Rich System shall consist of moisture-cure zinc-rich primer, an urethane intermediate coat and an aliphatic urethane finish coat.

**3520.4 COLOR**

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. Color “Draw Down” samples shall be submitted to the Chemical Laboratory for verification of the finish coat color.

**3520.5 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.

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**| 3520.6 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 (**1 pint**).

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

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3532

Exterior Polyurethane Paint

3532.1 SCOPE

This specification covers exterior polyurethane finish paint for use on steel lighting cabinets, signs, handrails, traffic signal poles and transformer bases.

3532.2 REQUIREMENTS

A General Requirements

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

B Specific Requirements.....3520.3A

The finish coat shall be an aliphatic polyurethane finish coat listed on the Mn/DOT Approved Product List for Organic Zinc Rich Paint Systems.

Only Mn/DOT Approved Paint Systems are allowed for use. The Approved Products List can be accessed on the Office of Materials website.

The finish coat shall be used with intermediate coat or primer and intermediate coat from the same approved system.

C Color

The finish coat colors shall be chosen from the Federal Standard 595B colors and have a semi-gloss finish. Finish coat color or colors if different than below shall be specified in the Contract.

Dark Green- Federal Standard Number 595B Color Number 14062. Yellow- Federal Standard Number 595B Color number 13538.

3532.3 INSPECTION, SAMPLING AND TESTING

When requested, the 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, AASHTO, ASTM, and Federal test methods.

Color "Draw Down" samples shall be submitted to the Chemical Laboratory for verification of the finish coat color.

3533

Aluminum Moisture Cure Polyurethane Paint

3533.1 SCOPE

This specification covers aluminum and micaeous iron oxide filled moisture cure polyurethane paint for use as a finish coat on bridges, sign posts, traffic signal poles, and luminaire extensions.

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**3533.2 REQUIREMENTS**

**A General Requirements**

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

**B Specific Requirements**

Only Mn/DOT Approved Paint Systems are allowed for use. The Approved Products List can be accessed on the Office of Materials website.

The finish coat shall be used with intermediate coat or primer and intermediate coat from the same approved system.

**3533.3 INSPECTION, SAMPLING AND TESTING**

When requested, the manufacturer shall submit certified samples of paints to be used on the Department projects. Sample size shall be 0.5 L (**1 pint**).

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

Color "Draw Down" samples shall be submitted to the Chemical Laboratory for verification of the finish coat color.

**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. 595B unless otherwise specified. Only light fast colorants shall be used.

Only Mn/DOT approved acrylic latex paint shall be used for use.

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

**3590**

**Epoxy Resin Pavement Markings  
(Free of Toxic Heavy Metals)**

**3590.1 SCOPE**

The work shall consist of furnishing and installing reflectorized white and yellow two-component, 100 percent solids epoxy resin

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pavement markings. Application shall be in accordance with 2582, including lines, legends, symbols, crosswalks and stop lines placed on properly prepared asphaltic and portland cement concrete pavement surfaces in accordance with the Contract and as directed by the Engineer. Upon curing, the materials produce pavement markings of specified thickness, width and retroreflectivity that resist wear from high traffic volumes for several years. During darkness and weather permitting, yellow markings shall be readily distinguishable from white markings.

#### **3590.2 GENERAL REQUIREMENTS**

Before any epoxy product is acceptable for bid, it shall be field tested, evaluated, approved and assigned a product identification number by the Mn/DOT Materials Engineering Section. Approved epoxy pavement marking is placed on the qualified products list, which can be found on the Office of Traffic Engineering website.

No change in product identification, chemical composition as indicated by infrared spectrophotometry and/or chemical analysis, or changes in the application requirements will be allowed. Any such changes shall be submitted for further evaluation.

This specification provides for the classification of epoxy resin pavement marking systems by type. Type I – A fast cure material suitable for line applications and, under ideal conditions, may not require coning. Type II – A slow cure material suitable for all applications of pavement markings under controlled traffic conditions, i.e., coning is required and flagging may be as directed by the Engineer.

**Only Slow Dry Type II epoxy material shall be used for epoxy pavement markings except when specified otherwise in the Proposal.**

Shelf Life – The individual components shall not require mixing prior to use when stored for a period of 12 months.

#### **3590.3 SPECIFIC REQUIREMENTS**

The material shall be composed of epoxy resins and pigments only. No solvents are to be given off to the environment upon application to a pavement surface.

The composition shall be within the tolerance permitted for the product tested and approved by Mn/DOT. Type II material shall be completely free of TMPTA (Tri-Methylol Propane Tri-Acrylate) and other multi-functional monomers.

**All materials shall be free of lead, cadmium, mercury, hexavalent chromium and other toxic heavy metals as defined by the United States Environmental Protection Agency.**

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Color – The color of the white epoxy shall be a pure flat white, free of tints. The color of the yellow epoxy shall closely match Color Number 33538 of Federal Standard 595 and shall conform to the following CIE Chromaticity limits using illuminant "C":

x | 0.470 | 0.485 | 0.520 | 0.480  
y | 0.440 | 0.460 | 0.450 | 0.420

Daylight Directional Reflectance (Y), white, minimum 83  
Daylight Directional Reflectance (Y), yellow, minimum 50

Testing will be according to:

Daylight Directional Reflectance ..... ASTM D 2805  
Color..... ASTM D 2805

**3590.4 SAMPLING AND TESTING**

0.5 L (**1 pint**) samples of each manufacturer's lot or batch furnished for the contract shall be **submitted to Mn/DOT at the time of manufacturing**. 0.5 L (**1 pint**) samples of both Part A (yellow/white) and Part B must be submitted to the Mn/DOT Materials Laboratory. Samples shall be identified as follows:

- 1. Manufacturer's Name
- 2. Manufacturer's Product Number
- 3. Lot/Batch Number
- 4. Date Manufactured
- 5. Color
- 6. Intended State project numbers

The manufacturer shall certify that the components meet the requirements of these specifications and are on the Mn/DOT's Qualified Products List available on the Office of Traffic Engineering Website.

Containers for epoxy components shall be marked with the manufacturer's name, product identification number, lot or batch number, date of manufacture, color, and net weight of contents.

**3591**

**High Solids Water-Based Traffic Paint**

**3591.1 SCOPE**

This specification covers fast-dry white and yellow acrylic latex traffic marking paints for use with drop-on glass beads for application on concrete and bituminous pavements.

**3591.2 REQUIREMENTS****A General Requirements****A1 Quality**

The paint shall be formulated from first-grade materials and shall be suitable in all respects for application at elevated spray temperatures with drop-on glass beads using conventional traffic striping equipment. The finished paint shall be smooth and homogeneous, free of coarse particles, skins or any other foreign materials that are detrimental to its application or appearance.

**A2 Package Stability**

Within a period of twelve months from the time of delivery, the paint shall not cake, settle, liver, thicken, skin, curdle, gel or show any other objectionable properties which cannot readily be corrected with minimal stirring. Any paint with properties that make it unsuitable for use within the specified twelve months shall be returned to the supplier for credit. It shall be the manufacturer's responsibility to add sufficient anti-settling agents, stabilizers and other additives to insure proper storage stability.

**A3 Manufacturing and Packaging**

Manufacturer shall be capable of producing paint in batches of 3786 L (**1,000 gallons**) or larger. The paint shall be screened with a 40 mesh or finer screen to remove any coarse particles, skins or foreign material.

The paint shall be packaged in lined, new totes, 208 L (**55 gallon**), or 19 L (**5 gallon**) containers as specified. To prevent formation of "skins", the manufacturer shall use a "float" of ammonia water on the paint surface, or a "floating type" plastic liner on the top of the filled container, or some other means that will effectively prevent skinning.

Drums shall be Full Removable-Head Universal meeting the requirements of DOT-17H; covers shall have one 51 mm (**2 inch**) and one 19 mm (**¾ inch**) fitting. Each container shall be marked with the manufacturer's name, type of paint, batch number, date of manufacture, gross weight and container weight.

**B Properties of Finished Paint**

The exact composition of the paints shall be left to the discretion of the manufacturer, provided the finished paint meets the requirements of this specification.

Wgt per gal, 25 °C ( <b>77 °F</b> ), lbs, min	12.0
Viscosity, Krebs Stormer, <b>77 °F</b> , K.U.	80 - 100
Grind, Hegman, minimum	3
Total Solids, % by weight, minimum	73
Non-volatile vehicle, % by weight, minimum	43
Pigment, % by weight	45 - 62

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Titanium Dioxide, white paint, <b>lbs/gal</b> , min.	1.0
Dry Time, 12 mil WFT, @ 65% RH, minutes, max	12
Dry Through, @ 90 % RH, minutes, max	130
Daylight Directional Reflectance, white, min.	83
Daylight Directional Reflectance, yellow, min.	50
Contrast Ratio, minimum	0.98
Bleeding Ratio, minimum	0.97
Flexibility and Adhesion	No cracking or flaking
Water Resistance	No blistering or loss of adhesion
Settling	Rating of 6 or better
Skimming, 48 hrs	None
Track Free Time, minutes, maximum	3
pH, minimum	9.6
Lab Retro-reflectivity, white, min., mcd/m <sup>2</sup> /lux	300
Lab Retro-reflectivity, yellow, min., mcd/m <sup>2</sup> /lux	200

**C Specific Requirements**

C1 The vehicle shall be composed of a 100% acrylic polymer such as Rohm and Haas E-2706, or an approved equal.

C2 The color of the dry white paint shall be a pure flat white, free of tint. The color of the yellow paint shall conform to the following CIE Chromaticity limits using illuminant "D65":

x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

C3 Organic Yellow Pigment. The prime pigment in the organic yellow paint shall be Color Index Pigment Yellow Number 65 or Number 75.

C4 Heavy Metals. The white and organic yellow paints shall be free of lead, mercury, cadmium, hexavalent chromium and other toxic heavy metals as defined by the United States Environmental Protection Agency.

**3591.3 INSPECTION, SAMPLING AND TESTING**

**A Inspection and Sampling**

For paint ordered by private contractors for use on Minnesota painting contracts, the manufacturer shall submit a 0.5 L (**1 pint**) sample of each batch along with a letter certifying the sample represents the full manufactured batch.

The department reserves the right to base acceptance upon samples taken at the point of delivery or from a contractors supply. Sample size shall be 0.5 L (**1 pint**).

**B Manufacturer's Certification**

Manufacturer shall submit certified test results with each batch of paint produced for use in Minnesota under this specification. Tests conducted on each batch shall include; weight per gallon, viscosity, and drying time. Testing for all other parameters in this specification shall be carried out annually at the start of production. Certified test results shall be promptly submitted to the Mn/DOT Materials Laboratory at 1400 E. Gervais, Maplewood, Minnesota, 55109.

Weight Per Gallon	ASTM D 1475
Viscosity	ASTM D 562
Fineness Of Grind	ASTM D 1210
Total Solids	ASTM D 2369
Total Pigment	ASTM D 2371
Titanium Dioxide	ASTM D 4563 ; D 1394
Dry Time(12 mils wet)	ASTM D 711 (modified)
Daylight Directional Reflectance	ASTM D 2805
Contrast Ratio(15 mils wet)	ASTM D 2805
Bleeding Ratio	Federal Specification TT-P-85
Color	ASTM D 2805
pH	ASTM E 70
Retro-reflectivity	Mn/DOT Method

**C Approval Process**

**Only Mn/DOT Approved High Solids Water-Based Traffic Paint is allowed for use.** The Qualified Products List and Product Qualification Process can be accessed on the Traffic Engineering website. Mn/DOT's pavement marking material Qualified Products List is available on the Office of Traffic Engineering website.

**3592****Drop-On Glass Beads****3592.1 SCOPE**

This specification covers treated glass beads for retroreflectorizing traffic marking paint.

**3592.2 GENERAL REQUIREMENTS**

Beads for use with water-based paints will have a dual surface treatment consisting of a moisture resistant silicone treatment, and a silane adherence surface treatment as recommended by paint manufacturer. Beads for use with epoxy resins will have a moisture resistant silicone surface treatment, as recommended by the epoxy resin manufacturer.

The beads will be made from clean colorless transparent glass. They will be smooth, spherically shaped, and free from milkiness, pits,

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excessive air bubbles, chips and foreign material. The beads will be suitable for application using conventional striping equipment, and will produce a retro-reflectorized line when viewed at night with automobile headlights.

#### 3592.3 SPECIFIC REQUIREMENTS

The glass beads will meet the requirements of AASHTO M 247 Type 1 "standard gradation" except the beads will have a minimum of 80 percent true spheres. The dual treated beads will meet the moisture resistant requirements of AASHTO M 247 Section 4.4.2 and pass the adherence treatment Dansyl Chloride Test. The moisture resistant silicone treated beads will meet AASHTO M 247 Section 4.2.2.

#### 3592.4 SAMPLING AND TESTING

The beads will be sampled at the rate of one sample per 4000 kg (**10,000 pounds**) of beads. For beads shipped in 22 kg (**50 pounds**) bags a sample will consist of two bags selected at random and reduced to approximately one quart using a sample splitter. For bulk shipments, sampling will be by means of a perforated tube type "sampling thief." Three samples from each of three separate containers will be combined for one sample.

Testing will be according to the requirements of AASHTO M 247.

#### 3592.5 ACCEPTANCE

Unless otherwise specified the beads will be packaged in moisture-proof multi-wall shipping bags. Each container will be marked with name and address of the manufacturer, type of moisture treatment, batch number and date of manufacture. The containers and contents will be delivered in a good, dry condition. Any beads not meeting the requirements of this specification or delivered in an unusable condition will be rejected.

**Only Mn/DOT Approved treated glass beads are allowed for use.** The Qualified Products List and Product Qualification Process can be accessed on the Traffic Engineering website. Mn/DOT's pavement marking material Approved Products List is available on the Office of Traffic Engineering website.

**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 contains 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.

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**TABLE 3601-1  
RANDOM RIPRAP REQUIREMENTS**

Mass kilogram (pounds)	Size mm (inches) (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

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**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 inches)	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<sup>3</sup> (40 cubic yards), the Engineer may require, that size and quality compliance be referenced to a control unit consisting of approximately 3 m<sup>3</sup> (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**

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**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.

**3604**

**Precast Articulated Concrete**

**3604.1 SCOPE**

This specification covers manufactured articulated concrete block and mat revetment systems for protection of embankment slopes, river channels and spillways and vehicle accesses where the soil is susceptible to erosion. The two systems:

**A Articulated Block Mat - closed cell or open celled**

This system is cabled together blocks into a prefabricated mat placed over a geotextile, meeting the following material specifications.

**B Articulated Interlocking Block - closed cell or open celled**

This system consists of hand placed blocks onto a geotextile, meeting the following material specifications.

**3604.2 REQUIREMENTS**

The Articulated Block Mat systems are made up of individual concrete blocks that are strung together with cable. These mats are placed side-by-side and clamped together and anchored to provide one homogeneous erosion protection system. Articulated Interlocking Block is individual concrete blocks interlocked together to form a soil protecting paver system. All systems consist of either all-open cells or all closed cells system. Open cell units shall have a minimum of 10% open area.

**A Concrete ..... 2461**

Blocks shall be manufactured in a plant having a Mn/DOT-approved quality control plan, shall have a design air content of 6.5%, shall have less than 1.0 % loss in 100 freeze/thaw cycles when tested in accordance with ASTM C1262 using a distilled water solution, and shall have less than 1.0% loss in 50 freeze/thaw cycles when tested in

accordance with ASTM C67. Concrete shall have a maximum absorption of 7.0% when tested in accordance with ASTM C140.

Wet cast concrete blocks shall have a minimum design strength of 27.6 Mpa (**4000 PSI**) @ 28 days when tested in accordance with ASTM C 140.

Dry cast concrete blocks shall have a minimum design strength of 40.0 Mpa (**5800 PSI**) @ 28 days when tested in accordance with ASTM-C-140.

**B Cable**

In systems that utilize cables, the cables shall be stainless steel or shall be galvanized with a minimum estimated life span of 50 years.

**C Geotextile Filter** ..... 3733

Shall be in accordance with the manufacture’s recommendations and be sized appropriately for the soil conditions present.

**D Clamps**

Sufficient galvanized or stainless steel wire rope clamps/sleeves shall be used to secure loops of adjoining mats.

**E Anchors**

Anchors used to secure the top and exposed sides of the mattress shall have a pull resistance of 905 kg (**2000 pounds**).

**F Fine Filter Aggregate** ..... 3149

Bedding sand shall conform to the grading requirements of 3149.2J. Sand shall be spread 25 mm (**1 inches**) thick evenly over the compacted subgrade when requested by the manufacture for placing articulated interlocking block.

**3604.3 SAMPLING AND TESTING**

A Manufacture’s certification that the revetment system and all of its components meet the requirements of this specification shall be supplied.

**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

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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/m<sup>3</sup> (**10 pound per 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 <b>(24 inches)</b>	910 mm <b>(36 inches)</b>
Thickness of each side of leg	93 mm <b>(3.6 inches)</b>	142 mm <b>(5.5 inches)</b>
Kerf corner reinforcement	46 mm <b>(1.8 inches)</b>	92 mm <b>(2.7 inches)</b>
Overall weight of assembled unit	35 kg <b>(78 pounds)</b>	119 kg <b>(265 pounds)</b>

\* 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.

**3616.3**

**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 70°C (**158 °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**

**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

**3661.1**

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.

**3622.3 INSPECTION AND ACCEPTANCE ..... 3236**

**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.

**3630.2 REQUIREMENTS ..... 3238**

**A Materials**

- A1 Concrete ..... 2461
- A2 Mix Designation ..... 2533
- A3 Reinforcement Bars ..... 3301

**B Concrete Finish**

When required by the Plans or Special Provisions, 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.

**3630.3 INSPECTION AND ACCEPTANCE ..... 3236**

**3661**

**Reinforced Concrete Cribbing**

**3661.1 SCOPE**

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

**3661.2**

**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.

**A Materials**

A1 Coarse Aggregate ..... 3137

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/m<sup>3</sup> (**556 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.

## 3661.2

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 70°C (158 °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.

**3661.3**

**3661.3 INSPECTION AND ACCEPTANCE ..... 3238**

**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/m<sup>3</sup> (**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<sup>3</sup> (**115 pounds per cubic foot**).
- (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.

**3667.3**

**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

**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 Mn/DOT approved joint sealers are allowed for use. The most current Approved Products list can be accessed on the Office of Materials website.

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 °C (77 °F), maximum..... 90
- (3) Bond Test, 50% extension, @-18 °C (0 °F) ..... Pass 5 cycles
- (4) Flow, 60 °C (140 °F), mm, maximum ..... 5

**3719.3**

- (5) Resilience, 25 °C (77 °F), minimum, % ..... 40
- (6) Softening Point, °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**

Sample 5 kg (**10 pounds**) from each lot. Samples shall be taken from the application wand.

**B Methods of Test**

Testing shall be according to the appropriate test methods reference on ASTM D 6690 Type I 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 °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 12.7 mm ± 0.25 mm ( $\frac{1}{2} \pm 0.01$  inch) apart enclosing a reservoir of 50 mm by 50 mm by 12.7 mm (**2 inch by 2 inch by  $\frac{1}{2}$  inch**).

3721

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.

**TABLE 3721-1**

<b>Property</b>	<b>Requirements</b>	<b>Test Method</b>
<u>Tensile strength, Using Die D,</u> Before Aging, min.	14 MPa ( <b>2000 psi</b> )	ASTM D 412
After oven aging, 70 hours. @ 100 °C ( <b>212 °F</b> ), loss, %	30 max.	ASTM D 573
<u>Elongation at Break,</u> Before aging, %	250 min.	ASTM D 412
After oven aging, 70 hrs. @ 100 °C ( <b>212 °F</b> ) loss, %	40 max.	ASTM D 573
<u>Permanent set at Break, %</u>	10 max.	ASTM D 412
<u>Hardness, Type A Durometer,</u> Before aging	55 ± 5	ASTM D 2240
After oven aging, 70 hours @ 100 °C ( <b>212 °F</b> ), points change	0 to + 10	ASTM D 2240
After 70 hours @ -10 °C ( <b>14 °F</b> ), points change	0 to + 15	ASTM D 2240
<u>Ozone Resistance</u> After 70 hours @ 40 °C ( <b>104 °F</b> ), under 20 % strain, 303 mPa ( <b>300 pphm</b> ) in air	No Cracks	ASTM D 1149 (A)
<u>Mass Change in Oil, After 22 hours in Oil No. 3 (ASTM D 471), mass change</u>	45% max.	Mn/DOT Method (C)
<u>Compression-Deflection Characteristics</u>		

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Property	Requirements	Test Method
20 mm ( <b>13/16 inch</b> ) Seal:		Mn/DOT Method (C)
Force @ 16.5 mm,	0.70 N/mm min	
Force @ <b>0.65 inch pounds/linear inch</b>	( <b>4 min</b> )	Mn/DOT Method (C)
Force @ 10.5 mm,	3.50 N/mm max.	Mn/DOT Method (C)
Force @ <b>0.41 inch pounds/linear inch</b>	( <b>20 max</b> )	Mn/DOT Method (C)
32 mm ( <b>1-1/4 inch</b> ) Seal:		
Force @25 mm ( <b>1 inch</b> ),	0.90 N/mm min.	Mn/DOT Method (C)
Force @ <b>1.00 inch pounds/linear inch</b>	( <b>5 min.</b> )	Mn/DOT Method (C)
50 mm ( <b>2 inch</b> ) Seal:		
Force @ 41 mm	0.90 N/mm min	Mn/DOT Method (C)
Force @ <b>1.62 inch pounds/linear inch</b>	( <b>5 min.</b> )	Mn/DOT Method (C)
65 mm ( <b>2-1/2 inch</b> ) Seal:		
Force @ 54 mm	0.90 N/mm min.	Mn/DOT Method (C)
Force @ <b>2.13 inch pounds/linear inch</b>	( <b>5 min.</b> )	Mn/DOT Method (C)
75 mm ( <b>3 inch</b> ) Seal:		
Force @ 65 mm,	0.90 N/mm min	Mn/DOT Method (C)
Force @ <b>2.50 inch pounds/linear inch</b>	( <b>5 min.</b> )	Mn/DOT Method (C)
90 mm (3-1/2 inch) Seal:		
Force @ 75 mm	0.90 N/mm min.	Mn/DOT Method (C)
Force @ <b>3.00 inch pounds/linear inch</b>	( <b>5 min.</b> )	Mn/DOT Method (C)
<u>Recovery Under Deflection of</u>		
<u>50 % of the Nominal Seal Width</u>		
After 70 hours @ 100 °C ( <b>212 °F</b> ) ,	85 % min. (B)	Mn/DOT Method (C)
After 72 hours @ -10 °C ( <b>14 °F</b> ),	88 % min. (B)	Mn/DOT Method (C)
After 22 hours @ -29 °C ( <b>-20 °F</b> ),	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 subplot, e.g., a suffix number or letter to the lot number. Individual lot numbers or subplot numbers shall be limited to one every 8-hour shift or 1800 m (**6000 linear feet**),

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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 subplot 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 ( <b>8.0 pounds/gallon</b> ) ± 10%
Solids content .....	72 to 74 %, by mass ( <b>weight</b> )
Adhesive to remain fluid from .....	-15°C ( <b>5°F</b> ) to 50 °C ( <b>120°F</b> )
Film strength, ASTM D 412 .....	8250 kPa ( <b>1200 psi</b> )
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 subplot will be cause for rejection of that entire lot or subplot.

**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 subplot.

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.

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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 inches**) 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,

### 3721.3

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 3721-2  
SPECIFIED SPECIMEN SIZE AND TEST DEFLECTIONS**

Nominal Width of Seal mm (inches)	Column A Specimen Length 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)	16.5 mm (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 (½ 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 (½ pound); 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 23°C (73°F), with a tolerance of 2°C (5°F). 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

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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 ( $\frac{1}{2}$  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 Significant Places in Specified Limiting Values.

## 3722

### Silicone Joint Sealant

#### 3722.1 SCOPE

This specification covers a one-component silicone joint sealant for use in concrete pavement joints and cracks. When properly applied and cured, the sealant shall protect the pavement from intrusion of water and incompressible material.

#### 3722.2 REQUIREMENTS

##### A General Requirements

The sealer shall be a primer-less, one-component, low modulus, moisture curing silicone polymer without any solvents or diluents that would cause shrinkage or expansion during curing. The sealant shall be smooth and uniform in appearance with a consistency to provide for satisfactory application by means of air pressure guns or hand caulking applicators. The sealant shall cure to produce a seal with excellent adhesion to concrete, flexibility, and resistance to moisture and penetration of incompressibles over a wide range of winter and summer temperatures.

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The sealant shall be capable of withstanding repeated joint movement of -50% to +100% without any loss of adhesion to the concrete and without any cohesion failure. Any change in the composition of the material shall require a new qualification test.

#### **B Physical Requirements**

<b>Test</b>	<b>Requirement</b>	<b>Test Method</b>
Tack Free Time (hours maximum)	5	ASTM C 679
Hardness, Shore A (maximum)	25	ASTM D 661
Ultimate Elongation (% minimum)	800	ASTM D 412
Tensile Stress at 150% Elongation ( <b>psi</b> maximum)	45	ASTM D 412
Resilience (% minimum)	75	ASTM D 5329
Non-Immersed Bond to Concrete, -29 °C (-20°F), 100% extension	Pass 5 cycles	ASTM D5893
Water-Immersed Bond to Concrete, -29 °C (-20°F), 100% extension	Pass 5 cycles	ASTM D5893

#### **3722.3 SAMPLING**

Each lot of material shall be sampled at the time of application. Sample shall be one pint, in a well-sealed container. Only silicone joint sealant appearing on Mn/DOT's Approved Product List shall be allowed in the work. The Approved Products List and Qualification Procedure can be accessed on the Office of Materials website.

### **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.

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**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 Mn/DOT approved joint sealers are allowed for use. The most current Approved Products list can be accessed on the Office of Materials website.

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 6690 Type II except for the following modifications:

- (1) Cone penetration at 25 °C (77 °F), 150 g, 5 s, .....60 - 90
- (2) Bond at -29 °C (-20 °F), 3 cycles, 100% extension.....Passes
- (3) Mandrel bend test at -34 °C (-29 °F), 25 mm (1 inch) mandrel .....No cracking
- (4) Resilience at 25 °C (77 °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**

Sample 5 kg (10 pound) from each lot. Samples shall be taken from the application wand.

**B Methods of Test**

B1 Testing shall be according to ASTM D 6690 Type II 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 D 6690 Type II, Flow Test, and conditioned at -34 °C (-29 °F) for a minimum of 4 hours.

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### 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  $100 \pm 5$  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  $23 \pm 1.7$  °C, the blocks shall be cut into 25 x 50 x 75 mm (1 x 2 x 3 inches) 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  $12.5 \pm 0.25$  mm ( $\frac{1}{2} \pm 0.01$  inch) apart enclosing a reservoir of 50 x 50 x 12.5 mm (2 x 2 x  $\frac{1}{2}$  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 Mn/DOT approved joint sealers are allowed for use. The most current Approved Products list can be accessed on the Office of Materials website.

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

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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 °C (77 °F)**, dmm (ASTM D5329) .100 - 150
2. Cone penetration, **-18 °C (0 °F)**, dmm (ASTM D5329 modified)..... 25 min.
3. Flow, **60°C (140 °F)**, 5h (ASTM D5329)..... 10 mm max.
4. Resilience (ASTM D5329) ..... 30 - 60 %
5. Bond, **-29 °C (-20 °F)**, 200% extension (ASTM D5329) ..... Pass 3 cycles
6. 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**

Sample 5 kg (**10 pounds**) from each lot. Samples shall be taken from the application wand.

#### **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  $100 \pm 5$  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

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(**2 inch**) cube specimens). After curing one day in moist air and six days in water at  $23 \pm 1.7$  °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  $12.7 \pm 0.25$  mm (**1 inch  $\pm$  0.1 inch**) apart enclosing a reservoir of 50.8 by 50.8 by 12.7 mm (**2 x 2 x 1/2 inch**).

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**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, 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:

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- (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 kg/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 A-A-272A, for the grade and type 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.

Four types of caulking compound are covered as follows:

- Type I – Oil base caulk
- Type II – Siliconized acrylic caulk
- Type III – Butyl rubber
- Type IV – 100% silicone

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, andrevet 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:

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**TABLE 3733-1  
Geotextile Property Requirements**

Geotextile Property	Test Method (ASTM)  Units	Type (A)						
		I		II	III	IV	V	VI
		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)	0.425 (40)	0.425 (40) 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	2.75 relaxed	0.5	0.3	0.3	0.05	0.05 (G)
B6 Puncture Strength minimum	D6241 N (pounds)	--	800 (180)	--	--	--	--	--
B7 Wide Width Strip Tensile Strength min. ea. principal direction	D4595 kN/m (pounds/ft)	--	--	--	--	--	--	(C)

- (A) Minimum average roll values (MARV) based on average of at least three tests per swatch (sample). (Manufacturers' MARV shall meet or exceed these requirements.)
- (B) Sock shall meet requirements of ASTM D6707-01, classification Type H: fabric. Sock shall be knit of polymeric materials, exhibit minimum snag or run 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. (Type V typically does not have a Wide Width Strip Tensile Strength requirement.)
- (D) This shall apply when seaming is specified or permitted in the Contract. Strength Specifications shall apply to both factory and

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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 maximum 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 (MARV) for the geotextile. (MARV 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 rates shown in the Schedule of Materials Control. Swatches shall be full roll width and at least 1 m (3 feet) 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.

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**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 ( $\frac{1}{2}$  inch) or less in thickness shall be all elastomer. Pads over 13 mm ( $\frac{1}{2}$  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 205°C (**400 °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 ( $\frac{1}{4}$  inch) of elastomer.

Tolerances for dimensions and configurations shall be in accordance with Division II, Section 18, 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 ( $\frac{1}{4}$  inch +  $\frac{1}{8}$  -  $\frac{1}{16}$  inch).

**B Physical Properties**

**B1 Elastomer**

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

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TEST	ASTM Designation	Requirements
Hardness (Type A) .....	D 2240 w/2 kg .....	55 ± 5
Tensile Strength, .....	D 412 .....	17 MPa ( <b>2500 psi</b> ) Min.
Elongation at Break, % .....	D 412 .....	400, Min.
Compression Set, 22 hours at 70°C ( <b>158 °F</b> ), % ....	D 395 (Method B).....	25 Max.
Tear Strength,.....	D 624 (Die C).....	.....
.....	.....	32 kN/mm ( <b>180 pounds/inch</b> ) Min.
Ozone Resistance, 20% strain, 100 hours at 38°± 1°C ( <b>100° ± 2 °F</b> ).....	D 1149 (A) .....	No cracks
Low Temperature Stiffness, Young's Modulus at -34 °C ( <b>-30 °F</b> ) .....	.....	.....
.....	D 797 .....	34 MPa ( <b>5000 psi</b> ) Max.
Low Temperature Brittleness, 5 hours at -40°C ( <b>-40 °F</b> ) .....	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 100°C (**212 °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:

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<b>SHAPE FACTOR</b>	<b>APPLIED LOAD</b>	
	<b>5.5 MPa (800 psi)</b>	<b>8.3 MPa (1200 psi)</b>
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 shall 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****3754.1 SCOPE**

This Specification covers liquid membrane-forming compounds suitable for spray application on portland cement concrete surfaces which are exposed to the air to retard the loss of water during the early hardening period.

**3754.2 REQUIREMENTS****A General Requirements**

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 white pigmented Type 2, Class B.

This compound must be protected from freezing prior to application.

This material shall be tested at an application rate of 5 m<sup>2</sup>/l (200 square feet per gallon).

**B Requirements for Concrete Pavement Membrane Curing Compound****B1 General**

This product shall be identified as 3754 AMS and shall meet the following requirements:

- (a) The resin shall be 100 percent poly-alpha-methylstyrene.
- (b) The curing compound shall conform to all requirements according to Table 3754-1.
- (c) The shelf life of the product shall be 6 months from the date of manufacture. The product may be re-tested by the Mn/DOT Office of Materials Laboratory and re-approved, if the physical and chemical properties have not changed, for an additional six months. However, the maximum shelf life shall not exceed one year from manufacture date.

3754.2

**TABLE 3754-1  
REQUIREMENTS FOR 3754 AMS CURING COMPOUND**

Properties	Minimum	Maximum
Total Solids, % by weight of compound	42	
% Reflectance in 72 hours (ASTM E1347)	65	
Loss of Water, kg/m <sup>2</sup> in 24 hours (ASTM C156)		0.15
Loss of Water, kg/m <sup>2</sup> in 72 hours (ASTM C156)		0.40
Settling Test, ml/100 ml in 72 hours <sup>(A)</sup>		2
V.O.C. Content, g/L		350
Infrared Spectrum, Vehicle <sup>(B)</sup>	100% $\alpha$ methylstyrene	

<sup>(A)</sup> Test Method on file at the Mn/DOT Office of Materials

Laboratory

<sup>(B)</sup> The infrared scan for the dried vehicle from the curing compound shall match the infrared scan on file at the Office of Materials Laboratory.

**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)**

<b>Oilphase (50 ± 4% by volume)</b>	<b>Percent by Mass (weight)</b>
Boiled Linseed Oil .....	80
Z-8 Viscosity Linseed Oil.....	20
<b>Waterphase (50 ± 4% by volume)</b> .....	100

**C Physical Requirements**

The compound shall be sprayable above 4°C (40 °F). 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.

**3757****Membrane Waterproofing System****3757.1 SCOPE**

This Specification covers a membrane waterproofing system to be used for waterproofing below-grade joints in concrete structures, tunnels and other below grade applications on concrete structures.

**3757.2 REQUIREMENTS****A General Requirements**

The approved membrane waterproofing system shall consist of a primer, a rubberized asphalt membrane on a cross-laminated polyethylene carrier film, mastic and protection layer.

**Only Mn/DOT Membrane Waterproofing Systems shall be allowed for use. The Approved Product List can be accessed on the Office of Materials website.**

**B Specific Requirements**

1. Primer- The primer shall be a solvent-based primer specially formulated for use with approved waterproofing system.  
The primer shall meet EPA VOC Standards for Architectural Coatings.
2. Membrane

<b>Property</b>	<b>Specification</b>	<b>Test Method</b>
Thickness, mils	56+	ASTM 3767-Method A
Tensile Strength, MPa (PSI)	1.7 (250)+	ASTM D-412 Die C
Elongation, %	300+	ASTM D-412 Die C
Composition	Rubber Asphalt	Infrared Scan

### 3757.2

#### 3. Carrier Film

Property	Specification	Test Method
Thickness, mils	4+	ASTM 3767-Method A
Composition	Polyethylene	Infrared Scan

#### 4. Composite Membrane

Property	Specification	Test Method
Pliability, 180° bend, 25 mm (1 inch) mandrel @ -32°C (-25°F)	Unaffected	ASTM 146
Permeance, Perms	.05 -	ASTM E96, B
Peel Adhesion, kg/mm (lbs/inch)	5+	ASTM D 903 Modified
Water Absorption, %	0.1-, 72 hours	ASTM 1970

### 3757.3 INSPECTION, SAMPLING AND TESTING

The manufacturer shall submit a one square foot sample of the membrane along with a letter of certification and test results stating that the membranes meets the requirements of this specification. Other components of the waterproofing system do not need to be sampled for testing.

The manufacturer shall also submit detailed technical data sheets for all components of the membrane waterproofing system.

### 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 Underwriters' Laboratories, Inc. (UL) 6 and Underwriters' Laboratories, Inc. (UL) 514B.

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 Underwriters' Laboratories Inc. (UL) 6 and Underwriters' Laboratories Inc. (UL) 514B.

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 Polyvinyl Chloride (PVC) and High Density Polyethylene (HDPE) non-metallic conduit and fittings for electrical systems.

**3803.2 REQUIREMENTS**

Polyvinyl Chloride (PVC) non-metallic conduit and fittings shall conform to the requirements of Underwriters' Laboratories, Inc. (UL) 514B and 651. High Density Polyethylene (HDPE) conduit shall be in accordance with ASTM F 2160 and UL 651B.

If the Contract fails to specify the type of conduit to be furnished, heavy-wall rigid PVC or HDPE Schedule 40 plastic conduit and fittings

**3803.2**

(sectional or continuous lengths) shall be furnished, except all conduit runs under roadway surfaces shall be heavy-wall rigid PVC or HDPE Schedule 80 plastic conduit and conduit fittings (sectional or continuous lengths).

All non-metallic conduit used as electrical conduit shall be color coded RED to indicate electrical use and shall be UL Listed for underground use. All non-metallic conduit shall have smooth interior and exterior surfaces.

**3803.3 INSPECTION AND TESTING ..... 3801**

**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 4-bolt slip fitter type mounting that allows engagement with at least 203 mm (**8 inches**) of the bracket arm and permits any necessary adjustment to orient the luminaire with the roadway for proper light distribution.

## 3810.2

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 EEL/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

### 3810.2

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 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.

### 3810.3

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) 250 W High Pressure Sodium according to ANSI Code No. S50 clear 250 W.
- (3) 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, or approval by the Department's District Traffic Engineer 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 Signing Engineer
- (e) District Traffic Engineer

All luminaires or fixtures shall be approved before installation.

3811

**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/hr (**80 mph**) with a 1.3 gust factor. Design service life shall not be less than 20 years.

Light standards specified to be breakaway shall have certification from the Manufacturer that the light standard meets the AASHTO breakaway specifications.

**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.

### 3811.2

Preceding requirements 3, 4, 6, and 7 can be satisfied if the Department has previously approved the manufacturer's design (to these same Specifications) 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<sup>2</sup> (**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<sup>2</sup> (**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.

Light standards shall be breakaway or non-breakaway in accordance with the Contract.

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 Contract or required by the design analysis.

## 3811.2

### **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 Contract. Cleaning, painting, and galvanizing shall be performed in accordance with 2471.3L and 2478.

### **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.

Light standards fabricated from aluminum shall have a factory installed vibration dampener and an aluminum wall thickness of 4.78 mm (**0.188 inches**).

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

## 3812.2

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 District Traffic 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) Traffic Electrical Systems Engineer
- (e) District 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.

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- (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 (**3.0 fc**), with a tolerance of 0.6 lx (**0.05 fc**), 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 EEL/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 District Traffic 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) Traffic Electrical Systems 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 preemption (EVP) equipment for use with 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 and traffic signal pedestals as indicated in the Contract. All mounting hardware and attachment to mast arms and pedestals 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 - one channel, two way - one channel, or two way - two channel as required by the Contract.
- (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 -40 to +85°C (**-40 to +185 °F**).
- (6) -- "Weatherproof".
- (7) -- To have a center frequency and tolerance as follows:  
Preemption: 14.035 Hz. +/-0.05 Hz.  
Priority: 9.639 Hz. +/-0.03 Hz.
- (8) -- Capable of a reception angle providing wide coverage and a reception range variable up to approximately 550 m (**1800 feet**).
- (9) -- The detector must be responsive to optical energy impulses generated from a distance of 550 m (**1800 feet**) by a pulsed Xenon source emitting a total energy flash of 0.75 - 0.85 joules, with a rise time less than one microsecond, and a half power point pulse width of between 0.3 and 30 microseconds. The Contractor shall furnish rack mounted EVP phase selectors (or other approved equal EVP equipment to be installed in the traffic signal cabinet) to be installed in the Department furnished cabinet by Mn/DOT personnel. Each phase selector shall be a card rack mounted unit and shall be compatible with the detector card rack within the Department furnished traffic signal cabinet. The detection range, and programming of the preemption and priority shall be adjustable from within the traffic signal cabinet. Each

## 3814.2

channel output shall deliver a constant signal for preemption activation and a pulsed output for priority activation. Each phase selector, however, shall be programmed for preemption only. Each phase selector shall include the control timer "MAX CALL TIME" that will limit or modify the duration of a preemption control condition and can be either programmed from a PC-type computer, or mechanically selectable. The default setting shall be 120 seconds. Each EVP phase selector shall be manufactured by the same manufacturer as the EVP detectors.

ALL EVP PHASE SELECTORS (OR OTHER APPROVED EQUAL EVP EQUIPMENT TO BE INSTALLED IN THE TRAFFIC SIGNAL CABINET) SHALL BE DELIVERED TO THE DEPARTMENT AT THE Mn/DOT CENTRAL ELECTRICAL SERVICES UNIT (FOR APPROVAL, AND FOR INSTALLATION INTO THE DEPARTMENT FURNISHED TRAFFIC SIGNAL CABINET) AT LEAST THIRTY (30) NORMAL WORKING DAYS IN ADVANCE OF WHEN THE DEPARTMENT FURNISHED TRAFFIC SIGNAL CABINET IS REQUIRED ON THE JOB SITE.

### **B EVP Indicator Lights**

Each EVP indicator light shall be a 75 watt (or equivalent light output) white flood type lamp mounted within an outdoor type flood lamp housing. The solid white indication shall be visible at a distance of at least 150 m (**500 feet**).

## 3814.3 INSPECTION AND TESTING

The emergency vehicle preemption (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. 14, 12, 10, 8, 6, 4, 3, 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 (**¼ 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 Blank**

**B5 Grounding Conductors**

Each equipment grounding conductor or grounding electrode conductor that is installed as an individual conductor in conduit 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 that is not installed in conduit shall be a bare uninsulated solid copper wire, No. 6, and shall conform to ASTM B 1 or ASTM B 2 for solid wires.

## 3815.2

### 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 600 V armored multiple conductor cable shall have four conductors, each covered with chemically cross-linked thermosetting polyethylene insulation, circuit identification, conductors cabled, filler, binder, an inner polyvinyl chloride (PVC) jacket, armor, and an outer jacket of PVC which when assembled shall produce a completed cable of circular cross-section. The bronze tape armor shall be between the two PVC jackets. All fillers shall be of a moisture resistant material, not of paper or jute.

The conductors of the armored cable shall be color coded (either actual solid color insulations, or surface labeled) Red, Black, White, or Green to indicate the circuit identifications.

The inner polyvinyl chloride (PVC) jacket shall be heat and moisture resistant, minimum average thickness of 1.14 mm (45 mils), and meet the requirements of ICEA S-95-658 (NEMA WC70).

The armor shall be a single thickness bronze tape meeting ASTM B 130 with a minimum thickness of 254  $\mu\text{m}$  (0.01 inch) and a spiral overlap of not less than 6.35 mm (0.25 inch).

The outer polyvinyl chloride (PVC) jacket shall be heat, moisture, and sunlight resistant, minimum average thickness of 2.03 mm (80 mils), and meet the requirements of ICEA S-95-658 (NEMA WC70).

#### 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 the fourth conductor being an 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-95-658, NEMA publication No. WC70).

#### 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/NEMA "Standard for Control Cable" (ICEA Publication No. S-73-532, NEMA publication No. WC57).

## 3815.2

- (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 E, Method 1, Table E-1, of ICEA Publication No. S-73-532, NEMA Publication No. WC57, 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  $\mu\text{m}$  (**20 mils**) of polyethylene plus 254  $\mu\text{m}$  (**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 0.76 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.

### 3815.2

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 75°C (**167°F**), 600 V, colored coded yellow, blue, orange.
- (b) Ground Drain Wire - No. 20 (7x28) stranded, individually tinned copper.
- (c) Shield - Aluminized polyester shield with 20 percent overlap.
- (d) Jacket - Black PVC jacket.  
1 mm (**0.04 inch**) nominal wall thickness.  
80°C (**175°F**) 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 to the latest issue of ANSI/ICEA S-80-576.

##### C6b Outdoor Installation in Conduit

Telephone cable for outdoor installation in conduit shall utilize No. 19 conductors and shall conform to RUS 7 CFR 1755.390, "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 7 CFR 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 RUS Bulletin 1753F-204(PE7), RUS Specification for Aerial Service Wires," 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.

C7a Video Cable (RG-\_\_U)

The cable shall bear the nomenclature and the manufacturer's name. 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  $\Omega$ . The capacitance shall be 56.8 pF/100 m (**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/100 foot**).

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 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 105°C to -40°C. 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 per meter (**41 pF/foot**).

C9 Blank

C10 Blank

C11 Blank

C12 Blank

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### 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 CFR 1755.900 (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;

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- (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 180° apart), one ripcord under the armor and one ripcord under the inner jacket;
- (13) the cable outside diameter is < 18 mm (**0.7 inches**);
- (14) have a minimum loaded bend radius of 250 mm (**10 inches**) and minimum installed bend radius of 200 mm (**8 inches**);
- (15) have a nominal weight of less than 250 kg/km (**0.17 pound per foot**)
- (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  $\mu\text{m}$  of 62.5  $\mu\text{m}$ ;
- (4) the cladding diameter is within 2  $\mu\text{m}$  of 125  $\mu\text{m}$ ;
- (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  $\mu\text{m}$ ;
- (2) the diameter of the cladding is within 1  $\mu\text{m}$  of 125  $\mu\text{m}$ ;
- (3) the coating diameter is within 5  $\mu\text{m}$  of 245  $\mu\text{m}$ ;
- (4) The coating is a dual layer acrylate coating in physical contact with the cladding surface;

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- (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  $\mu\text{m}$  of 9.20  $\mu\text{m}$  at 1310 nm and 1.00  $\mu\text{m}$  of 10.50  $\mu\text{m}$  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  $\leq 0.5 \mu\text{m}$ ;
- (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
- (13) 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 (**0.38 psi**) 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 0.3 dB loss. The SM fibers normally shall have an FC-PC connector with less than 0.3 dB loss. The connector loss after 1000 matings, shall be less than 0.2 dB. The connector return loss shall be greater than 52 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. Multimode jackets are orange and singlemode jackets are yellow. All jackets are sequentially numbered.

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.

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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.

C14 Microwave and Sonic Detector Cable

Microwave and sonic detector lead-in cable (4/c #18 indicated in the Plans) shall be a twisted four-conductor shielded cable with a ground drain wire.

*Construction:* Stranded tinned copper conductors, color coded polyethylene insulation, conductors cabled, aluminum-polyester foil shield with stranded tinned copper drain wire, gray PVC jacket.

*Conductors:* No. 18 AWG stranded, UL Style 2464, 80 degree C, 300 volt, shall meet the requirements of ASTM B33

*Color code:* Black, Red, White, Green.

*Drain wire:* No. 20 AWG stranded. Drain wire on outside of shield.

*Cable O.D.:* Outside diameter nominal 6 mm (**0.245 inch**).

C15 Reduced Diameter Signal Control Cable

Cables from terminal blocks in mast arm pole transformer bases and pedestal bases to the terminal blocks in vehicle signal faces, pedestrian signal faces, flashing beacons, and emergency vehicle preemption (EVP) indicator lights and pedestrian push buttons shall be a reduced diameter control cable, 14 AWG, 600 volt, multiple XLPE insulated conductors in accordance with the following:

*Conductor:* Class B (seven stranded) soft-drawn bare or tinned copper per ASTM B3, ASTM B8, or ASTM B33.

*Insulation:* Reduce thickness crosslinked (XLPE) that meets ICEA S-73-532 (NEMA WC 57) and UL 44 acceptable for 0°C (**162 °F**) wet and dry locations.

*Circuit Identification:* Conductors are color coded per ICEA S-73-532 (NEMA WC 57) Appendix E, Method 1, Table E2, except that a white conductor shall be inserted as Conductor No. 2 as follows:

- Conductor No. 1 Black
- Conductor No. 2 White
- Conductor No. 3 Red
- Conductor No. 4 Blue
- Conductor No. 5 Orange
- Conductor No. 6 Yellow
- Conductor No. 7 Brown.

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Assembly:	Individual conductors are cabled with <i>non</i> -hygroscopic fillers where necessary to form a round compact core and wrapped with a binder of polyester tape.
Jacket:	Reduced wall thickness, sunlight resistant, flame retardant, and crosslinked polyolefin (XLPO) jacket that meets UL 1277. Maximum outside cable diameter shall be as follows: 2/c #14 – 7.9 mm ( <b>0.310 in.</b> ) 4/c #14 – 9.1 mm ( <b>0.360 in.</b> ) 5/c #14 - 10.0 mm ( <b>0.395 in.</b> ) 7/c #14 – 10.9 mm ( <b>0.430 in.</b> )
Surface Marking:	The jacket surface shall be ink printed or indented. The jacket shall have the following information: Maximum Rated Voltage Type of Cable Size and Number of Conductors UL Label Manufacturer's Name

### 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.

**3815.3**

**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.

3831

**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<sup>2</sup> (**100 square inch**) 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 (**¾ 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.

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### 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.

### C3 Handhole Covers on Mast Arm Pole Standards

The Contractor shall seal all 76 mm x 127 mm (**3 inch by 5 inch**) handholes on the mast arm pole standard with a clear silicone caulk to ensure a moisture free seal between the handhole cover and the handhole opening.

### 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 250 W high pressure sodium, or as otherwise indicated in the Contract. 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.

All luminaires shall have a minimum 5-year Manufacturer's warranty period.

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

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

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

The wires connecting the luminaire to the underground cable in the signal pole transformer base shall be a UF 14-2 W/G cable with a 6A cartridge type fuse. The UF 14-2 W/G cable shall be UL Listed. The

### 3831.2

fuse shall be mounted in an approved inline molded watertight fuse connector/holder with casing that shall be located at the level of the transformer base handhole. The inline molded fuse connector/holder shall be approved by the Engineer before installation.

Sufficient excess conductor length shall be provided to allow withdrawal of the connected fuse holder. The neutral and grounding wires shall not be fused.

The Contractor shall furnish and install a wire holder that supports the luminaire cable/conductors within the end of the luminaire slipfitter near the connection point of the luminaire. The wire holder shall be approved by the Engineer before installation.

### 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) Traffic Electrical Systems Engineer
- (e) Spare or District Traffic Engineer

## 3832

### Traffic Signal Pedestal

#### 3832.1 SCOPE

This Specification covers the 100 mm (**4 inch**) trade size 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.

Traffic signal pedestals shall meet applicable AASHTO requirements for structural supports.

##### B Pedestal Shaft

###### 1. Steel Pedestal Shafts

Steel pedestal shafts shall be in accordance with the Contract

The pedestal shafts shall be clean on both the inner and outer surfaces. The outer surface shall be blast clean.

The pedestal shaft shall be painted on the inner and outer surfaces with 2 coats of prime paint conforming to 3507. The total dried primer

thickness is 76  $\mu\text{m}$  (**3 mil**). Finish paint the outside of the shaft with two coats of yellow paint that conforms to 3532, or as otherwise specified in the Contract. The total thickness of the dried primer and finish coats is at least 140  $\mu\text{m}$  (**5 ½ mil**). Scratches or other damages to the paint render the shaft unacceptable for installation.

If scratches or other damage occurs during installation, the pedestal base shall be repaired or replaced to the satisfaction of the Engineer.

#### 2. Aluminum Pedestal Shafts

The pedestal shaft shall be anodized aluminum, Schedule 80, 100 mm (**4 inch**) nominal trade size. The overall length of the pedestal shaft shall be as indicated in the Contract. The aluminum alloy shall be 6061T6. The shaft wall shall be 8.6 mm (**0.337 inches**) thick and weigh 7.69 kg/m (**5.18 pounds per foot**). Threads are per ANSIB2.1. The RCS pedestal shaft shall be hard coat clear anodized aluminum shaft that meets Specification MIL-A-8625 Type III, Class I. The shaft shall be spun finished.

#### C Pedestal Base

The pedestal base shall be a square transformer base. The upper end shall be threaded to receive a nominal 100 mm (**4 inch**) pipe shaft.

Each pedestal base shall be fabricated from cast aluminum and shall meet or exceed 2001 AASHTO breakaway requirements. Test reports from a Federal Highway Administration (FHWA) approved independent laboratory shall be provided certifying that the pedestal base has been tested and meets all requirements. A statement of certification from the FHWA stating such tests have been accepted and approved shall be supplied by the manufacturer.

#### C1 Access Door

The access door shall have a locking mechanism on the inside top and a fixed catch on the inside bottom. The locking mechanism shall include a 6.4 mm (**¼ inch**) diameter x 40 mm (**1 ½ inch**) stainless steel allen-head cap screw and is part of the door. The cap screw shall go through the door, through a U shaped bracket, and be held in place by two hex-head locknuts.

#### C2 Ground Connector

One UL Inc listed ground wire connector shall be mounted with a single bolt on each adjacent sidewall to the access door, 76.2 mm (**3 inches**) in from the door and 200 mm (**8 inches**) above the base bottom of each sidewall.

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

### 3832.2

#### C3 Anchor Rods

Anchor rods shall be 19 mm ( $\frac{3}{4}$  inch) x 460 mm (**18 inches**) minimum. Anchor rods, nuts, and washers shall be in accordance with 3385 (Type A), or as otherwise specified in the Contract.

Pedestal washers shall meet the following requirements (or as otherwise specified in the Contract):

Each pedestal washer shall be a hardened steel (at least Grade 5) washer, round formed, in accordance with applicable provisions of 3391.2B and shall be galvanized either by the hot-dip process or by the mechanical process as specified in 3392. The pedestal washer shall have the following dimensions:

Diameter:	66 mm ( <b>2 ½ inches</b> )
Thickness:	19 mm ( $\frac{3}{4}$ inches)
Center Punch Hole:	21 mm ( <b>13/16 inch</b> )

#### C4 Re-inforcing Collars

Pedestal re-inforcing collars (wind collars) shall be as specified in the Contract.

#### C5 Pedestal Base Finish

##### 1. Painted Pedestal Base

The pedestal base shall be shop painted on the inner and outer surfaces with 2 coats of prime paint conforming to 3507. The dried primer shall be 76 µm (**3 mil**) thick. The outer surface shall be finish painted with two coats of green paint that conforms to 3532, or equivalent Manufacture's shop coat paint as specified in 2565.3T. The combined depth of the primer and finish coats shall be 140 µm (**5 ½ mil**). Scratches or other damage to the paint render the base unacceptable for installation. If scratches or other damage occurs during installation, the pedestal base shall be repaired or replaced to the satisfaction of the Engineer.

##### 2. Anodized Pedestal Base

If required by the Contract, the Contractor shall black hard coat anodize the outer and inner surfaces of the pedestal base in accordance with MIL-A-8525 Type III Class 2. The coating shall be continuous, uniform in appearance, and free from scratches and other blemishes.

### 3832.3 INSPECTION AND TESTING

The pedestal shaft and pedestal base shall be approved by the Engineer prior to 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, shall be a single pole, two wire, momentary contact push button, and an enclosed weatherproof switching unit where the switch and actuator are a hermetically sealed unit. The switching unit shall have an actuating force of no more than 2.3 kilograms (**5 pounds**) to operate the button; 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 shall have a minimum 50.8 mm (**2 inch**) actuator button to accommodate actuation by any means available. The actuator button and the push button housing shall be contrasting colors. The push button housing shall be fabricated of a non-corrosive material designed for shaft mounting (ribbed back), and to permit internal wiring within the shaft. A saddle shall be furnished if necessary to secure a rigid installation. Pedestrian push buttons shall be on the approved list as indicated in the Contract.

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.

## 3833.2

### **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 sheet aluminum in accordance with 3352.2A1a, shall utilize a white non-reflectorized background, and shall have black painted legend, border, and arrow in accordance with 3352.2A4. 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 otherwise specified in the Contract. Standard ITE vehicle signal faces shall be constructed in accordance with the current 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.

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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 MN MUTCD.

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 (or other housing material as specified in the Contract).

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).

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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 ¼ 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 ½ inches**) for a nominal 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 (**9.5 inches**) for a nominal 300 mm (**12 inches**) vehicle signal indication and a minimum of 180 mm (**7 inches**) for a nominal 200 mm (**8 inch**) 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

#### A6a Light Emitting Diode (LED) Units

All light emitting diode (LED) units shall be as specified in the Contract.

#### A6b Incandescent Units

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 be circular in shape with a visible nominal diameter of 200 mm (**8 inch**) or 300 mm (**12 inch**) as specified in the Contract. The lens shall be of the

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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.

### A6c 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.

### A6d 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.

### A6e 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

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housing door is closed. The reflector shall have an opening in the back for the lamp receptacle.

#### A6f 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.

#### A6g 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**

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

- 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.

#### A6h 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 105°C (**220°F**) rating thermoplastic conductor insulation. The conductors shall be securely fastened to the lamp receptacle and with sufficient length to reach the

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terminal block with the reflector fully open. The thermoplastic insulation shall, at minus 36°C (**minus 34° 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 yellow in accordance with 3532, or approved equivalent.

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 (**12 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 zinc-rich primer in accordance with 3520, or approve equivalent, and finish painted yellow in accordance with 3532, or approved equivalent. The lens holder and interior of the signal housing shall be flat black.

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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 ½ 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 mounting surfaces without affecting water and light integrity of the special signal face.

### B5 Electrical

Each lamp fixture shall consist of a separately accessible housing and integral lamp support, indexed ceramic socket, and a self-aligning, quick-release lamp retainer. Electrical 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 (1000 foot candles)** and damped for any decrease from **10 764 lx (1000 foot candles)**.

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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 40°C to plus 77°C (**minus 40 to plus 165°F**) 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 ½ inch**) diameter standard steel pipe signal brackets and malleable iron pipe fittings, or as otherwise specified in the Contract.

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.

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

Non-metallic ornamental caps shall not be used to plug unused openings in signal bracket pipe fittings, signal indication housings, and pedestal slipfitter collars. Aluminum ornamental caps are acceptable.

One way signal head mounts and all required appurtenances for mounting vehicle and pedestrian signal faces to mast arms, vertical pole shafts, and pedestal shafts shall be in accordance with Mn/DOT Standard Plate No. 8124 and as specified in the Contract.

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.

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