DIVISION III
MATERIALS

3101 Portland Cement
Cement shall be from certified sources only. Portland cement furnished under this Specification shall conform to AASHTO M 85 for the type specified except as herein modified:

Fines shall be measured by the Air permeability test.
All delivery invoices shall include a standardized Cement Certification Statement which is as follows: (insert company name) certifies that the cement produced at (insert plant and location) conforms to AASHTO and Mn/DOT Specifications for Type (insert Type) cement. The change of source or color, or both, of cement on a Project shall not be permitted without the written approval of the Concrete Engineer.

3102 Ground Granulated Blast Furnace Slag
Ground Granulated Blast Furnace Slag shall be from certified sources only. Ground Granulated Blast Furnace Slag (GGBFS) furnished under this Specification shall conform to AASHTO M-302 except as herein modified:

The allowable slag classifications are limited to Grade 100 or Grade 120.
All delivery invoices shall include a standardized GGBFS Certification Statement which is as follows: (insert company name) certifies that the slag produced at (insert plant and location) conforms to AASHTO and Mn/DOT Specifications for Grade (insert Grade) GGBFS. The change of source or color, or both, of slag on a Project shall not be permitted without the written approval of the Concrete Engineer.

3103 Portland-Pozzolan Cement
Portland-Pozzolan cement shall be from certified sources only. Portland-Pozzolan cement furnished under this Specification shall conform to AASHTO M 240, Type IS, Type IP or Type IP-A, except as modified by the following:
(1) The fly ash constituent of the interground cement shall not exceed 20 percent.
(2) The fly ash constituent of blended cement shall not exceed 15 percent.
All delivery invoices shall include a standardized Cement Certification Statement which is as follows: (insert company name) certifies that the cement produced at (insert plant and location) conforms to AASHTO and Mn/DOT Specifications for Type (insert Type) cement. The change of source or color, or both, of cement on a Project shall not be permitted without the written approval of the Concrete Engineer.

3105
Bagged Portland Cement Concrete
Patching Mix Grade 3U18

3105.1 SCOPE
This Specification provides for a dry, bagged concrete patching mix for repairing portland cement concrete pavement.

3105.2 REQUIREMENTS
A  Materials
The materials for the patching mix shall meet the following requirements of the type and grade specified.

Cement .............................................................. 3101
Fine Aggregate ............................................. 3126
Coarse Aggregate ............................................ 3137

Materials to be used with this patching mix to make concrete shall meet the following requirements:

Water................................................................. 3906
Admixtures .................................................... 3113

B  Gradation
The coarse and fine aggregate shall be blended at 50-50 ratio by volume to meet the following gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>80-100</td>
</tr>
<tr>
<td>2.36 mm (#8)</td>
<td>40-80</td>
</tr>
<tr>
<td>1.18 mm (#16)</td>
<td>25-50</td>
</tr>
<tr>
<td>600 µm (#30)</td>
<td>15-35</td>
</tr>
<tr>
<td>300 µm (#50)</td>
<td>0-18</td>
</tr>
<tr>
<td>150 µm (#100)</td>
<td>0-8</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>2.3 Maximum</td>
</tr>
</tbody>
</table>

C  Mix Proportions
The mix proportions shall be as follows per 34.1 kg (75 pound) bag of dry mix:

| Type I Cement | 8.1 kg (17.8 pounds) |
| Coarse Aggregate | 12.9 kg (28.3 pounds) |
| Fine Aggregate | 13.1 kg (28.9 pounds) |
D  Blending

Prior to blending with the cement, the coarse and fine aggregate shall be dried in a method approved by the Concrete Engineer.

The blending device shall be capable of producing the required mix proportions within a tolerance of 2 percent. The proportioning device shall be equipped with a warning device to indicate when the system is out-of-tolerance. The cement and aggregate shall be blended before the mix is bagged.

The blending device shall have the capability to stop the flow of cement to allow sampling of the blended coarse and fine aggregate.

The equipment shall be designed so that sufficient quantities of cement and aggregate may be run out separately to check their masses (weights) and thus ensure that the blending proportions meet mix requirements.

E  Bags and Batch Identification

The bags shall be moisture-proof, have sufficient strength to resist tearing and hold 34.1 kg (75 pounds) of mix.

The bags shall be identified by the following statement printed clearly on the bags:

"Mn/DOT GRADE 3U18 CONCRETE PATCH MIX – 34.1 kg (75 pounds)"

The batch shall be identified by the date mixed, such as 07/13/99. The instructions for mixing into concrete shall be printed on the bag.

3105.3  SAMPLING AND APPROVAL

All materials shall be sampled according to an approved Quality Control Program prior to blending at the bagging site. This shall be construed to mean the individual materials as well as the aggregate blend. Providing the materials meet requirements, the batch will be designated "approved" by the Agency and identified by the bagging date. Additional field sampling will not be required.

3106  Hydrated Lime

Hydrated lime furnished for use in soil drying or stabilization shall conform to AASHTO M 216.

Hydrated lime furnished for use in mortar for sewer applications shall conform to ASTM C 207, Type S.

Hydrated lime furnished for use in mortar, other than for sewer applications, or road pavement mixtures shall conform to ASTM C 207 for Type N.
Masonry Cement

Masonry cement furnished for use in mortar for sewer applications shall conform to ASTM C 91, Type S.

Masonry cements furnished for use in mortar, other than for sewer applications, shall conform to ASTM C 270 and the type specified by the Engineer.

Admixtures for Concrete

3113.1 SCOPE
This Specification covers materials intended for use as admixtures to be added to concrete mixtures in the field. All admixtures for concrete shall be Mn/DOT approved.

3113.2 GENERAL
This Specification covers three classes of admixtures, described as follows:
Class I - Accelerating, Retarding, and Water-Reducing admixtures.
   Type A - Water-reducing
   Type B - Retarding
   Type C - Accelerating
   Type D - Water-reducing and retardung.
   Type E - Water-reducing and accelerating.
   Type F - Water-reducing, high range.
   Type G - Water-reducing, high range and retarding
Class II - Air-Entraining Admixtures
Class III - Calcium Chloride

3113.3 REQUIREMENTS
A  Materials
A1  Class I
   Class I admixtures shall conform to AASHTO M 194. In addition, Type B through Type G admixtures shall require specific approval for use on the intended Project. This approval will only be granted when the Contractor can adequately demonstrate, to the Concrete Engineer, the ability to properly mix, control and place concretes containing the specific admixture.
A2  Class II
   Class II admixtures shall conform to AASHTO M 154 except as hereinafter provided.
   (a) Tests for bleeding, bond strength and volume change will not be required.

750
(b) The air-entraining admixture as used shall have a strength such that not more than 2.5 L (2 quarts) of the solution per m³ (cubic yard) of concrete will produce the required air content in the concrete.

c) Any air-entraining admixture solution made from Vinsol resin shall have a concentration between 14 and 17 percent solids by mass (weight) at the time it is measured and dispensed into the concrete batch. The use of admixtures containing 14 to 30 percent solids may be permitted when used in conjunction with concrete containing fly ash.

A3 Class III

Class III admixtures (calcium chloride) shall conform to AASHTO M 144.

B Acceptance

B1 For any Class I or Class II admixture proposed for use, the Contractor shall submit certified test reports, including a print of the infrared spectrum of the material, covering tests made by a laboratory approved by the Engineer. Determination as to compliance with these Specifications may be based on the certified test results submitted.

B2 When the Contractor proposes to use an admixture that has been previously approved, he shall submit a certification stating that the admixture is the same as that previously approved. If an admixture offered for use is essentially the same (with only minor differences in concentration) as another previously approved material, a certification will be required stating that the product is essentially the same as the approved admixture and that no other admixture or chemical agent is present.

B3 When the Contractor proposes to use a Class II admixture that is manufactured by neutralizing Vinsol resin with caustic soda (sodium hydroxide), he may submit a certification concerning the admixture in the following form which may be accepted by the Engineer in lieu of the certified test reports required above.

"This is to certify that the product (trade name) as manufactured and sold by the (company) is an aqueous solution of Vinsol resin that has been neutralized with sodium hydroxide. The ratio of sodium hydroxide to Vinsol resin is one part of sodium hydroxide to (number) parts of Vinsol resin. The percentage of solids based on the residue dried at 105°C (221 °F) is (number). No other additive or chemical agent is present in this solution."

B4 Any admixture may be accepted on the basis of the certified test results or certification submitted, with the provision that the Department reserves the right to perform additional tests on samples of the material furnished for the work, to determine its compliance with this Specification and suitability of the admixture for the use intended.
3113.4  

3113.4 SAMPLING AND TESTING  
Samples shall be taken in rates and sizes according to the Schedule of Materials Control.
Tests may be made upon samples taken from the product proposed to be furnished by the Contractor for use on the Project or upon samples submitted and certified by the manufacturer as representative of the admixture to be supplied.

3115  
Fly Ash for Use in Portland Cement Concrete
Fly Ash shall be from certified sources only. Fly ash furnished under this Specification for use in portland cement concrete shall conform to ASTM C 618, Class F or Class C, except as modified by the following:

Chemical Requirements

<table>
<thead>
<tr>
<th></th>
<th>Class F</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO, %, max</td>
<td>30.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Loss on ignition, %, max</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Available alkalies as Na₂O, %, max</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Physical Requirements

<table>
<thead>
<tr>
<th></th>
<th>Class F</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fineness:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air permeability, mm²/kg, min</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Quantity retained when wet sieved on a 45 µm (# 325) sieve, %, max</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Water requirement, % of control, max</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Strength activity index with Portland cement, at 7 days, % of control, min</td>
<td>75.0</td>
<td>75.0</td>
</tr>
<tr>
<td>Specific gravity, variation from established value, max</td>
<td>± 0.12</td>
<td>± 0.12</td>
</tr>
</tbody>
</table>

NOTE: The established value for specific gravity is that value which is stated in the source approval given by the Materials Manufacturer.

Fly ash produced at plants where the limestone injection process is used for controlling air pollutants will be considered unacceptable for use in portland cement concrete.
All delivery invoices shall include a standardized Fly Ash Certification Statement which is as follows: (insert company name) certifies that the fly ash produced at (insert power plant and location) conforms to ASTM and Mn/DOT Specifications for Class (insert Class) fly ash. The change of source or color, or both, of fly ash on a Project shall not be permitted without the written approval of the Concrete Engineer and the Engineer.

Fly ash which meets the requirements of both Class C and Class F shall be considered as being Class C Fly Ash.

3126

Fine Aggregate for Portland Cement Concrete

3126.1 SCOPE

This Specification covers fine aggregate for use in Portland cement concrete.

3126.2 REQUIREMENTS

A  Composition

The fine aggregate shall be a natural sand consisting of particles of sound, durable rock, except that when fine and coarse aggregates are produced simultaneously and by the same operations from natural gravel deposits, the fine aggregate may contain particles of crushed rock of such nature and quantity as are incidentally produced by the normal operations of crushing and screening the oversize material of the deposit.

B  Washing

The fine aggregate shall be washed.

C  Deleterious Substances

The quantity of deleterious substances, as determined by mass (weight), shall not exceed the following limits:

C1  Coal and Lignite ...........................................................0.3%
C2  BLANK
C3  Other deleterious substances such as shale, alkali, mica, soft and flaky particles, cumulative total ........................................................... 2.5%

D  Organic Impurities

The fine aggregate shall be free of injurious quantities of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength requirements specified in 3126.2E.

E  Structural Strength

When subjected to the structural strength tests, mortar specimens containing the fine aggregate shall develop a compressive strength at
the age of 3 days when using high early strength portland cement, or at 7 days when using standard portland cement, of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded Ottawa sand having a fineness modulus of 2.40 with a tolerance of 0.10.

**F Gradation Requirements**

Fine aggregate shall be well graded from coarse to fine; and when tested by means of laboratory sieves, shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.50 mm (3/8 inch)</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm (# 4)</td>
<td>95-100</td>
</tr>
<tr>
<td>2.36 mm (# 8) (A)</td>
<td>80-100</td>
</tr>
<tr>
<td>1.18 mm (# 16)</td>
<td>55-85</td>
</tr>
<tr>
<td>600 µm (# 30)</td>
<td>30-60</td>
</tr>
<tr>
<td>300 µm (# 50) (B)</td>
<td>5-30</td>
</tr>
<tr>
<td>150 µm (# 100)</td>
<td>0-10</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>0-2.5</td>
</tr>
</tbody>
</table>

(A) If the fine aggregate is used with a coarse aggregate that meets the requirements for coarse aggregate designation CA-15, the quantity passing the 2.36 mm (# 8) sieve may be decreased to 75 percent.

(B) Fine aggregate of which less than 5 percent passes a 300 µm (# 50) sieve may be used provided an approved inorganic material is added, by separate measurement, to correct the deficiency in gradation.

**G Requirements for Uniformity of Grading**

The gradation requirements specified above represent the extreme limits that will determine acceptability for use of fine aggregate from all sources of supply. However, the gradation from any one source shall be reasonably uniform and free from wide variation within the gradation limits.

For the purpose of controlling the uniformity of the materials from each individual source, an initial Fineness Modulus will be determined when the work begins. Thereafter, additional determinations will be made as additional material is delivered to the work and any material that shows a deviation from the initially determined Fineness Modulus of more than 0.20 tolerance shall be rejected or, at the discretion of the Engineer, it may be used subject to such adjustments in the mix composition as the Engineer deems necessary to compensate for the variation in gradation.
The Fineness Modulus of fine aggregate is determined by subtracting the total of the cumulative percentages, by mass, passing the following standard sieves having square openings, from 7 and dividing by 100. Standard sieves are 9.50 mm (⅜ inch), 4.75 mm (# 4), 2.36 mm (# 8), 1.18 mm (# 16), 600 µm (# 30), 300 µm (# 50), and 150 µm (# 100).

3126.3 SAMPLING AND TESTING

Sufficient material must be produced and stockpiled prior to starting concrete production to permit proper sampling and testing of the material before it is used. If material is produced from a previously undeveloped source, the following minimum quantities shall be available for sampling and testing prior to the beginning of construction operations:

(a) For concrete pavement construction, ......1000 metric tons (tons)
(b) For all other types of concrete construction, At least one half of the total quantity required for the work or 200 metric tons (tons), whichever is the smaller.

When questionable aggregate is encountered, the aggregate shall be separated when produced into distinct units of not more than 100 metric tons (tons) nor less than 25 metric tons (tons) or the total required (whichever is less). These units shall be kept separate for a sufficient time to permit proper sampling and testing.

Sampling and testing of fine aggregate will be done in accordance with the following:

A  Sampling, Sieve Analysis, Deleterious Substances,
   Quantity of Material Passing the
   75 µm (# 200) Sieve ..............Mn/DOT Concrete Manual
B  Coal and Lignite ............................AASHTO T 113
C  Organic Impurities ........................ AASHTO T 21
D  Structural Strength.........................AASHTO T 71-60
E  Specific Gravity and Absorption
   ............................................Mn/DOT Laboratory Manual
F  Alkali Silica Reactivity
   ............................................. ASTM C 1260 (Mn/DOT Modified)

3127

Fine Aggregate for Bituminous Seal Coat

3127.1 SCOPE

This Specification covers fine aggregate for use in bituminous seal coat.
3127.2 REQUISITES

A Composition

The aggregate shall consist of sound, durable particles of sand, gravel or crushed stone, or combinations thereof. It shall be clean, uniform in quality and free from wood, bark, roots and other deleterious material. All aggregate to be used for bituminous seal coat shall conform to Class A, B, C, or D as described in 3137.2B.

B Gradation and Quality

<table>
<thead>
<tr>
<th>TABLE 3127-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINE AGGREGATE FOR BITUMINOUS SEAL COAT</td>
</tr>
<tr>
<td>Total Percent Passing (by mass)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>FA-1 Sand AASHTO</th>
<th>FA-2 (A) Size No. 9 AASHTO</th>
<th>FA-3 (A) Size No. 8 AASHTO</th>
<th>FA-4 Size No. 7 AASHTO</th>
<th>FA-5 Size No. 6 AASHTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0 mm (1 inch)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>19.0 mm (¾ inch)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>90-100</td>
</tr>
<tr>
<td>12.5 mm (½ inch)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>90-100</td>
<td>20-55</td>
</tr>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>100</td>
<td>100</td>
<td>85-100</td>
<td>40-70</td>
<td>0-15</td>
</tr>
<tr>
<td>6.3 mm (¼ inch)</td>
<td>100</td>
<td>100</td>
<td>40-70</td>
<td>0-15</td>
<td>0-5</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>95-100</td>
<td>85-100</td>
<td>0-15</td>
<td>0-5</td>
<td>---</td>
</tr>
<tr>
<td>2.36 mm (#8)</td>
<td>--</td>
<td>10-40</td>
<td>0-5</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1.18 mm (#16)</td>
<td>45-80</td>
<td>0-10</td>
<td>---</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>300 μm (#50)</td>
<td>10-30</td>
<td>0-5</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>150 μm (#100)</td>
<td>2-10</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>75 μm (#200)</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
</tr>
<tr>
<td>% Shale, Max, by Weight</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Static Stripping Test</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Flakiness Index, Maximum</td>
<td>N/A</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Los Angeles Rattler Loss, % Max on Plus 4.75 mm Fraction</td>
<td>--</td>
<td>--</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

(A) Except as otherwise specified in the Plans or in the detailed Specifications for a specific type of work, only Classes A, C, or D (as described in 3137.2B) will be permitted.

3127.3 SAMPLING AND TESTING

A Sampling, Sieve Analysis, and Shale Test ..................Mn/DOT Bituminous Manual

B Static Stripping Test ..................AASHTO T 96
Mortar Sand

Mortar sand shall conform to AASHTO M 45 and shall be uniformly graded from fine to coarse with the following limits:

<table>
<thead>
<tr>
<th>Percent</th>
<th>Description</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 2.36 mm (# 8)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Passing 300 µm (# 50)</td>
<td>15-40</td>
<td></td>
</tr>
<tr>
<td>Passing 150 µm (# 100)</td>
<td>0-10</td>
<td></td>
</tr>
<tr>
<td>Passing 75 µm (# 200)</td>
<td>0-5</td>
<td></td>
</tr>
</tbody>
</table>

Coarse Aggregate for Portland Cement Concrete

3137.1 SCOPE

This Specification covers coarse aggregate for use in portland cement concrete.

3137.2 REQUIREMENTS

A General

For sources that have not been previously tested, or for sources of questionable quality, the aggregate may be used only if specifically approved by the Engineer and then only after it has been evaluated and determined to be satisfactory for the proposed use.

The Engineer shall be notified at least 4 weeks prior to use of the proposed aggregate, to permit special studies as necessary to determine its suitability. To determine suitability of any aggregate, the Engineer may consider the results of laboratory tests, the behavior of the rock under natural exposure conditions, the behavior of portland cement concrete in which aggregate from the same or similar geological formations or deposits has been used, or such other tests or criteria as may be deemed appropriate.

B Classification

The aggregate shall conform to one of the following classifications. The class of aggregate to be used shall be optional with the Contractor unless otherwise specified in the Contract.
B1  Class A
Class A aggregate shall consist of crushed quarry or mine trap rock (basalt, diabase, gabbro or other related igneous rock types), quartzite, gneiss or granite. Other igneous or metamorphic quarry or mine rock may be used only with specific approval of the Engineer. Crushed aggregate produced from igneous or quartzite stones retained on a 100 mm (4 inch) screen will also be permitted by approval of the Engineer.

B2  Class B
Class B aggregate shall consist of all other crushed quarry or mine rock; i.e., carbonates, rhyolite, schist.

B3  Class C
Class C aggregate shall consist of natural or partly crushed natural gravel obtained from a natural gravel deposit. It may contain a quantity of material obtained from crushing the oversize stone in a deposit, provided such crushed material is uniformly mixed with the natural, uncrushed particles.

B4  Class D
Class D aggregate shall consist of a mixture of any two or more classes of approved aggregate (A, B, C, and R). The use of Class D aggregate, as well as the relative proportions of the different constituent aggregates, shall be subject to the approval of the Engineer. The relative proportions of the constituent aggregates shall be accurately controlled either by the use of a blending belt approved by the Engineer prior to production or by separately weighing each aggregate during the batching operations.

B5  Class R
Class R aggregate shall consist of aggregate obtained from recycling concrete, which shall be crushed to the specified gradation. It shall be handled and stockpiled in such a manner that it will not become contaminated with foreign matter.

Concrete removal and crushing operations must take into account any special problems associated with the presence of reinforcing steel. The fine fraction (passing the 4.75 mm (#4) sieve) obtained in crushing the old concrete shall be removed to the extent possible and be wasted.

The original source of the aggregate must be known so the Engineer can determine its suitability for the intended use. Quality requirements of 3137.2D shall not apply specifically; however, the Engineer may consider any of those requirements in determining suitability of the aggregate.
C  Washing
All coarse aggregate except for Class A aggregate shall be washed.
All coarse aggregate shall meet the 75 µm (# 200) sieve requirements of 3137.2D1.

D  Quality Requirements
D1  Aggregate for General Use
The following percentages, shall not be exceeded:

<table>
<thead>
<tr>
<th>Percent By Mass (Weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Shale,</td>
</tr>
<tr>
<td>In the fraction retained on the 12.5 mm (½ inch) sieve ......... 0.4</td>
</tr>
<tr>
<td>Retained on the 4.75 mm (# 4) sieve as a percentage of the total material .......................................................... 0.7</td>
</tr>
<tr>
<td>(b) Soft Iron Oxide Particles (paint rock and ochre) .............. 0.3</td>
</tr>
<tr>
<td>(c) Total Spall Materials (includes items a and b percentages of the above, plus other iron oxide particles, unsound cherts, pyrite, and other materials having similar characteristics).</td>
</tr>
<tr>
<td>In fraction retained on the 12.5 mm (½ inch) sieve ............. 1.0</td>
</tr>
<tr>
<td>Retained on the 4.75 mm (# 4) sieve, as a percentage of the total material .......................................................... 1.5</td>
</tr>
<tr>
<td>(d) Soft Particles (exclusive of items a, b, and c above)........ 2.5</td>
</tr>
<tr>
<td>(e) Clay Balls and Lumps ..................................................... 0.3</td>
</tr>
<tr>
<td>(f) Sum of Materials listed under items c, d, and e above ......... 3.5</td>
</tr>
<tr>
<td>(For item c use percent in total sample retained on the 4.75 mm (# 4) sieve)</td>
</tr>
<tr>
<td>(g) Slate ............................................................................... 3.0</td>
</tr>
<tr>
<td>(h) Thin or Elongated Pieces (maximum thickness less than 25 percent of the maximum width, or maximum length more than 3 times the maximum width) .......................................................... 15</td>
</tr>
<tr>
<td>(i) Material Passing 75 µm (# 200) sieve, on individual fractions... 1.0</td>
</tr>
<tr>
<td>(j) Los Angeles Rattler Loss,</td>
</tr>
<tr>
<td>On total sample ................................................................. 40</td>
</tr>
<tr>
<td>(k) Freezing and Thawing, loss at 16 cycles ............................. 12</td>
</tr>
<tr>
<td>(l) Soundness (Magnesium Sulfate),</td>
</tr>
<tr>
<td>Loss at 5 cycles for any fraction of the coarse aggregate as used in the work ......................................................... 15</td>
</tr>
<tr>
<td>Materials from two or more sources may not be blended to obtain a fraction meeting this sulfate soundness requirement.</td>
</tr>
</tbody>
</table>

D2  Aggregate for Bridge Superstructure
For use in any part of a bridge superstructure (deck, railing, posts, curbs, sidewalks, and median strips), quality requirements for the coarse aggregate shall be as prescribed in 3137.2D1 above, except as modified or supplemented by the following maximum percentages:
(a) Shale,
   In the fraction retained on the 12.5 mm (½ inch) sieve .......... 0.2
   Retained on the 4.75 mm (# 4) sieve as a percentage of the
   total material ................................................................. 0.3
(b) Soft Iron Oxide Particles (paint rock and ochre) .............. 0.2
(c) Total Spall Materials (includes items a and b percentages of the
    above, plus other iron oxide particles, unsound cherts, pyrite, and
    other materials having similar characteristics). Retained on the 4.75
    mm (# 4) sieve as a percentage of the total material .......... 0.3
(d) Soft Particles (exclusive of items a, b, and c above) ........... 2.5
(e) Clay Balls and Lumps ....................................................... 0.3
(f) Sum of Materials listed under items c, d, and e above .......... 3.0
(g) Maximum carbonate in Class C and Class D aggregates by
    mass (weight) ........................................................................ 30
(h) Maximum absorption for Class B aggregate ....................... 1.7

D3 Aggregate for Concrete Paving
   For use in any part of a concrete pavement, quality requirements for
   the coarse aggregate shall be as prescribed in 3137.2D1 above, except
   as modified or supplemented by the following maximum percentages:
   All fractions of the coarse aggregate for concrete pavement shall
   meet one of the following requirements:
   (a) Class A aggregate
   (b) Class B aggregate with a maximum absorption .............. 1.75%
   (c) Class C aggregate with a maximum carbonate
       by mass (weight) ............................................................... 30%
   (d) The Contractor may use Class R aggregate with (a), (b), or (c)
       above in concrete pavement upon receiving written approval from
       the Concrete Engineer. Such approval will be given only if the
       Concrete Engineer can adequately trace the source of the original
       coarse aggregate and subsequently determines that source to be
       satisfactory for the use intended.
NOTE: The use of CA-6, CA-7 or CA-8, requires the approval of the
Concrete Engineer.

E Gradation Requirements
   Coarse aggregate shall be the uniform product of the plant
producing it, unless it is necessary to remove some of the sizes in order
to meet the following gradation requirements. Unless otherwise
specified, coarse aggregate shall contain all of the sizes included within
the specified limits. Broken or noncontinuous gradations will not be
permitted.
The gradations required, or which will be permitted at the Contractor's option, will be specified in the concrete mix number. The requirements of these gradations are listed in Table 3137-2. Whenever the size of coarse aggregate selected for use has less than 100 percent passing the 25.0 mm (1 inch) sieve, the coarse aggregate shall be produced, furnished, and proportioned for the work in at least two fractions. The Contractor shall maintain a uniform gradation in each size of coarse aggregate used during the handling and batching operations.

3137.3 SAMPLING AND TESTING

Sufficient material must be produced and stockpiled prior to starting construction operations to permit proper sampling and testing of the material before it is used. If material is produced from a previously undeveloped source, the following minimum quantities of material must be available for sampling and testing prior to the beginning of construction operations:

(a) For concrete pavement construction, 1000 metric tons (tons).  
(b) For all other types of construction, at least one-half of the quantity required for the work, or 250 metric tons (tons), whichever is the smaller.

When questionable materials are encountered, the aggregate shall be separated when produced into distinct units of not less than 25 metric tons (tons) (unless a smaller quantity is required for the Project) nor more than 100 metric tons (tons). These units shall be kept separate for a sufficient time to permit proper sampling and testing.

Sampling and testing of coarse aggregate shall be in accordance with the following methods:

A  Sampling, Sieve Analysis, Shale Test, Quantity of Material Passing the 75 µm (# 200) Sieve...................................... Mn/DOT Concrete Manual
B  Specific Gravity and Absorption ............................................Mn/DOT Laboratory Manual
C  Density
   The density of the aggregate will be determined in accordance with the procedure described in AASHTO T 19; except that the measure shall have an inside diameter of 462 mm (18.19 inches) and an inside height of 538 mm (21.18 inches).
D  Los Angeles Rattler Loss...........................AASHTO T 96
E  Void Content
   The procedure for determining voids in the aggregate shall be as outlined in AASHTO T 19, except that the void content shall be based on an oven-dry and compacted (by rodding) condition of the aggregate, and a value of 1000 kg/m³ (62.3 pounds per cubic foot) for water.
3137.3

F Deleterious Materials
The percentages, by mass (weight), of such materials as coal, lignite, iron oxide particles, slate and similar deleterious substances will be determined by visual analysis of the sample.

G Freezing and Thawing
The aggregate will be tested for resistance to freezing and thawing in water and alcohol, and for strain and freeze-thawing, in accordance with the procedures on file at the Mn/DOT Office of Materials.

H Soundness (Magnesium Sulfate)
The sulfate soundness of the aggregate will be determined by using the procedure described in AASHTO T 104, except as modified in the Mn/DOT Laboratory Manual.

I Blank

J Soft Particles
The percentage of soft particles will be determined by the Method of Test for Scratch Hardness of Coarse Aggregate in the Mn/DOT Laboratory Manual.

## TABLE 3137-1
COARSE AGGREGATE FRACTION SIZE FOR CONCRETE

Percent by mass (weight) passing square opening sieves *(A)*

<table>
<thead>
<tr>
<th>Size Numbers</th>
<th>Fraction size (2 in)</th>
<th>50 mm (2 in)</th>
<th>37.5 mm (1 ½ in)</th>
<th>31.5 mm (1 in)</th>
<th>25.0 mm (⅜ in)</th>
<th>19.0 mm (⅜ in)</th>
<th>16.0 mm (⅜ in)</th>
<th>12.5 mm (⅜ in)</th>
<th>9.5 mm (⅜ in)</th>
<th>4.75 mm (#4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-0</td>
<td></td>
<td>100</td>
<td>95-100</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td></td>
</tr>
<tr>
<td>CA-1</td>
<td>100</td>
<td>80-100</td>
<td>80-100</td>
<td>5-30</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-2</td>
<td>100</td>
<td>90-100</td>
<td>90-100</td>
<td>5-35</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-2M</td>
<td>100</td>
<td>90-100</td>
<td>90-100</td>
<td>20-50</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-3</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>5-35</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-3M</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>20-55</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-4</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>25-60</td>
<td>0-10</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-4M</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>40-75</td>
<td>0-15</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-5</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>30-60</td>
<td>0-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-6</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>40-70</td>
<td>0-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-7</td>
<td>100</td>
<td>85-100</td>
<td>85-100</td>
<td>50-100</td>
<td>0-25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-8 (A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The limit on the 9.5 mm (⅜ inch) sieve for CA-5 shall be 20-60 when used with CA-1 to obtain CA-15 as given in Table 3137-2.

*(A)* For CA-8, not more than 5 percent shall pass the 300 µm (#50) sieve.

762
The coarse aggregate specified or selected for use in the work shall conform to the gradation requirements given in Table 3137-2 and shall be obtained by individually proportioning the separate fractions whenever required.

<table>
<thead>
<tr>
<th>Aggregate Designation</th>
<th>90 mm (3 1/8 in.)</th>
<th>75.0 mm (3 in.)</th>
<th>56.0 mm (2 1/4 in.)</th>
<th>37.5 mm (1 1/2 in.)</th>
<th>25.0 mm (1 in.)</th>
<th>19.0 mm (3/4 in.)</th>
<th>16.0 mm (5/8 in.)</th>
<th>12.5 mm (1/2 in.)</th>
<th>9.5 mm (3/8 in.)</th>
<th>4.75 mm (# 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-00</td>
<td>100</td>
<td>95-100</td>
<td>0-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-15</td>
<td>100</td>
<td>90-100</td>
<td>25-75</td>
<td>5-25</td>
<td>0-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-25 or 2M6</td>
<td>100</td>
<td>95-100</td>
<td>40-70</td>
<td>20-40</td>
<td>0-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-35 or 3M6</td>
<td>100</td>
<td>90-100</td>
<td>50-80</td>
<td>20-45</td>
<td>0-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-45 or 4M6</td>
<td>100</td>
<td>95-100</td>
<td>60-90</td>
<td>25-55</td>
<td>0-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-50</td>
<td>100</td>
<td>90-100</td>
<td>30-60</td>
<td>0-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-60</td>
<td>100</td>
<td>95-100</td>
<td>40-70</td>
<td>0-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-70</td>
<td>100</td>
<td>95-100</td>
<td>50-100</td>
<td>0-25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-80 (A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*A) For CA-80, not more than 5 percent shall pass the 300 µm (# 50) sieve.
3138

Aggregate for Surface and Base Courses

3138.1 SCOPE
This Specification covers the quality of aggregates used in construction of aggregate surfaced roads, shoulders and dense graded base courses.

3138.2 REQUIREMENTS
A Aggregate Composition

The source of supply and quality of the material is subject to approval by the Engineer in accordance with 1601.

A1 Virgin Aggregate Composition

Classes 1, 2, 3, 4, 5 and 6 shall meet the following requirements:

All aggregate sources (pits and quarries) from which surface and/or base course aggregates are produced shall be stripped to uncover suitable materials for use. In quarries, all weathered rock will be removed prior to production of the face.

The mixture shall consist of 100 percent virgin aggregates (unless noted otherwise), and shall consist of sound durable particles or fragments of gravel and sand, crushed quarry or mine rock, crushed gravel or stone or any combination thereof; except that, Class 2 aggregates shall consist of 100 percent crushed quarry or mine rock.

The Engineer may allow aggregates containing a limited quantity of binder soil; however, the aggregates shall not contain sod, roots, plants, other organic matter, or other objectionable material. All materials shall be free from lumps or balls of clay.

A2 Salvaged/Recycled Aggregate Mixtures

Class 7

Salvaged/recycled aggregate materials may be used or blended with a combination of virgin and salvaged/recycled aggregates or 100% salvaged/recycled aggregate materials as permitted in accordance with the following requirements. These composite mixtures/blends shall be designated as Class 7.

The composite mixture/blend shall meet the following requirements:

(a) A salvage/recycled mixture shall have a minimum of 10 percent by mass (weight) salvage/recycle aggregate material incorporated into the mixture to be considered a salvage/recycled mixture.

(b) Virgin aggregates that are incorporated into the mixture shall meet the requirements in Sections 3138.2A1, 3138.2D, and 3138.2E.

(c) The salvaged/recycled aggregate portion of the mixture shall consist of sound durable particles produced by crushing, screening and grading to the required sizes from materials which were salvaged from the following sources: Portland cement concrete.
pavement removal and/or other concrete structural elements, bituminous pavement removal, aggregate bases underlying bituminous and concrete pavements. Incorporation of recycled glass into the aggregate mixture during production will be permitted. The composite mixture may be produced from any combination of these salvaged/recycled aggregate materials (including glass), unless otherwise specifically modified or prohibited in the plans and/or special provisions.

(d) The Engineer may allow aggregate containing a limited quantity of binder soil. However, the composite aggregate mixture/blend shall not contain sod, roots, plants, building rubble, building brick, wood, plaster, reinforcing steel or other similar objectionable or deleterious materials and shall be free of lumps or balls of clay.

(e) The requirements of 3138 A2(a), Salvaged Bituminous Aggregate Mixtures; 3138 A2(b), Salvaged Crushed Concrete Aggregate; and 3138 A2(c), Reclaimed Glass.

(f) Blending of the various types of aggregates (virgin and recycle/salvage aggregates), shall be done during production. The final product shall consist of a uniform blend of all the composite materials.

Class 7 may be substituted for Classes 1, 3, 4, 5 and 6 unless otherwise specifically modified or prohibited in the plans and/or Special Provisions.

A2a Salvaged Bituminous Aggregate Mixtures

Salvaged bituminous aggregate mixtures may be used in accordance with the following applications and requirements:

(a) Aggregate base course.

Salvaged bituminous mixture may be used either alone or in combination with other aggregate materials (virgin and/or salvaged/recycled) in the production of the base course mixture.

However, the bitumen content of the composite mixture shall not exceed 3.0 percent by mass (by weight). Nonconforming materials shall be subject to the provisions of Table 2211-D.

(b) Surfacing aggregate (travel lanes and/or shoulders).

All aggregates used for surfacing shall have 100% passing the 19 mm (¾ inch) sieve. The aggregates may contain up to 100 percent salvaged bituminous materials. (No limit on bitumen content).

A2b Salvaged Crushed Concrete Aggregate

Crushed concrete aggregate may be used singularly or blended with virgin and/or other permitted salvaged/recycled aggregate materials in accordance with the following applications and requirements:
3138.2

(1) Aggregate base course applications.
   (a) Where drainage layers and/or perforated drainage pipes are not installed or will not be installed:
      i. Crushed concrete may be used in the production of aggregate base course mixtures provided that the final product meets all other requirements of this specification.
   (b) Where drainage layers and/or perforated drainage pipes are installed or will be installed. One of the following requirements must be met:
      i. Crushed concrete, blended with other permitted aggregates (virgin and/or recycled), may be used on any type of subgrade soil provided that at least 95% of the crushed concrete aggregate particles are retained on the 4.75 mm (# 4) sieve. The blended aggregate base must meet the gradation requirements of this specification.
      ii. Crushed concrete aggregates may be used singularly or blended with other permitted aggregate materials when placed over material meeting the requirements of 3149.2B2, Select Granular, provided that the amount crushed concrete aggregate does not exceed the equivalent of 75 mm (3 inches) of 100 percent crushed concrete; such as, 150 mm (6 inches) of a 50/50 blend of crushed concrete and permitted aggregate material. If crushed concrete aggregate is used (singularly or blended) for the base course and for stabilizing the subgrade at the same location, the total equivalent application rate shall not exceed a 75 mm (3 inches) thickness (approximately 160 kg/m² (300 pounds per square yard) of surface area).
      iii. Crushed concrete may be used up to 100% in construction of the filter/separation layer under a permeable aggregate base drainage layer (i.e. OGAB, PASB, PCSB) in accordance with the applicable drainage specifications.

(2) Other Applications.
   With and without drainage layer and/or perforated pipe installation, crushed concrete may be used for:
   i. Surfacing and base course(s) in the shoulder area.
   ii. Surfacing aggregate-surfaced roads (including shoulders).
A2c  Reclaimed Glass

Unless otherwise specifically modified or prohibited in the Plans and/or Special Provisions, up to 10 percent by mass (weight) reclaimed glass may be mixed/blended with virgin and/or salvaged/recycled aggregate materials during the crushing operation in the production of the aggregate base course mixture in accordance with the following:

1. Sources
   Reclaimed glass shall consist of eligible secondary glass available from any source willing and able to certify their supply sources and composition of glass as required in paragraph 7, below.

2. Composition
   Reclaimed glass shall consist only of the following eligible types of glass products: a. container glass used for consumer food and beverages; b. beverage drinking glasses; c. plain ceramic or china dinnerware; d. building window glass free of any framing material; and e. other types of glass that can be certified and approved by Mn/DOT's Office of Environmental Services on an individual source basis.
   Reclaimed glass or other salvaged aggregates shall not consist of the following prohibited types of materials: a. any hazardous waste as defined in MPCA Rules 7045; b. hazardous substance in regulated quantities listed in 40 CFR, Table 302.4; c. automobile windshields or other glass from automobiles; d. light bulbs of any type; e. porcelain products; f. laboratory glass; and g. television, computer or other cathode ray monitor tubes.

3. Debris Content
   The reclaimed glass shall not contain more than 5 percent debris, by visual inspection. Debris includes any non-glass material such as: paper, foil, plastics, metal, corks, wood debris, food residue, or other deleterious materials. The percentage of debris shall be estimated using the American Geophysical Institute Visual Method. (AGI Data Sheet 15.1 and 15.2 Comparison Chart for Estimating Percent Composition, 1982.)

4. Storage
   Interim storage of reclaimed glass stockpiles shall be on locations with: a. minimum of 1.2 m (4 feet) depth of suitable soils separating groundwater; b. a minimum of 50 m (150 feet) away from any surface water body; and
3138.2

c. a maximum slope for four percent (4%) if sloped to any surface water body.

5. Ratio of Reclaimed Glass
   Up to 10 percent by mass (weight) reclaimed glass may be mixed virgin and/or other salvaged/recycled aggregate materials during the crushing operation in the production of the aggregate mixture.

6. Applications
   Reclaimed glass blended with other aggregates may be used for aggregate base course mixtures. Reclaimed glass shall not be used in aggregate surfacing applications including shoulder surfacing.

7. Certification
   a. The contractor shall provide documentation certifying that the reclaimed glass: (i) is only from sources that have given the contractor the certification required in paragraph b) below, sub-item (ii), is comprised of only eligible types of reclaimed glass; (iii) does not contain any prohibited materials; (iv) meets debris content requirements; (v) meets the blending ratio requirements; and (vi) is or will be stored according to storage requirements described in paragraph 4 above.

   b. Documentation shall include, at a minimum: (i) written certification from sources of reclaimed glass, such as recycling centers, that a good faith effort of public education was used to inform resident and business of the eligible and prohibited types of glass to be included for recycling, (ii) written certification by recycling centers that their independent sources of reclaimed glass, such as private recyclables haulers, have been notified in writing of these composition and public education requirements and have agreed in writing to comply with them; and (iii) description of the reclaimed glass blending methods used to assure required blending ratios.

A3 Limestone and/or Dolostone
   The following provisions shall apply in these listed counties:
   Anoka - 02  Ramsey - 62
   Carver - 10  Scott - 70
   Dakota - 19  Washington - 82
   Hennepin - 27
   All counties in Mn/DOT's District 6
(a) If crushed carbonate (limestone or dolostone) quarry/bedrock is used in total or in part for base or shoulder applications, unless exempted below, the portion passing the 75 µm (#200) sieve of the carbonate aggregate insoluble residue shall not exceed 10 percent.

(b) An exemption to this 10 percent insoluble residue Specification will be made for carbonate rock to be used as temporary by-passes and parking lots. Use on other specific non-exempted applications must be approved by the Engineer. For these exempted applications, the portion passing the 75 µm (#200) sieve of the carbonate aggregate insoluble residue test shall not exceed 16 percent.

B Gradation .......................... TABLES 3138-1 and 2

In the event that it is necessary to add a portion of the overburden or binder soil from an outside source, the materials shall be introduced into the aggregate producing plant at a uniform rate by a separate conveyor simultaneously with the base aggregate. The binder soils or overburden shall meet 3146.

If Class 7 is substituted for Classes 1, 3, 4, 5, or 6, it shall meet the gradation requirements of the substituted class (Table 3138-1); except that, for Class 5 and 6, up to 5.0 percent by mass (weight) of the total composite mixture may exceed the 25.0 mm (1 inch) sieve but 100 percent must pass the 37.5 mm (1.5 inches) sieve. Surfacing aggregate mixtures containing salvaged materials shall meet the gradation requirements of the materials specified in the Plan. All gradations will be run on the composite mixture before extraction of the bituminous material.

If Class 7 is substituted for Classes 5 or 6, and with the approval of the Engineer, the Contractor may produce Class 7 base material meeting the gradation requirements in Table 3138-2. The final product shall meet all other requirements of this specification.

When the use of salvaged aggregates is specified and/or shown in the plans as Class 7 the gradation requirements shall be as shown in Table 3138-1, Class 6, or Table 3138-2. The final product shall meet all other requirements of this specification.
TABLE 3138-1
BASE AND SURFACING AGGREGATE
Total Percent Passing

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Class 1 (A)</th>
<th>Class 2</th>
<th>Class 3 (A)</th>
<th>Class 4 (A)</th>
<th>Class 5 (A)</th>
<th>Class 6 (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 mm (3 inches)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>50 mm (2 inches)</td>
<td>--</td>
<td>--</td>
<td>100</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>37.5 mm (1½ inches)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>25.0 mm (1 inch)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>19.0 mm (% inch)</td>
<td>100</td>
<td>100</td>
<td>--</td>
<td>--</td>
<td>90-100</td>
<td>90-100</td>
</tr>
<tr>
<td>9.5 mm (3/8 inch)</td>
<td>65-95.</td>
<td>65-90.</td>
<td>--</td>
<td>--</td>
<td>50-90</td>
<td>50-85</td>
</tr>
<tr>
<td>4.75 mm (# 4)</td>
<td>40-85.</td>
<td>35-70</td>
<td>35-100</td>
<td>35-100</td>
<td>35-80</td>
<td>35-70</td>
</tr>
<tr>
<td>2.00 mm (# 10)</td>
<td>25-70</td>
<td>25-45</td>
<td>20-100</td>
<td>20-100</td>
<td>20-650</td>
<td>20-55</td>
</tr>
<tr>
<td>425 µm (# 40)</td>
<td>10-45</td>
<td>12-30</td>
<td>5-50</td>
<td>5-35</td>
<td>10-35</td>
<td>10-30</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>8.0-15.0</td>
<td>5.0-13.0</td>
<td>5.0-10.0</td>
<td>4.0-10.0</td>
<td>3.0-10.0</td>
<td>3.0-7.0</td>
</tr>
</tbody>
</table>

(A) When salvaged materials are substituted for another class of aggregate, it shall meet the gradation requirements of the class being replaced except as amended in 3138.2 B.

(B) The gradation requirements for aggregates containing 60% or more crushed quarry rock may be amended with the concurrence of the Project Engineer and the Grading and Base Engineer.
### TABLE 3138-2
OPTIONAL Class 7 BASE AGGREGATE
Total Percent Passing

<table>
<thead>
<tr>
<th>Total Percent Passing Sieve Size</th>
<th>Class 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 mm (3 inches)</td>
<td>--</td>
</tr>
<tr>
<td>50 mm (2 inches)</td>
<td>100</td>
</tr>
<tr>
<td>37.5 mm (1½ inches)</td>
<td>95-100</td>
</tr>
<tr>
<td>25.0 mm (1 inch)</td>
<td>65-95</td>
</tr>
<tr>
<td>19.0 mm (¾ inch)</td>
<td>45-85</td>
</tr>
<tr>
<td>9.5 mm (3/8 inch)</td>
<td>35-70</td>
</tr>
<tr>
<td>4.75 mm (# 4)</td>
<td>15-45</td>
</tr>
<tr>
<td>2.00 mm (# 10)</td>
<td>10-30</td>
</tr>
<tr>
<td>425 µm (# 40)</td>
<td>5-25</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>&lt;12.0</td>
</tr>
</tbody>
</table>

In the production of Class 7 aggregate materials, the different aggregate types shall be blended at uniform proportions/rates.

At the time of testing, aggregate mixtures containing salvaged materials shall be further identified as to the type of recycle/salvage aggregate materials that are incorporated into the final product by the following designations:

- B - Bituminous Mixture ......................................................... 7(B)
- C - Concrete ........................................................................... 7(C)
- BC - Bituminous and Concrete ........................................... 7(BC)
- G - Glass ................................................................................ 7(G)
- BG ....................................................................................... 7(BG)
- CG ........................................................................................ 7(CG)
- BCG ..................................................................................... 7(BCG)
- M - Misc. - must be specified in Special Provisions

#### Crushing
Crushing will be required for Class 5 and 6 aggregates. For these classes of aggregate, crushing will be required of all stones larger than the maximum size permitted by the gradation requirements and that will pass a grizzly or bar grate having parallel bars spaced 200 mm (8 inches) apart. However, the Engineer may allow rejection of oversize material when excessive crushing results in an unsatisfactory gradation.
Class 6 aggregates shall contain at least 15 percent crushed material. Class 5 aggregates shall contain at least 10 percent crushed material. The percentage of crushing shall be determined by the procedures described in the Grading and Base Manual. A tolerance of 2 percent will be allowed on each individual test, but the average of all material tested for the project shall meet the specification requirements. It may be necessary to add stones or crushed rock from another source to meet the crushing requirements.

**D Los Angeles Rattler Loss**

The Los Angeles Rattler Loss requirements shall apply only to the crushed quarry or mine rock portion of the aggregate.

<table>
<thead>
<tr>
<th>Class of Aggregates</th>
<th>Los Angeles Rattler Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 4, 5, 6, 7</td>
<td>40% maximum</td>
</tr>
<tr>
<td>6, ...</td>
<td>35% maximum</td>
</tr>
</tbody>
</table>

The LAR maximum loss shown for Class 7 shall be determined on the virgin aggregate portion of the mixture prior to the incorporation of the salvage/recycle materials into the final composite mixture.

**E Shale**

Class 3, 4, and 5 aggregate shall contain not more than 10.0 percent shale in the total sample; except that, when the part passing a 75 µm (#200) sieve exceeds 7.0 percent, the percentage of shale in the total sample shall not exceed 7.0 percent.

Class 6 aggregate shall contain not more than 7.0 percent shale in the total sample.

The virgin aggregate portion of the Class 7 mixture shall not contain more shale than allowed for the Class of aggregate that the substitution is being made. Testing for compliance shall be performed prior to the incorporation of the salvage/recycled materials into the final composite mixture.

**3138.3 SAMPLING AND TESTING**

Samples for testing to determine compliance with the aggregate gradation specifications for base and shoulder surfacing will be obtained from the roadway at a time when the material is ready for compaction. The samples may be obtained from the windrow or after blending and spreading of the material on the roadway. However, Classes 1, 2 and 7 shoulder surfacing aggregates may be sampled from a stockpile, tested, and accepted before roadway placement, provided that:

(a) No more than 25 percent of the stockpile samples fail to meet gradation requirements.

(b) The average of all stockpile tests meet requirements.

(c) The contractor mixes the material during placement to the satisfaction of the Engineer.
The stockpile shall be sampled at the rate of one field gradation test per metric tons (tons) of aggregate used on the project. If calcium chloride is incorporated in a central mixing plant, the aggregate will be sampled before such materials are added.

A Sampling, Sieve Analysis, Shale, and Crushing Test ........... Mn/DOT Grading and Base Manual
B Los Angeles Rattler Loss..................................................... Mn/DOT Laboratory Manual Method 1210
C Sampling and Shale Tests ................................................ Mn/DOT Laboratory Manual Method 1210
D Bitumen Content: ......... Mn/DOT Laboratory Manual
a) By Extraction......................................................... Method 1852
E Insoluble Residue............. Mn/DOT Laboratory Manual
F Reclaimed Glass ........... American Geophysical Institute
This specification covers graded aggregate for use in bituminous mixtures.

The aggregate shall consist of sound, durable particles of gravel and sand, crushed stone and sand, or combinations thereof. It shall be free of matter such as metal, glass, plastic, brick, rubber, and any other objectionable material. Coarse aggregate shall be free from coatings of clay and silt to the satisfaction of the Engineer.

The Contractor shall not compensate for the lack of fines by adding soil materials such as clay, loam, or silt. Overburden shall not be blended into the bituminous aggregate.

The aggregate shall conform to one of the following classifications. The class of aggregate to be used shall be the Contractor’s option unless otherwise specified in the Contract.

Class A aggregate shall consist of crushed igneous bedrock (specifically; basalt gabbro, granite, rhyolite, diorite and andosite) and rock from the Sioux Quartzite formation. Other igneous or metamorphic rock may be used with specific approval of the Engineer. Class A materials may contain no more than 4.0% non-Class A aggregate. This recognizes the fact that some quarries may contain small pockets of non-Class A material within that source. Intentional blending or addition of non-Class A material is strictly prohibited!

Class B aggregate shall consist of crushed rock from all other bedrock sources as carbonate and metamorphic rocks. (gneiss or schist)

Class C aggregate shall consist of natural or partly crushed natural gravel obtained from a natural gravel deposit.

Class D aggregate shall consist of 100 percent crushed natural gravel. The crushed gravel shall be produced from material retained on a square mesh sieve having an opening at least twice as large as the Specification permits for the maximum size of the aggregate in the composite asphalt mixture. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.
A2e  Class E
Class E aggregate shall consist of a mixture of any two or more of
the following: Class A, Class B, and/or Class D. The relative
proportions of the constituent aggregates shall be accurately controlled
either by the use of a blending belt approved by the Engineer prior to
production or by separately weighing each aggregate during batching
operations.

A3  Bituminous Mixture Components
Components for bituminous mixtures produced under 2360 shall be
Class A, Class B, Class C, Class D, Class E, taconite tailings, steel slag,
or combination thereof. The use of Class E aggregate, as well as the
relative proportions of the different constituent aggregates, shall be
subject to the approval of the Engineer.

A3a  Steel Slag (SS)
Steel slag may be used in quantities not to exceed 25 percent of the
mass of the total aggregate. Stockpiles will be accepted for use if the
total expansion, determined by ASTM D4792, is less than 0.50%.

A3b  Taconite Tailings (TT)
Taconite tailings shall be obtained from ore that is mined westerly
of a north-south line located east of Biwabik, MN (R15W-R16W);
except that taconite tailings from ore mined in southwestern Wisconsin
will also be permitted for use. Approved taconite tailing sources are on file with the Bituminous
Engineer.

B  Gradation
See 2360.2E for gradation requirements.

C  Crushing
C1  Blank
C2  Manufactured Crushed Fines (minus 4.75 mm (# 4) material)
for Bituminous Mixtures produced under 2360
All Class A, B, D, and E material that passes the 4.75 mm (# 4)
sieve will be considered as crushed fines.
To produce Manufactured Crushed Fines (minus 4.75 mm (# 4) material) from Class C aggregate, the following procedure can be used. Retained material from a gravel source by passing the gravel over a 9.5 mm (⅜ inch) or larger sieve, prior to mechanical crushing. The amount of carryover (material finer than the selected screen) shall not exceed ten percent. The material which passes the 9.5 mm (⅜ inch) screen shall not be incorporated into the manufactured crushed fines but may be used to the extent that it qualifies for natural sand. The material retained on the 9.5 mm (⅜ inch) screen shall be crushed. The material that passes the 4.75 mm (# 4) screen, after crushing, will be considered as 100% crushed fines. Material retained on the 4.75 mm (# 4) screen after crushing will not be counted as crushed plus 4.75 mm (# 4) material, until tested.

D  Quality Requirements
See 2360.2C for aggregate quality requirements.

3139.3  SAMPLING AND TESTING
A  Sampling; Sieve Analysis; Lumps, Crushing; Shale Test; Spall Test:..... Mn/DOT Bituminous Manual
B  Los Angeles Rattler Test ......................... AASHTO T 96
C  Soundness (Magnesium Sulfate)...............AASHTO T 104
D  Insoluble Residue ..............................................Mn/DOT Materials Laboratory 1221

3145
Mineral Filler

3145.1  SCOPE
This Specification covers materials to be used as mineral filler in the construction of bituminous surfaces.

3145.2  REQUIREMENTS
A  Composition
Mineral filler shall consist of carbonate dust, Portland cement, hydrated lime, crushed rock screenings, fly ash, or rotary lime kiln dust, subject to approval by the Engineer.
Crushed rock screenings to be used as mineral filler shall be of such composition and quality that the bituminous mixture containing the rock screenings will have stability and durability equivalent to those of the comparable mixture containing one of the other acceptable filler materials. The rock screenings shall be free from clay and shale.
B  Gradation
The mineral filler shall all be finer than a 4.75 mm (# 4) sieve and shall contain not less than 25 percent of material passing a 75 µm (# 200) sieve.
The portion of the filler passing the 75 µm (#{200}) sieve shall meet the following gradation (does not apply to cement or hydrated lime):
Percent finer than 0.020 mm ................................................... 35-100
Percent finer than 0.005 mm ............................................... 10-40
Percent finer than 0.001 mm ....................................................... 1-25

C Condition
Mineral filler which is to be added directly to the dried aggregate for the bituminous mixture shall be thoroughly dry and free from lumps consisting of aggregations of fine particles.

Crushed rock screenings used as mineral filler shall be of uniform gradation and shall be processed and handled in such a manner as will prevent segregation. The rock screenings shall be dried by passing through the dryer.

3145.3 SAMPLING AND TESTING
A Sampling .................... Mn/DOT Bituminous Manual
B Fineness
  Sieve Analysis ....................... AASHTO T 27
  Hydrometer Analysis.................. AASHTO T 88.4
(A) This procedure is modified to permit the use of Gum Arabic as a dispersing agent if flocculation occurs.

3146 Binder Soil

3146.1 SCOPE
This Specification covers soil material for use as a binding agent in soil-stabilized aggregate mixtures for base and surface courses.

3146.2 REQUIREMENTS
A Composition
The binder soil shall consist principally of fine soil particles, but it may contain gravel pebbles provided their size does not exceed the maximum size of the aggregate being used. The gradation of the binder soil shall be such that, at the time it is added to the aggregate, 100 percent will pass a 19.0 mm (¾ inch) sieve and at least 50 percent will pass a 4.75 mm (#4) sieve.

The binder soil shall not contain sod, roots, plants, leaf mold, or any other objectionable material.

Flyash, incinerator ash, or any other materials that are a byproduct of a manufacturing process or a waste material are not considered binder soil.

B Physical Properties
The fraction of the binder soil which passes a 425 µm (#40) sieve shall have a liquid limit not greater than 45.
3146.3 SAMPLING AND TESTING
A  Sampling........................................Mn/DOT Grading and Base Manual
B  Liquid Limit ........................................AASHTO T 89
C  Sieve Analysis........ Mn/DOT Grading and Base Manual

3149
Granular Material

3149.1 SCOPE
This Specification covers granular material for use in bedding or backfilling structures and miscellaneous service facilities; for use in grading construction to correct or improve subgrade and foundation weaknesses; or for other specified purposes.

3149.2 REQUIREMENTS
The source of supply and quality of the material is subject to approval by the Engineer in accordance with 1601.

The material shall consist of sound durable particles of gravel and sand, crushed quarry or mine rock, crushed gravel or stone, crushed concrete, salvaged bituminous mixture, or any combination thereof, subject to the requirements hereof. The material shall not contain sod, roots, plants, other organic matter, reinforcing steel, or other objectionable material.

Unless otherwise permitted, specific gravity of the material shall be not less than 2.300 nor more than 2.900.

In the production of stabilizing aggregate (3149.2C) and aggregate bedding (3149.2G), crushing will be required of all stones larger than the maximum size permitted by the gradation requirements and that will pass a grizzly or bar grate having parallel bars spaced 200 mm (8 inches) apart. However, the Engineer may allow rejection of oversize material when excessive crushing results in an unsatisfactory gradation. The crushed particles in stabilizing aggregate and aggregate bedding shall be not less than 10 percent of the material. The percentage of crushing shall be determined by the procedures describe in the Grading and Base Manual. A tolerance of 2 percent will be allowed on each individual test made to determine the percent of crushing, but the average of all material tested for the Project shall meet the Specification requirements. To meet the crushing requirements, it may be necessary to add stones or crushed rock from another source.

A  Salvaged Bituminous Mixture, Crushed Concrete, and Crushed Carbonates

The Contractor may use salvaged bituminous, crushed concrete and crushed carbonates as a granular material except as limited below.
A1   Salvaged Bituminous Mixture
The Contractor shall not use salvaged bituminous mixture as a filter aggregate (3149.2H and 3149.2J).

The bitumen content in the composite aggregate shall not exceed 3.0 percent by mass. Nonconforming materials shall be subject to the provisions of Table 2211-D.

A2   Crushed Concrete
The Contractor must receive the Engineer's approval before using crushed concrete in proximity to perforated drains for all uses not specifically addressed in the Contract. The Contractor shall not use crushed concrete as a granular material in embankment or backfill where perforated pipe is installed, or is to be installed, or where water moving through these materials may enter the perforated pipe, except as:

(a) Granular material (3149) below the invert elevation of any perforated subsurface drainage pipe.
(b) Granular material (3149) provided that:
   (1) All concrete material is larger than the 4.75 mm (# 4) sieve.
   (2) Concrete material between the 4.75 mm (# 4) sieve and the 50 mm (2 inch) sieve does not exceed 15 percent by mass, based on the composite of all material smaller than 50 mm (2 inch).
   (3) When the concrete material is larger than 50 mm (2 inch) the limitations described in the above provisions of (2) shall not apply. However, the Contractor shall not place material larger than 50 mm (2 inch) within 600 mm (2 feet) of the location of any perforated pipe drain that will subsequently be placed by machine trencher. Such material must be blended/mixed as appropriate with other non-concrete materials to meet all gradation and construction requirements.
   (4) For perforated drains associated with retaining walls/structures, the above provisions (1) through (3) shall apply only to the portion of select granular modified (0-10 percent passing the 75 µm (# 200) sieve) above the invert of the perforated pipe and within the zone 450 mm (18 inches) from the pipe centerline and up and away from the structure at a 2 vertical to 1 horizontal slope.
(c) As stabilizing aggregate (3149.2C). However, the application rate shall not exceed the equivalent of 160 kg per m² (300 pounds per square yard) of surface area (approximately 75 mm (3 inches) thick), such as, 160 kg (300 pounds) of 100 percent crushed concrete, 320 kg (600 pounds) of 50/50 blend of crushed concrete and permitted aggregate, etc. If the crushed concrete
aggregate/blends are used as both stabilizing aggregate and aggregate base at the same location, the total equivalent application rate shall not exceed 160 kg per m² (300 pounds per square yard) of surface area (approximately 75 mm (3 inches) thick) as described above.

A3 Crushed Carbonates................................. 3138.2A3

B Granular and Select Granular Borrow

B1 Granular Borrow

Granular borrow, for general use in embankment or backfill construction, may be any pit-run or crusher-run material that is so graded from coarse to fine that, the ratio of the portion passing the 75 µm (#200) sieve divided by the portion passing the 25.0 mm (1 inch) sieve may not exceed 20 percent by mass. The material shall not contain oversize salvaged bituminous particles or stone, rock, or concrete fragments in excess of the quantity or size permissible for placement as specified.

B2 Select Granular Borrow

Select granular borrow, for special use in embankment or backfill construction or other specified purposes, may be any pit-run or crusher-run material that is so graded from coarse to fine that, the ratio of the portion passing the 75 µm (#200) sieve divided by the portion passing the 25 mm (1 inch) sieve may not exceed 12 percent by mass. The material shall not contain oversize salvaged bituminous particles or stone, rock, or concrete fragments in excess of the quantity or size permissible for placement as specified.

C Stabilizing Aggregate

Stabilizing aggregate used in improving subgrade stability shall meet the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0 mm (1 inch)</td>
<td>100</td>
</tr>
<tr>
<td>19.0 mm (¾ inch)</td>
<td>90-100</td>
</tr>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>50-95</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>35-85</td>
</tr>
<tr>
<td>2.00 mm (#10)</td>
<td>20-70</td>
</tr>
<tr>
<td>425 µm (#40)</td>
<td>10-45</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>7-15</td>
</tr>
</tbody>
</table>

When the aggregate consists totally of crushed concrete the part passing the 75 µm (#200) sieve shall be not less than 3 percent nor more than 15 percent. (Also see 3149.2A2.) Stabilizing aggregate shall contain a minimum mass of crushed particles in accordance with the requirements of 3149.2.
D   Granular Backfill
Granular backfill material may be any pit-run or crusher-run mineral product that will all pass a 75 mm (3 inch) sieve and that is so graded from coarse to fine that, the ratio of the portion passing the 75 µm (#200) sieve divided by the portion passing the 25 mm (1 inch) sieve may not exceed 20 percent by mass.

E   Aggregate Backfill
Aggregate backfill material shall be a graded mineral product meeting the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm (2 inch)</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>35-100</td>
</tr>
<tr>
<td>2.00 mm (#10)</td>
<td>20-70</td>
</tr>
<tr>
<td>425 µm (#40)</td>
<td>10-35</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>3-10</td>
</tr>
</tbody>
</table>

F   Granular Bedding
Granular bedding material shall be a graded aggregate product of which 100 percent will pass the 25.0 mm (1 inch) sieve and not more than 10 percent will pass the 75 µm (#200) sieve.

G   Aggregate Bedding
Aggregate bedding material shall be a graded mineral product meeting the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0 mm (1 inch)</td>
<td>100</td>
</tr>
<tr>
<td>19.0 mm (¾ inch)</td>
<td>90-100</td>
</tr>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>50-90</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>35-80</td>
</tr>
<tr>
<td>2.00 mm (#10)</td>
<td>20-65</td>
</tr>
<tr>
<td>425 µm (#40)</td>
<td>10-35</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>3-10</td>
</tr>
</tbody>
</table>

Aggregate bedding material shall contain a minimum mass of crushed particles in accordance with the requirements of 3149.2.

H   Coarse Filter Aggregate
Coarse filter aggregate shall be a free draining mineral product, excluding crushed carbonate quarry rock, crushed concrete, and salvaged bituminous mixture, and meeting the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0 mm (1 inch)</td>
<td>100</td>
</tr>
<tr>
<td>19.0 mm (¾ inch)</td>
<td>85-100</td>
</tr>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>30-60</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>0-10</td>
</tr>
</tbody>
</table>

I   Blank
3149.2

J Fine Filter Aggregate
Fine filter aggregate shall be a free draining mineral product, excluding crushed carbonate quarry rock, crushed concrete, and salvaged bituminous mixture, and meeting the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>.......................................................... 100</td>
</tr>
<tr>
<td>4.75 mm (# 4)</td>
<td>......................................................... 90-100</td>
</tr>
<tr>
<td>2.00 mm (# 10)</td>
<td>.......................................................... 45-90</td>
</tr>
<tr>
<td>425 µm (# 40)</td>
<td>.......................................................... 5-35</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>.......................................................... 0-3</td>
</tr>
</tbody>
</table>

K Sand Cover
Sand cover material shall consist of sound durable particles of sand and gravel meeting the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 mm (# 4)</td>
<td>.......................................................... 100</td>
</tr>
<tr>
<td>2.00 mm (# 10)</td>
<td>.......................................................... 95-100</td>
</tr>
<tr>
<td>425 µm (# 40)</td>
<td>.......................................................... 0-50</td>
</tr>
<tr>
<td>75 µm (# 200)</td>
<td>.......................................................... 0-8</td>
</tr>
</tbody>
</table>

3149.3 SAMPLING AND TESTING
A Sampling and Testing

B Bitumen Content
a) By Extraction

C Insoluble Residue

3151 Bituminous Material

3151.1 SCOPE
This specification covers bituminous materials consisting of asphalt binder, cut-back asphalt, and asphalt emulsion.

3151.2 REQUIREMENTS
The bituminous materials used shall meet the following requirements for the type and grade specified. Only Bituminous Material supplied from a Mn/DOT certified source is approved for use. A list of certified sources can be accessed on the Office of Materials website.
A   Asphalt Binder
   Only Performance Grade (PG) Asphalt Binder is approved for use. PG Asphalt Binder shall conform to AASHTO M 320 and the Combined State Binder Group Method of Acceptance for Asphalt Binder. A copy of the Combined State Binder Group Method of Acceptance for Asphalt Binder is on file with the Chemical Laboratory.

   Use asphalt binder supplier recommendations for mixing and compaction temperatures.

B   Medium Curing Liquid Asphalt   AASHTO M 82
   In lieu of viscosity of the residue, the penetration at 25ºC (77ºF); 100 g; 5 s, shall be 120 to 250 for all grades.

C   Emulsified Asphalt
   Emulsified asphalt shall meet the requirements of AASHTO M 140 for the type and grade specified, subject to the following modifications:
   (1) The viscosity for HFMS-2, HFMS-2h, and HFMS-2s grades shall be 50 SFS (Saybolt Furol, seconds) at 50ºC (122ºF), minimum.

D   Cationic Emulsified Asphalt
   Cationic Emulsified Asphalt shall meet the requirements of AASHTO M 208.

E   Polymer Modified Cationic Emulsified Asphalt
   Polymer Modified Cationic Asphalt shall meet the requirements of AASHTO M316-98.

F   Polymer Modified High Float Emulsified Asphalt

   HFMS-2P
   The emulsified asphalt must be homogeneous. Within 30 days of delivery and provide separation has not been caused by freezing, the emulsified asphalt shall be homogeneous after thorough mixing.
   The polymer modification shall be done before emulsification process.
   The emulsified asphalt shall conform to the requirements of Table 3151-1.

Table 3151-1. Emulsified Asphalt Requirements.

<table>
<thead>
<tr>
<th>Tests on Emulsion</th>
<th>Specification</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity, Saybolt Furol</td>
<td>50-450</td>
<td>AASHTO T-59</td>
</tr>
<tr>
<td>@ 50 ºC (122ºF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Stability, 24 hour, %</td>
<td>1.0 -</td>
<td>AASHTO T-59</td>
</tr>
<tr>
<td>Sieve Test, %</td>
<td>0.10 -</td>
<td>AASHTO T-59</td>
</tr>
<tr>
<td>Residue by Distillation, %</td>
<td>65+</td>
<td>AASHTO T-59</td>
</tr>
<tr>
<td>Oil distillate</td>
<td>3.0 -</td>
<td>AASHTO T-59</td>
</tr>
<tr>
<td>by volume of emulsion, %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3151.2  
Tests on Residue from Distillation

Penetration, 25 °C (77 °F), 100-200 AASHTO T-49
Float Test, 60 °C (140 °F), sec 1200+ AASHTO T-50
Elastic Recovery, % 58 AASHTO T-301

3151.3  SAMPLING
Sampling shall be in accordance with the procedures prescribed in AASHTO T-40 and the Schedule for Materials Control.

3161  
Anti-Stripping Additive

3161.1  SCOPE
This Specification covers anti-stripping additives which, when added to asphalt binder will improve its moisture-sensitivity and adhesion properties with aggregate.

3161.2  REQUIREMENTS
A  General
The additive shall be completely miscible in all types of bituminous materials and shall show no separation or settlement when the blended material is stored for an indefinite length of time at any temperature to which it might be exposed in actual use.

The additive shall have no injurious effect upon the bituminous material. The asphalt binder/anti-strip additive blend shall meet AASHTO M320.

B  Stability
The anti-stripping properties of the additive shall not be deleteriously affected by prolonged heating of the blend of additive and asphalt binder.

C  Concentration
The concentration of the additive shall be such that the bituminous mixture will meet the requirements of the Modified Lottman Test. The Modified Lottman Test procedure is on file in the Bituminous Office.

D  Packaging
If ordered in drums, the additive shall be shipped in the manufacturer's containers, properly labeled as to the name of the manufacturer, trade name or trade mark, manufacturer's lot number, date of manufacturer and the net mass of the contents.

The additive shall be of uniform consistency from drum to drum in a given shipment.
3161.3 SAMPLING AND TESTING
A General
The asphalt binder/anti-strip blend and the HMA shall be sampled and tested according to the Materials Control Schedule.

3165 Asphalt Primer for Dampproofing and Waterproofing
Asphalt primer for use with asphalt in dampproofing and waterproofing concrete and masonry surfaces above or below ground level shall conform to ASTM D 41-94.

3166 Asphalt for Dampproofing and Waterproofing
Asphalt for use as a mopping coat for dampproofing or as a plying or mopping cement in the construction of a membrane system of waterproofing shall conform to ASTM 449-89. Unless otherwise specified, Type II shall be used.
3201 Saturated Fabric for Waterproofing
The fabric shall conform to AASHTO M 117, and shall be saturated with asphalt.
The asphalt saturated fabric shall be used in conjunction with asphalt for waterproofing Mn/DOT 3166.

3204 Premolded Asphalt Plank
The asphalt plank shall conform to ASTM D 517 for the type specified in the Contract.

3222 Corrugated Aluminized Steel Pipe (Type 2)
3222.1 SCOPE
This Specification covers corrugated aluminized steel pipe and pipe arches intended for use in the construction of culverts, underdrains, and sewers.

3222.2 REQUIREMENTS
The pipe shall be fabricated from Type 2 aluminum-coated steel sheets conforming to AASHTO M 274. Pipe fabrication shall be in conformance with AASHTO M 36M, together with all applicable requirements of 3226.
Each pipe section shall bear the identification marks required by AASHTO M 274.

3225 Corrugated Aluminum Pipe
3225.1 SCOPE
This Specification covers corrugated aluminum alloy pipe for use as culverts and underdrains.
The size of circular pipes will be designated by the nominal inside diameter. The size of pipe-arches will be designated by the span width.

3225.2 REQUIREMENTS
The pipe shall conform to AASHTO M 196 together with the following additional requirements or modifications thereof:
A Physical Properties
Unless otherwise specified in the Plans or Special Provisions, the least thickness of metal listed for a specified diameter may be furnished.
B Coupling Bands
Field joints shall be made with aluminum alloy coupling bands conforming to AASHTO M 196 and to the details shown in the Plans.
3225.2 Aprons

Aluminum aprons for circular pipes shall be manufactured in accordance with the pertinent requirements of these Specifications for corrugated aluminum pipe and shall conform to the dimensions, design, and details shown in the Plans.

D Identification Marks

Each pipe section shall bear the identification marks required by AASHTO M 196.

3225.3 INSPECTION AND TESTING

The sections under Inspection in AASHTO M 196 shall apply.

3226 Corrugated Steel Pipe

3226.1 SCOPE

This Specification covers prefabricated corrugated steel pipe intended to be used in the construction of culverts and underdrains.

For the purposes of this Specification, the unmodified term "pipe" shall be understood to refer to any or all types.

The size of the circular pipe will be designated by the nominal inside diameter. The size of the pipe-arches will be designated by the span width.

3226.2 REQUIREMENTS

Pipe shall conform to AASHTO M 36M for the type specified in the Contract, together with the following modifications or additions thereto:

A Blank

B Dimensions

Dimensions shall conform to AASHTO M 36M except as modified below:

(1) Nominal sheet thickness for each size of pipe shall be as shown in the Plans. The sheet thickness designated shall be the "Specified Thickness" as given in Table 4 of AASHTO M 218.

(2) Corrugation size shall be 38 mm by 6.5 mm (1 ½ inch x ¼ inch), 68 mm x 13 mm (2 ¼ inch x ½ inch), 75 mm by 25 mm (3 inch x 1 inch), or 125 mm x 25 mm (5 inch x 1 inch) as shown in the Plan. The corrugation dimensions shall be in accordance with Table 1 of AASHTO M 36M for the size furnished.

(3) Corrugation size for spiral ribbed pipe shall be 19 mm x 19 mm x 190 mm (¾ inch x ¾ inch x 7 ½ inch). The corrugation dimensions shall be in accordance with Table 3 of AASHTO M 36M for the size furnished. The section properties shall be in accordance with AASHTO Design Criteria for Highway Bridges, Section 12.5.4.
C  Blank

D  Appurtenant Parts and Sections

Metallic coated steel aprons shall be fabricated in accordance with the pertinent requirements of this Specification and 3351.

Elbow, tee, and wye sections shall be furnished as required for each installation, and they shall be fabricated from standard pipe sections, using mitered and welded joints, forming the required intersection angles. Special adapters shall be furnished as necessary to make connections between different sizes and types of pipe.

An outlet screen shall be furnished at each free end of underdrain systems. Metal end caps may be furnished to close the dead ends of pipe in lieu of installing concrete or vitrified clay plugs.

E  Identification Marks

Each pipe section shall bear the identification marks required by AASHTO M 196.

Sheet thickness, as designated in the markings on sheets and coils, shall be the Specified Thickness as given in Table 4 of AASHTO M 218.

3226.3 INSPECTION AND ACCEPTANCE

Units on which the spelter coating has been burned by shop welding or otherwise damaged in shop fabrication will not be accepted unless they are regalvanized satisfactorily by the hot-dip process or the metallizing process as described in AASHTO M 36M. Shop repairs shall not be made with zinc paint. Spelter coating repairs by the metallizing process will be required on butt-welded seams of helical corrugated pipe if the adjacent spelter coating is burned to a width exceeding three times the metal thickness.

Upon delivery, each unit will be inspected for compliance with the details of construction, workmanship, and finish requirements. In addition to all other defects constituting cause for rejection, any units damaged during shipment or fabrication at the job site will be subject to rejection.

Repairs to spelter coating made necessary by field welding or fabrication at the job site may be accomplished by zinc painting, in lieu of regalvanizing. The Contractor shall use a Mn/DOT approved zinc-rich coating. The approved products list can be accessed on the Office of Materials website. The area to be coated shall be cleaned by sandblasting or other methods approved by the Engineer. Application of the zinc coating shall be in accordance with detailed instructions supplied by the paint manufacturer.
Bituminous Coated Corrugated Metal Pipe

3227.1 SCOPE
This Specification covers bituminous coated corrugated metal pipe and pipe-arches intended for use in the construction of culverts.

The bituminous coating shall be one of three types, as specified in the Contract, and as defined by the following:
- Type A - Fully Bituminous Coated
- Type B - Half Bituminous Coated, with Paved Invert
- Type C - Fully Bituminous coated, with Paved Invert

3227.2 REQUIREMENTS
The uncoated pipe and connecting bands, together with aprons when specified, shall conform to 3226.

The bituminous coating shall conform to AASHTO M 190, for the type of coating specified in the Contract. Pipe with Type A coating shall be furnished when no other type is specified.

The coated pipe shall meet AASHTO M 190 for the Shock Test and Flow Test, and shall also pass the Impact Test as described by the following:

A steel ball 57 mm (2 ¾ inches) in diameter and having a mass of 758 g (1.67 pounds) shall be dropped from a height of 2300 mm (7 ½ feet) through a vertical tube 75 mm (3 inches) in diameter, upon the outside crest of a representative sample. This test shall be conducted with the specimen at a temperature of -1°C (30°F). Failure of the material is indicated by its spalling from the metal on the inside of the pipe or by the formation (on the inside of the pipe) of cracks longer than 13 mm (½ inch) from the point of impact.

3227.3 INSPECTION AND TESTING
Sampling and testing will be performed in accordance with the applicable provisions of AASHTO M 190, except as modified by the following:
(a) Specimens for the Impervious and Impact tests shall consist of a segment taken from the coated pipe or coupling band.
(b) Bituminous material specimens may be secured from the material as used or stripped from the coated pipe or band.

Inspect the finished product for satisfactory workmanship in all particulars. The bituminous coating shall be a continuous film: free from cracks, burned areas, blisters, and other injurious defects.
3228
Aramid-Bonded Corrugated Steel Pipe

3228.1 SCOPE
This Specification covers corrugated steel pipe having aramid fiber impregnated in the spelter coating during fabrication of the sheets and with a bituminous coating being applied to the pipe after fabrication. When Type C aramid bonded corrugated steel pipe is specified, the pipe shall also have a paved invert.

3228.2 REQUIREMENTS
The pipe and connecting bands shall be fabricated in accordance with 3226, together with the following additional requirements or modifications:

A  Aramid Bonding
The base metal sheets shall be galvanized on both sides by the hot-dip process, with the spelter being applied at such rate that, when sampled and tested as prescribed, the recoverable quantity of spelter, after the aramid bond has been removed, shall be not less than 460 g/m² (1 ½ ounce per square foot). The mass of spelter is the total quantity of galvanizing on both sides of a sheet, expressed as grams/m² (ounces per square foot) of sheet.

Both sides of the zinc coated metal sheets shall be coated with a layer of aramid fiber applied in sheet form and pressed into the molten zinc. The finished sheets shall show careful workmanship and shall be free from injurious defects such as blisters, areas lacking aramid or zinc spots.

B  Bituminous Coating
After fabrication of the pipe with aramid bonded sheets, the pipe and coupling bands shall be given a full bituminous coating in accordance with AASHTO M 190 for Type A.

C  Invert Paving
When a paved invert is specified, the bituminous coated aramid bonded pipe shall also be given the paved invert treatment in accordance with AASHTO M 190 for Type C.

D  Physical Properties
The finished pipe (coated and paved) shall weigh not less than the theoretical computed mass.

E  Repair of Damaged Coating
Units on which the coating has been damaged by welding or otherwise damaged in fabrication, shipment, or installation shall be repaired to the Engineer's satisfaction by having the damaged portions cleaned, primed, and recoated with the original materials or approved equals.
3228.3

3228.3 INSPECTION AND TESTING
Sampling and testing will be performed in accordance with the applicable provisions of AASHTO M 190, except as modified by the following:
(a) Specimens for the impervious and impact tests shall consist of a segment taken from the coated pipe or coupling band.
(b) Bituminous material specimens may be secured from the material as used or stripped from the coated pipe or coupling-band.
(c) Solubility in Trichloroethylene ......................... AASHTO T 44
Inspection of the finished product shall show careful workmanship in all particulars. The bituminous coating shall be a continuous film, free of cracks, burned areas, blisters, and other injurious defects.
NOTE: Aramid-Bonded corrugated steel pipe shall conform to this Specification; however, when this material is specified in the Contract, material meeting 3229, Polymeric Coated Corrugated Steel Pipe, may be furnished as an approved alternate.

3229
Polymeric Coated Corrugated Steel Pipe
3229.1 SCOPE
This Specification covers polymeric coated corrugated steel pipe for use as culverts and underdrains.
Pipe furnished under this Specification shall be fabricated from precoated galvanized steel sheets conforming to AASHTO M 246. Pipe fabrication shall be in conformance with AASHTO M 245 together with all applicable requirements of 3226.
3229.2 REQUIREMENTS
When Type C coating is specified, the polymer coating thickness shall be as shown in the Plans.
In the absence of a prescribed coating type, the pipe shall be furnished with Type B coating.

3231
Galvanized Steel Structural Plate for Pipe, Pipe-Arches, and Arches
3231.1 SCOPE
This Specification covers galvanized corrugated steel structural plate and fasteners for use in the construction of pipe, pipe-arches, underpasses, and special shapes for field assembly.
3233.2 REQUIREMENTS
The structural plates and fasteners shall conform to AASHTO M 167, together with the following additional requirements or modifications:

A Fabrication
The plate thickness and section modulus shall be as shown in the Plans, or a different thickness and section modulus providing equal or greater strength may be furnished. The plate thickness designated shall be the specified thickness as given in Table 3 of AASHTO M 167.

The size and shape of the plates shall be such that the finished structure will have the dimensions shown in the Plans, and that either the longitudinal or transverse seams will be staggered in the finished structure.

All bolt holes shall be punched before the sheets are galvanized.

B Workmanship and Finish
All plates shall show careful and finished workmanship. Among other causes for rejection, the following defects are specified as constituting poor workmanship, and the presence of any of these defects in an individual plate or in general in any shipment shall constitute sufficient cause for rejection:

1. Incorrect plate shape, or unevenly lined or spaced bolt holes.
2. Plates with ragged edges, or with illegible or improper markings.
3. Bruised, scaled, broken, or improperly repaired spelter coating.
4. Dents or bends in the metal plate.

3231.3 INSPECTION AND ACCEPTANCE 3226.3

Aluminum Alloy Structural Plate for Pipe, Pipe-Arches, and Arches

3233

3233.1 SCOPE
This Specification covers corrugated aluminum alloy structural plate, accessories and fasteners for use in the construction of pipe, pipe-arches, arches, and special shapes, for field assembly.

3233.2 REQUIREMENTS
The structural plates, accessories and fasteners shall conform to AASHTO M 219, together with the following additional requirements or modifications:

A Fabrication
Plate thickness, pipe shape, sheet fabrication details, and assembly bolting shall be as shown in the Plans.

B Workmanship and Finish
All plates shall show careful and finished workmanship. Among other causes for rejection, the following defects are specified as
constituting poor workmanship, and the presence of any of these defects in an individual plate or in general in any shipment shall constitute sufficient cause for rejection:

1. Incorrect plate shape, or unevenly lined or spaced bolt holes.
2. Plates with ragged edges, or with illegible or improper markings.
3. Dents or bends in the metal plates.

3236
Reinforced Concrete Pipe

3236.1 SCOPE
This Specification covers reinforced concrete pipe of circular, arch, elliptical, or special shape and design, with appropriate appurtenances, used in the construction of culverts, sewers or underpasses.

3236.2 REQUIREMENTS
Reinforced concrete pipe shall conform to the following AASHTO Specifications, as identified by design, and subject to the additional requirements or modifications contained herein:

(a) Circular Pipe ....................................................... AASHTO M 170
(b) Pipe-Arch ............................................................ AASHTO M 206
(c) Elliptical Pipe......................................................... AASHTO M 207

Concrete aprons shall be manufactured in conformance with the Plans, together with the Specifications applying to the pipe design to which they are fitted.

Concrete cattle pass units shall be manufactured in conformance with the Plans and the pertinent requirements of AASHTO M 170 for Class III pipe of equivalent wall thickness. Cattle pass and apron units will not be subjected to external load bearing tests.

A Materials
A1 Aggregate quality .......................... 3126 and 3137
A2 Form release agents .......................... 3902
A3 Portland cement ............................. AASHTO M 85

Cement substitutions and the use of admixtures in accordance with 2461.3D and 2461.3E will be permitted except that the calendar date restrictions on their use shall not apply.

Positive slump (wet cast) 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 shall be maintained within the range of 5 to 8 percent.

A4 Metal Reinforcement .......................... 2472
B  Pipe Design

Design requirements for pipe shape, diameter, wall thickness, compressive strength of the concrete, and the quantity and type of circumferential reinforcement shall be as shown in the Plans for the different classes of pipe. However, pipe manufactured in conformance with the AASHTO Design Tables will be accepted in the case of elliptical pipe. Where AASHTO design requirements differ from those specified in the Plans, compliance shall be with the Plans, unless the different AASHTO requirements are approved as an alternate prior to manufacture.

Placement of reinforcement shall be in accordance with applicable AASHTO Specification, except as otherwise required by the Plans or approved by the Engineer. Elliptical reinforcement will not be permitted in circular pipe. Wire mesh shall be lapped a minimum of one full mesh or twenty wire diameters, whichever is greater. Laps may be welded for pipe, however, only welders approved by the Materials Engineer may perform this task.

When pipe are furnished for installations where rubber gasket seals are required, the tongue and groove or alternative offset joint design shall be as indicated in the Plans. All surfaces of the joint upon which the gasket may bear shall be smooth and free of spalls, cracks, fractures, and other imperfections that would adversely affect the performance of the rubber gasket sealer.

C  Manufacture

The Contractor shall use products fabricated in a precast concrete fabrication plant that has been granted plant pre-approval for acceptance of precast concrete products by the Materials Engineer. This program is based on the American Concrete Pipe Association Quality Assurance Manual. Under this program Fabricators are required to set up their total production on a pre-approved basis and certify that products furnished to the Contractor comply with the Contract requirements. Acceptance of products under this program will be limited to each precast concrete Fabricator and to each of the several plants as specifically and formally agreed to by the Materials Engineer. The approval is limited to the identified sizes of round pipe, arch pipe, and appurtenances.

For pipe requiring shear steel, the inspector shall be notified at the beginning of a production run. Shear steel must be pinned. This will include, "B" wall pipe, 1350 mm (54 inches), Class 5 and larger.

The concrete units shall be cured by the steam or water curing methods, unless the use of a sealing membrane or other effective methods is specifically approved by the Engineer. When steam curing is used, atmospheric temperature in the curing chamber shall not exceed
3236.2

71°C (160°F). The concrete units shall be protected from freezing, after being cast and until the curing is completed.

D Physical Tests

The Fabricator shall drill cores from the units for compressive strength tests not less than 100 mm (4 inches) in diameter.

The Engineer may either take specimens for the absorption test by drilling cores from the unit or by taking cores from a dummy section. The Contractor shall make dummy section at the same time as the standard unit, with the same the concrete, and by the same manufacturing methods except that reinforcement may be omitted.

E Permissible Variations

Permissible variations in dimensions shall be as shown in the Plans, or in the absence of specific Plan tolerances for any specified dimensions, shall be in accordance with the AASHTO Specifications.

3236.3 INSPECTION AND ACCEPTANCE

The Materials Engineer is the Engineer with authority regarding this Specification. The Materials Engineer will inspect the plant, arrange for and authorize each precast concrete Fabricator, and the individual plants, to furnish precast concrete products under the pre-approval program. To obtain authorization, the Fabricator must agree to abide by all the terms, conditions, and requirements contained in this program.

In the case of non-compliance with the pre-approval program or evidence of non-conformance of certified products, the Engineer may make any or all of the following judgements against the Fabricator:

(a) Rejection of the individual product.
(b) Rejection of the questioned shipment.
(c) Rejection of the identified day's production.
(d) Loss of pre-approval privileges.

A Plant Quality Control

A quality control program will be established in accordance with the Quality Assurance Manual, written by the American Concrete Pipe Association (ACPA). The Fabricator's quality control program will ensure that all material components and finished products conform to the applicable Contract. Because operations vary at each of the different plants, a quality control program shall be developed for each individual plant. The program shall include, but not necessarily be limited to:
A1 Internal Quality Control Program, with systematic:
(a) Sampling and testing of component materials or documentation of acceptability if materials were previously inspected and tested, or received from a certified source.
(b) Inspection of product manufacturing including:
   (1) Reinforcing steel fabrication and placement.
   (2) Concrete mix design and proportioning.
   (3) Concrete placement and consolidation.
   (4) Concrete curing.
(c) Testing of finished products:
   (1) Strength of concrete cylinders.
   (2) Three-edge-bearing test (round pipe).
   (3) Absorption and air content of pipe cores. A core will be required once during the year from pipe of each class, size, and type of manufacture, to verify the correct steel placement.
(d) Final visual inspection and marking (stamping).
(e) Maintenance of plant facilities and equipment in good, accurate condition.
A2 Resident Quality Control Technicians, shall be appointed by the Fabricator to conduct the quality control testing. They shall:
(a) Be a trained/certified (Mn/DOT Level I, Concrete Field Tester or ACI, Grade I) quality control technician and is responsible for insuring the conformance of all pre-approved products to the requirements.
(b) Be knowledgeable of the:
   (1) Plans and Specification requirements.
   (2) Product manufacturing operations.
   (3) Significance of the Specification requirements in producing quality products.
(c) Have authority to correct and stop or to stop any operation that is found to be causing non-conforming attributes, and to reject all products not meeting these requirements.
(d) Ensure that all requirements which relate to producing pre-approved products are continuously met.
(e) Be responsible for contacting the Mn/DOT inspector for prior approval of all repairs of more than ten percent of the respective surface, inside or outside.
A3 Equipment Calibration................................. 1901, 2461.4D4
A4 System of Record Keeping, shall include but not be limited to:
(a) Component material sources and their acceptable quality test results, authorized certification or evidence of inspection and testing.

(b) Test results covering product manufacture and the finished product as listed in the records section of the APCA manual.

(c) Records of manufactured products, by:
   (1) Date.
   (2) Size.
   (3) Class.

(d) A running inventory of pre-approved products in stock.

(e) Equipment calibration reports.

B Quality Assurance

A quality assurance program of random sampling, testing, and inspection will be performed by a representative of the Materials Engineer at each pipe plant operating under this program. This quality assurance program will consist of but is not limited to:

(1) Random sampling and testing of the materials used in the manufacture of pre-approved products.

(2) Random sampling and testing of the pre-approved pipe produced.

(3) Observing of the manufacturing process.

(4) Review of the manufacturer's quality control tests, inspection, records, and stockpiling practices.

(5) Inspection of pre-approved product inventory.

The inspector should visit the Fabricator's plant at least once per week to perform the tasks listed above. The records file should be checked once a month, and a spot inspection by the Engineer should be done every 6 months. (At least once during seasonal production).

All units will be subject to final inspection upon delivery.

C Testing Rates

The Fabricator's testing for the quality control program may be conducted by the manufacturer's own certified personnel, a Professional Engineer, or an independent inspection laboratory.

Because the quality control program must be tailored to each individual plant, the schedule and testing rates may vary from plant to plant. The following is offered as guidelines for the sampling, testing, and inspection of materials and finished products to be included in the quality control program.

C1 Concrete - The Fabricator shall test the concrete on each mix used as follows:

(a) Air Entrainment - one test per day for each positive slump mix.

(b) Concrete Strength - strength testing shall be performed according to the "Cylinder and Core Guidelines for Precast Pipe and Box Culverts", kept on file by the Materials Engineer.
C2 Load Bearing Test

The Fabricator shall conduct Three-Edge Bearing tests in accordance with AASHTO M170, on each size and class of pipe at the rate of the following schedule.

<table>
<thead>
<tr>
<th>Size Range mm (inches)</th>
<th>Class Range</th>
<th>Test Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 to 450</td>
<td>Class 5 &amp; below</td>
<td>1 per 1500 meters</td>
</tr>
<tr>
<td>(12 to 18)</td>
<td></td>
<td>(1 per 5000 feet)</td>
</tr>
<tr>
<td>525 to 1200</td>
<td>Class 5 &amp; below</td>
<td>1 per 900 meters</td>
</tr>
<tr>
<td>(21 to 48)</td>
<td></td>
<td>(1 per 3000 feet)</td>
</tr>
<tr>
<td>1350 to 1800</td>
<td>Class 4 &amp; below</td>
<td>1 per 600 meters</td>
</tr>
<tr>
<td>(54 to 72)</td>
<td></td>
<td>(1 per 2000 feet)</td>
</tr>
<tr>
<td>1350 to 1800</td>
<td>Class 5</td>
<td>1 per 300 meters</td>
</tr>
<tr>
<td>(54 to 72)</td>
<td></td>
<td>(1 per 1000 feet)</td>
</tr>
<tr>
<td>1950 to 2400</td>
<td>All Classes</td>
<td>1 per 300 meters</td>
</tr>
<tr>
<td>(78 to 96)</td>
<td></td>
<td>(1 per 1000 feet)</td>
</tr>
</tbody>
</table>

The schedule of testing shall commence anew whenever the mix design is changed, the production system is shut down for major repairs and renovations, or at the beginning of a new production season.

All pipe shall have developed the specified D-load prior to shipment.

The Fabricator shall give the inspector 48 hour advance notice of the testing being performed. The Engineer reserves the right to select pipe to be tested. The Fabricator may be required to perform additional testing as directed by the Engineer at no additional cost.

D Pipe Marking

In addition to the marking requirements of AASHTO M170, the word "Certified" and the manufacturing plant identification, shall be stamped inside each unit 600 mm (24 inches) in diameter or larger and outside on each unit less than 600 mm (24 inches) in diameter. Each unit of pipe, or allied product, so marked identifies the unit as being in conformance with all requirements.

All products manufactured for special projects not meeting the standards of the pre-approved program must be stamped with an identifying Project number or buyer's name.

Pre-approved shipments may be accepted if the product is marked CERTIFIED PLANT COMPANY (Actual size 100 mm x 100 mm (4 inches x 4 inches); the company identification, the individual production plant, and that the product is "certified")
The manufacturer of pre-approved materials shall furnish, with each shipment, a certified bill of materials or invoice which identifies the project number, Contractor, the type of material, the number of pieces of each size, class and length of pipe. One copy of the certification document shall accompany the shipment for the Project Engineer. The certification shall be signed by a designated, responsible company representative and shall be stated as follows:

"The materials itemized in this shipment are certified to be in compliance with the applicable Minnesota Department of Transportation Specifications and the Project Plans."

Authorized Signature and Date

The manufacturer of pre-approved materials shall furnish at the end of each calendar year or at regular intervals during the year, an itemized summary report of the year's shipments to each project, detailing project number, contractor, product shipped, number of pieces, length and tonnage.

Shipment of pre-approved products shall not be made until all quality control tests and inspections have been completed and the materials are found to comply with all requirements.

E Stockpiling

Products approved for shipment shall be stockpiled in a manner such that each piece is accessible for quality assurance inspection. The Fabricator shall stockpile special (non-pre-approved) stock in areas separate from the pre-approved stock.

3238 Precast Concrete Box Culverts

3238.1 SCOPE

This Specification covers the construction of precast concrete single and multi-cell box culverts, headwalls, and aprons at a precasting plant.

3238.2 REQUIREMENTS

A Fabrication Drawings, Falsework and Forms

Prior to fabrication of these units, the Contractor shall furnish shop drawings to the Engineer for review by the Office of Bridges and Structures to facilitate the Department's inspection. These drawings shall be complete and comprehensive, and shall include the number of mats, their makeup and configuration, as well as stirrup sizes and spacing for each type of segment required by the Plans.
The minimum length of individual sections shall be 1.2 m (4 feet) with provisions for each section to be tied to the adjacent section with concrete pipe ties as detailed on Mn/DOT Standard Plate 3145 and as required by the Plans.

B  Materials

B1  Concrete ................................................................. 2461

Mix designations shall be as indicated in the Plans for the specific Items of work.

B2  Reinforcement Bars ................................................. 3301
B3  Steel Fabric .......................................................... 3303

When laps are required, the lap shall be at least one full mesh plus 50 mm (2 inches) for transverse laps or one full mesh plus 50 mm (2 inches) plus 2 end overhangs for longitudinal laps.

C  Forms

Forms shall be designed to withstand the pressure due to concrete, vibration, and impact without distortion. They shall be set and maintained in a mortar tight condition, free of warp and on a rigid foundation. Joints in the sectional forms shall have a tight fit without offset. Forms shall be set so that the dimensions of the precast unit will conform to the Plans. Forms which preclude the obtaining of dimensional tolerances shall be repaired or replaced prior to casting additional sections of the precast units.

The face of the forms in contact with the concrete shall be treated with form coating material meeting 3902 before the form is set in position. Forms shall be thoroughly cleaned of accumulations of oil, concrete, and other substances prior to use.

D  Reinforcement Steel

Reinforcement steel shall be accurately placed in the position shown in the Plans, secured with chairs, supported, and tied in accordance with 2472. The concrete cover on reinforcement bars, at any point, shall not be less than 40 mm (1 1/2 inches) or as stated in the Plans. Reinforcement supports in contact with the precasting forms shall be stainless steel, plastic tipped, or hot or mechanically galvanized. Such coatings shall extend at least 25 mm (1 inch) from the form surface. Tack welding of reinforcement is not permitted unless Grade A706 steel is used and then only when specifically approved by the Materials Engineer.

E  Placement of Concrete

Concrete for each precast unit shall not be placed until the forms and steel placement have been inspected by the Department's representative.

The concrete in each precast unit shall be placed without interruption. The Concrete shall be vibrated internally, externally, or
both, as required to produce uniformly dense concrete and in such a manner as to avoid displacement of enclosures or steel units. Internal vibration shall conform with 2401.3 except that internal vibrators shall have a vibrating head not greater than 32 mm (1 ¼ inch) in diameter and shall operate at a frequency of not less than 100 Hz (6000 impulses per minute).

F  Concrete Curing

The precast concrete units shall be cured by the steam or water curing methods, unless the use of sealing membrane or other methods are authorized by the Engineer. When steam curing is used, it shall be in accordance with 2405.3. The Fabricator shall supply a temperature recording device when a steam cure is used. The device shall be placed as directed by the Engineer, and the records shall be provided to the Engineer.

Concrete shall be cured until a minimum compressive strength of 17 Mpa (2500 pounds per square inch) is obtained as evidenced by control cylinders cured with the product. Control cylinders may be cured apart from the precast unit if measures are taken to ensure that curing conditions for the cylinder are the same as for the precast unit. These measures will include temperature recording devices for both the control cylinders and for the precast concrete unit.

G  Concrete Finishing and Repair

All formed surfaces of the precast units shall have a uniform dense surface finish. Immediately after removal of the forms, the concrete surfaces shall be examined for areas of unsound concrete and defective surfaces due to faulty forms or form assembly, improper concrete placement, improper form removal, and other causes.

Concrete with porosity, honeycomb, delamination, hollow sound, or segregated materials shall be removed and replaced, but not until the Department's representative has viewed the extent of the defective concrete and has approved the method of repair and the materials to be used and provided such repair is performed in a timely manner. Individual repairs over 0.4 m² (4 square feet) on an inside or outside surface, and repairs to the tongue or groove down to the steel and longer than 1.2 m (4 feet), will not be allowed in the finished product.

Minor surface cavities or irregularities which do not impair the service value of the precast unit and which are satisfactorily repaired before curing shall not constitute cause for rejection.

Only repair methods and materials approved by the Engineer and detailed in the plant quality control program may be used to repair defects.
The Contractor shall fabricate precast concrete box culverts, end sections and appurtenances in a precast concrete fabrication plant that has been certified by the American Concrete Pipe Association, by the National Precast Concrete Association, or by another organization approved by the Materials Engineer. All quality control and plant certification records shall be available for inspection by the Engineer upon request.

### 3238.3 INSPECTION AND ACCEPTANCE

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

Plant inspection will be made of the units and each approved unit will be stamped with the official mark of the Department. All authorized repairs must be made before the unit is stamped, and no units shall be shipped without the official stamp of approval. At least 24 hours notice of intent to ship shall be provided, and such notice shall not be given until all necessary finishing and repair work is completed.

All units will be subject to final inspection upon delivery.

The inside of each box section shall be marked to identify the Project Number, overfill height, and segment number as shown on the Plans.

#### 3241

**Plastic Truss Pipe**

Plastic truss pipe, together with the couplings and fittings thereof, shall comply with ASTM D 2680, Acrylonitrile-Butadiene-Styrene (ABS) and Polyvinyl Chloride (PVC) Composite Sewer Piping. Unless otherwise specified, joint type shall be optional with the Contractor.

A Certificate of Compliance, furnished by the pipe manufacturer, in accordance with 1603, shall accompany each shipment of pipe.

#### 3245

**Thermoplastic Pipe**

Thermoplastic pipe and fittings shall meet one of the following: AASHTO M 278, Class PF 50, Polyvinyl Chloride (PVC) Pipe; ASTM D 2751, Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe, SDR 35; ASTM D 3034, Type PSM PVC Sewer Pipe, SDR 35; ASTM F 758, Smooth-Wall PVC, Type PS 46; or ASTM F 949, PVC Corrugated Sewer Pipe.

When perforated pipe is specified, perforations shall conform to the applicable Specification. Unless otherwise specified, perforations shall be 5 to 10 mm (0.2 to 0.4 inch) diameter, spaced 75 mm (3 inches) center-to-center, and have two rows of holes for 100 mm (4 inch) pipe
and four rows for 150 to 250 mm (6 to 10 inch) pipe. When perforation dimensions are not indicated in the applicable Specification, they shall conform to any of the configurations indicated for other pipe types permitted herein. Unless otherwise specified, joint type shall be optional with the Contractor.

A Certificate of Compliance, furnished by the pipe manufacturer, in accordance with 1603, shall accompany each shipment of pipe.

3247 Corrugated Polyethylene Pipe

Corrugated polyethylene pipe, together with the couplings and fittings, shall comply with AASHTO M 294, and Design Section 18 of the AASHTO Standard Specifications for Highway Bridges.

A Certificate of Compliance, furnished by the pipe manufacturer, in accordance with 1603, shall accompany each shipment of pipe.

Storage and handling of corrugated polyethylene pipe shall be in accordance with the manufacturer's recommendations except that in no case shall corrugated polyethylene pipe be exposed to direct sunlight for a total time of more than 6 months after fabrication. Damaged pipe shall not be used.

3251 Clay Pipe

Clay pipe shall conform to ASTM C 700-02 for the size, type, and class specified, subject to the following provisions:
(1) Compression joint shall conform to ASTM C 425.
(2) When requested by the Engineer, the pipe manufacturer shall furnish a Certificate of Compliance covering the material delivered.

3252 Cast Iron Soil Pipe

Cast iron soil pipe and fittings shall conform to ASTM A 74 for the class specified.
Nonreinforced concrete pipe shall conform to the applicable requirements of 3236 and AASHTO M 86 for the specified diameter and strength class, and when perforated pipe is specified the pipe shall also conform to the applicable requirements of AASHTO M 175 for the perforation type specified. Class 1 pipe may be furnished unless a higher strength class is specified.

To determine acceptability of the pipe, crushing tests may be made on concrete cylinders in lieu of the three-edge bearing test, in which case the concrete shall develop a compressive strength of not less than 21 MPa (3000 pounds per square inch) at 14 days.

Drain Tile

Concrete drain tile shall conform to AASHTO M 178. Clay drain tile shall conform to AASHTO M 179 and the class may be Standard unless otherwise specified.

Corrugated Polyethylene Drainage Tubing

Corrugated polyethylene (PE) tubing and fittings shall meet AASHTO M 252. A Certificate of Compliance, furnished by the manufacturer, in accordance with 1603, shall accompany each shipment of tubing.
3301

Reinforcement Bars

3301.1 SCOPE

This specification covers deformed and plain reinforcing steel intended for use as reinforcement in concrete construction.

3301.2 REQUIREMENTS

Reinforcement bars (other than wire) shall conform to one of the following AASHTO Specifications, as would apply to the size, type and grade required:

(a) Billet Steel Bars .................................................... AASHTO M 31
(b) Rail Steel Bars .................................................... AASHTO M322M/M 322
(c) Axle Steel Bars .................................................... AASHTO M 322M/M 322

Type and grade requirements may be indicated in the Plans or Specifications for the class of work involved. If not otherwise specified, reinforcement bars shall be Grade 420 MPa (60,000 psi) of any type except as modified by the following provisions:

(a) Reinforcement bars for use in any part of a concrete bridge (including precast units thereof), box culvert, or retaining wall, shall be deformed billet steel bars.
(b) Reinforcement bars for use in all other concrete structures except those described above shall be deformed bars of any type and grade.
(c) Any bar upon which welding is permitted or required shall meet ASTM A 706. (Note: All A 706 bars have a 414 MPa (60,000 psi) minimal yield point.)

When epoxy coated reinforcement bars are specified, coating shall be in conformance with AASHTO M 284. Application of epoxy coating shall be made in a fusion bonded epoxy coating plant that has been granted "Certification" by the Concrete Reinforcing Steel Institute, or an organization approved by the Materials Engineer.

The plant's quality control office shall maintain documentation containing the data required by certification. This documentation shall contain test data and measurements taken at times and locations approved by the Engineer, ensuring that monitoring, by personnel not directly involved in production, is sufficient for compliance with approved procedures.

All reinforcement shall be fabricated, stored, and placed in accordance with 2472.

3301.3 INSPECTION AND ACCEPTANCE

If the Engineer's review of fabrication work discloses that approved procedures are not being followed, the Fabricator shall immediately correct the procedure. The Engineer will determine what additional testing must be done by the Fabricator or, if necessary, what part of the work must be repaired or replaced.
Dowel Bars

Dowel bars shall be fabricated from Grade 40 or 60 steel in accordance with AASHTO M31 or M322/M322 and be epoxy coated in conformance with AASHTO M284. Shearing will be permitted provided the coating is not damaged and subject to permissible deformation. Any deformation larger than true shape shall not exceed 1 mm (0.04 inch) increase in diameter or thickness and shall not extend more than 10 mm (0.40 inch) from the dowel end.

Steel Fabric

Steel fabric for concrete reinforcement shall conform to AASHTO M55 or M221 for plain or deformed wire as specified, with the exception that oversize wire may be permitted, in which case the limitation on the difference between the maximum and minimum diameters shall not apply. Unless otherwise specified, the fabric may be furnished in either flat sheets or rolls.

Spiral Reinforcement

Wire used in the fabrication of spiral cage reinforcement for round columns shall be Cold Drawn Steel Wire for Concrete Reinforcement conforming to AASHTO M32 (ASTM A82) for the size shown in the Plans. In lieu of the cold drawn steel wire specified above, plain or deformed Grade 60 Billet steel bars conforming to 3301 (ASTM A615), may be substituted. When the spiral reinforcement is to be spliced by welding, the provisions of ANSI/AWS D1.4, Structural Welding Code - Reinforcing Steel, shall apply.
Low Carbon Structural Steel

3306.1 SCOPE
This Specification covers carbon steel shapes, plates, bars, sheets, and strips.

3306.2 REQUIREMENTS
A General
Steel furnished under this Specification shall conform to the following ASTM requirements, the tensile requirements, and 3308.
Steel shapes, plates, and bars shall conform to ASTM A1011/A1011M, Grade 250 (36), Type 2.
B Tensile Requirements
Tensile tests are required for all sizes of shapes and bars.

General Requirements for Structural Steel

3308.1 SCOPE
This Specification shall apply to all steel furnished for structural applications as referenced in 2471.

3308.2 REQUIREMENTS
A General
All steel furnished for structural applications shall comply with the requirements of ASTM A 6/A 6M, subject to the additional requirements or modifications set forth herein.
B Quality
Weld repair of the base metal is not permitted without written approval of the Engineer.
The Contractor shall correct injurious defects such as pipes, seams, unapproved repairs, laminations, cracks, and segregations. Correcting defects and any testing necessary to determine the extent of the defects or to confirm the adequacy of repairs shall be done as required by the Engineer and at no expense to the Department. Defects on plates or rolled beams that reduce the thickness of the material in any given section by more than 30 percent shall be cause for rejection of the material.
C Tensile Test
For rolled beams, tensile specimen shall be taken from the mid-thickness of the flange and be oriented longitudinally to the rolling direction. The location and orientation of tensile specimens shall be noted on the mill test report.
D Impact Tests
Structural steel furnished for use in major structural components as defined in 2471.3D1, and/or identified by the Contract, shall be impact
tested. Impact testing will not be required for minor structural components unless it is specifically required by the Contract.
Structural steel that is impact tested shall meet the requirements of ASTM A 709/A 709M for zone 3 welded material.

3309
High Strength Low Alloy Structural Steel
3309.1 SCOPE
This Specification covers high strength, low alloy structural steel shapes, plates, bars, sheets, and strips.

3309.2 REQUIREMENTS
Shapes, plates, and bars furnished under this Specification shall conform to ASTM A 709/A 709M, Grade 345W (50W), and 3308.
Sheet and strip supplied to this Specification shall conform to ASTM A 606, Type 4 hot rolled material and 3308, except that the minimum yield strength shall be 345 MPa (50,000 psi).
Where the Contract does not specify the type of steel to be furnished, the supplier may furnish the material in any type listed. However, all material for any individual unpainted structure shall be of the same type.

3310
High Strength Low Alloy Columbium-Vanadium Steel
3310.1 SCOPE
This Specification covers high strength, low alloy columbium-vanadium steel shapes, plates, bars, sheets, and strips.

3310.2 REQUIREMENTS
Shapes, plates, and bars furnished under this Specification shall conform to ASTM A 709/A 709M, Grade 345 (50), and 3308.
Sheet and strip supplied to this Specification shall conform to A 1011/A 1011 M, Grade 340 (50) Class 1, and 3308.

3312
Stainless Steel
Stainless steel plates, sheet and strip shall conform to ASTM A 240 for Type 302 or 304 material. The finish shall be No. 4 polish except for sheet and strip used in bearing and modular expansion joint assemblies in which case the finish shall be No. 8 polish.
Stainless steel bars shall conform to ASTM A 276 for Type 302 or 304, Condition A (annealed). For pin stock, refer to 3314, Type IV.
Stainless steel for free machining applications (bolt stock, etc.) shall conform to ASTM A 582/A 582M for Type 303, Condition A, cold finished, unless otherwise specified. For bolt stock, refer to 3391.2E.
For descaling and cleaning stainless steel surfaces use ASTM A 380.
If the stainless steel is to be welded, the carbon content shall be no greater than 0.03 percent.

**Hot Rolled Bar Steel**

Rounds, squares, hexagons, or flats, supplied under this Specification, shall be one of the following types, as specified in the Contract:

**Type I - Carbon Bar Steel**
Carbon bar steel shall have a minimum yield strength of 310 MPa (45,000 psi), a minimum ultimate strength of 420 MPa (60,000 psi), and a minimum elongation of 20 percent in 50 mm (2 inches). ASTM A 400 "Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties" shall be used to select appropriate material specification and grade according to section and mechanical properties. Procurement of steel shall be in accordance with applicable procurement specifications.

**Type II - Alloy Bar Steel**
Alloy bar steel shall have a minimum yield strength of 380 MPa (55,000 psi), a minimum ultimate strength of 585 MPa (85,000 psi), and a minimum elongation of 15 percent in 50 mm (2 inches). ASTM A 400 "Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties" shall be used to select appropriate material specification and grade according to section and mechanical properties. Procurement of steel shall be in accordance with applicable procurement specifications.

**Type III - Heat-Treated Alloy Bar Steel (Rounds)**
Heat-treated alloy bar (round) steel shall be in accordance with A 434 with mechanical properties meeting Class BC.

**Type IV - Corrosion Resisting Cold Finished Rounds**
Hot rolled stainless steel bars used for bridge pins shall be cold finished to size in a fabrication shop and shall conform to the following: The base material shall be annealed and hot finished free machining, Type 303, as specified in ASTM A 582. After turning, the maximum size furnished shall not exceed 140 mm (5 ½ inches) in pin diameter.
Cold Finished Bar Steel

Rounds, squares, hexagons or flats, supplied under this Specification shall be one of the following types, as specified in the Contract.

Type I - Carbon Bar Steel

Cold finished carbon bar steel shall conform to ASTM A 108 for Grade C 1035. In addition, the following strength requirements shall apply unless otherwise specified.

- Rounds through 73 mm (2-7/8 inches) diameter and all hexagons and squares up to 75 mm (3 inches) maximum dimension across flats shall have a minimum yield strength of 415 MPa (60,000 psi), an ultimate strength of 485 MPa (70,000 psi) minimum, and a minimum elongation of 10 percent in 50 mm (2 inches).
- Rounds over 73 mm (2-7/8 inches) in diameter and all flats, hexagons and squares over 75 mm (3 inches) maximum dimension across flats shall have a minimum yield strength of 310 MPa (45,000 psi), an ultimate strength of 415 MPa (60,000 psi) minimum, and a minimum elongation of 20 percent in 50 mm (2 inches).

Type II - Alloy Bar Steel

Cold finished alloy bar steel shall conform to ASTM A 331 for corresponding grade AISI A 4140 or 4142, annealed and cold finished. In addition the following strength requirements shall apply, unless otherwise specified.

- Rounds through 74 mm (2-15/16 inches) in diameter and all hexagons and squares up to 75 mm (3 inches) maximum dimension across flats shall have a minimum yield strength of 520 MPa (75,000 psi), an ultimate strength of 655 MPa (95,000 psi) minimum, and a minimum elongation of 10 percent in 50 mm (2 inches).
- Rounds over 74 mm (2-15/16 inches), all hexagons, squares and flats over 75 mm (3 inches) maximum dimension across flats shall have a minimum yield strength of 380 MPa (55,000 psi), an ultimate strength of 585 MPa (85,000 psi) minimum, and a minimum elongation of 15 percent in 50 mm (2 inches).

Type III - Pre-Heat Treated Alloy Bar Steel (Rounds)

Cold finished pre-heat treated alloy bar steel shall conform to the following requirements. The base material shall conform to ASTM A 331 for corresponding Grade AISI A 4140 or 4142. The stock shall be pre-heat treated by quenching and tempering to meet the physical properties in Table 3313-1, but shall still be in a machinable condition.
Type IV - Corrosion Resisting Cold Finished Rounds
Cold finished stainless steel rounds for use as bridge pins shall conform to ASTM A 276 for Type No. 316, annealed and centerless ground. The maximum size furnished shall not exceed 115 mm (4.5 inches) in pin diameter.

3315
Steel Forgings

3315.1 SCOPE
Material furnished under this Specification shall conform to one of three types, as set forth herein and as specified in the Contract. When the Contract fails to specify a type, Type I shall be furnished.

3315.2 REQUIREMENTS
A Material Requirements
Type I - Carbon Steel Forgings
Carbon steel forgings shall conform to ASTM A 668/A 668M Class D, forged from blooms, billets, bars, or slabs meeting ASTM A 711 for Grade C 1035 or Grade C 1040.

Type II - Alloy Steel Forgings
Alloy steel forgings, for sizes up to and including 225 mm (9 inches) in thickness or diameter, shall conform to ASTM A 668/A 668M Class G.

Alloy steel forgings, for sizes over 225 mm (9 inches) in thickness or diameter, shall conform to ASTM A 668/A 668M, Class H.

Alloy steel forgings shall be made from alloy steel blooms, billets, bars, or slabs meeting ASTM A 711 for Grades A 4140, A 4142, or A 4145.

Type III - Corrosion Resisting Steel Forgings
Corrosion resisting steel forgings shall be made from billets or bars primarily produced for reforging in compliance with ASTM A 314, Type No. 316.

The steel forgings shall meet the applicable physical and chemical requirements for hot-rolled materials as specified in ASTM A 276. The material shall be Type 316, fully annealed in such a manner as to develop maximum corrosion resisting properties. The forgings shall have a workmanlike finish and shall be free from injurious defects.

B Machine Finishing
All machining shall be done after the annealing process has been completed. For finishing, refer to 2471.
A 50 mm (2 inch) round hole shall be bored longitudinally through the center of each type (carbon steel, alloy steel or corrosion resisting steel) pin roller that measures over 225 mm (9 inches) in diameter unless otherwise shown in the Plans or specified in the Contract.

C Test Requirements

All applicable physical and chemical tests required by the ASTM Specifications for Type I, II, and III material shall be made by the supplier.

Magnetic particle tests shall be made on Type I forgings in accordance with ASTM E 709.

Magnetic particle tests shall be made on Type II forgings in accordance with ASTM A 275/A 275M.

Ultrasonic tests shall be made on Type III forgings in accordance with ASTM A 388/A 388M.

All magnetic particle testing shall be done after the machining operations have been completed and shall be made by the supplier. Any serious defects such as bursts, cracks, pipes, internal cracks and flakes, or laminations shall be cause for rejection.

Certified reports of all tests (physical, chemical, magnetic particle and ultrasonic) shall be furnished to the Engineer.

3316

High Performance Steel (345 MPa Y.S.)

3316.1 SCOPE

This Specification covers high strength, low alloy structural steel shapes, plates, and bars, which have enhanced atmospheric corrosion resistance, weldability, and mechanical properties.

3316.2 REQUIREMENTS

Materials furnished to this specification shall conform to ASTM A 709/A 709M, Grade HPS 345W (HPS 50W), and 3308. Grade HPS 345W (HPS 50W) has minimum specified yield strength of 345 MPa (50 ksi).

3317

High Performance Steel (485 MPa Y.S.)

3317.1 SCOPE

This Specification covers high strength, low alloy structural steel shapes, plates, and bars, which have enhanced atmospheric corrosion resistance, weldability, and mechanical properties.
3317.2 REQUIREMENTS

Materials furnished to this specification shall conform to ASTM A 709/A 709M, Grade HPS 485W (HPS 70W), and 3308. Grade HPS 485W (HPS 70W) has minimum specified yield strength of 485 MPa (70 ksi).

3321 Gray Iron Castings

3321.1 SCOPE

This Specification covers gray iron castings for drainage or structural use. The castings are classified according to tensile strength, but provisions are made for acceptance of drainage castings and other ornamental or non-stress bearing castings on the basis of flexural tests.

3321.2 REQUIREMENTS

Castings furnished under this Specification shall conform to AASHTO M 105 for the class specified in the Contract. The castings shall be supplied by foundries that have been approved by the State Materials Engineer, subject to the additional requirements or modifications set forth hereinafter.

A Class Designation

Where no strength class is specified in the Contract, castings shall be furnished in accordance with the following:

1. Class 40C, or better, shall be furnished for all stress bearing castings such as bridge rockers, bolsters, and sliding shoes.
2. Class 35B, or better, shall be furnished for all bridge rail posts, light standard bases, drainage and manhole castings, and other castings subject to vehicle impact or vehicle loading.

B Special Requirements

For all drainage castings, the metal shall have a Brinell Hardness Number within the range of 190 to 265.

The lid-to-frame surfaces on all round casting assemblies shall be machine milled to provide true bearing around the entire circumference.

C Test Specimens

Three test bars shall be cast for each heat or tap. When alloys are added in the ladle, three test bars shall be cast for each ladle. Where continuous furnace pouring practice is used, two test bars shall be cast for the beginning and two for the end of cast.

For bridge bearing castings, not less than one test bar shall be cast for each casting, and unless the test bars are cast as an integral part of the bearing castings, the castings and test bars shall be poured in the presence of the Engineer's representative.
Each test bar shall be separately and properly identified to the corresponding castings by the use of symbols, letters or numbers cast on the test bar and casting.

When proper identification of castings and corresponding test bars cannot be established, the Engineer may require that test specimens be cut from selected castings representative of a lot and make tests on those samples to determine acceptability of the castings.

D  Foundry Control

Before casting is started, the manufacturer and the Engineer shall establish, in conference, a control procedure for the purpose of correlating casting operations, arranging for foundry inspection, and establishing an approved identification system. Unless otherwise agreed upon by the Engineer, the manufacturer shall identify all castings as follows:

1. Each casting shall bear an identification mark correlating the casting with test bars by the use of a system of heat numbers or a calendar date and tap number, using numerals not over 13 mm (1/2 inch) in size.

2. Each casting shall bear an identification mark indicating the source of manufacture, which mark shall either be a symbol not over 38 mm (1 1/2 inches) in greatest dimension or in letter form no greater than 19 mm (3/4 inches) in height and 50 mm (2 inches) in length.

3. Each casting shall bear the Department's type or style number shown in the Plans, in the size and location indicated.

On all castings of sufficient size, the above described identification marks shall be formed in the casting during manufacture. If the casting size is not sufficient for all marks, stamped metal tags wired to the castings shall be used for those markings that are not formed in the castings. The location of identification marks shall be subject to approval by the Engineer and shall be such that they will not interfere with assembly of parts and will not be removed during any machine finishing operations required. No manufacturer shall place its name on any casting in any other manner than specified above.

E  Casting Details

All castings shall conform to the dimensions shown in the Plans. Draft shall be provided by increasing the net dimensions. A tolerance of 3 mm (1/8 inch) in the overall general dimensions will be permitted, except that the tolerance in dimensions of grates and covers for drainage casting assemblies, and the openings into which they fit, will be limited to 1.5 mm (1/16 inch). In no case shall the thickness of metal be less than 1.5 mm (1/16 inch) less than the thickness shown in the Plans.
All castings shall have a density of at least 95 percent of the theoretical density of that type [based on 7080 kg/m³ (442 pounds/foot^3)] cast to the exact dimensions shown in the Plans.

All castings shall be poured in closed molds with proper gating, feeders, risers and sprues. They shall completely fill the molds and shall not be removed from the molds until properly cooled. Chilling the castings will not be permitted.

On all castings, the inside and re-entrant corners shall be boldly filleted and the outside corners and edges shall be rounded to a radius of not less than 3 mm (1/8 inch). For bridge bearings, a 13 mm (½ inch) fillet shall be used except where interference may result in an assembly.

**Workmanship and Finish**

All attachments of gates, risers, and sprues shall be carefully removed from the castings and any extensions remaining shall be ground flush to the casting surface. Castings damaged through careless removal of attachments will be rejected. No repairs will be permitted by welding.

All castings shall be free from sponginess, cracks, blow holes, warping, sand inclusions, cold shuts, chilled iron shrinks, and any other defects affecting the strength and value of the casting for the purpose intended. All contact surfaces between different castings in an assembly shall present a firm and even bearing, without rattling or rocking.

All castings shall be thoroughly cleaned of all foundry sand, rust, scale, and other foreign matter.

**INSPECTION AND TESTING**

The manufacturer shall cast the required number of test bars and machine finish all tension test specimens to the specified dimensions. Unless otherwise established by agreement with the Engineer, the manufacturer shall deliver all test specimens to the Materials Laboratory where testing will be done.

**3322**

**Carbon Steel Castings**

**3322.2 SCOPE**

This Specification covers mild to medium strength carbon steel castings for general applications requiring a tensile strength of 485 MPa (70,000 psi) or less.

**3322.2 REQUIREMENTS**

Castings furnished under this Specification shall conform to ASTM A 27M for the grade specified in the Contract, subject to the additional requirements or modifications set forth hereinafter.
A  Grade Designations

Where no strength grade is specified in the Contract, the castings shall meet the requirements for Grade 485-250 (70-36).

All castings shall be supplied in a normalized or normalized and tempered condition.

B  Test Specimens

The attachment of test coupons shall preferably be made by the use of a keel block, but in no case shall the attachment be such that the casting is structurally weakened.

For each casting in excess of 340 kg (750 pounds), two test coupons shall be cast integrally. For castings of less than 340 kg (750 pounds), two test coupons shall be furnished for each heat, and they shall be cast as ribs integrally with and below a special block not less than 150 x 150 x 50 mm (6 x 6 x 2 inches).

C  Foundry Control

Each casting shall have identification markings embossed on the casting, clearly indicating the heat from which the casting was poured, together with the bridge number and piece number. This same information shall also be die marked on the representative test coupons.

All test coupons and castings shall be properly marked for each heat. Coupons shall not be removed until after the castings have been heat-treated. Castings without proper identification will be rejected unless the inspector is able to identify corresponding test coupons by matching fractures.

D  Casting Details

The Contractor or Manufacturer shall furnish casting patterns, and they shall be so constructed as to produce a finished casting in true conformity with the dimensions and details shown in the Plans. Draft shall be provided by increasing the net dimensions, with no reduction in the metal thickness as specified.

All sharp angles shall be boldly filleted. Fillets shall be of such size that no reduction in planned clearance will result from their addition. External corners on all castings, except ornamental types, shall be rounded to a 5 mm (1/4 inch) radius.

Proper allowance shall be made for shrinkage and sufficient material shall be provided on all surfaces that are to be finished, so that after finishing is completed the castings will be of the specified size and all finished surfaces will be true and complete.

Split cores will not be permitted between unfinished surfaces of restricted clearance. Face cores shall be one piece unless subsequent machine finishing is to be done. The number and spacing of chaplets shall be such that the strength of the casting will not be impaired by their use. All chaplets shall be completely fused.

817
The casting shall be accomplished by methods that will ensure complete filling of all corners, arises and edges. Where practicable, castings having one machine surface shall be cast with that surface down. Metal from different melts shall not be used in the same casting. Castings shall not be withdrawn from the mold until they have properly cooled. Quenching of the castings to speed up cooling will not be permitted.

E Workmanship and Finish

Any structural defect in a casting such as blow holes, shrinks, pipes, sand holes, cracks, checks, slag inclusions, cold shuts, unfilled arises, warped surfaces, or deformation from core or flask movement, shall be cause for rejection. Castings with minor defects shall not be repaired until the Engineer has given permission. The Engineer shall approve the method of repair to be employed.

All extensions, high spots and rough edges resulting from pouring connections shall be ground smooth and flush with the casting surface. All castings shall be thoroughly cleaned of all foundry sand, rust, scale and other foreign matter after which they shall be painted, galvanized or metallized as specified elsewhere in the Contract.

The cleaning, painting, galvanizing and metallizing of castings shall be performed in accordance with applicable provisions of 2471 and 2476.

3322.3 INSPECTION AND TESTING

The Engineer shall have the right, when there is reason to suspect the soundness of a casting, to subject the casting to radiographic or magnetic particle inspection. The cost of such inspection shall be borne by the Contractor or manufacturer.

3323 Alloy Steel Castings

Castings furnished under this Specification shall conform to ASTM A 743 Grade CA-15, subject to the additional requirements or modifications set forth herein.

All castings shall be supplied in a normalized or normalized and tempered condition. The reduction of area requirement shall be 30 percent, minimum.

Test specimens, foundry control, casting details, workmanship and finish, and inspection and testing, shall be in accordance with 3322.2B through 3322.2F, except that two test coupons shall be cast integrally with each casting regardless of mass.
3324

Malleable Iron Castings

Castings furnished under this Specification shall conform to ASTM A 47M for the Grade specified in the Contract, subject to the additional requirements or modifications set forth herein.

Castings that are specified to be galvanized shall be so heat treated that they will meet the requirements for the specified grade after being galvanized. Galvanizing shall be in accordance with ASTM A 153.

3325

Wrought Bronze Plates

Wrought bronze plates furnished under this Specification shall be cold finished and shall conform to ASTM B 100 for Alloy C51000 or C65500, or to ASTM B 169 for Alloy C61400.

In addition, plates furnished according to ASTM B 169 shall meet the following hardness requirements:

<table>
<thead>
<tr>
<th>Plate Thickness (mm (inches))</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brinell</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 8 to 13 mm (5/16-½ inch) incl.</td>
<td>128 min.</td>
</tr>
<tr>
<td>Over 13 to 50 mm (½ to 2 inches) incl.</td>
<td>121 min.</td>
</tr>
</tbody>
</table>

3327

Bronze Castings - Type 1

Castings furnished under this Specification shall conform to ASTM B 584 for Alloy C83600.

This low strength copper alloy is suitable for nameplates and other castings having light detail allowing lightly filleted corners and permitting a natural patina.
Bronze Castings - Type 2

Castings furnished under this Specification shall conform to ASTM B 148 for Alloy C95300 or to ASTM B 584 for Alloy C86500, subject to the following:

1. Chemical composition of Alloy C86500 shall be modified to permit a maximum manganese content of 3.5 percent.
2. Compliance may be with either of the two designated alloys, unless the Plans specify one or the other.

This high strength copper alloy is suitable for bridge bearing plates, medium pressure bearing sleeves, bright ornamental castings and other items having light detail allowing medium filleted corners and slightly rounded arises and requiring a medium bright finish.

Lubricated Bronze Bearing Plates and Bushings

Bronze bearing plates shall be aluminum bronze conforming to ASTM B 148 for Alloy C95400 or C95500, or to ASTM B 169/B 169 M for Alloy C61400, Temper M20. Bronze bushings shall be manganese bronze conforming to ASTM B 584 for Alloy C86200 or C86300. Bearing plates and bushings shall be articles of standard production.

The bronze bearing plates and bushings shall have recesses that shall be completely filled with lubricating compound. The recesses shall be formed by trepanning, drilling, or the shell molding processes, and shall be as indicated in the Plans but in no case less than 5 mm (3/16 inch) in depth. The recesses shall have straight sides (not grooves) and shall not intersect the edges of the parent plate or bushing. They shall be uniformly spaced in a geometric pattern over the area of the bearing to be lubricated, with adjacent rows overlapping in the direction of motion.

The lubricating compound shall consist of graphite, metallic substances and a lubricant binder (not shellac or other gummy material), which forms a dense, nonplastic, lubricating insert capable of withstanding spalling and atmospheric elements. The top surface of the bearing insert shall be flush with or slightly above the surface of the bearing plate or bushing.

In both cases (bearing plates and bushings) the lubricated area shall comprise from 25 to 30 percent of the total area. If the plate or bushing manufacturer uses a bearing insert in the shape of a hollow cylinder, the net lubricated area shall be a minimum of 20 percent of the total area of the plate or bushing.
Where the Plans do not indicate which surfaces are to be lubricated, all surfaces that have provisions for movement other than flexural, shall have inserts.

Contact surfaces of both bearing plate and bushing shall have a 3.175 µm (125 micro inch) finish or better.

Bearing plates shall be true to detail, flat surfaces truly flat and curved surfaces true to radius with a permitted working tolerance of 500 µm (0.02 inch) between male and female fittings. The minimum net section of the bronze shall be 13 mm (½ inch).

Bushings shall have a minimum wall thickness of 10 mm (3/8 inch). Machine allowance for I.D. and O.D. operating fit of bushings shall be as recommended by the manufacturer unless otherwise indicated in the Plans.

The bronze and steel portions of bearing plates and bushings shall be assembled in the fabricating shop and matchmarked or bonded together and shipped as a unit.

### 3331
**Sheet Brass**

Sheet brass shall conform to ASTM B 36/B 36M for Alloy C26000 or C26800, in H02, H03, or H04 temper.

### 3332
**Sheet Copper**

Sheet copper shall conform to ASTM B 152/B 152 M for any type of copper that has a total copper plus silver content of not less than 99.9 percent, together with the following modifications and additions:

1. **Temper**
   - The Temper shall be Light Cold-Rolled.
2. **Resistivity and Embrittlement Tests**
   - These requirements are waived.
3. **Bend Test**
   - The copper sheet shall withstand being bent cold through an angle of 180 degrees flat upon itself without evidence of fracture on the outside of the bend portion.

### 3335
**Sheet Lead**

Sheet lead shall be prepared from pig lead conforming to ASTM B 29. The thickness shall be within a tolerance of 5 percent of the thickness shown in the Contract.
Wrought and Extruded Aluminum

Aluminum alloy products shall conform to the appropriate ASTM Specification as listed herein. The specific alloy and temper for a given application shall be as specified elsewhere in the Contract.

Sheet and plate products shall conform to ASTM B 209/B 209M (B 209), Alloy 1100, Alclad 2024, 3003, 5083, 5154, 5456, 6061, or Alclad 6061.

Standard structural shapes, rolled or extruded, shall conform to ASTM B 308/ B 308M, Alloy 6061-T6.

Pipe and tube products shall conform to the following:
(1) Drawn, seamless tube—ASTM B 210/B 210M, Alloy 6061 or 6063.
(2) Seamless pipe and seamless extruded tube—ASTM B 241/ B 241M, Alloy 6061 or 6063.
(3) Extruded structural pipe—ASTM B 429, Alloy 6061 or 6063. Sand castings shall conform to ASTM B 26/B 26M, Alloy SG70A (356.0) or S5B (443.0). Permanent mold castings shall conform to ASTM B 108, Alloy SG70A (9356.0), SG70B (A356.0), S5B (443.0), or S7A (A444.0).

Other miscellaneous aluminum products shall conform to the requirements specified in the Plans or Special Provisions.

Stainless Steel Clad Plate

Stainless steel clad plate shall conform to ASTM A 264. In addition, the following modifications shall apply.

Cladding shall be Type 316L stainless steel. Unless otherwise specified, the plate shall be clad on one side only to a nominal thickness of 10 percent, minimum 9 percent, of the total plate thickness, but not to exceed 13 mm (½ inch) of cladding.

The minimum shear strength of the cladding and the base metal shall be 140 MPa (20,000 psi) when tested according to ASTM A 264.

The clad surface of the plate shall have a sand blasted and pickled or blast cleaned and pickled finish.

The plate shall be supplied in a heat-treated condition. Heat treatment shall be performed in such a manner as to develop maximum corrosion resistant properties of the cladding.
Seven-Wire Strand for Prestressed Concrete

This Specification covers two grades of seven-wire, uncoated, stress-relieved steel strand for use in pretensioned and posttensioned prestressed concrete construction.

The steel strands shall conform to ASTM A 416, Grade 1725 (250), with a minimum ultimate tensile strength of 1725 MPa (250,000 psi), and ASTM A416, Grade 1860 (270), with a minimum ultimate tensile strength of 1860 MPa (270,000 psi), based on the nominal area of the strand.

Two copies of the mill certificate and two copies of the stress-strain curve representative of the lot to be used shall be submitted with samples to the Engineer. The mill certification shall include bond strength test results representative of the current year’s production showing that the manufacturing process produces strand with a bond strength of not less than 248 Mpa (36,000 psi) at a measured free end slip not greater than 2.4 mm (3/32 inch). Bond strength tests shall be performed or certified by an accredited independent testing laboratory and testing shall be done on an embedment length of 457 mm (18 inches) in accordance with standard test procedures on file in the Office of Materials and Road Research.

Sheet Steel Products

3351.1 SCOPE

This Specification covers the fabrication of galvanized sheet steel products for erosion control or other uses, such as open metal flumes or gutters, culvert headwalls or aprons, anti-seepage diaphragms, erosion dams, and cribbing.

3351.2 REQUIREMENTS

Wherever in this Specification the term "metal unit" is used, it shall mean any of the products specified.

A Materials

The galvanized steel used in the fabrication of metal units shall conform to ASTM A 929/A 929M except as modified hereinafter for different coating classes.

If the Plans or Specifications should specify a galvanized coating requirement other than 610 g/m² (2 ounces per square foot) of sheet, the pertinent galvanizing provisions of ASTM A 653/A 653M shall apply in lieu of those in ASTM A 929/A 929M.

The thickness of the steel be as shown in the Plans.

Rivets shall be galvanized or sherardized and shall be of the same base metal as the sheets. Unless otherwise specified, bolts, nuts and
3351.2

washers shall be commercial grade and shall be galvanized in accordance with ASTM A 153/A 153M. Other unspecified steel shapes, plates, bars and rods shall be made of steel conforming to 3306 and shall be galvanized in accordance with ASTM A 123/A 123M.

B Fabrication

All units furnished under this Specification shall be so fabricated that each unit will conform to the shape and dimensions shown in the Plans, and so as to avoid cracking or breaking the spelter coating on the galvanized sheets.

All units shall be so fabricated that units of the same nominal size and type will be fully interchangeable. No drilling, punching, or drifting to correct defects in manufacture will be allowed. The center of rivet or bolt hole shall not be less than twice its diameter from the edge of the metal. All slots, holes and lugs shall be properly located for accurate field assembly in accordance with the Plans.

Rivets shall be driven cold and in such a manner that the plates will be drawn tightly together throughout the entire lap. All rivets shall have neat, workmanlike and full hemispherical heads or heads of a form acceptable to the Engineer. Rivets shall be driven without bending and shall completely fill the hole.

3351.3 INSPECTION AND ACCEPTANCE  .................3226.3
3352

Signs, Delineators and Markers

3352.1 **SCOPE**

This Specification covers the fabrication of traffic signs, delineators and markers consisting of sign panels complete with legend, route markers and legend components as individual items.

For the purpose of this Specification, the term "legend" shall be understood to mean the border strip and all letters, numerals, and symbols that convey the message on signs.

3352.2 **REQUIREMENTS**

Fabrication of traffic signs, delineators and markers shall conform to the MN MUTCD and the provisions hereof.

A **Materials**

Colors shall conform to the Color Tolerance Charts available from the Federal Highway Administration, Department of Transportation, Washington, D.C., unless otherwise permitted or specified herein. When color tolerance charts are used, color compliance shall be determined by visual comparison with the appropriate chart.

A1 **Base Material for Sign Panels, Delineators and Markers**

All sign base material shall show no warp or twist and shall be flat to the extent that, when mounted, the finished sign, delineator or marker will lay flat against the post or mounting structure.

A1a **Sheet Aluminum**

Sheet aluminum for sign panels, delineators and markers shall conform to ASTM B 209M, for Alloy 5052-H38, or 6061-T6.

The thickness of sheet aluminum for single section sign panels, delineators and markers and for panel sections of multiple section signs and "Overlays" shall be in accordance with the following:

<table>
<thead>
<tr>
<th>Length of Longest Side</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm (inches)</td>
<td>mm (inch)</td>
</tr>
<tr>
<td>460 mm (18 inches) or less</td>
<td>1600 ± 100 (0.063 ± 0.004)</td>
</tr>
<tr>
<td>Over 460 mm (18 inches) through 760 mm (30 inches)</td>
<td>2030 ± 130 (0.080 ± 0.005)</td>
</tr>
<tr>
<td>Over 760 mm (30 inches)</td>
<td>2540 ± 130 (0.100 ± 0.005)</td>
</tr>
<tr>
<td>Overlays</td>
<td>1020 ± 100 (0.040 ± 0.004)</td>
</tr>
</tbody>
</table>

A1b **Extruded Aluminum, Bolted Type**

Extruded aluminum sections shall conform to ASTM B 221M, for Alloy 6063-T6.

Each 300 mm (12 inch) wide panel shall have a mass (weight) of at least 3765 g/m (2.53 pounds per foot) of length and each 150 mm (6 inches) wide panel shall have a mass (weight) of at least 1518 g/m (1.02 pounds per foot) of length.
3352.2

Hardware required to assemble the panel sections and attach to the supports shall be aluminum alloy as recommended by the manufacturer, or stainless steel, except that the nuts for post clip bolts shall be nylon insert stainless steel locknuts conforming to ASTM A 167 for Type 304.

A2 Reflective Sign Sheeting

Reflective sheeting for signs, barricades, reboundable drums, cones, and other traffic control devices shall meet the requirements of this Section. Reflective sheeting is classified according to the performance characteristics given in ASTM D 4956, including supplementary requirement S2, and any exceptions and/or additions included herein. Some standard sheeting types have been modified to reflect Minnesota requirements. Only Mn/DOT approved reflective sign sheeting is allowed for use. The Qualified Products List and Product Qualification Process can be accessed on the Traffic Engineering website.

A2a Sign Sheeting Type I (Typically used for highway signing, construction zone devices, and delineators). This sheeting shall meet the performance requirements of ASTM D 4956 for Type I sheeting.

A2b Sign Sheeting Type III

a) Sign Sheeting Type III (Typically used on rigid substrates). This sheeting shall meet the performance requirements of ASTM D 4956 for Type III sheeting.

b) Sign Sheeting Type III MC (Typically used for traffic cones). This sheeting shall conform to the performance requirements of ASTM D 4956 Type III material. The reflective sheeting shall have an identification mark on the surface. This mark shall signify that the sheeting meets all requirements of this specification. The identification mark shall not interfere with the functioning of the sheeting, but shall be visible to inspectors day and night without the use of special devices. This sheeting shall display the international worker symbol, in a repeat pattern, to permit this visual verification. This repeat pattern shall be such that any 100 mm x 100 mm (4 inch by 4 inch) square piece of this sheeting shall contain at least one full symbol. Impact resistance shall conform to the requirements of ASTM D4956 with the additional requirement that the material shall be tested at both 0 °C (32 °F) and 22 °C (72 °F).

c) Sign Sheeting Type III MD (Typically used on reboundable plastic drums and weighted channelizers). This sheeting shall conform to ASTM D 4956 Type III material. Impact resistance shall conform to the requirements of ASTM D4956 with the additional requirement that the material shall be tested at both 0 °C (32 °F) and 22 °C (72 °F).
d) Sign Sheeting Type III MT (Typically used on tubular markers). This sheeting shall meet the performance requirements of ASTM D4956 for Type III sheeting. The reflective sheeting shall have an identification mark on the surface. This mark shall signify that the sheeting meets all requirements of this specification. The identification mark shall not interfere with the functioning of the sheeting, but shall be visible to inspectors day and night without the use of special devices. This sheeting shall display the international worker symbol, in a repeat pattern, to permit this visual verification. This repeat pattern shall be such that any 100 mm x 100 mm (4 inch by 4 inch) square piece of this sheeting shall contain at least one full symbol. Impact resistance shall conform to the requirements of ASTM D4956 with the additional requirement that the material shall be tested at both 0 °C (32 °F) and 22 °C (72 °F).

A2c Sign Sheeting Type VI (Typically used for temporary roll-up signs). This sheeting shall conform to the performance requirements of ASTM D 4956 Type VI material, and meet the following fluorescent sign specifications for color and retroreflectivity:

- **Color specification limits**: Daytime color of the sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with the requirements of ASTM E 991. Computations shall be done in accordance with the requirements of ASTM E 308 for the 2º observer. Retroreflectivity shall conform to the following requirements:

A2d Sign Sheeting Type VII

- **a) Sign Sheeting Type VII (Typically used for rigid substrate construction signing and barricade faces)**. This sheeting shall conform to the performance requirements of ASTM D 4956 Type VII material.
- **b) Sign Sheeting Type VII MD (Typically used on reboundable plastic drums and weighted channelizers)**. This sheeting shall conform to the performance requirements of ASTM D 4956 Type VII material,
and meet the fluorescent sign specifications for color and retroreflectivity listed under A2d(c). Impact resistance shall conform to the requirements of ASTM D 4956 with the additional requirement that the material shall be tested at both 0°C (32°F) and 22°C (72°F).

c) Sign Sheeting Type VII MF (Typically used for rigid substrate orange background signing applying to detours or mobile operations). This sheeting shall conform to the performance requirements of ASTM D 4956 Type VII material, and meet the following fluorescent sign specifications for color and retroreflectivity:

### Color Specification Limits* (Daytime)

<table>
<thead>
<tr>
<th>Color</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>y</td>
</tr>
<tr>
<td>White</td>
<td>0.305</td>
<td>0.305</td>
</tr>
<tr>
<td>Fluorescent Orange</td>
<td>0.516</td>
<td>0.394</td>
</tr>
</tbody>
</table>

### Color Specification Limits* (Daytime)

<table>
<thead>
<tr>
<th>Color</th>
<th>3</th>
<th>4</th>
<th>Daytime Luminance Factor Y (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>y</td>
<td>min</td>
</tr>
<tr>
<td>White</td>
<td>0.335</td>
<td>0.375</td>
<td>0.285</td>
</tr>
<tr>
<td>Fluorescent Orange</td>
<td>0.655</td>
<td>0.345</td>
<td>0.581</td>
</tr>
</tbody>
</table>

### Minimum Coefficient of Retroreflection \( R_A \)

(Candelas per footcandle per square foot)

<table>
<thead>
<tr>
<th>Observation Angle (º)</th>
<th>Entrance Angle (º)</th>
<th>White</th>
<th>Fluorescent Orange</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>-4</td>
<td>550</td>
<td>180</td>
</tr>
<tr>
<td>0.2</td>
<td>+30</td>
<td>300</td>
<td>120</td>
</tr>
<tr>
<td>0.2</td>
<td>+45</td>
<td>130</td>
<td>40</td>
</tr>
<tr>
<td>0.5</td>
<td>-4</td>
<td>200</td>
<td>80</td>
</tr>
<tr>
<td>0.5</td>
<td>+30</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>0.5</td>
<td>+45</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>
A2e Sign Sheeting Type IX.

a) Sign Sheeting Type IX (Typically used for highway signing, markers, and delineators). This sheeting shall conform to the performance requirements of ASTM D 4956 Type IX material.

b) Sign Sheeting Type IX FL (Typically used for signs warning of non-motorized traffic, no passing zone pennants, hazard markers, and delineators). This sheeting shall conform to the performance requirements of ASTM D 4956 Type IX material, and meet the following fluorescent sign specifications for color and retroreflectivity:

Color specification limits: Daytime color of the sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with the requirements of ASTM E 991. Computations shall be done in accordance with the requirements of ASTM E 308 for the 2° observer. Color shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Color</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>Fluorescent Yellow-Green</td>
<td>0.390</td>
<td>0.610</td>
</tr>
<tr>
<td>(new and weathered)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorescent Yellow</td>
<td>0.521</td>
<td>0.424</td>
</tr>
<tr>
<td>(new and weathered)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Daytime Luminance Factor Y (%):

<table>
<thead>
<tr>
<th>Color</th>
<th>3</th>
<th>4</th>
<th>Daytime Luminance Factor Y (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
</tr>
<tr>
<td>Fluorescent Yellow-Green</td>
<td>0.421</td>
<td>0.486</td>
<td>0.368</td>
</tr>
<tr>
<td>(new and weathered)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorescent Yellow</td>
<td>0.479</td>
<td>0.520</td>
<td>0.454</td>
</tr>
<tr>
<td>(new and weathered)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.
Minimum Coefficient of Retroreflection $R_\alpha$ (Candelas per footcandle per square foot)

<table>
<thead>
<tr>
<th>Observation Angle (º)</th>
<th>Entrance Angle (º)</th>
<th>Fluorescent Yellow-Green</th>
<th>Fluorescent Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>-4</td>
<td>325</td>
<td>240</td>
</tr>
<tr>
<td>0.2</td>
<td>30</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>0.5</td>
<td>-4</td>
<td>236</td>
<td>165</td>
</tr>
<tr>
<td>0.5</td>
<td>30</td>
<td>105</td>
<td>75</td>
</tr>
<tr>
<td>1.0</td>
<td>-4</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>1.0</td>
<td>30</td>
<td>35</td>
<td>24</td>
</tr>
</tbody>
</table>

A3 Warranty Requirements

The reflective sheeting manufacturer shall provide the following warranties to the Department on their products:

a) Type IX Sheeting (Permanent Use) – 12 year warranty with 7 years being 100% full replacement covering all material and labor costs associated with fabrication and installation of the sign or device, and the final 5 years being 100% sheeting replacement.

b) Type IX FL Sheetig (Permanent Use) – 10 year warranty with 7 years being 100% full replacement covering all material and labor costs associated with fabrication and installation of the sign or device, and the final 3 years being 100% sheeting replacement.

c) Type III Sheeting (Permanent Use) - 10 year warranty with 7 years being 100% full replacement covering all material and labor costs associated with fabrication and installation of the sign or device, and the final 3 years being 100% sheeting replacement.

d) Prismatic and Rollup Sign Sheeting (Work Zone Use) – 3 year full replacement warranty covering all material and labor costs associated with fabrication of the sign or device.

The warranty shall cover the loss of retroreflectivity, loss of colorfastness, cracking and any other conditions inherent to the sheeting including inks and overlay film that causes it to be ineffective in providing the direction to the motorists as intended.

Minimum values of retroreflectivity maintained during the warranty period shall be the same as those required for the maintained coefficient of retroreflection values as indicated in these specifications.

Loss of colorfastness is considered to have occurred if the color of the sheeting is not within the color specification limits indicated in these specifications during the warranty period.

Applicable warranties for sign sheeting shall be turned over to the Department. The Department shall be named obligee on all manufacturers' warranties.
A4  Pigmented Plastic Film Sign Face

The sign face shall consist of a pigmented, flexible, weather-resistant plastic film. The film shall be free of streaks, blisters, wrinkles, and other surface imperfections.

The film surface shall have high gloss, shall show complete hiding when applied over a contrasting black and white surface and shall be sufficiently flexible to permit application over embossed surfaces. The film applied to aluminum panels in accordance with the established procedure and cured for 48 hours at temperatures of 21°C to 32°C (70-90 °F) shall have the following characteristics:

(a) Shall show no appreciable shrinkage in dimension from the edge of a panel after being subjected to a temperature of 65°C (150 °F) for 48 hours.

(b) Shall show no separation between film and adhesive when subjected to a temperature of -23°C (-10 °F) for 24 hours.

(c) Shall withstand immersion in distilled water for 24 hours with no visible effects on adhesion, color or general appearance.

(d) Shall show no delamination between film and adhesive after 24 hours at a temperature of 65°C (150 °F).

A5  Direct Applied Legend

Legend applied directly on the sign face, without first being applied to demountable shapes, shall conform to the following:

A5a  Sign Sheeting Type IX ....................................... 3352.2Aea

A5b  Blank

A5c  Screen Processed Painted Legend

Painted legend shall be applied to the face by direct or reverse screening process. The screen process paints used must have good adhesion when applied to reflective sheeting and enamel surfaces. Screen process paints shall be the type approved by the sheeting manufacturer.

A5d  Pigmented Plastic Film Legend

The legend shall consist of shapes cut from pigmented plastic film, 3352.2A4, applied directly to the sign face.

A6  Fasteners

A6a  Fasteners for Flat Sheet Sign Panel Sections

Fasteners for assembly of sign panel sections shall be solid pin rivets, consisting of a pin conforming to ASTM B 209M, Alloy 2024-T4 and a collar conforming to ASTM B 209M, Alloy 6061-T6. The pin shall be grooved to provide a firm grip for the swaged collar. Brazier head pins shall be used except that counter sunk head pins or shim collars of aluminum, stainless steel, nylon or vinyl plastic shall be used whenever necessary to eliminate interference with legend components or overlays.
3352.2

A6b Fasteners for Type Overlays

Fasteners used to attach Type Overlays shall be aluminum alloy pull-through rivets. Nylon washers shall be used under fastener heads to protect the surface of the reflective sheeting.

A7 Delineator Reflectors

Reflective sheeting reflectors shall consist of reflective sheeting shaped to plan dimensions and applied directly to the base or face material.

A7a Sign Sheeting Type IX ........................................ 3352.2Aea
A7b Blank
A7c Blank
A7d Markers

Each marker shall consist of a metal plate fabricated in accordance with the details shown in the Plans and the fabrication requirements specified in 3352.2B. The plate shall be aluminum conforming to 3352.2A1.

B Fabrication

B1 General

Signs, delineators and markers shall be fabricated so as to comply with the detailed Plans of signs and alphabets available from the Department.

It is the essence of these Specifications that, in addition to compliance with the details of fabrication, Plans and Special Provisions, the complete signs, delineators and markers shall be of quality workmanship in all free from cracks, wrinkles, blisters and other blemishes.

B2 Design and Dimensions

All finished signs, delineators and markers shall conform with the design, dimensions and punching shown in the Plans or described in the Special Provisions.

B3 Surface Treatment of Metal

B3a Aluminum Signs

The metal shall be thoroughly cleaned and treated, prior to application of reflectorizing material, to provide a satisfactory base for the sign face material. No chromate type chemical conversion treatment is allowed.

The chemicals or detergents used for cleaning or treating the metal shall be applied in strict accordance with the directions of the manufacturer. Sufficient laboratory facilities to test and control the concentration of the solutions used shall be maintained at the treatment plant. A log of the concentration of treating solutions shall be maintained.
B3c Cleaning and Handling

At the time of painting or application of reflectorizing material, all surfaces shall be thoroughly clean. The detergents or cleaners used shall not harm the surface treatment on the metal, if the metal has been previously treated.

After treatment and cleaning, sign base material shall not be handled except by device or clean canvas gloves until after application of sign face material.

B4 Applying Sign Face and Legend Sheeting

Application of reflective sheeting and pigmented plastic film sign face and legend material shall be in accordance with the recommendations of the manufacturer.

When the sign face consists of two or more pieces of sheeting, the sheeting must be carefully matched for color and brilliance to provide a uniform finish. Alternate successive width sections of sheeting must be reversed and consecutive to ensure that corresponding edges lie adjacent on the finished sign. For adhesive coated sheeting, the joints may be lapped approximately 6 mm (¼ inch) or butted tightly. Only butt splices will be permitted on signs to be screen processed with transparent color.

Reflective sheeting for background shall be edge sealed or clear coated as recommended by the sheeting manufacturer. The sealing material used shall be as supplied by the sheeting manufacturer, or an approved equal.

C Packaging

Before being packed, signs shall be allowed to stand for at least 12 hours. Single panel signs shall be packed in corrugated paper cartons or other containers of sufficient strength so that the package will not break nor will the signs be damaged in any way during shipment. Signs shall be separated by coated paper that will not stick to the sign face material. No package of single-panel signs shall weigh more than 57 kg (125 pounds), nor be more than 90 mm (3 ½ inches) in thickness. Multiple-panel signs do not require packaging unless shipped by public carrier, but must be delivered at the destination undamaged.

3352.3 SAMPLING, TESTING AND INSPECTION

All signs shall be subject to inspection at the time of manufacture, except that the Engineer may elect to inspect the signs at the destination only. In either case, final acceptance of signs will be made at the destination.

All materials shall be approved prior to use. The manufacturer shall notify the Engineer at least 14 days prior to fabrication of signs. An inspector may be sent to the plant to inspect the raw materials or any phase of the fabrication. When inspection is made at the point of
manufacture, each package of signs thus inspected will be stamped with the mark of inspection of the Department or its delegated representative.

3354
Preformed Plastic Markings for Permanent Traffic Lane Delineation and Legends

3354.1 SCOPE
This Specification covers patterned and unpatterned white and yellow 1.5 mm (60 mils) retroreflective pliant polymer sheeting prefabricated for inlay traffic marking on bituminous and concrete pavements. Patterned tape is generally used for longitudinal pavement markings and advance intersection message markings. Non-patterned tape is generally used for markings at intersections where turning vehicles occur.

3354.2 GENERAL REQUIREMENTS
This material shall be of high quality and workmanship to provide long life performance as retroreflective marking material. The beads shall be uniformly distributed throughout the polymer with strongly bonded protruding surface beads. The retroreflective pliant polymer, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and under normal traffic wear shall show no appreciable fading, lifting, or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion. The sheeting shall be provided with a precoated pressure sensitive adhesive.

The primary use of this material is for inlay markings. Where use may be desirable for small applications (not long lines) as an overlay, the material shall be applied with the proper primer system as recommended by the manufacturer and shall be applied prior to September 15th.

The markings shall be provided in a form that will facilitate rapid application and protect the markings in shipment and storage. The manufacturer, when bidding, shall identify all equipment necessary for proper application, and shall make recommendations for application that will ensure an effective performance life. Messages and Symbols shall be precut and be fabricated in conformance with MN MUTCD and FHWA publication Standard Alphabets for Highway Signs and Pavement Markings, and shall be furnished in custom kits. An individual letter or symbol shall be made up of separate pieces or
segments only to the extent supplied by the manufacturer. Standard rolls of line material may not be used to piece together individual letters or symbols. Lane line widths and colors shall be as specified by the Contracting Agency. The adhesive type shall also be as specified.

3354.3 SPECIFIC REQUIREMENTS

A  Composition
   Resins and Plasticizers, Minimum ......................................... 20%
   Pigments, Minimum .............................................................. 30%
   Graded Glass Beads, Minimum ............................................ 33%

B  Conformability and Resealing
   The marking film shall be sufficiently pliant to conform to the pavement contours, faults, and other irregularities under the action of traffic at normal pavement temperatures. The film shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.

C  Tensile Stress
   The film shall have a minimum tensile stress of 276 kPa (40 psi) at maximum load, when tested according to ASTM D 638M. A sample 150 mm x 25 mm x 1.5 mm (6 inches x 1 inch x 0.060 inch) shall be tested at a temperature between 21ºC to 27ºC (70 ºF to 81 ºF) using a jaw speed of 150 mm (6 inches) per minute.

D  Elongation
   The film shall have a minimum elongation of 15 percent at maximum load, when tested according to ASTM D 638M.

E  Skid Resistance
   The surface of the retroreflective pliant polymer shall provide an initial minimum skid resistance value of 35 British Pendulum Number (BPN) when tested according at ASTM E 303.

F  Thickness
   The retroreflective pliant polymer film, less adhesive, shall be a standard thickness of 1.5 mm (0.060 inches).

G  Color
   The white material shall be no darker than or yellower than 17778 of Federal Standard Number 595a Colors. The yellow material shall conform to the FHWA Yellow Color Tolerance Chart.

H  Method of Application
   It is required that the plastic material be applied on a clean, dry pavement surface, free of all dirt and foreign matter. The method of application shall be as recommended by the material manufacturer.

3354.4 SAMPLING AND TESTING
   The successful bidder will be required to submit samples of the material prior to award of the Contract. Materials will be tested for
compliance with the Specifications. The Contractor must submit samples (1 m (3 feet) minimum) of each color to be used, along with a copy of the manufacturer's certification.

Samples shall be labeled with the (a) name of manufacturer; (b) place of manufacture; (c) batch number or lot number; and (d) date of manufacture (month and year). Samples shall be submitted to the Materials Laboratory.

3355
Removable Preformed Plastic Pavement Markings for Traffic Lane Delineation and Legends

3355.1 SCOPE
This Specification covers removable retroreflective preformed plastic pavement markings, white and yellow, for use as temporary traffic markings.

3355.2 GENERAL REQUIREMENTS
Only Mn/DOT Qualified Products are allowed for use. The Qualified Product List and Product Qualification Process can be found on the Office of Traffic Engineering website. The markings shall be precoated with a pressure sensitive adhesive and shall be capable of adhering to asphalt concrete and Portland cement concrete surfaces in accordance with manufacturer's instructions without the use of heat, solvents, or other additional adhesive means, and shall be immediately ready for traffic after application.

The markings shall be capable of performing for the duration of a normal construction season and shall then be capable of being removed intact or in large pieces, either manually or with a recommended roll-up device.

The markings shall be provided in specified widths and shapes. Preformed words and symbols shall conform to the applicable shapes and sizes as outlined in the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD).

The material shall be packaged in accordance with accepted commercial standards and, when stored in a cool dry area indoors, shall be suitable for use for 1 year after the date of purchase.

3355.3 SPECIFIC REQUIREMENTS
A Composition
The removable preformed pavement markings shall consist of a mixture of high quality polymeric materials, pigments, and glass beads, with a reflective layer of beads bonded to the top surface. The material shall be reinforced by a non-metallic medium to facilitate removal.
B  Color
The color of the white material shall be no darker or yellower than 17778 of Federal Standard Number 595a. The color of the yellow shall conform to the following CIE Chromaticity limits using illuminant “D65”:

\[
\begin{align*}
    x &\approx 0.470 & 0.485 & 0.520 & 0.480 \\
    y &\approx 0.440 & 0.460 & 0.450 & 0.420
\end{align*}
\]

C  Retroreflectance
The white and yellow film shall have initial retroreflectance values as measured in accordance with the testing procedures of ASTM E-1710.

<table>
<thead>
<tr>
<th>Entrance Angle at 88.76 Degrees</th>
<th>Observation Angle at 1.05 Degrees</th>
<th>Specific Luminance (SL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>700</td>
<td>500</td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These retroreflectance values are based 30 meter geometry measured in mcd/m²/lux (mcd/square foot/foot candle).

D  Frictional Resistance
The surface of the retroreflective pavement marking film shall provide a minimum frictional resistance value of 35 British Pendulum Number (BPN) when tested according to ASTM E 303M.

E  Thickness
The retroreflective pavement marking film, including beads, shall be a minimum of 1.3 mm (50 mils) thick.

F  Removability
The marking tape, after being in place for a construction season under heavy traffic, shall be removable intact or in large pieces without using heat, solvents, grinding, or blasting. It is required that the supplier furnish material for prequalification testing and approval before furnishing this material for Department Projects.

G  Marking
Rolls of the material shall be marked to show the (1) name of manufacturer; (2) place of manufacture; (3) batch or lot number; and (4) date of manufacture (month and year).

3355.4   SAMPLING AND TESTING
The Contractor shall submit samples (3 m (10 feet) minimum) of each color to be used, along with a copy of the manufacturer's certification. The surface of the tape sample shall be clean and free of any dirt, adhesive or asphalt. The samples sent to the Materials Laboratory shall be received in such a condition to allow rolling out entire length of tape out on a surface for testing.
Structural Steel Tubing

This Specification covers steel tubing for structural use in trusses or bridge rails.

Steel tubing shall conform to the following ASTM requirements and Mn/DOT 3308. Unless otherwise indicated, structural tubing shall meet the requirements for Type A. Either welded or seamless products may be supplied for all applications. All tubing shall be easily weldable using conventional shop welding practices.

**Type A - Cold formed Carbon Steel Tubing**
Type A square or rectangular structural tubing shall meet the requirements of ASTM A 500, Grade B.

**Type B - Hot formed Carbon Steel Tubing**
Type B square or rectangular structural tubing shall meet the requirements of ASTM A 501.

**Type C - High Strength Low Alloy Weathering Steel Tubing**
Type C square or rectangular structural tubing shall meet the requirements of ASTM A 847 or ASTM A 618, Grades, Ia, Ib, or II.

Structural Steel Pipe

**3362.1 SCOPE**
This Specification covers steel pipe for structural use in railing.

**3362.2 REQUIREMENTS**
Steel pipe for structural use shall conform to ASTM A 53/A 53M, A 500, or A 501 (Welded and Seamless Pipe); ASTM A 106 (Seamless Pipe); or ASTM A 135 (Welded Pipe); with the following modifications and additions:

- Unless a different mass or wall thickness is specified in the Contract, the mass of pipe furnished shall be not less than the Standard for Schedule 40 of ASTM A 53/A 53M.
- The pipe furnished shall have minimum yield strength of 240 MPa (35,000 psi).
- The hydrostatic test will not be required unless specifically called for in the Contract.
- The pipe shall be free from all dirt, grease, loose scale and rust.
- The pipe shall have plain ends unless threaded ends are called for in the Contract.
- The pipe shall be free of mill stamps and large or heavy knurl marks.

Screw fittings 75 mm (3 inches) or less in diameter may be of either steel or malleable iron. Screw fittings over 75 mm (3 inches) in diameter shall be of cast steel.
High strength low alloy structural tube shall meet the requirements of ASTM A 618, Grade 1.
Welding fittings shall conform to ASTM A 234/A 234M for Factory-Made Wrought Carbon Steel and Ferritic Alloy Steel Welding Fittings. The grade used shall be equivalent to the tensile properties that are specified for the steel pipe.

**Aluminum Tube for Pipe Railing**
Aluminum alloy extruded tubes for bridge railing shall meet ASTM B 221 for Alloy 6061-T6510.

**Wrought Steel Pipe**
Wrought steel pipe shall conform to ASTM A 53/A 53M. Unless a different mass or wall thickness is specified in the Contract, the mass of pipe furnished shall be not less than the Standard for Schedule 40 of ASTM A 53/A 53M.
Unless otherwise specified, the pipe and fittings shall be galvanized. Screw fittings 75 mm (3 inches) in diameter or less may be cast steel or malleable iron. Screw fittings over 75 mm (3 inches) in diameter shall be of cast steel.
Welding fittings shall conform to ASTM A 234/A 234M for Butt Welding Fittings.

**Ductile Iron Pressure Pipe**
Ductile iron pressure pipe shall conform to ASTM A 377 for the diameter and applicable American Standard specified in the Contract. The pipe shall be coated with bituminous enamel lining and exterior coating.

**Copper Water Tube and Fittings**
Copper water tube shall conform to ASTM B 88/B 88M for Type A pipe, annealed. Fittings shall be red brass and of the flared type.
3371

Steel Shells for Concrete Piling

3371.1 SCOPE

This Specification covers steel shells for cast-in-place concrete piling.

3371.2 REQUIREMENTS

The steel shells for cast-in-place concrete piles shall be manufactured within the physical strength and chemical requirements of ASTM A 252, Grade 3; except that when fluted shells are included as an alternative they shall be cold-rolled fluted steel shells conforming to SAE 1010 or SAE 1015, with a minimum tensile yield strength of the fabricated section of not less than 345 MPa (50,000 psi), as determined in accordance with ASTM A 370.

The shells may be cylindrical or uniformly tapered, or a combination of these sections. Tapered piles shall have a diameter at the tip of not less than 200 mm (8 inches) and a diameter at the butt of not less than the nominal diameter specified in the Contract.

Steel shell thickness and strength shall be sufficient to withstand driving to substantial refusal as defined in 2452.3E, but in no case shall the nominal wall thickness be less than the thickness indicated in Table 3371-1.

Piling that will receive a painted finish as per 2452.3J shall be, at the time of coating, visually examined and shall be free of defects and be free of deleterious matter that would adversely affect the coating in the finished condition. Electric Resistance welded pipe pile shall have the outside "flash" of weld trimmed to an essentially flush condition.

Pipe containing an as described defect shall be given one of the following dispositions:
(a) The defect shall be removed by grinding in such a way that the ground area blends in smoothly with the contour of the pipe. Complete removal of the defect shall be verified by visual inspection of the ground area, and the wall thickness in the ground area shall not be adversely affected,
(b) The section of pipe containing the defect shall be cut off, or
(c) The entire pipe shall be rejected.
### TABLE 3371-1
### STEEL SHELL REQUIREMENTS

<table>
<thead>
<tr>
<th>Nominal Pile Size Specified in Plans</th>
<th>Nominal Outside Diameter</th>
<th>Minimum Wall Thickness (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>254 mm (10 inches)</td>
<td>254 mm</td>
<td>5.5 mm (0.230 inches)</td>
</tr>
<tr>
<td></td>
<td>273 mm</td>
<td>5.5 mm (0.230 inches)</td>
</tr>
<tr>
<td>310 mm (12 inches)</td>
<td>310 mm</td>
<td>6.3 mm (0.250 inches)</td>
</tr>
<tr>
<td></td>
<td>324 mm</td>
<td>6.3 mm (0.250 inches)</td>
</tr>
<tr>
<td></td>
<td>(A) 310 mm</td>
<td>4.5 mm (0.179 inches)</td>
</tr>
<tr>
<td>406 mm (16 inches)</td>
<td>406 mm</td>
<td>6.3 mm (0.250 inches)</td>
</tr>
<tr>
<td></td>
<td>(A) 406 mm</td>
<td>5.3 mm (0.209 inches)</td>
</tr>
<tr>
<td>457 mm (18 inches)</td>
<td>457 mm</td>
<td>8.7 mm (0.344 inches)</td>
</tr>
<tr>
<td></td>
<td>(A) 457 mm</td>
<td>6.3 mm (0.250 inches)</td>
</tr>
<tr>
<td>508 mm (20 inches)</td>
<td>508 mm</td>
<td>9.5 mm (0.375 inches)</td>
</tr>
<tr>
<td>610 mm (24 inches)</td>
<td>610 mm</td>
<td>12.7 mm (0.500 inches)</td>
</tr>
</tbody>
</table>

(A) Fluted and tapered shells shall not be used for exposed pile-bent piles except when specifically permitted in the Plans or Special Provisions for a particular structure.

(B) Unless otherwise noted in the Plans.

### 3371.3 CERTIFICATION AND TESTING

Three certified copies of heat number identified mill test reports and mill shipping papers shall be furnished for the steel to the Engineer before delivery of the material to the Project. The physical test reports and chemical analyses, included in the mill test reports, shall show that the specification requirements are met. The chemical analysis shall also include the actual carbon, manganese, and phosphorus contents.
3372

Steel Piling

3372.1 SCOPE
This Specification covers steel H-piles.

3372.2 REQUIREMENTS
Steel H-piles shall be bearing-pile sections of the size and mass per unit of length specified in the Plans and shall conform to ASTM A 36/A 36M for carbon steel shapes of structural quality.

3372.3 CERTIFICATION AND TESTING
The requirements for certification and testing are the same as those in 3371.3.

3373
Steel Sheet Piling

All steel sheet piling shall be of the style, dimensions and mass specified in the Contract and shall conform to ASTM A 328/A 328M or to ASTM A 572/A 572M for Grades 290 (42), 345 (50), or 415 (60).

3376
Fence Wire

3376.1 SCOPE
This Specification covers fencing wire of the barbed, woven, and chain link types, together with wire fasteners, tie wires, and tension wire.

3376.2 REQUIREMENTS

A  Barbed Wire
Barbed wire shall meet the requirements of AASHTO M 280. When size and construction are unspecified, barbed wire shall have 4-point full round barbs and 4230 N (950 pounds) minimum strand breaking strength. Unless otherwise specified, either zinc coated (galvanized) or aluminum coated steel barbed wire may be furnished.
Zinc coated steel barbed wire shall conform to AASHTO M 280 for Class 3 coating.
Aluminum coated steel barbed wire shall conform to ASTM A 585, Type I or II.

B  Woven Wire
Zinc coated steel woven wire shall conform to ASTM A 116, Class 3 coating, for the size and construction specified.
Aluminum coated steel woven wire shall conform to ASTM A 584, for the size and construction specified.
When size and construction are unspecified, any 3.8 mm (No. 9) diameter wire design may be furnished at the Contractor's option.
The vertical stay wires shall be joined to each horizontal line wire by the hinge joint method consisting of not less than one and one-half twists tightly wrapped.

C   Chain Link
Chain link fabric shall conform to AASHTO M 181 for the type specified. The finished wire size, size of mesh, type of selvage, and height of fabric shall be as shown in the Plans.
Type IV fabric, PVC coated steel, shall be Class A extruded and bonded, or shall be Class B bonded.

D   Miscellaneous Items
Wire fasteners, tension wire, fittings, and hardware items shall be furnished in compliance with AASHTO M 181, unless otherwise indicated in the Contract or approved by the Engineer.
Staples for attaching wire to wood posts shall be galvanized L or U shaped fasteners produced from 3.8 mm (No. 9) diameter wire, with shank length as specified in 2557.3C2. L-shaped staples shall have barbed, serrated or ring shanks. The staples shall be galvanized after fabrication in accordance with ASTM A 153.
Flat metal bands may be approved for use in lieu of wire fasteners.

3376.3   INSPECTION AND TESTING
Inspection and testing for compliance with the specified requirements shall be done at such time and place as the Engineer elects.

3379   Fence Gates

3379.1   SCOPE
This Specification covers vehicular gates and pedestrian gates with pipe frames.

3379.2   REQUIREMENTS
A   General
All pipe, hardware, fittings, fence wire, and appurtenances for each gate assembly shall be of similar material for all gates furnished for the Project.
B   Materials
The frame shall be of galvanized steel pipe or aluminum alloy pipe.
B1   Galvanized Steel Pipe
Galvanized steel pipe shall conform to ASTM A 53 for galvanized Standard Schedule 40 pipe with plain ends. The pipe need not be subjected to hydrostatic test.
3379.2

B2 Aluminum Alloy Pipe
   Aluminum alloy pipe shall conform to AASHTO M 181.
B3 Fittings and Hardware
   Corner fittings, tops, stretcher bars, truss rods, and other required
   fittings, hardware and appurtenances shall be of good commercial
   quality steel, malleable iron, wrought iron, or aluminum alloy, steel or
   iron shall be galvanized in accordance with AASHTO M 181. All
   galvanizing shall be done after fabrication.
B4 Wire
   Barbed wire shall conform to 3376.2A.
   For use with woven wire fence, the gate fabric shall conform to
   3376.2B.
   For use with chain link fence, the gate fabric shall conform to
   3376.2C.
C Physical Properties
   The physical properties of the gate and members shall be as shown
   in the Plans.
   All fittings, hardware, and other required appurtenances shall be
   fabricated to fasten and fit securely in the proper manner in accordance
   with the approved design.
   Hinges, and catch and locking devices shall be of approved design.

3379.3 INSPECTION AND TESTING
A Metal Pipe and Fittings .............................................. 3406
B Blank
C Fence Wire and Fasteners .......................................... 3376

3381 Wire Rope and Fittings for Cable Guardrail

3381.1 SCOPE
   This Specification covers wire rope and accessory fittings for use in
   cable guardrail construction.
3381.2 REQUIREMENTS
   Wire rope and fittings for proprietary high-tension cable guardrail
   systems shall conform to manufacturers specifications.
   Wire rope and fittings for low-tension cable guardrail shall conform
   to AASHTO M 30, together with the following additional requirements:
A Wire Rope Requirements
   Unless otherwise specified, the wire rope furnished shall meet the
   requirements for Type 1 with Class A coating.
B Fitting Requirements
   Unless otherwise specified, all bolts and nuts used in assembling the
   guardrail elements shall conform to ASTM A 307.
Dimensions of bolt heads and nuts shall conform to ANSI No. B 18.2 for the type specified in the Plans.

All externally threaded fittings such as end tie rods, anchor rods, post loops and splicing studs that transmit direct tensile stress shall have a minimum tensile strength of 520 MPa (75,000 psi). All internally threaded fittings such as turnbuckles, cable sockets and nuts shall withstand a proof load equal to 85 percent of the proof load requirements for nuts specified in Table III of ASTM A 307. All expansion assemblies, cable splices and connections shall withstand a proof load equal to the tensile strength required of the attached wire rope cable.

Rectangular plate washers and cable clamps shall be made from steel having a tensile strength of not less than 420 MPa (60,000 psi). Plain circular washers shall be ferrous metal conforming to ANSI/ASME B 18.22.1, Type A.

3381.3 SAMPLING AND TESTING
A  Samples for testing shall be of such size and number as directed by the Engineer.
B  Testing .......................................................AASHTO M 30

3382
Steel Plate Beams and Fittings for Traffic Barriers (Guardrail)

Steel plate beams and fittings for traffic barrier (guardrail) construction shall conform to AASHTO M 180 for the type and class specified in the Contract. Unless otherwise specified, beams meeting the requirements for Class A, Type II (galvanized), shall be furnished. The triple-spot test will be required on galvanized beams and fittings.

3385
Anchor Rods

3385.1 SCOPE
This Specification covers anchor rod material in four general strength levels. Other types of anchor rod material may be specified in the Plans or Special Provisions.

3385.2 REQUIREMENTS
An ASTM or product reference is given for each type of anchor rod material. Unless otherwise indicated, anchor rods shall meet the requirements for Type A and shall be fabricated from single rounds. Types A, B, and C shall be galvanized unless otherwise indicated in the plans or specifications.
A Type A - Carbon Steel Anchor Rods
Type A anchor rods shall meet the requirement of ASTM F 1554, Grade 36, Type 2A, with supplementary requirement S3 for permanent grade identification. Nuts and washers shall be as recommended in ASTM F 1554 for Grade 36 anchor rods.

B Type B - Intermediate Strength Anchor Rods
Type B anchor rods shall meet the requirements of ASTM F 1554, Grade 55, Type 2A, with supplementary requirement S1 for weldability and supplementary requirement S3 for permanent grade identification. Nuts and washers shall be as recommended in ASTM F 1554 for Grade 55 anchor rods.

C Type C - High Strength Anchor Rods
Type C anchor rods shall meet requirements of ASTM F 1554, Grade 105, Type 2A, with supplementary requirement S3 for permanent grade identification and supplementary requirement S5 for Charpy impact testing. Nuts and washers shall be as recommended in ASTM F 1554 for Grade 105 anchor rods. Type C Anchor rods shall not be tack welded or welded to other material to make up an anchorage cage, but shall be held in place mechanically by a means subject to approval by the Engineer.

D Type D - Stainless Steel Anchor Rods
Type D anchor rods, nuts, and washers shall be ASTM A 276 Type 304 or 316 stainless steel and shall meet the requirements of 3391.2 for stainless steel fasteners. Type D anchor rods shall not be tack welded or welded to other material to make up an anchorage cage, but shall be held in place mechanically by a means subject to approval by the Engineer.

3391 Fasteners

3391.1 SCOPE
This Specification covers various types and grades of fasteners for use in general and structural applications.

3391.2 REQUIREMENTS
Fasteners shall be of the type specified in the Plans. All bolts, nuts and washer dimensions shall conform to ANSI for the type indicated. Unless otherwise specified, threads shall be ANSI Coarse Thread Series and be Class 2A tolerance for bolts and Class 2B tolerance for nuts.

Where minimum bolt strength requirements are indicated, the testing shall be performed in accordance with ASTM A 370, except that a wedge shall not be used for testing other than High Strength Structural Steel Bolts, and reduced dimension specimens shall not be used for test purposes. Yield strength shall be determined by any applicable method
specified in ASTM E 8M. In all cases where bolts are supplied with nuts, the nuts shall be capable of withstanding a proof load equal to the required tensile strength of the bolt.

Test bolts and nuts, when required, shall be furnished for all types, in each size and length at a rate of 2 for each increment of 1000, or fraction thereof, of bolts supplied.

A Common Structural Steel Bolts

Bolts and nuts shall meet ASTM A 307. Bolts and nuts 13 mm (½ inch) and over in diameter shall be Grade B with heavy hexagon nuts.

B High Strength Structural Steel Bolts

The bolt washers shall meet ASTM A 325, Type 1 (Painted Structure) or Type 3 (Unpainted Weathering Steel Structure). Bolts shall have sufficient grip length to expose one thread beyond outside nut surface. Bolts may be reused once after having been fully tightened.

Nuts shall meet ASTM A 563/A 563M. Washers shall meet ASTM F 436/F 436M.

At the time of installation of the fasteners, all nuts shall be lubricated with a lubricant containing a water-soluble blue dye. The lubricant must be completely removable by power washing. The lubricant shall contain a dye that contrasts with the color of the coating as per ASTM A 563, supplementary requirement S2.1.

C Bolts for Wood Construction

Unless otherwise specified in the Plans, bolts for wood construction shall conform to the requirements for Common Structural Steel Bolts (3391.2A) and shall in addition, be galvanized by either a mechanical or hot dip process. The mass of coating shall be in conformance with ASTM A 153/A 153M.

D Stud Welded Fasteners

Studs shall be made of defect free weldable carbon steel in accordance with ASTM A 108 cold drawn bars, Grades 1015, 1018, or 1020 and shall be of a size and configuration as called for in the Contract. For the purpose of welding, each stud shall have fluxed tips or fluxed ferrules and shall be equipped with a suitable ceramic ring or ferrule arc shield.

The material for the studs shall have a minimum ultimate strength of 420 MPa (60,000 psi); a minimum yield strength of 345 MPa (50,000 psi); a minimum elongation of 20 percent in 50 mm (2 inches); and a minimum reduction of area of 50 percent.

Threaded studs shall be supplied with nuts capable of developing the minimum ultimate strength requirement of the net cross section area of the threaded portion of the stud.
The dimensional tolerance of head height and head diameter of shear connector studs shall be plus or minus 1.5 mm (1/16 inch).

All containers of studs shall be identified by the heat number of the steel from which the studs were produced.

E Stainless Steel Bolts

Stainless steel bolts and nuts shall be made of material conforming to ASTM A 276, Condition A or B, Type 302, 304, or 316. The finished bolts shall have minimum yield strength of 205 Mpa (30,000 psi), an ultimate tensile strength of 520 MPa (75,000 psi), and a minimum elongation of 40 percent in 50 mm (2 inches). Bolts, nuts, and washers (when required) shall be given, after all fabrication, a full anneal performed in such a manner as to promote maximum corrosion resistance of the stainless steel. In addition, after heat treatment, the parts shall be given an adequate pacifying treatment in a nitric acid solution. The pacifying treatment shall be done according to standard commercial practice. Bolt dimensions shall conform to the requirements for Regular Hexagon-head Cap Screws, ANSI B 18.2. All surfaces shall be finished in conformance with the American Bolt, Nut and Rivet Manufacturers. Nut dimensions shall conform to the requirements for Regular Finished Hexagon, ANSI B 18.2. Washers (when required) shall be as specified in the Plans.

F Tension Indicators

Compressible-washer type direct tension indicators, when used shall meet ASTM F 959/F 959M. In addition to the testing required therein, three (3) samples of each lot along with the test reports shall be submitted to the Materials Laboratory for testing. Failure of these washers shall be cause for rejection of the lot represented.

3392 Galvanized Hardware

Galvanized hardware and miscellaneous items shall be of the types specified in the Plans. They shall be galvanized either by the hot-dip process in accordance with ASTM A 153, or by the mechanical process in accordance with ASTM B 695, Class 50, Type I.

3394 Galvanized Structural Shapes

Galvanized structural shapes, plates and bars shall be made of the kind of metal specified in the Plans and shall be galvanized in accordance with ASTM A 123/A 123M.
3399.2

3399

Flap Gates

3399.1  SCOPE

This Specification covers drainage control gates of the flap type, which are designed primarily for direct attachment to the outlet ends of culvert and sewer pipe. However, when so indicated in the Plans, the gates shall include provisions for attachment to the outlet structure as required.

3399.2  REQUIREMENTS

A  Base Metal

The frame, flap, flange, hinge bars and other basic components of the gate assembly shall be of cast iron, cast steel, structural steel, or other approved metals. Hinge bushings and pins shall be of approved non-corrosive metal. Bronze or brass fittings shall not be used on gates that are to be attached to aluminum alloy drainage structures.

Iron castings shall conform to ASTM A 48, Class 30B or better, or to ASTM A 47/A 47M, Grade 32510. Steel castings shall conform to ASTM A 27, Grade 60-30 or better. Fabricated steel components shall meet 3306 or 3309.

B  Dimensions and Design

Flap gates shall be of a design that will permit direct attachment to pipe of the type and size specified, or to the outlet structure as required. The gates shall provide practical water tightness against a face pressure and shall open automatically under a back head to permit free outflow.

The flap hinge shall be double pivoted or otherwise designed so as to provide accurate seating of the flap and frame and ensure complete closure of the flap under its own mass. The hinge movement shall be limited by design so as to prevent the flap from becoming lodged in the frame opening.

The gates shall be designed to adequately withstand the seating head indicated in the Plans. If the seating head requirements are not so indicated, gates designed to withstand a 3 m (10 feet) seating head will be acceptable.

The gates shall be designed or installed to hang closed at all times. Suitable flange or hinge fastening adjustments shall be provided as necessary to provide a vertical frame seat when installed. The gate assembly shall include suitable provisions for attachment to the pipe or structure as required, by means of bolts, flanges, and compression bands or other devices.

For metal pipe installations, the gates may be shop assembled on a 600 mm (24 inch) section of pipe with rivets or bolts and the stub section of pipe, with gate attached, may be installed on a zero or flat grade when feasible.
3399.2

All critical dimensions and design details of the gate assembly shall be subject to approval by the Engineer. Shop drawings shall be furnished upon request.

C Fabrication and Assembly

All castings and fabricated steel components shall be finished in a workmanlike manner, and shall be free of injurious defects that will affect the strength and value for the purpose intended. All attachments shall be fully and carefully removed from castings.

The contact surfaces between frame and flap shall be machine milled or ground as necessary to provide true bearing around the entire circumference.

All cast steel and fabricated steel components of the gate assembly, including steel bolts, nuts and washers, shall be galvanized in accordance with ASTM A153 for the appropriate class of material, except that steel conforming to 3309 may be painted in lieu of galvanizing, in which case the painting shall be in accordance with 2478 with an aluminum finish coat. Iron castings shall be painted with an asphalt or coal-tar pitch varnish, or shall be galvanized as required for steel castings. Painting and galvanizing shall be done after fabrication and before assembly.

3399.3 INSPECTION AND TESTING

All physical test specimens necessary to make the tests required under this Specification shall be prepared and tested by the manufacturer at no cost to the Department. The manufacturer shall furnish certified test reports giving actual results of each test to the Engineer before delivery of material to the Project. The Engineer may require check tests to be made when results of previous tests are not conclusive.
3401
Flanged Channel Sign Posts

3401.1 SCOPE
This Specification covers rerolled rail steel and comparable new billet steel posts for signs, delineators, and guide posts.

3401.2 REQUIREMENTS

A  Material
The steel used in the manufacture of posts shall be rerolled rail steel or a comparable new billet steel. The steel shall conform to the mechanical requirements of ASTM A 499, Grade 60 and to the chemical requirements of ASTM A 1 for rails having nominal mass of 45 kg/m (91 pounds per yard) of length or heavier.

B  Length
The length of the posts shall be as indicated in the Plans or Special Provisions. A variation of more than 13 mm (½ inch) under the specified length will not be permitted.

C  Mass
The nominal mass of the posts shall be as specified in the Plans, 3.0, 3.7, 4.1, or 4.5 kg/m (2.0, 2.5, 2.75, or 3.0 pounds per foot) of length, before punching and exclusive of galvanizing, anchor plates, and other attachments. A variation up to 5 percent under the specified mass will be permitted.

D  Shape and Dimensions
The posts shall be of channel or modified channel section with flanges against which the sign will be placed. The front face of the flanges shall be flat and in the same plane so as to provide smooth, uniform bearing for the sign. The back of the posts shall be flat and parallel to the front. The cross section of the posts shall be symmetrical about the central axis perpendicular to the front and back.

The posts shall be straight, free from excessive bow, twist, and other injurious or unsightly defects.

E  Punching
When posts of 3.0 kg/m (2 pounds per foot) or more per unit of length are specified, they shall have holes punched along the centerline of the back at the spacing and of the diameter shown in the Plans.

All posts of 3.7 kg/m (2.5 pounds per foot) or more per unit of length shall have 10 mm (⅜ inch) diameter holes punched along the centerline of the back on either 25 or 75 mm (1 or 3 inch) centers beginning approximately 25 or 38 mm (1 or 1 ½ inch) from the top and extending the full length of the post. The holes shall be accurately spaced so that the distance between centers of any two holes will not vary more than 1.6 mm (1/16 inch) from multiples of 25 mm (1 inch).
3401.2

<table>
<thead>
<tr>
<th>TABLE 3401-1</th>
<th>NOMINAL DIMENSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass per Unit of Length in mm (inches)</td>
<td>3.0 kg</td>
</tr>
<tr>
<td></td>
<td>(2.0 lb.)</td>
</tr>
<tr>
<td>Wide</td>
<td></td>
</tr>
<tr>
<td>overall across front</td>
<td>76</td>
</tr>
<tr>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Back surface</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>flanges (bearing surface)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>(1/8)</td>
<td>(1/8)</td>
</tr>
<tr>
<td>Depth overall, front to back</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>(1 3/8)</td>
<td>(1 3/8)</td>
</tr>
<tr>
<td>Thickness of Metal, Flanges &amp; Back</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>(1/8)</td>
<td>(1/8)</td>
</tr>
<tr>
<td>Side</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>(1/8)</td>
<td>(1/8)</td>
</tr>
</tbody>
</table>

NOTE: Dimension requirements are for flat flange sections. Minor variation in the thickness requirements will be permitted for alternate sections, with bulbed flange-ends or double ribbed back, or both, specifically designed to increase the section modulus of the post.

The punching shall be so done that there will be no cracks radiating from the holes.

F  Galvanizing

All posts shall be galvanized in accordance with ASTM A 123.

3401.3  INSPECTION AND TESTING

The posts will be inspected for compliance with the foregoing requirements at such time and place as the Engineer may elect.

The supplier shall furnish a certified mill analysis giving the chemical composition of each lot or heat of posts delivered.

Samples for testing may be taken by the Engineer from any posts furnished.

If, during the inspection of any lot of posts, it becomes apparent that the quantity of rejections will exceed 20 percent of the entire lot, the Engineer may reject the entire lot.
3403  
Rolled Steel Fence Posts  

3403.1 SCOPE  
This Specification covers rolled steel posts and angles used for fencing.

3403.2 REQUIREMENTS  
Rolled steel line posts and all angle-section post assemblies (for end, gate, corner, or intermediate brace assemblies) shall be furnished in accordance with ASTM A 702 and the details shown in the Plans.

3403.3 INSPECTION AND TESTING  
The posts and braces will be inspected for compliance with the foregoing requirements at such time and place as the Engineer may elect.  
The supplier shall furnish a certified mill analysis giving the chemical composition of each lot or heat of posts delivered.  Samples for testing may be taken by the Engineer from any posts furnished.

3406  
Structural Metal Fence Posts  

3406.1 SCOPE  
This Specification covers tubular metal posts and rails, and metal roll-formed "C" posts, with fittings, for fencing.

3406.2 REQUIREMENTS  

A Materials  
The posts, rails, hardware, and fittings shall be manufactured in accordance with AASHTO M 181.  Grade 1 and Grade 2 posts will be allowed, except as follows: Grade 1 posts shall conform to ASTM A 53 for Schedule 40 galvanized steel pipe with plain ends.  In addition to the requirements of AASHTO M 181, interior coatings on Grade 2 posts will be required to withstand 650 hours of exposure to salt spray with no more than 5 percent red rust, when tested in accordance with ASTM B 117.  The Contractor shall obtain prior approval from the Materials Engineer before using Grade 2 posts.

Posts for a Project shall be of the same grade and coating type.  Post shall be Grade 1 when welding is required by the Contract.  Coatings on posts, hardware, and fittings shall be applied after welding and fabrication activities.

Tie wires, clips, and bands used for fastening chain link fabric to posts, rails, and braces shall be as specified in 3376.

Type IV (PVC) posts, rails, frames, sleeves, and hardware items shall be first coated with zinc and then Class B bonded to a minimum vinyl thickness of 250 μm (0.01 inch).
3406.2

B Dimensions

Posts, rails, and stretcher bars shall be as shown in the Contract. The AASHTO M 181 acceptable tolerance shall govern, except that posts more than 13 mm (1/2 inch) under the specified length will not be accepted.

All fittings and hardware shall be designed and fabricated to fasten to the posts in the proper manner. The tops shall be designed to fit securely over the posts.

3406.3 INSPECTION AND TESTING

Inspection for compliance with the foregoing requirements will be at such time and place as the Engineer may elect.

If, during the inspection of any lot, it becomes apparent that the quantity of rejections will exceed 20 percent of the entire lot, the Engineer may reject the entire lot.

Along with the samples, the Contractor shall provide a manufacturer's certification that the material was manufactured, sampled, tested, and inspected in accordance with these Specifications and has been found to meet these requirements. Results of salt spray testing shall also be provided when Grade 2 posts are used.

3412 Wood Guardrail Posts

3412.1 SCOPE

This Specification covers preservative treated wood posts for use in guardrail construction. It includes both round posts and sawed timber posts of rectangular cross section, together with offset blocks.

3412.2 REQUIREMENTS

A Round Posts

A1 Species of Wood

Treated posts shall be of Northern White Cedar, Western Red Cedar, Jack Pine, Norway (Red) Pine, Lodgepole Pine, Ponderosa Pine, or Southern (Yellow) Pine.

A2 Seasoning

Wood for treated posts shall be sufficiently air-seasoned, in an approved manner for a suitable length of time and under favorable climatic conditions, or otherwise conditioned as part of the treating process to permit adequate penetration of preservative without damage to the posts.

A3 Dimensions and Finish

Only naturally round posts will be accepted. All inner bark shall be shaved off, and all knots shall be closely trimmed.

Bottom end of the posts shall be sawed square. Length, nominal diameter, and top finish of the posts shall be as required by the Plans.
All debarking, trimming, and sizing operations shall be completed prior to preservative treatment.

A4 Quality

Knots will be permitted if sound, smoothly trimmed, and plainly do not impair the strength of the posts.

Excessive checking will not be permitted. Checks wider than 6 mm (¼ inch) will be regarded as excessive.

One way sweep not to exceed 50 mm (2 inch) will be permitted.

Winding twist will be permitted unless it is unsightly and exaggerated.

Short kinks will not be permitted.

No decay will be permitted except that in Northern White Cedar, one pipe rot not over 10 mm (3/8 inch) in diameter will be allowed in the top of the post. Butt rot or ring rot will be permitted in Northern White Cedar provided the combination of the two does not exceed 5 percent of the butt area.

Defects of any kind that, in the opinion of the Engineer, give the post an unsightly appearance or impair the strength or durability will be cause for rejection.

B Sawed Timber Posts

B1 Species and Grade

The species permitted shall be Douglas Fir, Southern (Yellow) Pine, Jack Pine, Norway (Red) Pine, or Ponderosa Pine.

Sawed timber posts shall be of such grade as will meet the following permissible characteristics and limiting provisions: Stained sapwood, splits approximately three-fourths the thickness; seasoning checks—single or opposite each other - with a sum total depth equal to approximately one-half the thickness; heavy torn grain; close grain, slope of grain full length not to exceed 1 in 12; pitch streaks, medium pitch pockets; wane approximately one-eighth of any face; shakes approximately one-third the thickness; knots well spaced, sound and tight, knot clusters not permitted; knots may be anywhere, but the knot sizes shall not exceed 30 mm in 130 mm (1-3/16 inches in 5 inch) widths, 40 mm in 150 mm (1 ½ inches in 6 inch) widths, or 50 mm in 200 mm (2 inches in 8 inch) widths. In rectangular sizes the wider face determines the size of the knots permitted.

B2 Dimensions

The posts and offset blocks shall be sawn to the full nominal dimensions shown in the Plans. Surfacing will not be required. Slight variations in sawing will be permitted to the extent that variations from the nominal for dry material shall not exceed 6 mm (¼ inch) under or 13 mm (½ inch) over.
3412.2

C Preservative Treatment
All posts and offset blocks shall be treated in accordance with 3491. The treated posts and offset blocks shall have a dry surface and shall be free of excess preservative.

3412.3 INSPECTION ........................................................................ 3426

3413
Wood Fence Posts (Treated)

3413.1 SCOPE
This Specification covers preservative treated wood posts for use in fence construction.

3413.2 REQUIREMENTS
A Species of Wood
The posts shall be of Northern White Cedar or any species of pine, except Lodgepole, and shall be cut from live, growing trees.

B Seasoning
Posts shall be sufficiently air-seasoned, in an approved manner for a suitable length of time and under favorable climatic conditions, or otherwise conditioned as part of the treating process to permit adequate penetration of preservative without damage to the posts.

C Manufacture
C1 Peeling
The posts shall have all of the inner bark shaved off and the knots shall be closely trimmed before the posts are treated.

C2 End Finish
The ends of all posts shall be cut square unless they are to be set by driving, in which case the larger end may have a blunt point. The length of the point shall not be more than one and one-half times the diameter of the pointed end.

C3 Dimensions
Only naturally round posts will be acceptable. The length and minimum diameter of the posts shall be as shown in the Plans or specified in the Contract. Posts with a diameter at the small end up to 50 mm (2 inches) greater than the minimum specified will be acceptable.

The diameters of wood posts as shown in the Plans shall in all cases be construed to be the minimum permissible diameter at the small end.

C4 Quality
Knots will be permitted if sound, smoothly trimmed, and plainly do not impair the strength of the posts.

Excessive checking will not be permitted.
Short kinks will not be permitted. A line drawn between centers of the butt and tip shall not fall outside the center of the post by more than 2 percent of the post length.

Winding twist will be permitted provided it is not unsightly or exaggerated.

No decay will be permitted except that in Northern White Cedar, one pipe rot not over 6 mm (¼ inch) in diameter will be allowed.

Defects of any kind that, in the opinion of the Engineer, give the post an unsightly appearance or impair the strength or durability will be cause for rejection.

D Preservative Treatment

Posts shall be treated in accordance with 3491.

All cutting, trimming and pointing of ends shall be done prior to treatment.

The treated posts shall have a dry surface and shall be free from dripping or excessive preservative.

3413.3 INSPECTION .......................................................... 3426

3426 Structural Timber

3426.1 SCOPE

This Specification covers structural timbers for dimensional lumber, joists and planks, beams and stringers, posts and timbers.

Definitions of Terms .................................................. ASTM D 9
Nomenclature .......................................................... ASTM D 1165

3426.2 REQUIREMENTS

A Species of Wood

The species permitted shall be West Coast Douglas Fir or Southern (Yellow) Pine. Other species of wood will be permitted only when provided for in the Plans, in the Special Provisions or in the purchase order.

B Standard Sizes

All structural timber furnished shall conform to the dimensions specified for either rough or surfaced stock.

C Preservative Treatment

When treated timber is specified, the timber shall be treated in accordance with 3491.

D Grading

The Contractor shall provide commercial stress grades of lumber and timber with grade description that meet the stress requirements. The numerical stress values of structural timber and lumber that are indicated in the Contract are the minimum requirements. Stress graded material meeting grading rules developed from ASTM D 245, Methods
for Establishing Structural Grades of Lumber as tabulated by the National Design Specification for Wood Construction (NDS) will be acceptable as meeting stress requirements.

NOTE: The Standard Grading and Dressing Rules of the West Coast Lumber Inspection Bureau, the Standard Grading Rules for Western Lumber of the Western Wood Products Association, and the Standard Grading Rules for Southern Pine of the Southern Pine Inspection Bureau, are in conformance with the basic provisions of ASTM D 245.

3426.3 INSPECTION
The Department will inspect for treatment as provided in 3491. The Department will make final inspection and acceptance as follows:
(a) In cases of direct purchases by the Department, at the point of delivery.
(b) In cases of materials furnished and installed by a Contractor, at the site of the work.

3457 Lumber
3457.1 SCOPE
This Specification covers lumber intended for general building purposes.
Definition of terms....................................................... ASTM D 9
3457.2 REQUIREMENTS
The species permitted shall be Douglas Fir, Norway (Red) Pine, Ponderosa Pine, White Pine, or Southern (Yellow) Pine.
The lumber shall be graded in accordance with grading rules, adopted by regional associations of lumber manufacturers, which conform to the basic provisions of the American Lumber Standards.
Unless otherwise specified, the lumber furnished shall be No. 1 grade.
All lumber shall be grade marked.
3457.3 INSPECTION ............................................................. 3426

3462 Plank for Wearing Course
3462.1 SCOPE
This Specification covers lumber to be used as plank for wearing course on bridges.
Definition of terms....................................................... ASTM D 9
3471.2 REQUIREMENTS


The plank shall be of sound live-cut timber, well seasoned, and free from pocket rot, dry rot, red heart, cavities, bad checks, loose slivers, loose heart, shakes, splits, any incipient decay, unsound, loose or decayed knots, ant or worm holes. Checks in the ends of planks shall not extend more than 225 mm (9 inches) into the piece. All planks shall be free from crook. No plank shall have any corner wane greater than 13 mm (½ inch).

The planks shall be surfaced on 1 side and 1 edge (S1S1E), but may be surfaced on 2 edges, shall have lengths of not less than 2 m (6 feet) or more than 5 m (16 feet), shall have a uniform width and thickness through their entire length, shall be straight, and shall have square-sawed ends. Skip on the planed surfaces will be permitted, but not to exceed 15 percent of the surfaced area of any individual plank. All planks having heart center appearing on one side shall be surfaced on the heart side.

All planks furnished for any one bridge shall have the same thickness, which shall in no case be less than 38 mm (1 ½ inch) after surfacing. Planks furnished for any one bridge may have nominal widths of 150 mm (6 inches), 200 mm (8 inches), or both. The minimum widths after surfacing shall be not less than 140 mm (5 ½ inches) and 185 mm (7 ¼ inches) respectively. All planks of each nominal width furnished for any one bridge shall have the same actual width.

When treated plank are specified, the preservative treatment shall be in accordance with 3491.
3471.2
A3 For Temporary Structures
If untreated timber piling is permitted for temporary structures, any species that will withstand driving to the required bearing and penetration without damage to the piling may be used.

3471.3 GENERAL REQUIREMENTS
The piling shall satisfactorily withstand driving without breaking or suffering excessive brooming or splitting.
All piling shall be cut from sound, live trees except that fire-killed, blight-killed or wind-felled trees may be used provided the sapwood has not been charred and there is no decay or evidence of attack by insects. Piles shall be free from any defects that might impair their strength or durability.

A Quality of Timber
The sapwood thickness at the butt end shall be not less than 19 mm (¾ inch) in Douglas Fir Norway (Red) Pine and Jack Pine, and shall be not less than 50 mm (2 inches) in Southern Yellow Pine and Ponderosa Pine.
For untreated trestle piles the heartwood shall have a diameter not less then 80 percent of the diameter of the pile at the butt.
Checks wider than 6 mm (¼ inch) will not be permitted.

B Peeling
All piles shall be peeled by removing all of the rough bark and at least 80 percent of the inner bark. No strip of inner bark remaining on the pile shall be over 20 mm (¾ inch) wide and 200 mm (8 inches) long, and there shall be at least 25 mm (1 inch) of clean wood surface between any two such strips. Not less than 80 percent of the surface on any circumference shall be cleaned wood.

C Straightness
Piles shall be cut above the ground swell and shall have a gradual taper from the point of butt measurement to the tip.
A line drawn from the center of the butt to the center of the tip shall lie wholly within the body of the pile. The distance from such a line to the center of the pile at any point shall not exceed 1 percent of the length of the pile.
Bends may be permitted within the upper 75 percent of the length of the pile (measured from the butt end) provided the deviation of the centerline of the pile from a line stretched from the center of the pile above the bend to the center of the pile below the bend does not exceed 4 percent of the length of the bend and in no case exceeds 64 mm (2 ½ inches). Within the lower 25 percent of the length of the pile but in no case less than 3 m (10 feet) (measured from the tip end), the deviation in any bend, as determined above, shall not exceed 25 mm (1 inch).
Piles shall be free of twist exceeding on half the circumference in any 6 m (20 feet) of length.

All Piles shall have the ends sawed off square. All knots shall be trimmed close to the body of the pile.

**Knots**

Piling shall contain no unsound knots. Sound knots will be permitted provided the diameter of any knot does not exceed 100 mm (4 inches) or 35 percent of the minimum diameter of the pile at the section where the knot occurs. The sum of the diameters of all knots occurring in a 300 mm (12 inch) length of any pile shall not exceed twice the diameter of the maximum permissible knot at the section where they occur.

Knot clusters will not be permitted. A knot cluster is two or more knots grouped together, the fibers of the wood being deflected around the entire unit. A group of single knots, with fibers deflected around each knot separately, is not a cluster, even though the knots may be in close proximity.

**Density**

The number of annual rings in any pile when measured at the butt shall average not less than 4 per 25 mm (1 inch) over the outer 75 mm (3 inches) of a representative radial line from the pith. The outer 25 mm (1 inch) within the measured section shall have a minimum of four rings.

**Dimensions**

Sound piles shall have a minimum diameter at the tip, measured under the bark, as follows:

<table>
<thead>
<tr>
<th>Length of Pile</th>
<th>Tip Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 12 m (40 feet)</td>
<td>200 mm (8 inches)</td>
</tr>
<tr>
<td>12 to 22 m (40 to 74 feet), Incl.</td>
<td>175 mm (7 inches)</td>
</tr>
<tr>
<td>Over 22 to 27 m (74 to 90 feet), Incl.</td>
<td>150 mm (6 inches)</td>
</tr>
<tr>
<td>Over 27 m (90 feet)</td>
<td>125 mm (5 inches)</td>
</tr>
</tbody>
</table>

The minimum diameter measured under the bark at 1 m (3 feet) from the butt shall be as follows for all species:

<table>
<thead>
<tr>
<th>Length of Pile</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 8 m (25 feet)</td>
<td>280 mm (11 inches)</td>
</tr>
<tr>
<td>8 to 16 m (25 to 54 feet), Incl.</td>
<td>300 mm (12 inches)</td>
</tr>
<tr>
<td>Over 16 m (54 feet)</td>
<td>330 mm (13 inches)</td>
</tr>
</tbody>
</table>

The diameter of the pile at the butt shall not exceed 500 mm (20 inches).

The diameter of a pile shall be considered as its average diameter and its diameter shall be determined by measuring the circumference and dividing by 3.14 or by averaging the maximum and minimum diameters at the locations specified above for butt and tip diameters.
3471.3

G  Preservative Treatment

Piling shall be treated in accordance with 3491 unless otherwise specified in the Contract.

3471.4 INSPECTION .......................... 3426

3491

Preservatives and Preservative Treatment of Timber Products

3491.1 SCOPE

This Specification covers wood preservatives and preservative treatment, by pressure process, of lumber, timber, piling, posts, poles, and structural glued laminated members.

3491.2 REQUIREMENTS

A  Materials

A1  Timber Products

Timber, lumber, piling, and posts shall conform to the appropriate Specifications as referenced or as otherwise specified in the Contract.

A2  Preservatives ........................................ AWPA

A2a  Creosote Oil ..................................... AWPA P1

A2b  Pentachlorophenol ............................... AWPA P8

Unless otherwise specified, the pentachlorophenol solution for wood treatment shall consist of not less than 5.0 percent of pentachlorophenol in heavy petroleum solvent (AWPA P9, Type A).

A2c  Ammoniacal Copper Arsenate (ACA) ............. AWPA P5

A2d  Chromated Copper Arsenate (CCA)

.................................................. AWPA P5, Types A, B, or C

A2e  Ammoniacal Copper Zinc Arsenate (ACZA) ..... AWPA P5

A2f  Copper Naphthenate for Field Application ....... AWPA P8

B  Preservative Treatment

Along with the provisions hereof, preservative treatment shall be in accordance with the requirements and recommendations of AWPA Standard C1 and the applicable AWPA Commodity Standards.

B1  Preparation for Treatment

B1a  General Requirements

Since difficulty may be encountered in obtaining the specified retention and penetration, it is the responsibility of the supplier to select wood materials for treatment that have sufficient sapwood thickness to permit penetration and retention as specified. Suitable conditioning and, for some species, incising prior to the treatment, and the use of treating conditions that do not damage the wood according to AWPA Standards C1 and C3, are additional responsibilities of the supplier.

B1b  Framing

Bored holes shall be of the diameters specified by the following for different hardware types:
(1) For round drift bolts and dowels - equal to diameter of bolt or dowel.
(2) For square drift bolts and dowels - 2 mm (1/16 inch) greater than least dimension of bolt or dowel.
(3) For machine bolts - 2 mm (1/16 inch) greater than diameter of bolt.
(4) For rods - 2 mm (1/16 inch) greater than diameter of the rod.
(5) For lag screws - not more than 2 mm (1/16 inch) greater than the body diameter of the screw at the root of the thread.

B1c Incising

Incising is a method used to ensure proper penetration of the preservative. All lumber and timbers of species that are difficult to penetrate, such as Douglas Fir, Western Larch, Western Hemlock, Redwood, Jack Pine, and Ponderosa Pine shall be incised before treatment provided the incising will not make the material unfit for the use intended. Pines that are predominantly heartwood shall be incised. The Engineer may waive the incising requirement if penetration and retention requirements can be met without incising.

B1d Seasoning

All sawn material that is to be treated with an oil-type preservative and be used in buildings or other construction where high moisture content or shrinkage would be objectionable shall be dried to a moisture content of not more than 19 percent before treatment.

When sawn material is treated with chromated copper arsenate the moisture content prior to treatment, as determined by the ASTM D 4442 oven-dried method or a calibrated resistance-type moisture measuring device approved by the Engineer, shall not be more than 19 percent for material 100 mm (4 inches) or less in nominal thickness and not more than 25 percent for material over 100 mm (4 inches) in nominal thickness. The moisture content shall be measured at a depth equivalent to the required penetration.

When treated with ammoniacal copper arsenate, sawn material shall be suitably seasoned or conditioned prior to treatment.

Unless otherwise specified, lumber 100 mm (4 inches) or less in nominal thickness and plywood treated with a waterborne preservative shall be dried after treatment to a moisture content of not more than 19 percent.

C Method of Treatment

Unless otherwise specified, the Department will allow any of the preservative material listed in 3491.2, except that the Contractor:
(1) Shall not use CCA for treating Douglas Fir.
(2) May use copper naphthenate, but only for field treatment of damaged treated areas.
(3) Shall use the same preservative for all of the product furnished for each Contract item.

Treatment with waterborne preservative shall be made by the full-cell process.

D Results of Treatment

Unless otherwise specified, retention of preservatives shall be in conformance with Table 3491-1. Preservative retention shall be determined by the lime ignition assay method or with the AWPA A1 and A2 asome x-ray fluorescence analyzer. Penetration and other treatment requirements shall be in accordance with AWPA Standard C1 and the AWPA Commodity Standards listed in Table 3491-1.

E Handling Treated Products

Care and handling of preservative treated wood products shall be in accordance with AWPA Standard M4.

F Product Marking

The Contractor shall have the species, commercial grade, and the type of treatment marked on the treated material by hammer or heat brand, dye stamp, or metal tag in accordance with AWPA M1 and M6, except that branding of piles shall be on the butt end. The charge number shall be included in the markings on treated piles.

Sawn materials 50 mm (2 inches) or less in nominal thickness and plywood treated with oil-type preservatives may be bundled with the tags being attached to the bundles. In lieu of bundle tags, when such materials are treated with waterborne preservative, the required information may be dye stamped on the outer pieces of the bundle.

3491.3 INSPECTION AND QUALITY ASSURANCE

Inspection of materials and treatment by an independent commercial inspection agency shall be the responsibility of the Contractor and the supplier of the treated wood products. Only agencies approved by the Department's Materials Engineer may be used for materials furnished for Department work. The inspection agency shall be engaged by the Contractor directly or through the Contractor's supplier. No direct compensation will be made for these inspection costs, it being understood that the costs of inspection are included in the Contract bid prices for treated wood products.

This inspection shall be conducted in accordance with AWPA M2. With each shipment of treated materials, a Certificate of Compliance shall be furnished by the supplier in accordance with 1603. This certificate shall be accompanied by the inspection report of the commercial inspection agency and the treating company's report of treatment. A copy of the Certificate of Compliance and supporting reports shall be submitted directly to the Materials Engineer.
The Department reserves the right to conduct its own inspection of the treated products upon delivery to the Project site. Should the results of the Department's inspection disagree with those of the inspection agency, the Department's findings shall be conclusive and binding.

### TABLE 3491-1 (C)

**MINIMUM PRESERVATIVE RETENTION REQUIREMENTS (AWPA)**

<table>
<thead>
<tr>
<th>Product and Usage (B)</th>
<th>Creosote kg retained/m³ (Pound retained/foot³) of Wood</th>
<th>Pentachlorophenol kg retained/m³ (Pound retained/foot³)</th>
<th>ACA kg retained/m³ (Pound retained/foot³)</th>
<th>ACZA kg retained/m³ (Pound retained/foot³)</th>
<th>CCA kg retained/m³ (Pound retained/foot³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Piles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Southern Pine, Ponderosa Pine, Jack pine &amp; Red Pine</td>
<td>192 (12.0)</td>
<td>9.6 (0.60)</td>
<td>12.8 (0.80)</td>
<td>12.8 (0.80)</td>
<td>C3</td>
</tr>
<tr>
<td>A2 Coastal Douglas Fir</td>
<td>272 (17.0)</td>
<td>13.6 (0.85)</td>
<td>16.0 (1.00)</td>
<td></td>
<td>C3</td>
</tr>
<tr>
<td><strong>B Posts: Fence, Guide &amp; Sight</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1 Round</td>
<td>128 (8.0)</td>
<td>6.4 (0.40)</td>
<td>6.4 (0.40)</td>
<td>6.4 (0.40)</td>
<td>C5</td>
</tr>
<tr>
<td>B2 Sawn Four Sides</td>
<td>160 (10.0)</td>
<td>8.0 (0.50)</td>
<td>8.0 (0.50)</td>
<td>8.0 (0.50)</td>
<td>C2</td>
</tr>
<tr>
<td><strong>C Posts: Guardrail &amp; Spacer Blocks, Noise Walls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1 Round</td>
<td>160 (10.0)</td>
<td>8.0 (0.50)</td>
<td>8.0 (0.50)</td>
<td>8.0 (0.50)</td>
<td>C5</td>
</tr>
<tr>
<td>C2 Sawn Four Sides</td>
<td>192 (12.0)</td>
<td>9.6 (0.60)</td>
<td>8.0 (0.50)</td>
<td>8.0 (0.50)</td>
<td>C2</td>
</tr>
<tr>
<td><strong>D Poles, Lighting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1 Southern Pine, Ponderosa Pine</td>
<td></td>
<td></td>
<td>6.1 (0.38)</td>
<td>9.6 (0.60)</td>
<td>C4</td>
</tr>
<tr>
<td>D2 Red Pine</td>
<td></td>
<td></td>
<td>8.5 (0.53)</td>
<td>9.6 (0.60)</td>
<td>C4</td>
</tr>
<tr>
<td>D3 Coastal Douglas-fir</td>
<td></td>
<td></td>
<td>7.2 (0.45)</td>
<td>9.6 (0.60)</td>
<td>C4</td>
</tr>
<tr>
<td>D4 Jack Pine, Lodgepole Pine</td>
<td></td>
<td></td>
<td>9.6 (0.60)</td>
<td>9.6 (0.60)</td>
<td>C4</td>
</tr>
<tr>
<td>D5 Western Red Cedar, Western Larch</td>
<td></td>
<td></td>
<td>12.8 (0.75)</td>
<td>9.6 (0.60)</td>
<td>C4</td>
</tr>
<tr>
<td><strong>E Lumber and Timber</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridges, Prefab (Nail Laminated), Panels, other Structural Members, Culverts and other uses</td>
<td>192 (12.0)</td>
<td>9.6 (0.60)</td>
<td>9.6 (0.60)</td>
<td>9.6 (0.60)</td>
<td>C2</td>
</tr>
<tr>
<td><strong>F Lumber and Timber</strong> (not in contact with ground or water)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1 Handrails, Side walk Plank</td>
<td></td>
<td></td>
<td></td>
<td>4.0 (0.25)</td>
<td>4.0 (0.25)</td>
</tr>
<tr>
<td>F2 Noise Wall Facing</td>
<td>128 (8.0)</td>
<td>6.4 (0.40)</td>
<td></td>
<td>4.0 (0.25)</td>
<td>C2</td>
</tr>
<tr>
<td><strong>G Glued-Laminated Structural Members</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G1 Glued-Laminated Structural Members</td>
<td>192 (12.0)</td>
<td>9.6 (0.60)</td>
<td></td>
<td></td>
<td>C28</td>
</tr>
<tr>
<td><strong>H Plywood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1 In contact with ground or water</td>
<td>160 (10.0)</td>
<td>8.0 (0.50)</td>
<td>6.4 (0.40)</td>
<td>6.4 (0.40)</td>
<td>C9</td>
</tr>
<tr>
<td>H2 For use above ground</td>
<td>128 (8.0)</td>
<td>6.4 (0.40)</td>
<td>4.0 (0.25)</td>
<td>4.0 (0.25)</td>
<td>8</td>
</tr>
</tbody>
</table>

(A) CCA shall not be used for the treatment of Douglas Fir.

(B) Southern Pine is the same as Southern Yellow Pine. Red Pine is the same as Norway Pine.

(C) If the retention in this table differs from AWPA C14, the retention requirements of AWPA C14 shall govern for Products and Usage "A" through "G" and AWPA C9 shall govern for Products and Usage "H."
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.
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 .................................................. 3501
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.
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 an 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.
3520.6

| 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.
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
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.
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
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-Methyl 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.
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":

<table>
<thead>
<tr>
<th>x</th>
<th>0.470</th>
<th>0.485</th>
<th>0.520</th>
<th>0.480</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>0.440</td>
<td>0.460</td>
<td>0.450</td>
<td>0.420</td>
</tr>
</tbody>
</table>

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, thicken, 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.

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wgt per gal, 25 °C (77 °F), lbs, min</td>
<td>12.0</td>
</tr>
<tr>
<td>Viscosity, Krebs Stormer, 77 °F, K.U.</td>
<td>80 - 100</td>
</tr>
<tr>
<td>Grind, Hegman, minimum</td>
<td>3</td>
</tr>
<tr>
<td>Total Solids, % by weight, minimum</td>
<td>73</td>
</tr>
<tr>
<td>Non-volatile vehicle, % by weight, minimum</td>
<td>43</td>
</tr>
<tr>
<td>Pigment, % by weight</td>
<td>45 - 62</td>
</tr>
</tbody>
</table>
Titanium Dioxide, white paint, lbs/gal, 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
Skinning, 48 hrs None
Track Free Time, minutes, maximum 3
pH, minimum 9.6
Lab Retro-reflectivity, white, min., mcd/m²/lux 300
Lab Retro-reflectivity, yellow, min., mcd/m²/lux 200

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.

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

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,
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.
3601.1 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.
### TABLE 3601-1
RANDOM RIPRAP REQUIREMENTS

<table>
<thead>
<tr>
<th>Mass (kilogram)</th>
<th>Size (mm)</th>
<th>Approx. % of Total Mass Smaller than Given Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>450 (1000)</td>
<td>600 (24)</td>
<td>I: --, II: --, III: 100, IV: --, V: --</td>
</tr>
<tr>
<td>300 (650)</td>
<td>525 (21)</td>
<td>I: --, II: --, III: --, IV: 75, V: --</td>
</tr>
<tr>
<td>180 (400)</td>
<td>450 (18)</td>
<td>I: --, II: 100, III: --, IV: --, V: --</td>
</tr>
<tr>
<td>113 (250)</td>
<td>375 (15)</td>
<td>I: --, II: --, III: 75, IV: 50, V: --</td>
</tr>
<tr>
<td>55 (120)</td>
<td>300 (12)</td>
<td>I: 100, II: 75, III: 50, IV: --, V: --</td>
</tr>
<tr>
<td>22 (50)</td>
<td>225 (9)</td>
<td>I: --, II: 75, III: 50, IV: --, V: --</td>
</tr>
<tr>
<td>7 (15)</td>
<td>150 (6)</td>
<td>I: 100, II: 50, III: --, IV: --, V: 10</td>
</tr>
<tr>
<td>2 (5)</td>
<td>100 (4)</td>
<td>I: --, II: --, III: 10, IV: --, V: --</td>
</tr>
<tr>
<td>1 (2)</td>
<td>75 (3)</td>
<td>I: --, II: 50, III: --, IV: 10, V: --</td>
</tr>
<tr>
<td>--</td>
<td>50 (2)</td>
<td>I: --, II: 10, III: --, IV: --, V: --</td>
</tr>
<tr>
<td>--</td>
<td>25 (1)</td>
<td>I: 10, II: --, III: --, IV: --, V: --</td>
</tr>
</tbody>
</table>

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

**B Filter Material**

**B1 Granular Filter**

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

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

GRANULAR FILTER MATERIAL

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 mm (6 inches)</td>
<td>100</td>
</tr>
<tr>
<td>75 mm (3 inches)</td>
<td>75-95</td>
</tr>
<tr>
<td>25 mm (1 inches)</td>
<td>35-75</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>10-40</td>
</tr>
<tr>
<td>2.00 mm (#10)</td>
<td>5-25</td>
</tr>
<tr>
<td>425 µm (#40)</td>
<td>0-10</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>0-5</td>
</tr>
</tbody>
</table>

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 m³ (40 cubic yards), the Engineer may require, that size and quality compliance be referenced to a control unit consisting of approximately 3 m³ (4 cubic yards) of riprap constructed at the source or construction site. When the Engineer requires and approves a control unit for reference, the control unit shall remain intact during the course of riprap construction until being incorporated as the last stones placed. The Contractor shall use production stone equivalent in all respects to the stone placed in the approved control unit.

3602 Gabions and Revet Mattresses Materials

3602.1 SCOPE

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

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

A Gabion ................................................... Rectangular Basket
B Revet Mattress ..................... Thin Flat Rectangular Basket
3602.2 REQUIREMENTS

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

3602.3 SAMPLING AND TESTING

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

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 C140.

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
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
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
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/m³ (10 pound per cubic foot). Physical requirements shall be as indicated in Table 3608-1:

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

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

3608.3 SAMPLING AND TESTING

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

3612

Sewer Brick (Clay)

3612.1 SCOPE

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

3612.2 REQUIREMENTS

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

3612.3 SAMPLING AND TESTING

A  Compressive Strength and Absorption .................................................. AASHTO T 32
B  Freezing and Thawing............................................................................. AASHTO T 32
C  Bricks for testing shall be selected by the Engineer.

The manufacturer or seller shall furnish test specimens without charge.
3613
Building Brick (Clay or Shale)
Building brick (clay or shale) shall conform to AASHTO M 114. Three grades of brick are covered; SW, MW, and NW. The grade required will be specified in the Contract.

3614
Building Brick (Sand-Lime)
Building brick (sand-lime) shall conform to ASTM C 73. Unless otherwise specified the grade required shall be MW.

3615
Building Brick (Concrete)
Building brick (concrete) shall conform to ASTM C 55. Unless otherwise specified the grade required shall be S-II.

3616
Sewer Brick (Concrete)

3616.1 SCOPE
This Specification covers concrete brick for use in the construction of catch basin and manholes.

3616.2 REQUIREMENTS
The units shall conform in quality to ASTM C 139, except that:
(a) At the time of delivery to the site of the work, the minimum compressive strength requirements shall be 28 Mpa (4100 psi) for any individual unit, and 31 MPa (4500 psi) for the average of three units.
(b) The concrete units shall be cured by the steam or water curing methods, unless the use of a sealing membrane or other curing methods are authorized by the Engineer. When steam curing is used, atmospheric temperature in the curing chamber shall not exceed 70ºC (158 ºF). 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.
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.

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.
- Calcium Chloride
  - 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.
- Physical Properties
  - Dimensions, shape, wall thickness, and the type and quantity of reinforcement shall be in conformance with the Plans.
  - Manufacturers may produce the alternative spigot-up joint. Manufacturers may also produce the alternative offset joint. This type of offset joint is to be used with the profile or pre-lubricated pipe seal system.
  - The concrete shall develop a compressive strength of not less than 21 Mpa (3100 psi) at 14 days. Cores taken from the finished units shall have a compressive strength of not less than 28 MPa (4200 psi) at 28 days. However, all manhole sections including Structural Manhole
Covers, Standard Plate 4020, shall attain full design strength prior to shipment.

**C  Manufacture**

The units shall be true to shape and their surfaces shall be smooth, dense and uniform in appearance. Minor surface cavities or irregularities that do not impair the service value of the unit and that can be corrected without marring the appearance shall be filled with mortar as soon as the forms are removed. Forms shall remain in place until they can be removed without damage to the unit.

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

**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 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/m³ (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.
The forms shall remain in place until they can be removed without damage to the units. The units shall be cured for a sufficient length of time as will develop the specified compressive strength. The units shall be protected from freezing, after being cast and until curing is completed. The units shall be cured by the steam or water curing methods, as described in AASHTO M 199, unless the use of a sealing membrane or other effective methods are specifically approved by the Engineer. When steam curing is used, atmospheric temperature in the curing chamber shall not exceed 70ºC (158 ºF)

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/m3 (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/m3 (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.
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.
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.

Joint and Crack Sealer

(3719)

(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
(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 (½ ± 0.01 inch) apart enclosing a reservoir of 50 mm by 50 mm by 12.7 mm (2 inch by 2 inch by ½ inch).
3721 Preformed Elastomeric Compression Joint Seals for Concrete

3721.1 SCOPE
This Specification covers preformed elastic joint seals of the open-cell compression type, intended for use in sealing joints in concrete pavements, bridges and other structures. It also covers the lubricant-adhesive used when installing the seals.

3721.2 REQUIREMENTS
A Requirements for Seals
A1 Composition and Manufacture
The seals shall be preformed and manufactured from vulcanized elastomeric compound using polymerized chloroprene as the only polymer.
A2 Size and Shape
The size, shape and dimensional tolerances of the seals shall be as shown in the Plans or otherwise specified. Alternate shapes may be used upon approval of the Engineer.
A3 Physical Properties
The material shall conform to the physical properties prescribed below.

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

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirements</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mm (13/16 inch) Seal:</td>
<td></td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 16.5 mm,</td>
<td>0.70 N/mm min.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 0.65 inch pounds/linear inch</td>
<td>(4 min)</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 10.5 mm,</td>
<td>3.50 N/mm max.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 0.41 inch pounds/linear inch</td>
<td>(20 max)</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>32 mm (1-1/4 inch) Seal:</td>
<td></td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 25 mm (1 inch),</td>
<td>0.90 N/mm min.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 1.00 inch pounds/linear inch</td>
<td>(5 min.)</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>50 mm (2 inch) Seal:</td>
<td></td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 41 mm,</td>
<td>0.90 N/mm min.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 1.02 inch pounds/linear inch</td>
<td>(5 min.)</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>65 mm (2-1/2 inch) Seal:</td>
<td></td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 54 mm,</td>
<td>0.90 N/mm min.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 2.13 inch pounds/linear inch</td>
<td>(5 min.)</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>75 mm (3 inch) Seal:</td>
<td></td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 65 mm,</td>
<td>0.90 N/mm min.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 2.50 inch pounds/linear inch</td>
<td>(5 min.)</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>90 mm (3-1/2 inch) Seal:</td>
<td></td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 75 mm,</td>
<td>0.90 N/mm min.</td>
<td>Mn/DOT Method (C)</td>
</tr>
<tr>
<td>Force @ 3.00 inch pounds/linear inch</td>
<td>(5 min.)</td>
<td>Mn/DOT Method (C)</td>
</tr>
</tbody>
</table>

**Recovery Under Deflection of 50 % of the Nominal Seal Width**

After 70 hours @ 100 ºC (212 ºF), | 85 % min. (B) | Mn/DOT Method (C) |
After 72 hours @ -10 ºC (14 ºF), | 88 % min. (B) | Mn/DOT Method (C) |
After 22 hours @ -29 ºC (-20 ºF), | 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 100ºC (212 ºF) shall mean the specimen has failed the test.  
(C) Refer to 3721.3C of this Specification for the Test Method.

### A4 Identification and Marking

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

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

B Requirements for Lubricant-Adhesive

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

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

The lubricant-adhesive shall have the following physical properties:
- Average density: 1 kg/L (8.0 pounds/gallon) ± 10%
- Solids content: 72 to 74 %, by mass (weight)
- Adhesive to remain fluid from -15°C (5°F) to 50 ºC (120°F)
- Film strength, ASTM D 412: 8250 kPa (1200 psi)
- Elongation: 350%

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

3721.3 SAMPLING AND TESTING

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

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

A Sampling

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

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

B Sample Preparation

All test specimens shall be prepared in accordance with ASTM D 2240 and D 412 from samples taken of the joint seals as delivered to the Project.
Specimens for low-temperature and high-temperature recovery tests shall be approximately 125 mm (5 inches) long and shall be taken at random from the sample representing the lot or shipment under test. Specimens for low-temperature recovery tests shall be lightly dusted with talc on both the internal and outside surfaces to prevent adhesion between all internal surfaces and between the outside surface and the metal compression plates. Specimens for the high-temperature recovery test shall be tested as received except that the outside surfaces only shall be dusted lightly with talc. Specimens for test of mass (weight) change in oil shall be approximately 75 mm (3 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,
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:

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

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:
\[
\% \text{ Change in Mass} = \frac{(W_2 - W_1) \times 100}{W_1}
\]
Where: \( W_1 \) = Initial mass of specimen in grams.
\( W_2 \) = 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>
<thead>
<tr>
<th>Nominal Width of Seal mm (inches)</th>
<th>Column A Specimen Length 5 mm (0.2 inch)</th>
<th>Column B Test Width for Min. Pressure mm (inches)</th>
<th>Column C Test Width for Max. Pressure mm (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mm (13/16 inch)</td>
<td>100 mm (4 inch)</td>
<td>16.5 mm (0.65 inch)</td>
<td>10 mm (0.41 inch)</td>
</tr>
<tr>
<td>32 mm (1-1/4 inch)</td>
<td>100 mm (4 inch)</td>
<td>25.0 mm (1.00 inch)</td>
<td>11 mm (0.44 inch)</td>
</tr>
<tr>
<td>50 mm (2 inch)</td>
<td>150 mm (6 inch)</td>
<td>41.0 mm (1.62 inch)</td>
<td>17 mm (0.69 inch)</td>
</tr>
<tr>
<td>90 mm (3-1/2 inch)</td>
<td>150 mm (6 inch)</td>
<td>75.0 mm (3.00 inch)</td>
<td>35 mm (1.38 inch)</td>
</tr>
</tbody>
</table>

(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 inch) 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
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
(½ 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.
The sealant shall be capable of withstandng 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

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

### 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.
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.
3725.2

B3 Cement Mortar Blocks (Mn/DOT Method)

Prepare mortar using one part high early Portland Cement conforming to AASHTO M 85 Type III and two parts by weight of clean, uniformly graded, concrete fine aggregate conforming to AASHTO M 6. Add sufficient water to produce a flow of 100 ± 5 when tested in accordance with the procedure for determination of consistency of cement described in section 9 of AASHTO T 106, Test for Compressive Strength of Hydraulic Cement Mortars (using 50 mm (2 inch) cube specimens). After curing one day in moist air and six days in water at 23 ± 1.7 °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 ± 0.25 mm (½ ± 0.01 inch) apart enclosing a reservoir of 50 x 50 x 12.5 mm (2 x 2 x ½ inch).

3724

Sewer Joint Sealing Compound
(Hot-Poured)

The sealer shall conform to Federal Specification SS-S-169 for Class I 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
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 ± 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 ºC, the blocks shall be cut into 25.4 by 50.8 by
76.2 mm (1 x 2 x 3 inch) test blocks using a diamond saw blade.
Discard the 25.4 mm (1 inch) strips in contact with the vertical sides of
the mold.

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

3726
Preformed Gasket Seals for Concrete Pipe
Preformed gasket type seals for effecting flexible watertight joints
in concrete pipe shall conform to AASHTO M 198 for Type A (rubber)
or Type B (plastic) as required for the specific joint design of the pipe
furnished.

3728
Bituminous Mastic Joint Sealer for Pipe
This Specification covers a cold applied, mineral filled, joint sealing
compound for joints of bell and spigot or tongue and groove, concrete
or clay culvert, sewer, or drain pipe.

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

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

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

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

The bituminous mastic sealer shall meet the following test
requirements:
(1) Grease cone penetration (unworked), 150 g, 25°C (77°F), 5 s, ASTM D 217, .............................................. 17.5 to 30.0 mm
(2) Density ................................ 1.0 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


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 1 - For use in wrapping subsurface drain pipe or for other specified drainage applications.
Type II - For use in wrapping joints of concrete pipe culvert and as a cover over drain field aggregate.
Type III - For use under Classes I and II random riprap, gabions, and revet mattresses.
Type IV - For use under Classes III and IV random riprap, hand-placed riprap, and quarry-run riprap.
Type V - For use in separating materials (stabilization).
Type VI - For use in earth reinforcement and Class V random riprap.
3733.2 REQUIREMENTS

A General

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

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

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

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

B Physical Properties

Geotextile shall conform to the requirements of Table 3733-1:
<table>
<thead>
<tr>
<th>Geotextile Property</th>
<th>Test Method (ASTM)</th>
<th>Type (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>I</td>
</tr>
<tr>
<td>B1 Grab Tensile Strength minimum, each principal direction</td>
<td>D4632 kN</td>
<td>0.45 (100)</td>
</tr>
<tr>
<td>B2 Elongation minimum, each principal direction</td>
<td>D4632 percent</td>
<td>--</td>
</tr>
<tr>
<td>B3 Seam Breaking Strength minimum (D)</td>
<td>D4632 kN</td>
<td>0.40 (90)</td>
</tr>
<tr>
<td>B4 Apparent Opening Size (AOS) maximum opening size or range (E)</td>
<td>D4751 mm</td>
<td>0.425 (40)</td>
</tr>
<tr>
<td>B5 Permittivity minimum (F)</td>
<td>D4491 falling head</td>
<td>0.275 relaxed</td>
</tr>
<tr>
<td>B6 Puncture Strength minimum (G)</td>
<td>D6241 N</td>
<td>--</td>
</tr>
<tr>
<td>B7 Wide Width Strip Tensile Strength min. ea. principal direction</td>
<td>D4595 kN/m</td>
<td>--</td>
</tr>
</tbody>
</table>

(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
field seams. Minimum thread strength for sewing shall be 110 N (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: \( P = \frac{K}{L} \) 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 Engineer's 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.
Elastomeric Bearing Pads

3741.1 SCOPE
This Specification covers elastomeric bearing pads for use in bridges and other structures.

3741.2 REQUIREMENTS
A General
The elastomeric portion of the bearing pads shall be 100 percent virgin chloroprene. Pads shall be cast in molds under pressure and heat to the required Plan thickness.

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

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

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 (¼ 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 (¼ inch+⅛ -1/16 inch).

B Physical Properties
B1 Elastomer
The elastomer, as determined from test specimens, shall conform to the following:
<table>
<thead>
<tr>
<th>ASTM Designation</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 2240 w/2 kg</td>
<td>Hardness (Type A) Min. 55 ± 5</td>
</tr>
<tr>
<td>D 412</td>
<td>Tensile Strength: Min. 17 MPa (2500 psi)</td>
</tr>
<tr>
<td>D 412</td>
<td>Elongation at Break, % Min. 400</td>
</tr>
<tr>
<td>D 395 (Method B)</td>
<td>Compression Set, 22 hours at 70°C (158°F), % Max. 25</td>
</tr>
<tr>
<td>D 624 (Die C)</td>
<td>Tear Strength, Min. 32 kN/mm (180 pounds/inch)</td>
</tr>
<tr>
<td>D 1149 (A)</td>
<td>Ozone Resistance, 20% strain, 100 hours at 38°C ± 1°F No cracks</td>
</tr>
<tr>
<td>D 797</td>
<td>Low Temperature Stiffness, Young's Modulus at –34 °C (-30 °F) Max. 34 MPa (5000 psi)</td>
</tr>
<tr>
<td>D 746</td>
<td>Low Temperature Brittleness, 5 hours at –40°C (-40 °F) Passed</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, %</td>
<td>-15</td>
</tr>
<tr>
<td>Hardness, points</td>
<td>+10</td>
</tr>
<tr>
<td>Elongation at Break, %</td>
<td>-40*</td>
</tr>
</tbody>
</table>

* (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 (% 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:
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 m²/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**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids, % by weight of compound</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>% Reflectance in 72 hours (ASTM E1347)</td>
<td></td>
<td>65</td>
</tr>
<tr>
<td>Loss of Water, kg/m² in 24 hours (ASTM C156)</td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>Loss of Water, kg/m² in 72 hours (ASTM C156)</td>
<td></td>
<td>0.40</td>
</tr>
<tr>
<td>Settling Test, ml/100 ml in 72 hours(^{(A)})</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>V.O.C. Content, g/L</td>
<td></td>
<td>350</td>
</tr>
<tr>
<td>Infrared Spectrum, Vehicle(^{(B)})</td>
<td></td>
<td>100% α methylstylene</td>
</tr>
</tbody>
</table>

\(^{(A)}\) Test Method on file at the Mn/DOT Office of Materials Laboratory

\(^{(B)}\) 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)**

<table>
<thead>
<tr>
<th>Oilphase (50 ± 4% by volume)</th>
<th>Percent by Mass (weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiled Linseed Oil</td>
<td>80</td>
</tr>
<tr>
<td>Z-8 Viscosity Linseed Oil</td>
<td>20</td>
</tr>
</tbody>
</table>

| Waterphase (50 ± 4% by volume) | 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

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness, mils</td>
<td>56+</td>
<td>ASTM 3767-Method A</td>
</tr>
<tr>
<td>Tensile Strength, MPa (PSI)</td>
<td>1.7 (250)+</td>
<td>ASTM D-412 Die C</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>300+</td>
<td>ASTM D-412 Die C</td>
</tr>
<tr>
<td>Composition</td>
<td>Rubber Asphalt</td>
<td>Infrared Scan</td>
</tr>
</tbody>
</table>
3757.2

3. Carrier Film

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness, mils</td>
<td>4+</td>
<td>ASTM 3767-Method A</td>
</tr>
<tr>
<td>Composition</td>
<td>Polyethylene</td>
<td>Infrared Scan</td>
</tr>
</tbody>
</table>

4. Composite Membrane

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

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

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

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

If specified in the Contract, the luminaires shall include an EEI/NEMA standard 3-terminal twist-lock type photoelectric control mounting receptacle and photoelectric control. The photoelectric control shall be in accordance with 3812.

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

C  Sign Lighting Fixture

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

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

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

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

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

5. Door easily removed from the fixture housing without tools and attached to the fixture housing by one of the following methods:
   a. Cast aluminum hinge (rear) and stainless steel latch (front). A galvanized steel brace shall be attached to the door and fixture housing to hold door in an open position during maintenance.
   b. Stainless steel latches front and rear. A hinge type mechanism shall be attached to the door and fixture housing, in each back corner, to allow the door to rest in an open position during maintenance.

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

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

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

(b) A heavy duty mogul base porcelain lamp socket
(c) A 175 W (H39KC-175/DX) or a 250 W (H37KC-250/DX) lamp with a deluxe white mogul base mercury vapor unit designed for horizontal operation. The lamp wattage shall be as specified in the Contract.
(d) A ballast that is "seated" to prevent movement during shipment or other vibrations.
(e) Electrical conductors within the fixture housing sized and installed in accordance with National Electrical Code.
(f) Electrical components within the fixture housing shielded in accordance with UL requirements.
(g) An outdoor, cold weather start, high power factor, constant wattage ballast for a 175 W or 250 W mercury vapor lamp as specified in the Contract. The ballast shall provide regulation within a 2 percent variation in lamp watts and with a 13 percent variation in primary volts and have adequate means of heat dissipation.

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

D Underpass Lighting Fixture

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

The underpass fixture shall include a rear die-cast back housing that encloses the ballast, starter board, lamp socket, reflector, and a refractor frame assembly. The back housing shall be finished with a black polyester powder paint coating. The refractor frame shall be anodized etched aluminum, painted gray. The back housing assembly shall mount against the wall and the refractor frame assembly shall fasten to it by means of concealed hinges and a single point, positive acting latch. Gasketing material shall be of the molded T-type attached to the refractor frame assembly. Stainless steel retaining cables shall be provided between the refractor frame assembly and the back housing.
Overall dimensions shall be approximately 406 mm (16 inches) square x 295 mm (11 ½ inches) deep. All insulation shall be UL listed Class H; the ballast and starter board shall be positioned for maximum heat dissipation; the supply wires into the unit are to be of the proper temperature rating.
The optical unit shall include the lamp, fluted specular aluminum reflector and molded prismatic borosilicate thermal-shock-resistant glass refractor. The dimensions of the refractor shall be approximately 406 mm (16 inches) square x 101 mm (4 inches) deep and the refractor shall have internal splitting prisms and external dispersing prisms. The underpass fixture shall have a main beam between 70 and 76 degrees vertically and between 20 and 25 degrees laterally.

E  Lamps (High Pressure Sodium)

The high pressure sodium lamp shall have a mogul base, a 24 000 average rated life hours (at 10 hours per start), and a lamp burning position as required by the luminaire and lamp manufacturers. The lamps are as follows:
(1) 150 W High Pressure Sodium according to ANSI Code No. S55 clear 150 W.
(2) 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

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.
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 m² (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 m² (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
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.
3812.2

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

3812.3 INSPECTION AND TESTING

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

The Contractor shall submit to the Engineer, for approval by the 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.
3814.2

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
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, 6, 4, 2, 1/0, etc., indicated in the Contract) shall be Type THW, Type THWN, or Type XHHW insulation.

B2 Roadway Loop Detector Conductors

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

(b) Conductors for roadway embedded saw-cut loop detectors shall be No. 14, stranded copper, insulated with filled chemically cross-linked thermosetting polyethylene (XLPE), or XHHW insulation per UL 44. In addition, the conductor shall have a black polyethylene tubing that has a nominal outside diameter of 6.35 mm (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.
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 µm (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).
(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 µm (20 mils) of polyethylene plus 254 µm (10 mils) of PVC.

(g) The outer jacket shall be PVC.

C4 Loop Detector Lead-in Cable

This section covers loop detector lead-in cable for use in traffic control signal systems and Traffic Management Systems. Loop detector lead-in cable shall conform to one of the following:

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

(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 Ω. 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 105ºC to -40ºC. The conductors shall be color coded or numbered at 300 mm (12 inch) intervals.

The capacitance between adjacent conductors shall be less than 134.4 pF per meter (41 pF/foot).
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;
(8) armored cables have an inner sheath of medium density, polyethylene (MDPE) of 1 mm thickness;
(9) inner sheath is applied directly over tensile strength members and water blocking tape;
(10) have armor of plastic-coated, corrugated-steel tape over a second layer of water-blocking tape;
(11) have a 1.4 mm thick MDPE outer jacket containing carbon black;
(12) have two ripcords (approximately 180º apart), one ripcord under the armor and one ripcord under the inner jacket;
(13) the cable outside diameter is < 18 mm (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 µm of 62.5 µm;
(4) the cladding diameter is within 2 µm of 125 µm;
(5) the numerical aperture is within 0.015 of 0.275;
(6) the attenuation coefficient is 3.5 dB/km or less at 850 nm and 1.0 dB/km or less at 1300 nm;
(7) attenuation at the water peak (1383 nm < 2.1 dB/km);
(8) The ITC of the cable is > or equal to 160 MHZ/km at 850 nm and 600 MHZ/km at 1300 nm;
(9) Mn/DOT does not allow factory fusion splices.

C13c  Singlemode Properties

The EIA Class IVa singlemode fibers in cables comply with the following:
(1) the core diameter is typically 8.3 µm;
(2) the diameter of the cladding is within 1µm of 125 µm;
(3) the coating diameter is within 5 µm of 245 µm;
(4) The coating is a dual layer acrylate coating in physical contact with the cladding surface;
3815.2

(5) ZDW: 1301.5 to 1321.5 nm;
(6) cutoff wavelength: < 1260 nm;
(7) maximum attenuation at 1310 nm is 0.35 dB/km and 0.25 dB or less/km at 1550 nm;
(8) the mode field diameter is within 0.4 µm of 9.20 µm at 1310 nm and 1.00 µm of 10.50 µm at 1550 nm;
(9) the maximum dispersion is 3.2 ps/nm•km from 1285 to 1330 nm and < 18 ps/nm•km at 1550 nm;
(10) Core-to-cladding offset (Core/cladding concentricity) is ≤ 0.5 µm;
(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.
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 pedestrian 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 0ºC (162 ºF) 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.
Assembly: Individual conductors are cabled with non-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 (0.310 in.)
- 4/c #14 – 9.1 mm (0.360 in.)
- 5/c #14 - 10.0 mm (0.395 in.)
- 7/c #14 – 10.9 mm (0.430 in.)

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 on 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 require certified test reports covering the physical and electrical properties of the signal control cable.

C Video Cables
The manufacturer shall sweep test the video cable 100 percent. The test shall be performed using the structural return loss method. The Contractor shall furnish the test certifications to the Engineer and obtain approval before installing the cable.
D  Camera Control Cables
The Contractor shall furnish the test certification of the properties and construction of the camera control cable and obtain approval from the Engineer before delivering the cable.
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 m² (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.
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
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 µm (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 µm (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 (½ 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 crosslot 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.
C3 Anchor Rods
Anchor rods shall be 19 mm (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 (2 ½ inches)
- Thickness: 19 mm (¾ inches)
- Center Punch Hole: 21 mm (13/16 inch)

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 Manufacturer'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.
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).
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
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
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>
<thead>
<tr>
<th>Indication</th>
<th>Size (Diameter)</th>
<th>Initial Wattage</th>
<th>Initial Lumens</th>
<th>Light Center Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCULAR RED</td>
<td>300 mm (12 inches)</td>
<td>150</td>
<td>1950</td>
<td>76 mm (3 inches)</td>
</tr>
<tr>
<td>CIRCULAR YELLOW</td>
<td>300 mm (12 inches)</td>
<td>69</td>
<td>675</td>
<td>62 mm (2-7/16 inches)</td>
</tr>
<tr>
<td>CIRCULAR GREEN</td>
<td>300 mm (12 inches)</td>
<td>150</td>
<td>1950</td>
<td>76 mm (3 inches)</td>
</tr>
<tr>
<td>ARROW</td>
<td>300 mm (12 inches)</td>
<td>150</td>
<td>1950</td>
<td>76 mm (3 inches)</td>
</tr>
<tr>
<td>CIRCULAR RED</td>
<td>200 mm (8 inches)</td>
<td>116</td>
<td>1280</td>
<td>62 mm (2-7/16 inches)</td>
</tr>
<tr>
<td>CIRCULAR YELLOW</td>
<td>200 mm (8 inches)</td>
<td>69</td>
<td>675</td>
<td>62 mm (2-7/16 inches)</td>
</tr>
<tr>
<td>CIRCULAR GREEN</td>
<td>200 mm (8 inches)</td>
<td>116</td>
<td>1280</td>
<td>62 mm (2-7/16 inches)</td>
</tr>
</tbody>
</table>

**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
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.
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).
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.

3834.3 INSPECTION AND TESTING ................................. 3833
3835

Pedestrian Signal Faces

3835.1 SCOPE
This Specification covers pedestrian signal faces to direct pedestrian movements as part of a traffic control signal system.

3835.2 REQUIREMENTS
A General
Pedestrian signal faces shall be furnished where specified in the Contract. Pedestrian signal faces shall be constructed in accordance with the current ITE Pedestrian Traffic Control Signal Indication standard.

Pedestrian signal faces shall utilize light emitting diode (LED) module. The LED module shall meet or exceed ITE Pedestrian Traffic Control Signal Indications - Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules. Components shall be compatible with standard signal hardware and shall be interchangeable with other units of similar construction.

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

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

Each pedestrian signal face shall be a single unit housing with the signal indication size a nominal 406 mm x 457 mm (16 inch x 18 inch) with side by side or overlapping symbol messages. Each symbol message ("WALKING PERSON" and "UPRAISED HAND") shall be illuminated by the use of light-emitting diodes (LED’s).

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

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

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

B Housing
The housing material of each pedestrian signal indication shall be a one-piece, corrosion-resistant, aluminum alloy die casting with all sides, top, and bottom integrally cast. All parts of the housing shall be clean, smooth, and free from cracks, sharp burrs, and other imperfections. Four mounting lugs shall be integrally cast into the top and bottom area at equal distances permitting the housing door to hinge from either side. All interior mounting locations shall be symmetrically positioned.
The housing shall have an integral 72-teeth serrated boss as part of the top and as part of the bottom of the housing for use with standard signal mounting hardware. Each boss shall have reinforcing ribs projecting the load bearing stress to the entire housing.

**C Housing Door**

The housing door of each pedestrian signal indication shall be a one-piece, corrosion-resistant, aluminum alloy die casting. The door shall be suitably hinged and shall be forced tightly against the housing by stainless steel locking devices. All other door hardware shall be of stainless steel material.

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

The housing door shall accommodate the pedestrian signal LED module.

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

**D Gasketing**

Gasketing shall be provided between the housing and the housing door to exclude dust and moisture and ensure a weather-tight enclosure when closed.

**E Visor**

The pedestrian signal face shall have a removable tunnel type visor attached to the housing door by four stainless steel screws. The visor shall be a minimum of 178 mm (7 inches) in length with all sides of the visor approximately the same length.

The visor shall be fabricated from sheet aluminum and shall encompass the entire top and sides (bottom open) of the pedestrian signal indication and shall be designed to fit tightly against the housing door so as to prevent any perceptible filtration of light between the door and the visor. The top of the visor shall have a minimum downward tilt of approximately 3.5 degrees. The visor shall be secured to the housing door by stainless steel screws.

**F Optical Unit**

The optical unit of each pedestrian signal indication shall consist of an LED module for the "Upraised Hand" symbol and the "Walking Person" symbol.

The LED module for the "Upraised Hand" symbol and the "Walking Person" symbol shall be in accordance with the latest issue of ITEPedestrian Traffic Control Signal Indications - "Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules" Both the Walking Person and "Upraised Hand" symbols shall be LED filled.
G  Wiring
The LED module of a pedestrian signal face shall be provided with three color coded copper conductors. The conductors shall be securely fastened to the lamp receptacle and with sufficient length to reach the terminal block with the reflector fully open. A terminal block shall be provided and securely fastened to the inside of one of the housings of a pedestrian signal face for connection of the conductors from each pedestrian signal indication lamp receptacle and the field conductors. The conductors from each lamp receptacle of a pedestrian signal face shall be run independently to the terminal block and shall not be bound together into a cable.

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

All surfaces of the housing shall be finish painted yellow in accordance with 3532, or approved equivalent.

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

I  Blank

J  Signal Brackets and Pipe Fittings........................ 3834.2C

3835.3  INSPECTION AND TESTING ................................. 3833

The pedestrian signal faces shall be approved by the Engineer prior to procurement. Prior to Engineer acceptance of the LED indications, the manufacturer shall supply to the Engineer independent test results performed on the product for color and intensity. The Contractor shall submit to the Engineer, for approval, four sets of manufacturer's drawings, specifications of the pedestrian signal face, all warranty information, a Manufacturer's Certificate of Conformance to this specification, and all other pertinent manufacturer data. As part of the pertinent manufacturer data, the Contractor shall include the product invoice.

3837  Electrical Service Equipment

3837.1  SCOPE

This Specification covers electrical service equipment for controlling and distributing electrical power, providing over-current protection, and providing a means to cut off power to items of electrical equipment, as part of a traffic control signal system, roadway lighting system, automatic traffic recorder system, or other electrical system.
3837.2 REQUIREMENTS
A Service Equipment
A1 General

The Contractor shall furnish and install a meter socket, disconnecting means, ground rod, grounding and bonding materials, conduit, conduit fittings, power conductors, and, for installations on wood poles, conduit risers and weatherhead, for electrical service for the traffic control signal system, roadway lighting system, automatic traffic recorder system, or other electrical system, where required by Contract.

For installation on a wood pole, the power conductors above the disconnecting means, through the meter socket to the weatherhead, shall be sized appropriately for the rating of the service disconnect, shall meet the requirements of the power company, and shall extend beyond the weatherhead for connection to the power conductors from the source of power; which connection will be made by others at no cost to the Contractor.

All parts of the service equipment shall utilize copper wire and shall have connections that are UL listed for use with copper wire.

A2 Meter Socket

The meter socket shall contain a positive bypass mechanism, shall have lugs that will allow the power conductors to be stripped and laid into the lugs without being cut, and shall be approved by the power company. The meter will be furnished and installed by others.

A3 Circuit Breaker Load Center

Unless otherwise indicated in the Contract, the disconnecting means shall be a 3-wire, solid neutral, 100 A, 120/240 VAC, NEMA 3R rain-tight enclosure for outdoor use, circuit breaker load center, UL listed for use as service equipment.

The load center shall have a front cover and inner dead front cover. The front cover shall be hinged at the top (with a slip hinge arrangement that permits leaving the cover in an open position) and snap closes at the bottom. Both covers shall be easily removable for installation, maintenance, and wiring.

Any lugs that are required for power conductor connections in the load center shall be UL listed for use with copper wire, shall be solderless (set screw type), and shall be the appropriate size for the conductors with which they are used.

The circuit breaker load center shall be provided with an isolated, bondable neutral bar with capacity to accept the number and size of neutral and grounding conductors as indicated in the Contract or required by the NEC. Bonding of the neutral shall be in accordance with the NEC.
Unless otherwise specified in the Contract, the Contractor shall furnish and install circuit breakers in the load center as follows:

(a) - one 2-pole, 100 A main circuit breaker.
(b) - one 1-pole, 60 A circuit breaker for signal system.
(c) - two 1-pole, 15 A circuit breakers for roadway lighting.

Circuit breakers shall be 120/240 VAC, and shall be clearly marked with the "ON" and "OFF" positions and identified with the load that it is carrying, such as "SIGNALS" or "LIGHTING". The circuit breakers and the load center enclosure shall be of the same manufacturer.

A4  General Duty Safety Switch

When specified in the Contract, the disconnecting means shall be a 3-wire, fusible, 2-pole, solid neutral, single throw, 60 A, 120/240 VAC, NEMA 3R (rain-tight enclosure for outdoor use), general duty safety switch, UL listed as suitable for use as service equipment. Any lugs contained in the safety switch shall be appropriate for the material and size of the conductors with which they are used. The Contractor shall furnish the required fuses.

The general duty safety switch shall be provided with an isolated, bondable neutral bar with capacity to accept the number and size of neutral and grounding conductors as indicated in the Contract or required by the NEC. Bonding of the neutral shall be in accordance with the NEC.

A5  Heavy Duty Safety Switch

The safety switch shall be provided to turn off power to the sign lights. The safety switch shall be:

1. A NEMA 3R rain tight enclosure for outdoor use.
2. 30 ampere, heavy duty, single throw, fusible with an insulated solid neutral.
3. Rated 240 volts AC for a 120/240 volt sign lighting system and 600 volts AC for a 240/480 volt sign lighting system.
4. Provided with two 20 ampere cartridge type fuses, and
5. 3-wire, 2-pole. For the 600 volt AC switch, 4 wire, 3 pole is acceptable.

The rain tight enclosure shall be fabricated from sheet metal, zinc coated and have a gray finish coat.

The safety switch shall be installed in a vertical upright position.

A6  Enclosed Circuit Breaker

When specified in the Contract, an enclosed circuit breaker shall be furnished and installed where indicated in the Plans for cutting power to the electrical system or systems.

The circuit breaker shall be mounted in a NEMA 3R rain-tight enclosure for outdoor use. The circuit breaker shall be a 2-pole, 100 A, 120/240 VAC, thermo-magnetic breaker, UL listed as suitable for use as
service equipment, and shall be clearly marked with "ON" and "OFF" positions and identified with the load it is carrying, such as EQUIPMENT PAD. If lugs are required for power conductor connections to the breaker, they shall be UL listed for use with copper wire and shall be solderless (set screw type). The rain-tight enclosure shall have provisions for a padlock (furnished by others).

A7  Signal Service Cabinet

The signal service cabinet shall consist of an external meter socket, main and branch circuit breakers, luminaire test switch, enclosed photoelectric control, and provisions for a battery back-up system. The signal service cabinet shall be as detailed in the Contract.

B  Transformer and Circuit Breaker Assembly

B1  Transformer

The transformer shall be an outdoor, general purpose, dry type transformer. Transformer Specifications shall be as follows:

(a) Primary - 480 V, two 5-percent taps below 480 V.
(b) Secondary- 120/240 VAC.
(c) Rating - 7.5 KVA, single phase
(d) Size - Approximately 400 mm (16 inches) high, 300 mm (12 inches) wide, and 270 mm (10 ½ inches) deep.

The transformer and related wiring compartment shall be UL listed for indoor-outdoor applications and shall meet applicable NEMA and IEEE standards. The transformer shall be mounted on the equipment pad as detailed in the Contract to the satisfaction of the Engineer.

B2  Enclosed Circuit Breaker

The transformer shall be protected by a circuit breaker mounted in a NEMA 3R rain-tight enclosure for outdoor use. The circuit breaker shall be a 2-pole, 20 A, 480 VAC, thermo-magnetic breaker. If lugs are required for power conductor connections to the breaker, they shall be UL listed for use with copper wire and shall be solderless (set screw type). The rain-tight enclosure shall have provisions for a padlock (furnished by others). The circuit breaker enclosure shall be mounted as detailed in the Contract to the satisfaction of the Engineer.

3837.3  INSPECTION AND TESTING

The Contractor shall submit to the Engineer, for approval, six sets of manufacturer's drawings and specifications for the transformer and circuit breaker assembly proposed for installation.

The drawings shall be distributed, after approval, to the following:

(a) Contractor
(b) Contractor's Fabricator
(c) Engineer
(d) Traffic Electrical Systems Engineer
(e) District Traffic Engineer
3837.3

(f) Traffic Signal Cabinet or other pad mount cabinet

All items of electrical service equipment shall be approved before installation.

3838

Electrical Junction Boxes

3838.1 SCOPE

This Specification covers junction boxes for providing access to electrical wiring, facilitating the installation of electrical wiring, and for changing from field cable wiring to individual conductors as part of a traffic control signal system, freeway ramp control signal, automatic traffic recorder system, roadway lighting system, or other electrical system.

3838.2 REQUIREMENTS

A Metal Junction Boxes Attached to a Bridge

Metal junction boxes required to be mounted to a bridge shall be NEMA Type 4 galvanized cast iron boxes with covers.

The junction boxes shall have four mounting lugs.

Junction boxes shall meet the minimum size requirements of the NEC and shall be adequately sized to permit easy installation of all electrical cables and conductors routed through the junction box. The cover shall be of the same material as the box, fastened with stainless steel hex-head screws or bolts and nuts, and equipped with a neoprene gasket around the entire perimeter of the cover.

Each conduit entrance shall accommodate the nominal outside diameter of the conduit specified and shall be bossed and threaded to provide five full threads.

Junction boxes shall be attached using two unit threaded bolt anchorages conforming to the Contract or, if not specified, approved by the Engineer, with the required hardware to permit removal of the junction box.

B Metal Junction Boxes on Wood Poles

The Contractor shall furnish and install a metal junction box with terminal blocks whenever installing temporary traffic control signal systems; flashing beacon systems; advance warning flashers; or vehicle, pedestrian signal faces, or flashing signal indications on wood poles.

Each metal junction box shall conform to NEC requirements, shall be NEMA Type 3R, shall be at least 300 mm (12 inches) square by 150 mm (6 inches) deep with a 6 mm (¼ inch) drain hole on the bottom side, and shall have a cover with a gasket around the entire perimeter of the cover. The cover shall be attached by stainless steel screws.

Each metal junction box shall have terminal blocks for terminating field conductors and traffic signal conductors. Terminal blocks shall be
as described in 2565.3J, shall be firmly attached to the back of the junction box in such a manner that the terminal screws of the terminal block face the box opening, and shall be covered with an electrical insulating coating after all conductor terminations on the terminal block.

Liquid-tight flexible metal conduit and conduit fittings as required shall be furnished and installed between the metal junction box and each type wood pole mounted signal bracketing.

C Junction Boxes in Non-Metallic (NMC) Conduit Runs Attached to a Bridge

Junction boxes required to be mounted to the bridge shall be NMC junction boxes with a cover attached by stainless steel screws. Each NMC junction box shall be sized at least 150 mm (6 inches) square by 150 mm (6 inches) deep and shall be attached to the bridge in a manner approved by the Engineer. Each NMC junction box shall conform to NEC requirements.

D Blank

E Junction Boxes for Roadway Lighting Systems

Junction boxes specified for roadway lighting systems shall be NEMA Type 4, hot dip galvanized cast iron with interchangeable cover and side hub plates, brass cap screws, gaskets for cover and hub plates, suitable for use with rigid steel conduit.

The junction box shall have inside dimensions of 216 x 216 x 100 mm (8 ½ x 8 ½ x 4 inches) unless otherwise specified in the Contract. The junction boxes shall have four mounting lugs.

The cover shall be of the same material as the box, fastened with stainless steel hex-head screws or bolts and nuts, and equipped with a neoprene gasket around the perimeter of the cover.

Each conduit entrance shall accommodate the nominal outside diameter of the conduit specified and shall be bossed and threaded to provide five full threads.

Junction boxes shall be attached to concrete using masonry anchorages or power activated studs with the required hardware to permit removal of the junction box.

3838.3 INSPECTION AND TESTING

Three sets of shop drawings of the metal junction boxes and mounting details that the Contractor proposes to install shall be submitted to the Engineer for approval.
3839

Conduit Expansion Fittings

3839.1 SCOPE
This Specification covers conduit expansion fittings for use in conduit runs attached to bridges.

3839.2 REQUIREMENTS
Each expansion fitting shall be a weatherproof manufactured unit providing for conduit movement as specified in the Contract. A fitting providing for a minimum movement of 25 mm (1 inch) may be furnished if no movement is specified in the Contract.

Expansion fittings for use with RMC or IMC shall be iron or steel protected by galvanizing or plating and shall be UL listed.

Expansion fittings for use with NMC shall be intended for use with the particular type of conduit.

3839.3 INSPECTION AND TESTING
The expansion fittings shall be approved by the Engineer before installation.

3840

Wood Poles

3840.1 SCOPE
This Specification covers wood poles for use in traffic control signal systems, electric lighting systems, and mounting service equipment.

3840.2 REQUIREMENTS
The Contractor shall furnish wood poles:
(a) Conforming to the American Standard Specifications and Dimensions for Wood Poles (ANSI 2051).
(b) Of the length specified in the Plans.
(c) Of Class II unless otherwise specified in the Contract.
(d) Of the species in Table 3491-1.
(e) Treated with preservative in accordance with 3491, lighting poles. Creosote shall not be used.

3840.3 INSPECTION AND TESTING ................................. 3491

3850

Lighting Service Cabinet

3850.1 SCOPE
This Specification covers electrical service cabinets used for distributing electrical power, providing overcurrent protection and providing a means to cut off power to all or part of a roadway lighting system.
3850.2 REQUIREMENTS
A General
The Contractor shall furnish a complete and operational lighting service cabinet as specified in the Contract. The lighting service cabinet shall be a single phase, 3 wire, weatherproof cabinet, and shall contain circuit breakers, lighting contactor(s), photoelectric control with test switch(es), power distribution blocks when specified, and neutral/ground bonding bar(s).

The cabinet shall be located such that the door is orientated 90 to 180 degrees to the roadway, away from traffic.

The cabinet and its contents shall comply with the requirements of the Underwriters Laboratory Inc. (UL) standards UL-508 and UL-508A. The enclosure shall have a NEMA 3R rating.

For lighting circuits serving luminaires rated at 120 V, the lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 120/240 VAC. The lighting contactor coil shall be rated for 120 VAC.

For lighting circuits serving luminaires rated at 240 V, the lighting service cabinet shall have circuit breakers and lighting contactor contacts rated for 240/480 VAC. The lighting contactor coil shall be rated for 240 VAC.

B Electrical Equipment and Wiring
B1 Circuit Breakers
Circuit breakers shall be thermo-magnetic type. Main circuit breakers shall be located on the line side of the lighting contactor(s).

The lighting contactor(s) shall be located on the line side of the branch circuit breakers. Each branch circuit breaker shall be bolted onto a copper bus and shall be labeled as specified in 2545. Spacers shall cover empty circuit breaker spaces for circuits that are not used.

The branch circuit breakers shall be sized to accommodate a No. 4 AWG wire.

B2 Lighting Contactors
The lighting contactor(s) shall be 2-pole, normally open, electrically held, open type, and shall be rated for tungsten filament and ballast lighting loads. The control coil shall be actuated by a photocell and protected by a 15 A circuit breaker on the line side of the photocell and test switch.

The lighting contactor shall be as specified in the Contract.

B3 Test Switches
The test switch shall be a heavy duty, single pole, double throw, two position, rotary switch. One switch position shall be labeled "AUTOMATIC" and the other switch position shall be labeled "TEST". In the "AUTOMATIC" position, the test switch shall connect the coil of
the lighting contactor to the AC+ (SWITCHED) from the photoelectric control, providing photoelectric control of the lighting circuit. In the "TEST" position, the test switch shall connect the coil of the lighting contactor to the AC+ (UNSWITCHED) from the photoelectric control, providing power to the lighting circuit regardless of the state of the photoelectric control.

B4 Component Arrangement

The main circuit breaker, lighting contactor, photoelectric control with test switch, power distribution blocks when specified, and branch circuit breakers shall be arranged and wired as indicated in the Contract.

The main breaker, lighting contactor(s), power distribution blocks, and branch circuit breaker(s) shall be mounted on a removable panel. A separate dead front shall cover the panel and shall be hinged on one side and held in place with quick release captive fasteners.

All neutral/ground bonding bars and bus bars shall be copper.

All terminals/connectors shall be UL listed for copper wire.

All wiring inside the cabinet shall be sufficient length to allow for contraction.

Three single conductors in accordance with 3815.2B1 shall be provided from the cabinet to the source of power and shall be the size indicated in the Contract.

C Photoelectric Control

A photoelectric control mounting receptacle (EEI/NEMA standard 3-terminal twist-lock type), photoelectric control, and photoelectric control shield when specified shall be mounted within the cabinet near the two lexan windows or 3 m (10 feet) above the ground on top of a rigid steel conduit rising vertically and entering the side of the cabinet. When specified, the conduit shall be 41 mm (1 ½ inch) nominal diameter for a pad mounted cabinet and 21 mm (¾ inch) nominal diameter for a pole mounted cabinet. The wires to the photoelectric control mounting receptacle shall be single conductor No. 14 stranded copper conductors in accordance with 3815. The photoelectric control shall be in accordance with 3812.

D Type L1 and L2 Service Cabinet

In addition to meeting the general requirements above, the Type L1 and Type L2 lighting service cabinet shall meet the following requirements:

D1 Cabinet Enclosure Construction

The lighting service cabinet shall be constructed from a minimum 3 mm (0.125 inch) thick aluminum conforming to the requirements of ASTM B 209 for 5052-H32 aluminum sheet. The Aluminum cabinet shall be anodized to match the Duranodic finish #311 after all machining has been completed.
The cabinet shall be pad mounted with dimensions of 1525 mm (60 inches) high, 835 mm (33 inches) wide and 355 mm (14 inches) deep. The cabinet shall be secured to a concrete pad by four 19 mm (¾ inch) diameter, 150 mm (6 inch) long, high strength anchor bolts in a 660 mm x 280 mm (26 inch x 11 inch) center to center rectangular bolt pattern.

The cabinet flanges shall have slotted holes for mounting the cabinet to anchor rods. The holes shall be reinforced on the top side of the flange with a piece of 3 mm (0.125 inch) aluminum 150 mm (6 inches) long and same width as the mounting flange.

A gasket shall be provided for mounting the cabinet on a concrete pad. The gasket shall consist of a four piece 13 mm (½ inch) thick x 64 mm (2 ½ inch) wide solid butyl rubber gasket with drilled holes, shaped to match the mounting flange and slots on the bottom of the cabinet. The Contractor shall leave one 13 mm (½ inch) gap in the gasket to ensure proper water drainage.

The cabinet shall have two compartments. The right compartment shall be 1525 mm (60 inches) high, 685 mm (27 inches) wide and 355 mm (14 inches) deep, providing space for the lighting service panel and the photoelectric control circuit. The service panel shall be installed 150 mm (6 inches) from the bottom of the cabinet to provide access to the anchor bolts when mounting the cabinet. The cabinet shall have an enclosed left compartment to provide space for the 50 mm (2 inch) conduit containing the power conductors to the meter. This compartment shall be 760 mm (30 inches) high, 150 mm (6 inches) deep and 355 mm (14 inches) wide. An opening and a hub shall be provided on the top of this compartment to facilitate wiring to the meter socket. The edge of the opening shall be properly protected. This compartment shall have a 610 mm x 355 mm (24 inch x 14 inch) removable front panel 180 mm (7 inches) from the bottom of the cabinet. The panel fasteners shall be of stainless steel or other non-corroding material.

The cabinet shall have a weathertight hinged door opening to the right (right-handed door). The door shall be equipped with a three-point locking mechanism that operates from a single easy-turning handle. The upper and lower locking points of the locking mechanism shall each have a pair of nylon rollers. The shaft size of the handle shall be a minimum of 16 mm (5/8 inch) diameter or 13 mm (½ inch) square. The cabinet door shall lock with a standard police lock and key (1 key shall be furnished).

The hinges, hinge pins, locks and lock covers shall be of stainless steel or other non-corroding material. Hinges may be welded on or fastened with stainless steel tamperproof bolts.
The cabinet door shall have two sets of 100 mm x 255 mm (4 inch x 10 inch) louvered vents, with screening or perforated metal, installed approximately 255 mm (10 inches) from the bottom. The two sets of vents shall be separated by approximately 50 mm (2 inches).

Two circular windows shall be at the right upper back corner of the cabinet for the photocell. One window shall be on the back cabinet wall and the other shall be on the right cabinet wall. The windows shall have a diameter of 90 mm (3.5 inches).

The windows shall be of 3 mm (0.125 inch) thick lexan and be installed in a manner that does not sacrifice the weather-tightness or the security of the cabinet.

The cabinet top shall be crowned or slanted to the rear to prevent standing water, and shall provide a 50 mm (2 inch) overhang above the door beyond the front of the cabinet. The overhang shall provide venting for the entire cabinet.

The cabinet lifting provisions shall meet the UL requirements for the NEMA 3R. The lifting provisions shall consist of two aluminum lifting ears mounted to the enclosure, allowing a bar or hooks to be inserted through both ears for lifting the cabinet.

The lifting ears shall have a lifting capacity equal to the weight of the completely wired cabinet plus 25 percent, a 227 kg (500 pound) capacity minimum. Each lifting ear shall have a 25 mm (1 inch) hole, the bottom of which shall be flush with the top of the cabinet or within 3 mm (1/8 inch) of the cabinet. The top of the lifting ears shall be between 50 mm (2 inches) and 55 mm (2 1/8 inches) above the cabinet. The lifting ears shall be secured to the cabinet by corrosion resistant bolts.

The cabinet enclosure shall be of good workmanship. All seams and joints shall be smooth and even, without cracks or pinholes. There shall be no sharp corners or jagged edges.

The exterior seams for cabinet and doors shall be continuously welded or sealed with silicon sealant. All exterior welds shall be ground smooth. All sharp edges shall be filed.

D2 Electrical Equipment and Wiring

A self contained meter socket, rated for 200 Ampere, 480 volts, commercial type with a lever actuated positive bypass mechanism in accordance with 3837.2A2 shall be mounted to the left cabinet wall facing to the left. The meter socket shall be listed as approved for commercial use by the power company. The top of the meter socket shall be right under the left lifting ear. A chase nipple (minimum 50.8 mm (minimum 2 inches)) shall be installed at the bottom of the meter socket to provide connection to the left compartment of the cabinet.
For metered feed points, meters will be furnished and installed by others.

The lighting service cabinet shall have two copper power distribution blocks to provide tapping from the primary feeds to the 100 amp circuit breaker. The power distribution block shall have lugs suitable for use with 75°C (167°F) conductors; shall be rated for 600 volt; and shall have a flammability rating of UL 94V-0.

The Type L1 lighting service cabinet shall be provided with one 2-pole, 100 A main circuit breaker; one 2-pole, 100 A lighting contactor; two 20-A single pole branch circuit breakers for each three-wire lighting branch circuit indicated in the Plans or Special Provisions; and capacity for a total of eight single pole branch circuit breakers.

The Type L2 lighting service cabinet shall be provided with one 2-pole, 100 A main circuit breaker; one 2-pole, 100 A lighting contactor; one 20-A single pole branch circuit breaker for each three-wire lighting branch circuit indicated in the Plans or Special Provisions; and capacity for a total of sixteen single pole branch circuit breakers.

E Blank
F Blank

G Type A Service Cabinet

In addition to meeting the general requirements above, the Type A lighting service cabinet shall meet the following requirements:

G1 Cabinet Enclosure Construction

The Type A lighting service cabinet shall be a wood pole mounted cabinet, or as otherwise specified in the Contract, with approximate dimensions 1270 mm (50 inches) high, 419 mm (16 ½ inches) wide, and 203 mm (8 inches) deep. The cabinet shall have provisions for being secured to the wood pole by means of two iron straps and two 13 mm (½ inch) diameter by 153 mm (6 inch) long lag screws.

G2 Electrical Equipment and Wiring

The cabinet shall be provided with one 2-pole, 100 A main circuit breaker; one 2-pole, 100 A lighting contactor; two 20-A single pole branch circuit breakers for each three-wire lighting branch circuit indicated in the Plans or Special Provisions; and capacity for a total of eight single pole branch circuit breakers.

The Contractor shall furnish and install a 53 mm (2 inch) RSC riser and weatherhead above the Type A lighting service cabinet to a point 600 mm (2 feet) below the secondary terminal taps of the feed point.
transformer, or to a point designated by the power company. The service entrance conductors above the cabinet shall be No. 2 in accordance with 3815. The conductors shall extend up the conduit riser, through the weatherhead, and terminate a minimum of 1525 mm (5 feet) beyond the weatherhead for connection to the power conductors from the source of power; which connection will be made by others at no cost to the Contractor.

A 53 mm (2 inch) RSC stubout with insulating bushing shall be provided below the cabinet to a point a minimum of 610 mm (24 inches) below the ground line for each armored cable entering the cabinet.

H  Type B Service Cabinet

In addition to meeting the general requirements above, the Type B lighting service cabinet shall meet the following requirements.

H1  Cabinet Enclosure Construction

The Type B lighting service cabinet shall be a wood pole mounted cabinet, or as otherwise specified in the Contract, with approximate dimensions 762 mm (30 inches), 610 mm (24 inches) wide, and 203 mm (8 inches) deep. The cabinet shall have provisions for being secured to the wood pole by means of two iron straps and two 13 mm (½ inch) diameter by 153 mm (6 inch) long lag screws.

H2  Electrical Equipment and Wiring

The cabinet shall be provided with one 2-pole, 30 A main circuit breaker; two single pole, 30 A branch circuit breakers; and one 2-pole, 30 A lighting contractor.

The Contractor shall furnish and install a 53 mm (2 inch) RSC riser and weatherhead above the Type B lighting service cabinet to a point 600 mm (2 feet) below the secondary terminal taps of the feed point transformer, or to a point designated by the power company. The service entrance conductors above the cabinet shall be No. 6, in accordance with 3815. The conductors shall extend up the conduit riser, through the weatherhead, and terminate a minimum of 1525 mm (5 feet) beyond the weatherhead for connection to the power conductors from the source of power; which connection will be made by others at no cost to the Contractor.

A 53 mm (2 inch) RSC stubout with insulating bushing shall be provided below the cabinet to a point a minimum of 610 mm (24 inches) below the ground line for each armored cable entering the cabinet.

3850.3 INSPECTION AND TESTING

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

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

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

All light service cabinets shall be approved before installation.
3861

Plant Stock

3861.1 SCOPE
This Specification covers trees, shrubs, vines, and perennials of various species and varieties suitable for roadside landscape planting. The term "plant" shall mean any or all trees, shrubs, vines or perennials specified.

3861.2 REQUIREMENTS
Unless otherwise specified as collected stock (wild or grown in other than nursery conditions) or Department-furnished transplants, all plants furnished shall be from nursery grown stock and shall bear evidence of proper nursery care during growth. Plants will not be considered to be nursery grown unless they have been growing in a nursery for at least 2 years.

The Contractor shall comply with the current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects," published by the Mn/DOT Landscape Architecture Unit, as the minimum and maximum criteria and standard for grading and accepting plant stock.

A Classification of Plants
Trees, shrubs, vines and perennials commonly used for landscaping purposes will be classified by species, variety, and size or age as indicated in the Contract.

When a dimensional size is specified in the Contract, it shall indicate the minimum range of height, stem caliper (diameter), or spread acceptable, as measured in accordance with standards in the current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects."

B Blank

C Plant Names
All botanical and common names of plant materials specified shall be based on descriptions by Bailey in the latest edition of "Hortus Third."

D Plant Hardiness
All plant stock shall be deemed acceptable for hardiness if it is hardy to the Minnesota zone where the project site is located and:
1) Plant stock can be documented as continuously grown for at least the last two years within the acceptable limits shown on the Acceptable Plant Stock Growing Range Limits map in the Plan or
2) Plant stock, if grown outside the acceptable growing range limits, can be documented as having the seed source or root and graft stock originating from within the acceptable growing range limits.
Any questions regarding plant stock hardiness or botanical identification will be resolved by the Engineer.

E  **Previous Transplanting**

All plants with the exception of seedlings, perennials, machine-transplants, and collected stock if specified, must bear evidence of previous transplanting or root pruning at least once during growth at the nursery. Trees from forest plantations are not acceptable, unless proper transplanting and root pruning has been practiced to develop compact and fibrous root systems suitable for transplanting success.

F  **Quality and Condition**

A Certificate of Nursery Inspection by the Department of Agriculture of the State or origin, or valid copy thereof, shall be supplied as specified in 2571.2A2 (Plant Stock Documentation).

All plants shall be first-class representatives of their normal species or variety, and shall be free of disease, disfiguring knots, sun scald, insect infestations, dead or broken branches, bark abrasions, and other objectionable conditions.

All trees shall have reasonably straight trunks and shall be fully branched and symmetrical on all sides as characterized by natural habits of growth and proper nursery care. Shrubs shall be of strong bushy stock with well developed and formed stems, canes, or branches. Vines and perennials shall be strong healthy plants of the size or age specified.

All plants shall have strongly developed root systems of sufficient size to permit successful establishment and good growth, typical of the species or variety specified. The root systems of container grown plants shall be sufficiently developed to hold the soil intact upon removal from the container. Large root stubs and/or large circling or girdling roots shall be considered evidence of lack of proper care and root pruning, and shall be sufficient cause for rejection of nursery grown plants.

G  **Digging and Handling**

All plants shall be dug and handled with reasonable care and skill as necessary to prevent damage to stems, roots, branches, and trunk.

Plants that are balled and burlapped (B & B) shall be dug in a manner that preserves a firm ball of undisturbed soil around the root system. Plants shall conform to the recommended balling and burlapping specifications set forth in the current edition of "Inspection and Contract Administration Guidelines for Mn/DOT Landscape Projects."

Balled and burlapped plants shall be wrapped and bound so that the soil ball will remain intact and solid while being handled, shipped, and planted. Handling shall always be by the soil ball and not by the plant’s branches or trunk. The use of wire baskets in conjunction with furnishing, loading, or planting balled and burlapped plants will be
3861.2

permitted; however, restrictions of 2571.3F (Installation of Plants) shall apply.

Packing and Shipping

All plant material shipments shall comply with the nursery inspection and plant quarantine regulations of the States of origin and destination as well as with Federal regulations governing interstate movement of nursery stock.

All plants shall be true to name, and each bundle, bale or individual plant shall be legibly and securely labeled with the names and sizes of each species or variety and with the quantity contained in the individual bundles, boxes or bales.

All plants shall be packed and shipped as necessary to ensure arrival at the planting site in good condition. From the time plants are dug and until delivered to the planting site, the roots shall be protected at all times against drying-out, by covering the root systems with a suitable moisture-holding material. They shall also be adequately protected against other damaging climatic conditions such as sun, wind, and freezing temperatures. When transported in closed vehicles, the plants shall have adequate ventilation to prevent unwanted sweating.

3861.3 SAMPLING AND INSPECTION

The plants shall be subject to inspection by the Engineer prior to planting, but such inspection shall not be considered as final acceptance. Final inspection and acceptance or rejection of plant stock shall be at the Project planting site.

All plants shall be in good condition upon delivery. Plants delivered with broken or bruised branches, stems, or canes will be rejected unless the damaged growth can be removed through pruning and without losing their symmetry or being trimmed to an unacceptable size. Balled and burlapped plants delivered with broken or disturbed balls, indicating the soil has been so loosened as to cause stripping of the small and fine feeding roots, will be rejected. Bare root plants shall be delivered in a dormant condition and should be installed while in a dormant condition. The Engineer may authorize installing plants that have broken dormancy, however, if authorized, the installation will be at the Contractor’s own risk, and the initial planting operations payment for these plants will be withheld until they are determined to be initially acceptable after the first year of plant establishment.

The Engineer may inspect up to three balled and burlapped or container plants, of each variety delivered to the planting site, at random and inspect for condition and size of the root system. This may include pulling back the burlap and wire basket or removing containers. Any plants that become unsuitable for planting due to inspection shall be replaced by the contractor without any compensation.
During the spring planting season, coniferous plants that have candel out (put out new growth) while being stored in a holding bin may be planted, however, coniferous plants that are dug after candeling out will be rejected. Coniferous trees not fully branched from bottom to top and those that have been heavily sheared or pruned will be rejected. Only unsheared or lightly sheared conifers (those that have not been sheared within the last growing season and display buds or growth at the terminal ends of branches) shall be accepted. Pine trees shall have a terminal leader bud and terminal leaders shorter than 500 mm (18 inches) in length. A new central leader must be trained in conifers delivered with multiple or missing leaders.

Plants not conforming to dimensional requirements will be rejected. In measuring the height of coniferous trees of the pine, spruce and fir species, the upper limits shall be the midpoint of the terminal leader.

All rejected plants shall be removed from the Project by the Contractor and shall be replaced with acceptable plants of the required species and variety, unless otherwise directed by the Engineer.

3876.2

Seed

3876.1 Scope

This Specification covers introduced grass/legume and native grass and forb seeds used for planting to provide vegetative cover.

Pure live seed (PLS) is the percent of seed germination plus dormant and/or hard seed times the percent of seed purity of each species.

3876.2 Requirements

A General Requirements

All seed shall conform to the latest seed law of the State, including those governing labeling and weed seed tolerances. Tolerances for Germination and Purity, as determined by the Department of Agriculture, shall only apply to seed that has been previously tested and approved by the Department of Agriculture as a seed lot. Test for germination and viability shall have been made within 9 months of the date of installation.

All legume seed, including native legumes, shall have been pre-inoculated with the proper bacterial culture for the species being inoculated and with the bacteria culture designed for this purpose (pre-inoculation), in the manner and within the time specified by the manufacturer.

All native grass and forb seed shall be of current production seed or harvested from the previous two growing seasons.
All sedge, rush and forb seed that requires special pregermination treatment such as cold moist stratification shall be so treated prior to installation.

All wild-type native grass and forb seed shall have a source of origin within Minnesota, eastern North Dakota, eastern South Dakota, northern Iowa, or western Wisconsin.

Origin certified seed shall have originated within the regions specified above and shall be accompanied by the appropriate Quality Mark documentation from the Minnesota Crop Improvement Association to verify this.

Wild-type is defined as seed that is derived directly from native, wild stock: including seed that was collected in the wild and placed into production or that which has been harvested directly from native stands. Wild-type varieties are regional or local ecotypes that have not undergone a selection process. Wild-type refers to all native seed referred to as "common" in the industry. Origin certified seed that is "yellow tag" is by definition wild type that has originated within a specified geographic region.

Native species requiring certification for origin shall have their origin documented by the Minnesota Crop Improvement Association (MCIA). This level of certification is at the "yellow tag" (YT) level according to the MCIA Quality Control program. Documentation for origin certification of native seeds shall accompany all shipments and shall be identified on the tags as well.

All native grass, sedge, rush and forb seed shall be either origin certified or wild-type. Origin shall be clearly identified on the seed label for all seed, including native forbs.

Use of varieties not listed herein will be considered unacceptable and will be subject to 1503.

B Requirements for Native Grasses, Sedges, Rushes

The Contractor shall supply and plant native grass as pure live seed (PLS). If the listed varieties are not available from the Approved Vendor or Source list on file with the Mn/DOT Erosion Control unit, other varieties may be substituted only by obtaining approval of the Engineer and the Erosion Control unit. The Contractor shall provide documentation of substitutions prior to acceptance. Germination values shall include not more than 20 percent dormant seed, except for wetland sedges, rushes and grasses for which up to 80% dormancy shall be allowed.

All native grass seeds that contain awns or excessive hairs shall be cleaned and de-bearded prior to their inclusion into mixtures.
TABLE 3876-1
NATIVE GRASS REQUIREMENTS
GERMINATION, PURITY, AND ACCEPTABLE VARIETIES

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Acceptable Origin &amp; Varieties</th>
<th>Purity Min. %</th>
<th>Germ. Min. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluestem, big</td>
<td>Andropogon gerardii</td>
<td>MN Certified (YT), Bison</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Grama, sideoats</td>
<td>Bouteloua curtipendula</td>
<td>MN Certified (YT)</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Grama, blue</td>
<td>Bouteloua gracilis</td>
<td>MN Certified (YT), SD, ND wild-type</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>Brome, fringed</td>
<td>Bromus ciliata</td>
<td>MN Certified (YT), MN, MT, Canada wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Brome, Kalm's</td>
<td>Bromus kalmii</td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Hairy wood chess</td>
<td>Bromus purgans</td>
<td>MN Certified (YT)</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Buffalo grass</td>
<td>Buchloe dactyloides</td>
<td>MN Certified (YT), MN, ND, SD, NE wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Blue-joint grass</td>
<td>Calamagrostis Canadensis</td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Sedge, bottle-brush</td>
<td>Carex comosa</td>
<td>MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>Sedge, tussock</td>
<td>Carex stricta</td>
<td>MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>Sedge, fox</td>
<td>Carex vulgineoida</td>
<td>MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>Wild rye, Canadian</td>
<td>Elymus canadensis</td>
<td>MN Certified (YT)</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Bottle brush grass</td>
<td>Elymus hystrix</td>
<td>MN wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Wheat grass, slender</td>
<td>Elymus trachycalus</td>
<td>MN Certified (YT), MN, ND, SD, Canada wild-type, Revenue</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Wild rye, Virginia</td>
<td>Elymus virginicus</td>
<td>MN Certified (YT), WI, IA wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Wheat grass, western</td>
<td>Elytrigia smithii</td>
<td>MN Certified (YT), MN, ND, SD wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Manna grass, reed</td>
<td>Glyceria grandis</td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Manna grass, fowl</td>
<td>Glyceria striata</td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Common rush</td>
<td>Juncus effusus</td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>June grass</td>
<td>Koeleria macrantha</td>
<td>MN Certified (YT), MN, ND, SD wild-type</td>
<td>85</td>
<td>70</td>
</tr>
</tbody>
</table>
### TABLE 3876-1
**NATIVE GRASS REQUIREMENTS**
**GERMINATION, PURITY, AND ACCEPTABLE VARIETIES**

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Acceptable Origin &amp; Varieties</th>
<th>Purity Min. %</th>
<th>Germ. Min. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch grass</td>
<td><em>Panicum virgatum</em></td>
<td>MN Certified (YT), Dakota</td>
<td>95</td>
<td>70</td>
</tr>
<tr>
<td>Bluegrass, fowl</td>
<td><em>Poa palustris</em></td>
<td>MN Certified (YT), MN, ND, Canada wild-type</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Bluestem, little</td>
<td><em>Schizachyrium scoparium</em></td>
<td>MN Certified (YT),</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Bulrush, green</td>
<td><em>Scirpus atrovirens</em></td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>Wool grass</td>
<td><em>Scirpus cyperinus</em></td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>Bulrush, soft-stem</td>
<td><em>Scirpus validus</em></td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>60</td>
</tr>
<tr>
<td>Indian grass</td>
<td><em>Sorghastrum nutans</em></td>
<td>MN Certified (YT)</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Cordgrass, prairie</td>
<td><em>Spartina pectinata</em></td>
<td>MN Certified (YT), MN wild-type</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Dropseed, rough</td>
<td><em>Sporobolus asper</em></td>
<td>MN Certified (YT), MN wild-type</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Dropseed, sand</td>
<td><em>Sporobolus cryptandrus</em></td>
<td>MN Certified (YT), MN, ND, SD wild-type</td>
<td>95</td>
<td>70</td>
</tr>
<tr>
<td>Dropseed, prairie</td>
<td><em>Sporobolus heterolepis</em></td>
<td>MN Certified (YT)</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Needle grass, green</td>
<td><em>Stipa viridula</em></td>
<td>MN Certified (YT), MN, ND, SD wild-type</td>
<td>90</td>
<td>80</td>
</tr>
</tbody>
</table>

### TABLE 3876-2
**INTRODUCED GRASS REQUIREMENTS**
**GERMINATION, PURITY, AND ACCEPTABLE VARIETIES**

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Acceptable Varieties</th>
<th>Purity Minimum %</th>
<th>Germination Minimum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentgrass, seaside</td>
<td><em>Agrostis palustris</em></td>
<td>--</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Redtop</td>
<td><em>Agrostis stolonifera</em></td>
<td>--</td>
<td>92</td>
<td>85</td>
</tr>
<tr>
<td>Oats</td>
<td><em>Avena sativa</em></td>
<td>--</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Brome, smooth</td>
<td><em>Bromus inermis</em></td>
<td>Lincoln, Carlton, Sac, Signal, Manchar</td>
<td>90</td>
<td>85</td>
</tr>
<tr>
<td>Trade Name</td>
<td>Scientific Name</td>
<td>Acceptable Varieties</td>
<td>Purity Minimum %</td>
<td>Germination Minimum %</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------</td>
<td>---------------------------------------</td>
<td>------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Fescue, hard</td>
<td>Festuca ovina var. duriauscula</td>
<td>Durar, Scaldis, Reliant II, Warwick, Aurora</td>
<td>95</td>
<td>85</td>
</tr>
<tr>
<td>Fescue, red</td>
<td>Festuca rubra</td>
<td>Wintergreen, Dawson, Pen Lawn, Cindy</td>
<td>97</td>
<td>85</td>
</tr>
<tr>
<td>Fescue, sheep's</td>
<td>Festuca sp.</td>
<td>--</td>
<td>95</td>
<td>85</td>
</tr>
<tr>
<td>Ryegrass, perennial</td>
<td>Lolium perene</td>
<td>--</td>
<td>99</td>
<td>90</td>
</tr>
<tr>
<td>Ryegrass, annual</td>
<td>Lolium italicum</td>
<td>--</td>
<td>99</td>
<td>90</td>
</tr>
<tr>
<td>Timothy</td>
<td>Phleum pratense</td>
<td>--</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Bluegrass, Canada</td>
<td>Poa compressa</td>
<td>Common, Reubens, Talon</td>
<td>95</td>
<td>82</td>
</tr>
<tr>
<td>Bluegrass, Kentucky-Elite</td>
<td>Poa pratensis</td>
<td>Adelphi, Aspen, Glade, Columbia, Estate, Eclipse, Jefferson, Midnight, Midnight II, NutGlade, Touchdown, Merit, Parade, Rambo, Fylking, Victa, Monopoly</td>
<td>95</td>
<td>82</td>
</tr>
<tr>
<td>Bluegrass, Kentucky-Improved</td>
<td>Poa pratensis</td>
<td>Baron, Odyssey, Rugby II, Shamrock</td>
<td>95</td>
<td>82</td>
</tr>
<tr>
<td>Bluegrass, Kentucky-Low Maintenance</td>
<td>Poa pratensis</td>
<td>America, Aquila, Caliber, Certified Park, Challenger, Impact, Kenblue, Nassau, Newport, Ram I, Nugget, Sydsport, South Dakota</td>
<td>95</td>
<td>82</td>
</tr>
<tr>
<td>Bluegrass, Kentucky-Park</td>
<td>Poa pratensis</td>
<td>Certified Park only</td>
<td>95</td>
<td>82</td>
</tr>
</tbody>
</table>
Table 3876-2

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Acceptable Varieties</th>
<th>Purity Minimum %</th>
<th>Germination Minimum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluegrass, SD Common</td>
<td>Poa pratensis</td>
<td>Bluegrass,</td>
<td>98</td>
<td>85</td>
</tr>
<tr>
<td>Alkali grass</td>
<td>Puccinella distans</td>
<td>Falt's, Saly</td>
<td>95</td>
<td>85</td>
</tr>
<tr>
<td>Wheat, winter</td>
<td>Triticum aestivum</td>
<td></td>
<td>99</td>
<td>85</td>
</tr>
</tbody>
</table>

D Requirements for Introduced Legumes...Table 3876-3

Germination values determined by test shall include dormant seed for legumes.

Table 3876-3

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Acceptable Varieties</th>
<th>Purity Minimum %</th>
<th>Germination Minimum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa, creeping</td>
<td>Medicago sativa</td>
<td>Rambler, Victoria, Teton, Travois, Spredor 2</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Alfalfa, perennial</td>
<td>Medicago sativa</td>
<td>Vernal</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Alfalfa, annual</td>
<td>Medicago sativa</td>
<td>Nitro, Condor, El Grande, Maricopa, Mesa, Prestige, Tulane, Westar, Beacon, Coronado, Mecca, Sundor</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Clover, alslike</td>
<td>Trifolium hybridum</td>
<td>--</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Clover, red</td>
<td>Trifolium pratense</td>
<td>Lakeland, Arlington</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Clover, white</td>
<td>Trifolium repens</td>
<td>----</td>
<td>99</td>
<td>85</td>
</tr>
</tbody>
</table>

E Requirements for Native Forbs (Wildflowers).......... Table 3876-4

All forb seed shall be of wild-type as defined in 3876.2A.
The Contractor shall supply and plant native forb seed as a bulk rate. Native forb seed shall be tested for viability with a standard germination test performed according to 3876.3. If the test meets or exceeds the minimum percent germination requirement for each respective species, the Engineer will accept the seed for viability. If a species is called for that is not listed in Table 3876-4, its purity shall be no less than 50 percent and its viability no less than 20 percent.

### TABLE 3876-4

**NATIVE FORB SPECIES (WILDFLOWERS) GERMINATION, PURITY, AND ACCEPTABLE VARIETIES**

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Purity Min. %</th>
<th>Germ. Min. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarrow</td>
<td>Achillea millefolium</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Hyssop, fragrant-giant</td>
<td>Agastache foeniculum</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Water Plantain</td>
<td>Alisma subcordatum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Meadow garlic</td>
<td>Allium canadense</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Onion, prairie</td>
<td>Allium stellatum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Anemone, Canada</td>
<td>Anemone canadensis</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Milkweed, marsh</td>
<td>Asclepias incarnata</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Milkweed, butterfly</td>
<td>Asclepias tuberosa</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Aster, sky-blue</td>
<td>Aster azureus</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, heath</td>
<td>Aster ericoides</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, smooth-blue</td>
<td>Aster laevis</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, large-leaved</td>
<td>Aster macrophyllus</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, New England</td>
<td>Aster novae-angliae</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, upland-white</td>
<td>Aster pharzroides</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, swamp</td>
<td>Aster panicous</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, silky</td>
<td>Aster sericeus</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, panicled</td>
<td>Aster simplex</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Aster, flat-topped</td>
<td>Aster Unbellatus</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Milkvetch, Canada</td>
<td>Astragalus canadensis</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Partridge pea</td>
<td>Chamiscrisis fasciulata</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Tic-seed, stiff</td>
<td>Coreopsis palmata</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Prairie clover, white</td>
<td>Dalea candidum</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Prairie clover, purple</td>
<td>Dalea parpureum</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Tick-trefoil, showy</td>
<td>Desmodium canadense</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Coneflower, narrow-leaved</td>
<td>Echinacea angustifolia</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Joe-pye weed</td>
<td>Eupatorium maculatum</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Boneset</td>
<td>Eupatorium perfoliatum</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Long-leaved bluets</td>
<td>Heliotia longifolia</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Sneeze weed</td>
<td>Helium autumnale</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Giant sunflower</td>
<td>Helianthus giganteus</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Ox-eye, common</td>
<td>Helopsis helianthoides</td>
<td>80</td>
<td>60</td>
</tr>
</tbody>
</table>
### TABLE 3876-4
NATIVE FORB SPECIES (WILDFLOWERS) GERMINATION, PURITY, AND ACCEPTABLE VARIETIES

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Scientific Name</th>
<th>Purity Min. %</th>
<th>Germ. Min. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great St. John’s wort</td>
<td>Hypericum pyramidatum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Iris, wild</td>
<td>Iris versicolor</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Iris, blue-flag</td>
<td>Iris virginica-shrevii</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Bushclover, round-headed</td>
<td>Lespedeza capitata</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Blazingstar, rough</td>
<td>Liatris aspera</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Blazingstar, dotted</td>
<td>Liatris punctata</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Blazingstar, tall</td>
<td>Liatris pycnostachya</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Lobelia, great-blue</td>
<td>Lobelia siphilitica</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Lupine, wild</td>
<td>Lupinus perennis</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Monkey flower</td>
<td>Mimulus ringens</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Bergamot, wild</td>
<td>Monarda fistulosa</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Bee balm, spotted</td>
<td>Monarda punctata</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>Beardtongue, foxglove</td>
<td>Penstemon digitalis</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Penstemon showy</td>
<td>Penstemon grandiflorum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Mountain mint</td>
<td>Pycnanthemum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Coneflower, columnar</td>
<td>Ratibida columnifera</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Coneflower, grey-headed</td>
<td>Ratibida pinnata</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Prairie rose</td>
<td>Rosa arkansana</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Black-eyed Susan's</td>
<td>Rudbeckia hirta</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Golden-glow, wild</td>
<td>Rudbeckia laciniata</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Brown-eyed Susan</td>
<td>Rudbeckia triloba</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Goldenrod, grass-leaved</td>
<td>Solidago graminifolia</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>Goldenrod, gray</td>
<td>Solidago nemoralis</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Goldenrod, upland</td>
<td>Solidago parishicolor</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Goldenrod, stiff</td>
<td>Solidago rigida</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Goldenrod, showy</td>
<td>Solidago speciosa</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Tall meadow rue</td>
<td>Thalictrum dasycarpum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Spiderwort, prairie</td>
<td>Tradescantia bracteata</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Spiderwort, Ohio</td>
<td>Tradescantia ohiensis</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Vervain, blue</td>
<td>Verbena hastata</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Vervain, hoary</td>
<td>Verbena stricta</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Ironweed</td>
<td>Veronica fasciculata</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Culver's root</td>
<td>Veronicastrum virginianum</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Vetch, American</td>
<td>Vicia americana</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Alexander's, heart-leaved</td>
<td>Zizia aptera</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Alexander's, golden</td>
<td>Zizia aurea</td>
<td>80</td>
<td>50</td>
</tr>
</tbody>
</table>

**F Seed Mixture Designations**

The seed mixture or species to be furnished and used shall be as indicated in the Contract. The mixtures shall be a uniform blend of the designated seeds, proportioned as specified in Table 3876-5.
Mixtures in the 300 series shall be blended according to size and texture so that they can be installed from the appropriate seed box. The fine seed shall be installed from the fine seed box and the fluffy seed from the fluffy seed box. Forbs are added to mixtures by blending fine and fluffy seeds with the corresponding grass seed components using the mixtures provided in Table 3876-6. The inclusion of forbs is indicated in Table 3876-5.

F1 Native Harvest

Unless otherwise specified, native harvest shall consist of seed that has been harvested directly from wild stands within 80 km (25 miles) of the Project. Seed originating from outside the specified area will not be acceptable. Approximately 70 percent of the mixture shall consist of big bluestem and Indian grass, each with a minimum germination percent of 70 percent. The minimum percent PLS of the big bluestem and Indian grass portion of the native harvest mix shall be no less than 50 percent. In addition, the native harvest shall contain a minimum of five species of native grasses and shall also consist of no less than 3 percent (by mass) of native forbs. All species contained in the native harvest mix shall be listed with their relative percentages on the packing slip. Components comprising less than 1 percent of the mix may be listed as "trace". Germination results for the species tested shall be contained on the label. In addition, the native harvest mix shall contain no more than 25 percent non-viable matter. Non-viable matter includes but is not limited to chaff, non-viable seed, hulls, trash, and straw.

### TABLE 3876-5
SEED MIXTURE DESIGNATIONS

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Plant Species</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Winter wheat</td>
<td>100.0</td>
</tr>
<tr>
<td>110</td>
<td>Oats</td>
<td>100.0</td>
</tr>
<tr>
<td>130</td>
<td>Oats</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>Winter wheat</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>Rye grass</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Alfalfa, annual</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
### Mixture: 150

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>16.8</td>
<td>15</td>
</tr>
<tr>
<td>Wheat-grass, slender</td>
<td>5.6</td>
<td>5</td>
</tr>
<tr>
<td>Red clover</td>
<td>11.2</td>
<td>10</td>
</tr>
<tr>
<td>Alfalfa, vernal</td>
<td>11.2</td>
<td>10</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 44.8 40 100.0

*Purpose: 1-2 Year Temporary Stabilization*

### Mixture: 190

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Red Clover</td>
<td>6.7</td>
<td>6</td>
</tr>
<tr>
<td>Alsike Clover</td>
<td>4.7</td>
<td>4.2</td>
</tr>
<tr>
<td>Alfalfa, creeping</td>
<td>10.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Brome grass, smooth</td>
<td>8.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>16.8</td>
<td>15</td>
</tr>
<tr>
<td>Wheat-grass, slender</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
<td>Vetch, hairy</td>
<td>16.8</td>
<td>15</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 67.2 60 100.0

*Purpose: 2-5 Years Roadside Stabilization*
### Mixture: 240

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brome grass, smooth</td>
<td>10.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Bluegrass, Kentucky &quot;Certified Park&quot;</td>
<td>22.6</td>
<td>20.2</td>
</tr>
<tr>
<td>Bluegrass, Canada</td>
<td>10.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Switch grass</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Wheat-grass, slender</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Fescue, Hard &quot;Reliant II&quot;</td>
<td>5.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>16.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Dropseed, sand</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Bluestem, little *</td>
<td>2.9*</td>
<td>2.6*</td>
</tr>
<tr>
<td>Red clover</td>
<td>5.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Prairie clover, purple</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 84 75 100.0

* Bulk with 50% PLS minimum

**Purpose: Sandy- Roadside**

### Mixture: 250

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brome grass, smooth</td>
<td>11.0</td>
<td>9.8</td>
</tr>
<tr>
<td>Bluegrass, Kentucky &quot;Certified Park&quot;</td>
<td>22.7</td>
<td>20.3</td>
</tr>
<tr>
<td>Bluegrass, Canada</td>
<td>11.0</td>
<td>9.8</td>
</tr>
<tr>
<td>Switch grass</td>
<td>2.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Wheat-grass, slender</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>16.5</td>
<td>14.7</td>
</tr>
<tr>
<td>Timothy</td>
<td>2.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Redtop</td>
<td>2.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Alfalfa, creeping</td>
<td>4.7</td>
<td>4.2</td>
</tr>
<tr>
<td>White Clover</td>
<td>2.4</td>
<td>2.1</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 78.6 70 100.0

**Purpose: General Roadside excluding sandy sites**
<table>
<thead>
<tr>
<th>Mixture: 260</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Bluegrass, Kentucky &quot;Certified Park&quot;</td>
<td>35.8</td>
<td>32</td>
</tr>
<tr>
<td>Bluegrass, Canada</td>
<td>11.2</td>
<td>10</td>
</tr>
<tr>
<td>Bluegrass, Kentucky - Low Maintenance</td>
<td>33.6</td>
<td>30</td>
</tr>
<tr>
<td>Fescue, hard</td>
<td>9.0</td>
<td>8</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>22.4</td>
<td>20</td>
</tr>
<tr>
<td>GRAND TOTALS:</td>
<td>112</td>
<td>100</td>
</tr>
</tbody>
</table>

1 Any accepted low maintenance Kentucky Bluegrass Except "Park"

**Purpose: Commercial Turf**

<table>
<thead>
<tr>
<th>Mixture: 270</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>kg/ac</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Bluegrass, Kentucky - Elite</td>
<td>33.6</td>
<td>30</td>
</tr>
<tr>
<td>Bluegrass, Kentucky - Improved</td>
<td>33.6</td>
<td>30</td>
</tr>
<tr>
<td>Bluegrass, Kentucky - Low Maintenance</td>
<td>33.6</td>
<td>30</td>
</tr>
<tr>
<td>Red fescue, creeping</td>
<td>10.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>22.8</td>
<td>20.4</td>
</tr>
<tr>
<td>GRAND TOTALS:</td>
<td>134.4</td>
<td>120</td>
</tr>
</tbody>
</table>

**Purpose: Residential Turf**

<table>
<thead>
<tr>
<th>Mixture: 280</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Alfalfa, creeping</td>
<td>16.8</td>
<td>15</td>
</tr>
<tr>
<td>Brome grass, smooth</td>
<td>11.2</td>
<td>10</td>
</tr>
<tr>
<td>Redtop</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
<td>Rye-grass, perennial</td>
<td>16.8</td>
<td>15</td>
</tr>
<tr>
<td>Switch grass</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>Timothy</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>Wheat-grass, slender</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
<td>GRAND TOTALS:</td>
<td>56</td>
<td>50</td>
</tr>
</tbody>
</table>

**Purpose: Agricultural Roadsides**
### Mixture: 310

<table>
<thead>
<tr>
<th>Common Name</th>
<th>PLS Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Bluestem, big</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Indian grass</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Wild-rye, Virginia</td>
<td>2.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Switch grass</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Blue-joint grass</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Green bulrush</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Wool grass</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Giant bur reed</td>
<td>0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Cordgrass, prairie</td>
<td>1.7</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Grass Totals:** 11.3 10.0 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Winter Wheat*</td>
<td>62.7</td>
<td>56.0</td>
</tr>
<tr>
<td>Rye-grass, annual</td>
<td>12.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Wheatgrass, slender</td>
<td>3.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Cover Crop Totals:** 78.3 70 100.0

*Oats to be substituted for spring plantings

*Purpose: Native mix for wetter areas. Infiltration ponds, dry ponds, wet ditches. Tall height.*

**Wet Forbs Mixture (Table 3876-6)**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:**

91.8 82.0 100.0

987
### Mixture: 325

<table>
<thead>
<tr>
<th>Common Name</th>
<th>PLS Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Bluestem, big</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Fringed brome</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Wheat grass, slender</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Virginia wild-rye</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Switch grass</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Fowl bluegrass</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Indian grass</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Prairie cord grass</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Grass Totals:** 11.4 10.0 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Blue-joint grass</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Bottlebrush sedge</td>
<td>0.34</td>
<td>0.3</td>
</tr>
<tr>
<td>Tussock sedge</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Fox sedge</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Reed manna grass</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Fowl manna grass</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Green bulrush</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Wool grass</td>
<td>0.22</td>
<td>0.2</td>
</tr>
<tr>
<td>Soft-stem bulrush</td>
<td>0.34</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Sedge Totals:** 2.22 2.0 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Winter Wheat*</td>
<td>61.6</td>
<td>56</td>
</tr>
<tr>
<td>Rye-grass, annual</td>
<td>12.3</td>
<td>11.2</td>
</tr>
<tr>
<td>Wheatgrass, slender</td>
<td>3.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Cover Crop Totals:** 77 70 100.0

<table>
<thead>
<tr>
<th>Wet Forbs Mixture (Table 3876-6)</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 92.8 84.0 100.0

*Oats to be substituted for spring plantings*

**Purpose:** Native sedge/prairie meadow mix. Reaches a height of 915 mm to 1220 mm (36 to 48 inches). Developed for use on hydric soils and for wetland restoration.
### Mixture: 328

<table>
<thead>
<tr>
<th>Common Name</th>
<th>PLS Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Bluestem, big</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>Brome, fringed</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>Wild-rye, Virginia</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>Switchgrass</td>
<td>1.1</td>
<td>1</td>
</tr>
<tr>
<td>Bluegrass, fowl</td>
<td>5.5</td>
<td>5</td>
</tr>
<tr>
<td>Indian grass</td>
<td>2.2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Grass Totals:** 17.6 16.0 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Winter Wheat*</td>
<td>61.6</td>
<td>56.0</td>
</tr>
<tr>
<td>Rye-grass, annual</td>
<td>12.3</td>
<td>11.2</td>
</tr>
<tr>
<td>Wheatgrass, slender</td>
<td>3.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Cover Crop Totals:** 77 70 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Milkweed, marsh</td>
<td>0.33</td>
<td>0.3</td>
</tr>
<tr>
<td>Prairie clover, purple</td>
<td>0.33</td>
<td>0.3</td>
</tr>
<tr>
<td>Tic-trefoil, showy</td>
<td>0.33</td>
<td>0.3</td>
</tr>
<tr>
<td>Sunflower, early</td>
<td>0.33</td>
<td>0.3</td>
</tr>
<tr>
<td>Black-eyed Susan</td>
<td>0.55</td>
<td>0.5</td>
</tr>
<tr>
<td>Vervain, blue</td>
<td>0.33</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Economy Forbs Totals:** 2.2 2.0 100.0

**GRAND TOTALS:** 96.8 88.0 100.0

*Oats to be substituted for spring plantings

**Purpose:** Native mix for infiltration ponds, dry ponds, temporary wet ditches. Tall height.
### Mixture: 330

<table>
<thead>
<tr>
<th>Common Name</th>
<th>PLS Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Grama, sideoats</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Grama, blue</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Bluestem, little</td>
<td>3.9</td>
<td>3.5</td>
</tr>
<tr>
<td>June grass</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Dropseed, sand</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Wild-rye, Canadian</td>
<td>3.4</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Grass Totals:** 15.7 14.0 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Winter Wheat*</td>
<td>62.7</td>
<td>56.0</td>
</tr>
<tr>
<td>Rye-grass, annual</td>
<td>12.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Wheatgrass, slender</td>
<td>3.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Cover Crop Totals:** 78.3 70.0 100.0

<table>
<thead>
<tr>
<th>Common Name</th>
<th>PLS Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Dry Forbs Mixture</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 94.6 84.5 100.0

*Oats to be substituted for spring plantings

**Application:** Native mix for Sandy/dry areas. Short height.
### Mixture: 340

<table>
<thead>
<tr>
<th>Common Name</th>
<th>PL Rate kg/ha</th>
<th>PL Rate lb/ac</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluestem, big</td>
<td>3.3</td>
<td>3.0</td>
<td>21.5</td>
</tr>
<tr>
<td>Bluestem, little</td>
<td>2.8</td>
<td>2.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Wild-rye, Canadian</td>
<td>2.2</td>
<td>2.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Grama, sideoats</td>
<td>2.2</td>
<td>2.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Switch grass</td>
<td>0.6</td>
<td>0.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Dropseed, sand</td>
<td>0.6</td>
<td>0.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Bluegrass, Canada</td>
<td>3.4</td>
<td>3.0</td>
<td>21.5</td>
</tr>
<tr>
<td>June grass</td>
<td>0.6</td>
<td>0.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Grass Totals:** 15.7 14.0 100.0

### Bulk Rate

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate kg/ha</th>
<th>Bulk Rate lb/ac</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Wheat*</td>
<td>62.7</td>
<td>56.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Rye-grass, annual</td>
<td>12.5</td>
<td>11.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Wheatgrass, slender</td>
<td>3.1</td>
<td>2.8</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**Cover Crop Totals:** 78.3 70.0 100.0

### Dry Forbs Mixture (Table 3876-6)

<table>
<thead>
<tr>
<th>Component</th>
<th>Rate kg/ha</th>
<th>Rate lb/ac</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>0.6</td>
<td>0.5</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**GRAND TOTALS:** 94.6 84.5 100.0

*Oats to be substituted for spring plantings

**Purpose:** Native mix for Sandy/Dry areas. Mid-height.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>PLS Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Bluestem, big</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Indian grass</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Bluestem, little</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Grama, sideoats</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Wild-rye, Canadian</td>
<td>2.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Switch grass</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Grass Totals:</strong></td>
<td><strong>15.7</strong></td>
<td><strong>14.0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Bulk Rate</th>
<th>% of Mix Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td>lb/ac</td>
</tr>
<tr>
<td>Winter Wheat*</td>
<td>62.7</td>
<td>56.0</td>
</tr>
<tr>
<td>Rye-grass, annual</td>
<td>12.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Wheatgrass, slender</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Cover Crop Totals:</strong></td>
<td><strong>78.3</strong></td>
<td><strong>70</strong></td>
</tr>
</tbody>
</table>

| Mesic Forbs Mixture (Table 3876-6) | 0.6 | 0.5 | 100.0 |

**GRAND TOTALS:** 94.6 84.5 100.0

*Oats to be substituted for spring plantings

*Application: Native mix for general roadside areas.*
**TABLE 3876-6**

**FORBS**

<table>
<thead>
<tr>
<th>Mixture: Mesic Forbs</th>
<th>Common Name</th>
<th>Botanical Name</th>
<th>% of Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aster, smooth-blue</td>
<td><em>Aster laevis</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Milkvetch, Canada</td>
<td><em>Astragalus canadensis</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Prairie clover, white</td>
<td><em>Dalea candidum</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Prairie clover, purple</td>
<td><em>Dalea purpureum</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Tick-trefoil, Showy</td>
<td><em>Desmodium canadense</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Coneflower, narrow-leaved</td>
<td><em>Echinacea angustifolia</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Ox-eye, common</td>
<td><em>Heliopsis helianthoides</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Coneflower, grey-headed</td>
<td><em>Ratibida pinnata</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Blazingstar, rough</td>
<td><em>Liatris aspera</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Blazingstar, tall</td>
<td><em>Liatris pycnostachya</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Bergamot, wild</td>
<td><em>Monarda fistulosa</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Penstemon, showy</td>
<td><em>Penstemon grandiflorum</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Mint, mountain</td>
<td><em>Pycnanthemum virginianum</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Coneflower, columnar</td>
<td><em>Ratibida columnifera</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Black-eyed Susan</td>
<td><em>Rudbeckia hirta</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Goldenrod, stiff</td>
<td><em>Solidago rigida</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Vervain, blue</td>
<td><em>Verbena hastata</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Vervain, hoary</td>
<td><em>Verbena stricta</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Alexanders, heart-leaved</td>
<td><em>Zizea aptera</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Alexanders, golden</td>
<td><em>Zizia aurea</em></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
</tbody>
</table>

Rate: 0.6 kg/ha (½ pounds per acre) Bulk.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Botanical Name</th>
<th>% of Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadplant</td>
<td><em>Amorpha canescens</em></td>
<td>10.0</td>
</tr>
<tr>
<td>Milkweed, butterfly</td>
<td><em>Asclepias tuberosa</em></td>
<td>2.0</td>
</tr>
<tr>
<td>Aster, heath</td>
<td><em>Aster ericoides</em></td>
<td>4.0</td>
</tr>
<tr>
<td>Tic-seed, stiff</td>
<td><em>Coreopsis palmate</em></td>
<td>2.0</td>
</tr>
<tr>
<td>Yarrow</td>
<td><em>Achillea millefolium</em></td>
<td>2.0</td>
</tr>
<tr>
<td>Long-leaved blueets</td>
<td><em>Hedyotis longifolia</em></td>
<td>1.0</td>
</tr>
<tr>
<td>Bushclover, round-headed</td>
<td><em>Lespedeza capitata</em></td>
<td>3.0</td>
</tr>
<tr>
<td>Blazingstar, rough</td>
<td><em>Liatris aspera</em></td>
<td>4.0</td>
</tr>
<tr>
<td>Blazingstar, dotted</td>
<td><em>Liatris punctata</em></td>
<td>3.0</td>
</tr>
<tr>
<td>Lupine, wild</td>
<td><em>Lupinus perennis</em></td>
<td>5.0</td>
</tr>
<tr>
<td>Prairie clover, white</td>
<td><em>Dalea candidum</em></td>
<td>5.0</td>
</tr>
<tr>
<td>Prairie clover, purple</td>
<td><em>Dalea purpureum</em></td>
<td>16.0</td>
</tr>
<tr>
<td>Prairie rose</td>
<td><em>Rosa arkansana</em></td>
<td>1.0</td>
</tr>
<tr>
<td>Black-eyed susan</td>
<td><em>Rudbeckia hirta</em></td>
<td>18.0</td>
</tr>
<tr>
<td>Goldenrod, gray</td>
<td><em>Solidago nemoralis</em></td>
<td>3.0</td>
</tr>
<tr>
<td>Goldenrod, upland</td>
<td><em>Solidago ptarmicoides</em></td>
<td>1.0</td>
</tr>
<tr>
<td>Goldenrod, stiff</td>
<td><em>Solidago rigida</em></td>
<td>2.0</td>
</tr>
<tr>
<td>Goldenrod, showy</td>
<td><em>Solidago spectosa</em></td>
<td>2.0</td>
</tr>
<tr>
<td>Vervain, hoary</td>
<td><em>Verbena stricta</em></td>
<td>14.0</td>
</tr>
<tr>
<td>Alexander's, golden</td>
<td><em>Zizea aurea</em></td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Rate: 0.6 kg/ha (½ pounds per acre) bulk
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Botanical Name</th>
<th>% of Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyssop, fragrant giant</td>
<td>Agastache foeniculum</td>
<td>2.0</td>
</tr>
<tr>
<td>Water plantain</td>
<td>Alisma subcordatum</td>
<td>4.0</td>
</tr>
<tr>
<td>Meadow garlic</td>
<td>Allium canadense</td>
<td>1.0</td>
</tr>
<tr>
<td>Anemone, Canada</td>
<td>Anemone Canadensis</td>
<td>1.0</td>
</tr>
<tr>
<td>Milkweed, marsh</td>
<td>Asclepias incarnata</td>
<td>2.0</td>
</tr>
<tr>
<td>Aster, panicked</td>
<td>Aster simplex</td>
<td>3.0</td>
</tr>
<tr>
<td>Aster, New England</td>
<td>Aster novaeangliae</td>
<td>3.0</td>
</tr>
<tr>
<td>Aster, red-stalked</td>
<td>Aster puniceus</td>
<td>3.0</td>
</tr>
<tr>
<td>Aster, flat-topped</td>
<td>Aster umbellatus</td>
<td>1.0</td>
</tr>
<tr>
<td>Tick trefoil, Canada</td>
<td>Desmodium glutinosum</td>
<td>1.0</td>
</tr>
<tr>
<td>Joe-pye weed</td>
<td>Eupatorium maculatum</td>
<td>17.0</td>
</tr>
<tr>
<td>Boneset</td>
<td>Eupatorium perfoliatum</td>
<td>10.0</td>
</tr>
<tr>
<td>Goldenrod, grass-leaved</td>
<td>Solidago graminifolia</td>
<td>2.0</td>
</tr>
<tr>
<td>Sneezeweed</td>
<td>Helianthus giganteus</td>
<td>2.0</td>
</tr>
<tr>
<td>Giant sunflower</td>
<td>Helianthus helianthoides</td>
<td>1.0</td>
</tr>
<tr>
<td>Ox-eye, common</td>
<td>Hypericum pyramidatum</td>
<td>2.0</td>
</tr>
<tr>
<td>Great St. John’s wort</td>
<td>Iris versicolor</td>
<td>1.0</td>
</tr>
<tr>
<td>Iris, wild</td>
<td>Liatris pycnostachya</td>
<td>8.0</td>
</tr>
<tr>
<td>Blazingstar, tall</td>
<td>Monarda fistulosa</td>
<td>1.0</td>
</tr>
<tr>
<td>Bergamot, wild</td>
<td>Dalea candidum</td>
<td>1.0</td>
</tr>
<tr>
<td>Prairie clover, white</td>
<td>Dalea purpureum</td>
<td>2.0</td>
</tr>
<tr>
<td>Mountain mint</td>
<td>Pycnanthemum virginianum</td>
<td>1.0</td>
</tr>
<tr>
<td>Black-eyed susan</td>
<td>Rudbeckia hirta</td>
<td>6.0</td>
</tr>
<tr>
<td>Goldenrod, stiff</td>
<td>Solidago rigida</td>
<td>2.0</td>
</tr>
<tr>
<td>Tall meadow rue</td>
<td>Thalictrum dasycarpum</td>
<td>2.0</td>
</tr>
<tr>
<td>Vervain, blue</td>
<td>Verbena hastata</td>
<td>14.0</td>
</tr>
<tr>
<td>Ironweed</td>
<td>Veronica fasciculate</td>
<td>1.0</td>
</tr>
<tr>
<td>Culver’s root</td>
<td>Veronicastrum virginicum</td>
<td>3.0</td>
</tr>
<tr>
<td>Alexander’s, golden</td>
<td>Zizea aurea</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Rate: 2.2 kg/ha (2 pounds/acre) bulk
3876.3 INSPECTION AND ACCEPTANCE

Certified Source - Sources with established quality control and so approved by the Erosion Control unit may supply seed in accordance with the Guaranteed Analysis method on file with the Mn/DOT Erosion Control unit. Seed guaranteed as meeting the pertinent requirements of this Specification shall be identified by official guaranteed analysis labels affixed to each container of seed in addition to the customary seed tag. For each lot of each type of seed, test reports from the Minnesota Department of Agriculture Seed Laboratory or a certified commercial seed analyst shall be available.

Noncertified source – All seed shall be sampled and tested prior to use. The Contractor shall submit to the Engineer the proposed source at least 6 weeks prior to time of use to allow adequate time for testing and approving the material. Current test results as conducted by a certified seed analyst or by a state Seed Laboratory may be accepted in lieu of Department testing.

As an alternate to the above testing or the Guaranteed Analysis method, Certified Seed bearing the Quality Mark of the Minnesota Crop Improvement Association will be acceptable. Certified Seed bearing the Quality Mark of agencies so authorized in other states will be acceptable providing that their germination and purity requirements equal or exceed those established by the Minnesota Crop Improvement Association.

The Department reserves the right to conduct its own inspection of seed either at the supplier's warehouse or at the Project site. Should the results of the Department's inspection disagree with those obtained at the origin, the Department's findings shall be conclusive and binding.

All bags of seed shall be labeled with the mixture number and the vendor from which it was obtained. All Seed not planted within 9 months after it has been tested for germination shall be sampled and retested before use, at no cost to the Department. Seed testing shall be in accordance with the methods on file with the Mn/DOT Erosion Control unit.

The Contractor shall obtain all native grass and forb seeds from an Approved Vendor or Source for native seeds as listed with the Mn/DOT Erosion Control unit or listed in the Contract. A Certification of Compliance shall be furnished for all native seed mixes supplied to the project in accordance with 1603. The Certificate of Compliance shall state the amount of origin certified seed if any in the mix and the conversion of PLS to bulk weight. Each native seed mixture shall have a separate Certificate of Compliance.
3877
Topsoil Borrow

3877.1 SCOPE
This Specification covers topsoil material used as a medium for establishing and sustaining healthy plant growth.

3877.2 REQUIREMENTS
Topsoil material furnished under this Specification shall be obtained from the soil horizons normally designated as "A" or "B" as defined by the Soil Science Society of America, or shall be obtained from alluvial deposits. The material shall meet the requirements given herein for the several classifications defined.

A Topsoil Borrow
Topsoil borrow for general use as a turf growing medium shall meet the requirements of Table 3877-1:

<table>
<thead>
<tr>
<th>Material Passing 2.00 mm (#10) Sieve</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>5%</td>
<td>30%</td>
</tr>
<tr>
<td>Silt</td>
<td>10%</td>
<td>70%</td>
</tr>
<tr>
<td>Sand &amp; Gravel</td>
<td>10%</td>
<td>70%</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>3%</td>
<td>20%</td>
</tr>
<tr>
<td>pH</td>
<td>6.1</td>
<td>7.8</td>
</tr>
</tbody>
</table>

B Select Topsoil Borrow
Select topsoil borrow for use as a plant growing medium in designated areas, such as landscape beds, shall meet the requirements of Table 3877-2:
TABLE 3877-2
SELECT TOPSOIL BORROW REQUIREMENTS

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Passing 2.00 mm</td>
<td>90%</td>
<td>--</td>
</tr>
<tr>
<td>(#10) Sieve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>5%</td>
<td>30%</td>
</tr>
<tr>
<td>Silt</td>
<td>10%</td>
<td>70%</td>
</tr>
<tr>
<td>Sand &amp; Gravel</td>
<td>20%</td>
<td>70%</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>3%</td>
<td>20%</td>
</tr>
<tr>
<td>pH</td>
<td>6.1</td>
<td>7.5</td>
</tr>
<tr>
<td>Extractible Phosphorous</td>
<td>30 kg per hectare</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(26.8 pounds/acre)</td>
<td></td>
</tr>
<tr>
<td>Exchangeable Potassium</td>
<td>150 kg per hectare</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(133.8 pounds/acre)</td>
<td></td>
</tr>
<tr>
<td>Soluble Salts</td>
<td>--</td>
<td>0.15 siemens per meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.5 mmho/cm)</td>
</tr>
</tbody>
</table>

C Premium Topsoil Borrow

Premium topsoil borrow for use as a plant growing medium in critical areas and top dressing erosion stabilization mats shall be screened and pulverized and meet the requirements of Table 3877-3:

TABLE 3877-3
PREMIUM TOPSOIL BORROW REQUIREMENT

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Passing 2.00 mm</td>
<td>95%</td>
<td>--</td>
</tr>
<tr>
<td>(#10) Sieve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td>Silt</td>
<td>25%</td>
<td>60%</td>
</tr>
<tr>
<td>Sand &amp; Gravel</td>
<td>25%</td>
<td>60%</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>pH</td>
<td>6.0</td>
<td>7.1</td>
</tr>
<tr>
<td>Soluble Salts</td>
<td>--</td>
<td>0.15 siemens/m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.5 mmho/cm)</td>
</tr>
</tbody>
</table>
3878.2

3877.3 SAMPLING AND TESTING
The Contractor shall submit to the Engineer a list of prospective sources for topsoil borrow at least 1 month prior to time of use to allow adequate time for inspecting, testing, and approving the sources.
Texture of the topsoil shall be classified according to the Engineering definition of particle size. Texture shall be determined by the method described in AASHTO T 88.
The current standard testing procedure of the University of Minnesota, Soil Science Department, Soils Testing Laboratory shall be used for determining pH, percent of organic matter, extractible phosphorous, exchangeable potassium, and soluble salts.

3878 Sod

3878.1 SCOPE
This Specification covers sod used for landscaping and erosion control.

3878.2 REQUIREMENTS
Sod shall consist of densely-rooted bluegrass or other permanent turf grasses as approved by the Engineer.
The sod shall be cut in uniform strips of not less than 300 mm (12 inches) in width and to a uniform thickness of 20 mm (¾ inch) or more as necessary so that practically all of the dense root system will be retained and be exposed in the bottom side of the sod.
When the sod is cut, it shall be sufficiently moist to withstand exposure and handling during the transplant operations. The sod shall have been raked free of debris and the top growth trimmed to a height of 25 to 75 mm (1-3 inches).
All sod furnished shall be in acceptable condition upon delivery to the work site. The sod strips shall not have dry or dead edges upon delivery. Between June 1 and September 15, sod shall not be cut more than 24 hours in advance of delivery.

A Lawn Sod
Lawn sod shall have a lush appearance, be dense, have a uniform texture, and bright in color throughout. The sod shall not contain grass with blade widths of 5 mm (0.2 inch) or greater. The sod shall be weed-free and shall contain no more than 5 mm (0.2 inch) of thatch over the base soil. The sod shall consist of a blend of 4 or 5 fine leafed turf grasses. At least two-thirds of the grasses, as determined by initial seeding proportions, shall be of improved and elite type Kentucky bluegrass varieties as defined in 3876.2C.
B  **Erosion Control Sod**

Sod used for general road side purposes and for erosion control shall be a low maintenance type, dense, and of uniform texture. The sod shall be free of noxious weeds and shall contain less than 3 percent grassy weeds, sedges, broadleaf weeds, or coarse grasses. The sod shall consist of a blend of 4 or 5 fine leafed turf grasses. At least two-thirds of the grasses, as determined by initial seeding proportions shall be of acceptable low maintenance Kentucky bluegrass varieties as defined in 3876.2C.

B1 **Netting**

The netting required in ditch bottoms in accordance with 2575.312, at a minimum, will meet the erosion control netting 3883 specifications with respect to material type, mesh openings, weight, and tensile strength.

B2 **Anchors**

On slope applications, or in ditch bottoms with intermittent flow less than 1.5 m/sec. *(5 feet/second)*, or in ditch bottoms where the sod is allowed to root before carrying water, the staples used to anchor the sod shall be U shaped 3 mm *(0.12 inch)* diameter or heavier steel wire having a span width of 25 mm *(1 inch)* and a length of 200 mm *(8 inches)* from top to bottom after bending.

In ditch bottom applications with flow velocities greater than 1.5 m/sec. *(5 feet/second)*, or in ditch bottoms susceptible to continuous flow before the sod can root into the ground, the shingled sod shall be overlaid with snow fence, chain link fence, jute, or a biodegradable netting with a minimum life span of 3 months over the top of the sod and securing it to the sod with anchors. The method of anchoring the overlaid material and sod to the ground shall be in accordance with 3888.2C, or wood stakes as appropriate. Unless directed otherwise by the Engineer, the chain link fence, jute or biodegradable netting does not need to be removed. Snow fence or other plastic non-biodegradable material shall be removed after the maintenance period or effective use period as determined by the Engineer.

C  **Salt Resistant Sod**

Salt resistant sod for use along boulevards or in a potential salt environment shall be a low maintenance type, fine leafed, and of uniform texture. The sod shall be free of noxious, broadleafed, and grassy weeds and shall contain less than 3 percent coarse grasses. The sod shall have originated from the blend of grass seed shown in Table 3878-1.
### TABLE 3878-1
SALT RESISTANT SOD

<table>
<thead>
<tr>
<th>Grass Type</th>
<th>Acceptable Varieties</th>
<th>Minimum Percent by Mass</th>
<th>Maximum Percent by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali grass</td>
<td>Fults, Salty</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Red fescue</td>
<td>Dawson, Cindy</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Park Kentucky bluegrass</td>
<td>Park</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Improved Kentucky bluegrass</td>
<td>(A)</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Low Maintenance Kentucky bluegrass</td>
<td>(B)</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

(A) Listed in 3876.2C
(B) Listed in 3876.2C excluding Park Kentucky bluegrass

#### D MINERAL SOD

Mineral sod shall be commercially produced on or harvested from mineral based soils. The soil upon which mineral sod is produced or harvested from shall consist of less than 10 percent organic matter by mass. The sod shall be dense, fine leafed, and of uniform texture. The sod shall be free of noxious, broadleafed, or grassy weeds and shall contain less than 3 percent coarse grasses. The sod shall consist of a blend of 4 or 5 fine leafed turf grasses. At least 35 percent of the grasses, as determined by initial seeding proportions, shall consist of improved type Kentucky bluegrass varieties defined in 3876.2C.

#### 3878.3 SAMPLING AND TESTING

Prior to delivery to the Project, the Contractor shall furnish the Engineer a certification from the grower stating the grass varieties contained in the sod. No sod shall be placed until the certification of varieties contained in the sod has been reviewed and accepted by the Engineer.

Test samples for determination of soil organic matter content of mineral sod will be obtained from the soil exposed in the bottom side of the sod rolls. Testing for organic matter content will be in accordance with ASTM D 2974.

The Department reserves the right to conduct its own inspection at any time of sod in the production fields or at the Project site. Representative samples of the sod shall be furnished upon request, in which case no sod shall be delivered until the samples have been approved.
3879

Agricultural Lime

3879.1 SCOPE

This Specification covers Agricultural Liming Material (ALM) containing calcium and/or magnesium compounds that are capable of neutralizing soil acidity and also providing a reasonable increase in soil pH within 6 months of soil incorporation.

3879.2 REQUIREMENTS

The ALM includes the following forms: limestone (calcitic or dolomitic), burned lime, slaked lime and marl. Gypsum is not a liming product. The lime product shall contain at least 80 percent Total Neutralizing Power (TNP). It shall be ground sufficiently fine so that 90 percent, including all the fine particles obtained in the grinding process, will pass through a 2.36 mm (# 8) sieve; at least 60 percent will pass through a 850 µm (#20) sieve; and at least 50 percent will pass through a 250 µm (#60) mesh sieve. The maximum water content of the lime material shall be 10%. The ALM shall have a minimum rating of 1120 kg ENP per metric ton (1000 lbs of ENP per ton) of ALM.

The ALM must be obtained from a Minnesota Department of Agriculture’s (MDA) licensed distributor or producer. For ALM supplied in bulk, the ALM must be delivered to the Project with the following information on a billing, delivery invoice or scale ticket label: 1) Distributor or producer’s name, address, telephone number, and source of production or stockpile location; 2) Customer’s name; 3) Date of sale or transfer; 4) Type of ALM; 5) Minimum kg of ENP per metric ton (lbs of ENP per ton), accurate within 3 percent; and 6) Weight or cubic meters (cubic yard) of ALM distributed and approximate weight per cubic meter (cubic yard). For ALM supplied in bags or other container types the following information must be affixed to the bag or container: 1) Distributor or producer’s name and address; 2) Minimum kg ENP per metric ton (lbs ENP per ton), accurate to within 3 percent; and 3) the net weight.

3879.3 SAMPLING AND TESTING

Samples shall be collected in accordance with the Minnesota Department of Agriculture’s (MDA) Agricultural Lime Official Sampling Methods. Samples must be submitted to either MDA or the University of Minnesota testing lab for analysis of %TNP, % passing the 2.36 mm, 850 µm and 250 µm (# 8, 20 and 60) sieves, % Dry Matter, and the kg ENP per metric ton (lbs ENP per ton) of Agricultural Lime Material (ALM) rating. Sampling and testing must take place within 90 days before applying the lime material to the land. The kg ENP per metric ton (lbs ENP per ton) of ALM is defined as
the product of 1000 kg ALM per Metric ton (2000 lbs ALM per ton) x 
(\% ENP/100) x (\% of Dry Matter/100). Material furnished under this 
Specification may be accepted on the basis of the Distributor’s or 
Producer’s guaranteed analysis. However, the Department reserves the 
right to sample, test, inspect and accept or reject the material bases on 
its own tests.

3880

Peat Moss

3880.1 SCOPE

This Specification covers peat moss used as a soil amendment for 
landscape plantings.

3880.2 REQUIREMENTS

Peat moss shall be of the hypnum, sphagnum, or reed sedge types as 
defined in ASTM D 2607. Other peaty soils will not be acceptable. 
The peat moss shall be a processed product reasonably free of wood and 
other extraneous matter and shall contain no weed seed or bacterium 
that may affect plant growth. The peat moss shall be uniform 
throughout meeting the requirements of Table 3880-1:

<table>
<thead>
<tr>
<th>TABLE 3880-1</th>
<th>PEAT MOSS REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>Moisture Content, % by mass</td>
<td>25</td>
</tr>
<tr>
<td>Ash Content, % by mass</td>
<td>--</td>
</tr>
<tr>
<td>pH</td>
<td>3.0</td>
</tr>
<tr>
<td>Fiber Content, %</td>
<td>33</td>
</tr>
</tbody>
</table>

At the time of delivery the peat moss shall be in an air-dried 
condition.

Quantity shall be expressed as loose volume. Package contents 
shall be determined by measuring loose material in a 0.03 m³ (1 cubic 
foot) measure.

3880.3 SAMPLING AND TESTING

Test samples shall be provided upon request and at a rate designated 
by the Engineer. Testing will be in accordance with the methods 
prescribed in ASTM D 2974. Testing for fiber content shall be as 
described in ASTM D 2607.

When delivered in package form, the material may be accepted on 
the basis of the manufacturer's guaranteed analysis.
3881

3881 Fertilizer

3881.1 SCOPE

This Specification covers fertilizer used for establishing vegetative cover and landscape plantings.

3881.2 REQUIREMENTS

A General

Fertilizer furnished under this Specification shall be a manufactured grade of the inorganic or organic type, produced in granular or granulated form. The fertilizer shall contain at least the minimum analysis specified, and shall be furnished as a blend or homogeneous form containing the specified percentages of total nitrogen, available phosphoric acid (or phosphorous), and water soluble potash (or potassium), in that order.

When the fertilizer is furnished in closed containers, they shall be clearly marked with the mass, type of nutrients, and the producer’s guaranteed analysis, all in accordance with State and Federal regulations.

When the fertilizer is furnished in bulk, each shipment shall be accompanied by a suitable bill-of-lading giving the mass, type of nutrients and a certificate of the producer’s guaranteed analysis.

B Types

Fertilizer shall conform to one of the following types, as specified in the Plan.

B1 Type 1- Commercial Fertilizer

Commercial fertilizer shall consist of dry granulated nutrients produced by mining and manufacturing processes and commonly used in the agricultural or lawn care industries. It shall contain the three major plant nutrients of nitrogen, phosphorous, and potassium. Commercial fertilizer may be furnished as a homogenous or blended form.

B2 Type 2- Phosphorous Free Fertilizer

Phosphorous free fertilizer shall meet the requirements of Type 1 commercial fertilizer except that it shall contain no phosphorous.

B3 Type 3- Slow Release Fertilizer

Slow release fertilizer shall be specifically processed to release nitrogen at a slow rate over a growing season. It shall contain the three major plant nutrients of nitrogen, phosphorous and potassium. Primary nitrogen sources shall be a coated prilled urea form. A minimum of 70% of the nitrogen component shall be a slow release water insoluble nitrogen.
B4  Type 4- Natural Based Fertilizer

Natural based fertilizer shall have a minimum of 50% of the mass and 50% of the macronutrients derived from natural or organic material. The product shall be a dry granulated product with a moisture content of less than 10%. The approximate size of the granules shall be between 2.8 – 0.6 mm (#7 and 30 sieve). Primary plant food sources are derived from aerobically composted turkey litter, hydrolyzed feathermeal, ammonium sulfate, ferrous sulfate and sulfate of potash. The product shall be free of any sewage sludge, raw manure or uncomposted organic matter.

3881.3  SAMPLING AND TESTING

Fertilizer may be accepted on the basis of the manufacturer's guaranteed analysis, but the Department reserves the right to sample and test the material at any time. Chemical analysis will be in accordance with methods established by the Association of Official Agricultural Chemists.

3882  Mulch Material

3882.1  SCOPE

This Specification covers mulch material for controlling erosion and establishing vegetative cover.

3882.2  REQUIREMENTS

Mulch material shall conform to the requirements for one of the following types, as specified in the Contract.

TYPE 1

Type 1 mulch shall consist of grain straw, hay, cuttings of agricultural grasses and legumes. When Type 1 is used in conjunction with native grasses (300 series Mixtures), it shall consist of grain straw only. The material shall be free of seed bearing stalks of noxious grasses or weeds as defined by the rules and regulations of the Minnesota Department of Agriculture.

Mulch containing Canada thistle or leafy spurge fragments or seeds shall be rejected. In addition, Type 1 mulch shall not contain the following species: cattail (Typha sp), reed canary grass (Phalaris arundinacea), birds-foot trefoil (Lotus corniculatus) or crown vetch (Coronilla varia). At the time of delivery the mulch shall be in an air dried condition. Bales used for bale barriers shall be densely packed rectangular shaped 350 x 450 x 850 mm (14 x 18 x 36 inches) minimum nominal size. Bales shall be tightly wrapped with two strands of twine or wire.
Type 3 mulch shall consist of clean grain straw (i.e. oats, wheat) that is certified by the Minnesota Crop Improvement Association (MCIA) to be weed free. All mulch bales shall be in an air dried condition at the time of delivery and shall have an MCIA inspection tag attached indicating that the mulch has passed inspection.

Type 4 mulch shall consist of a combination of Type 1 mulch and Type 5 Hydraulic Soil Stabilizer. The combination shall consist of 3.4 metric ton/hectare (1 ½ tons/acre) of Type 1 mulch and 840 kg/ha (750 pounds per acre) of Type 5 Hydraulic Soil Stabilizer.

Type 5 mulch shall consist of raw wood slash from either hard or soft timber harvested during clearing and grubbing operations on the Project. It shall be a product of a mechanical chipper, hammermill, or tub grinder. The material shall all pass a 100 mm (4 inch) screen and not more than 20 percent by mass of the material shall pass a 2.36 mm (0.1 inch) sieve. Maximum length of individual pieces shall not exceed 500 mm (20 inches).

Type 6 mulch shall consist of raw wood material from either hard or soft timber and shall be a product of a mechanical chipper, hammermill, or tub grinder. The material shall be substantially free of mold, dirt, sawdust, and foreign material and shall not be in an advanced state of decomposition. The material shall not contain chipped up manufactured boards or chemically treated wood, including but not limited to wafer board, particle board, and chromated copper arsenate (CCA) or penta treated wood. The material, when air dried, shall all pass a 100 mm (4 inch) screen and not more than 20 percent by mass of the material shall pass a 2.36 mm (0.1 inch) sieve. Unattached bark or green leaf composition, either singly or combined, shall not exceed 20 percent each by mass. Maximum length of individual pieces shall not exceed 500 mm (20 inches).

Type 7 (Prairie Mulch)

Prairie mulch shall be of a type that has been thrashed to remove seeds so that it consists of clippings, chaff, or residue from harvesting or cleaning operations. This material may be harvested from native stands or from native grass production fields. Prairie mulch shall be free of noxious weed seeds, and shall be from the Approved Sources list for native seeds on file on the Mn/DOT web pages under the Materials Engineering Section.
TYPE 8 (Prairie Hay)

Prairie hay shall be of a type that has not been thrashed to remove seeds so that it consists of material that has been bailed directly. This material may be harvested from native stands or from native grass fields. Prairie hay shall be free of noxious weed seeds, and shall be from the Approved Sources list for native seeds on file on the Mn/DOT web pages under the Materials Engineering Section.

TYPE 9

Aggregate mulch will be 9.5 to 50 mm (3/8 to 2 inches), with 5 percent by mass allowable passing the 9.50 mm (3/8 inch) sieve. Crushing is allowable, but not required.

3882.3 SAMPLING AND TESTING

Test samples, when required, shall be obtained at a rate determined by the Engineer. Testing for moisture content will be in accordance with ASTM D 4444 and sieve analysis in accordance with ASTM D 422. Type 5 Hydraulic Soil Stabilizer will be accepted on the basis of the manufacturer's certified results in accordance with 1603.

3883 Erosion Control Netting

3883.1 SCOPE

This Specification covers biodegradable mesh placed over Type 1 mulch, on the bottom of freshly placed sod, or on top of hydraulic soil stabilizer, or alone to reinforce the materials while vegetation is establishing.

3883.2 REQUIREMENTS

A Netting material shall conform to the following requirements for one of the following types, as specified in the Contract.

Type 1

Polypropylene netting shall consist of polypropylene plastic net with bonded joints. Mesh openings shall be a minimum of 15 mm (½ inch) to a maximum of 25 mm (1 inch) measured in either direction. The net shall have a minimum mass of 12.2 g/m² (2.5 pounds per 1,000 square feet). The minimum tensile force shall be 90 N per 4 strands (20 pounds/4 strands) in the length direction and 70 N (16 pounds) per 4-strands in the width direction. Tensile force shall be the average of three tests.
Type 2
Jute netting shall consist of jute yarn woven into an open mesh with approximate 25 mm (1 inch) openings. The net shall have a minimum mass of 0.40 kg/m² (0.92 pounds per square yard). Each strand shall be no less than 0.36 mm (0.14 inch) in diameter with a minimum yarn count of no less than 50 per meter (164 per foot).

Type 3
Coir netting shall be 100% coconut, woven material. The yarns shall be of machine spun coir twine uniformly twisted, with average thickness 4 mm-7.5 mm (0.16-0.3 inch). With 37-40 curls per 0.3 m (1 foot). The percent opening area shall be 48-68%.

Staples
Wire staples used to secure the netting shall be 3 mm (11 gauge) or heavier, steel wire, “U” shaped, and have a length of not less than 150 mm (6 inches), unless otherwise specified in the Contract.

3883.3 SAMPLING AND TESTING
Samples for testing shall be of such size and numbers as requested by the Engineer.

3884
Hydraulic Soil Stabilizer

3884.1 SCOPE
This specification covers soil-stabilizing materials, which are applied by hydro spreading and used for controlling erosion and establishing vegetative cover.

3884.2 REQUIREMENTS
Hydraulic soil stabilizers shall easily mix with water and shall be noncorrosive to hydraulic application equipment. They shall be nonfoaming and contain mixture enhancers to prevent foaming and mixing problems during agitation in the application equipment. Application equipment shall have both mechanical agitation and also slurry bypass.

Hydraulic soil stabilizers shall be considered safe to the applicator, adjacent workers, and the environment when properly applied according to Environmental Protection Agency (EPA) and other regulatory agencies. Material Safety Data Sheets (MSDS) shall be submitted annually to the Office of Environmental Services, Erosion Engineering Unit. The materials shall be nontoxic to plants, fish and other wildlife and shall be 100% biodegradable.
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| A    | **Type 1–Natural Tackifier**  
Water soluble natural proteins, vegetable gums, guar gums, starch, psyllium, pitch, or rosen type blended with gelling and hardening agents, or a water soluble blend of hydrophilic polymers, viscosifiers, sticking aids and other gums. Proof of the proper application rate as indicated by the manufacturer product label for the site conditions and time of year will be required.  
Guar gum based tackifiers shall consist of a minimum of 95% guar gum, by weight. The remaining 5% shall consist of dispersing and cross-link additives. Starch shall be a non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. For use needing less than three months of lasting duration. Psyllium shall be a finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. Pitch and Rosen shall be a non-ionic pitch and rosin emulsion that has a minimum solids content of 48 percent. The rosin shall be a minimum of 26 percent of the total solids content. The soil stabilizer shall be a non-corrosive, water-dilutable emulsion that cures to water-insoluble binding and cementing agent upon application. | |
| B    | **Type 2–BLANK** |
| C    | **Type 3–BLANK** |
| D    | **Type 4–BLANK** |
| E    | **Type 5–Hydromulch**  
Type 5 shall consist of wood cellulose fibers that shall contain no germination or growth inhibiting factors. It shall not contain nor be processed from sawdust or pulverized newspaper. It shall be dyed an appropriate color to allow visual metering of its application, and shall have the property of becoming dispersed and suspended when agitated in water. It shall contain 2.5 to 5.0 percent tackifier (Type 1) by weight when premixed in the bag. When Type 1 is added independently to the Type 5 mulch, it shall be added at the rate of the manufacturer’s recommendations. The tackifier shall be incidental to the Type 5 hydromulch material. When sprayed uniformly on the surface of the soil, the fibers shall form a blotter-like ground cover that readily absorbs water and allows infiltration to the underlying soil. Moisture content shall not exceed 15 percent at the time of delivery. When washed on an 850 µm sieve at least 50 percent shall be retained on the sieve. | |
| F    | **Type 6–Hydromulch blend**  
Type 6 shall meet the requirements of Type 5 above except that it shall be a blend of 40 to 60% recycled paper and 40 to 60% wood cellulose fibers by weight. | |
| G    | **Type 7–BLANK** |
3884.2

H Type 8–Bonded Fiber Matrix
Type 8 shall be composed of 100% wood or wood by-products. A minimum of 25% of the fibers shall average 10.16 mm (0.4 inches) in length and 50% or more shall be retained on a Clark Fiber Classifier 24-mesh screen. Fibers shall be colored with water soluble, non-toxic dye, to aid in uniform application over the site. The material shall contain a hydrocolloid based (guar gum) binder equaling 10% or greater by volume. The crosslinker shall contain slow-release and agricultural based fertilizers or other proprietary chemicals equaling less than 2% by volume. These binder and crosslinkers shall not dissolve or disperse upon rewetting. The moisture content of the matrix shall be 12% +/- 3% by weight. The mix ratio shall be 378–473 L (100 to 125 gallons) water to 24 kg (50 pounds) material.

3884.3 SAMPLING AND TESTING
Samples for laboratory testing shall be of numbers and size requested by the Engineer. Testing for moisture content will be in accordance with ASTM D4444 and particle sieve analysis in accordance with ASTM D422. For Type 8 hydraulic soil stabilizer a field “slump-test” or equivalent shall be performed to measure product specific free water movement in one time unit. This must be demonstrated to the Mn/DOT inspector prior to placement.

3884.4 CERTIFICATION AND TRAINING
Certification of Applicator will consist of Manufacture/Vendor Training program, consisting of a minimum of 4 hours of Classroom and Field Experience. Successful completion of the certification program shall be good for 2 years from the training date. Contractors wishing to use this specification shall provide written proof annually from the Manufacture/Vendor of a list of the individuals passing the Certification within the company. The Training program shall be subject to approval by Mn/DOT.

3885

Erosion Control Blankets

3885.1 SCOPE
This Specification covers biodegradable rolled out products used for controlling erosion, aiding the establishment of vegetation, and reinforcing vegetation on slopes, ditch bottoms and shorelines. The blankets are designed to reduce erosion until the vegetation is established. Typical uses for the blanket categories are as follows:

1010
<table>
<thead>
<tr>
<th>Category</th>
<th>Service Life</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>6-8 weeks</td>
<td>Flat areas, mowed areas</td>
</tr>
<tr>
<td>0</td>
<td>6-8 weeks</td>
<td>Flat areas, mowed areas</td>
</tr>
<tr>
<td>1</td>
<td>6-8 weeks</td>
<td>Flat areas, shoulder drain outlets, roadway shoulders, and lawns.</td>
</tr>
<tr>
<td>2</td>
<td>One Season</td>
<td>Slopes 1v:3h to 1v:2h less than 15 m (50 feet) long, ditches with gradients of 2 percent or less, flow velocities less than 1.0 m/second (3.5 feet/sec.).</td>
</tr>
<tr>
<td>3</td>
<td>One Season</td>
<td>Slopes 1v:3h to 1v:2h more than 15 m (50 feet) long, ditches with gradients of 3 percent or less, flow velocities less than 1.4 m/second (4.5 feet/sec.), flow depth 50 mm (2 inches) or less.</td>
</tr>
<tr>
<td>4</td>
<td>Semi-permanent</td>
<td>Slopes 1v:2h and steeper, ditches with gradients of 4 percent or less, flow velocities less than 1.7 m/sec. (5.5 feet/sec.), flow depth 75 mm (3 inches) or less.</td>
</tr>
<tr>
<td>5</td>
<td>Semi-permanent</td>
<td>Ditch bottoms with gradients of 5 percent and less, flow velocities less than 1.8 m/sec. (6 feet/sec.), and under 100 mm (4 inches) flow depth, water course banks within the normal flow elevation.</td>
</tr>
<tr>
<td>6</td>
<td>Permanent</td>
<td>Ditch bottoms with gradients of 6 percent and less, flow velocities less than 2 m/sec. (6.5 feet/sec.), and under 150 mm (6 inches) flow depth.</td>
</tr>
<tr>
<td>7</td>
<td>Permanent</td>
<td>Ditch bottoms with gradients of 7 percent and less, flow velocities less than 2.1 m/sec. (7 feet/sec.), and under 150 mm (6 inches) flow depth.</td>
</tr>
</tbody>
</table>
## 3885.2 REQUIREMENTS

### A Acceptable Types

Acceptable types of blankets allowed in the various categories shall be as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Acceptable Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Wood Cellulose 1S, NT, RD</td>
</tr>
<tr>
<td>0</td>
<td>Wood Fiber 0S, RD</td>
</tr>
<tr>
<td>1</td>
<td>Straw RD 1S, or Wood Fiber RD 1S</td>
</tr>
<tr>
<td>2</td>
<td>Straw 1S, or Wood Fiber 1S</td>
</tr>
<tr>
<td>3</td>
<td>Straw 2S, or Wood Fiber 2S</td>
</tr>
<tr>
<td>4</td>
<td>Straw/Coconut 2S, or Wood Fiber HV 2S</td>
</tr>
<tr>
<td>5</td>
<td>Straw/Coconut 2S</td>
</tr>
<tr>
<td>6</td>
<td>Straw/Coconut 3S, or Wood Fiber 3S</td>
</tr>
<tr>
<td>7</td>
<td>Coconut 3S, or Wood Fiber 3S</td>
</tr>
</tbody>
</table>

The lettering designation shall be defined as follows:

- **0S** - No netting, stitching only
- **1S** - Netting on one side
- **2S** - Netting on two sides
- **3S** - More than 2 nettings forming a three dimensional matrix
- **RD** - Rapidly degradable netting and stitching
- **NT** - No thread/stitching
- **HV** - High velocity

### B Physical Requirements

For Categories 1 through 5, the netting and stitching shall be composed of materials that have the same life expectancy. Blankets shall conform to the general requirements listed below and to their respective table requirements. Categories 00, 0, and 1 shall conform to Table 3885-1. Categories 2, 3, 4, and 5 shall conform to Table 3885-2. Categories 6 and 7 shall conform to Table 3885-3.
### TABLE 3885-1
RAPID DEGRADABLE BLANKET CRITERIA

<table>
<thead>
<tr>
<th>Category 00</th>
<th>Category 0</th>
<th>Category 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Cellulose Fiber 1S, NT, RD</td>
<td>Wood Fiber 0S, RD</td>
<td>Straw 1S, RD</td>
</tr>
<tr>
<td>Min. weight per m² (yd²)</td>
<td>0.20 kg (0.38 lb.)</td>
<td>0.4 kg (0.73 lb.)</td>
</tr>
<tr>
<td>Fiber Length. 80% must be greater than</td>
<td>12.7 mm (½ in.)</td>
<td>150 mm (6 in.)</td>
</tr>
<tr>
<td>Material</td>
<td>100% Wood Cellulose</td>
<td>100% Excelsior Fibers</td>
</tr>
<tr>
<td>Netting &amp; Stitching Service Life</td>
<td>6-8 weeks (No stitching)</td>
<td>6-8 weeks (No netting)</td>
</tr>
<tr>
<td>Netting &amp; Stitching Material</td>
<td>Rapid Photodegradable Polypropylene</td>
<td>Rapid Photodegradable Polypropylene</td>
</tr>
<tr>
<td>Netting Opening, Min.</td>
<td>13 x 13 mm (½ x ½ in.)</td>
<td>--</td>
</tr>
<tr>
<td>Min. Netting Weight per 836 m² (1000 Sq. Yd)</td>
<td>8 kg (17.7 lb.)</td>
<td>--</td>
</tr>
<tr>
<td>Category</td>
<td>Category 2</td>
<td>Category 3</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Straw 1S</td>
<td>0.27 kg (½ lb.)</td>
<td>0.27 kg (½ lb.)</td>
</tr>
<tr>
<td>Wood Fiber 1S</td>
<td>0.35 kg (0.64 lb.)</td>
<td>0.35 kg (0.64 lb.)</td>
</tr>
<tr>
<td>Fiber Length, 80% must be greater than</td>
<td>75 mm (3 in.)</td>
<td>150 mm (6 in.)</td>
</tr>
<tr>
<td>Material</td>
<td>100% Straw Cuttings</td>
<td>100% Excelsior Fibers</td>
</tr>
<tr>
<td>100% Excelsior Fibers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netting &amp; Stitching Backing Service Life</td>
<td>6-9 months</td>
<td>6-9 Months</td>
</tr>
<tr>
<td>Netting and Stitching Material</td>
<td>Polypropylene or Natural</td>
<td>Polypropylene or Natural</td>
</tr>
<tr>
<td>Netting Opening, Min.</td>
<td>13 x 13 mm (½ x ½ in.)</td>
<td>19 x 19 mm (¾ x ¾ in.)</td>
</tr>
<tr>
<td>Netting Weight per 836 m² (1000 sq. yd.) Min. Top</td>
<td>8 kg (17.7 lb.)</td>
<td>8 kg (17.7 lb.)</td>
</tr>
<tr>
<td>Netting Weight per 836 m² (1000 sq. yd.) Min. Bottom</td>
<td>8 kg (17.7 lb.)</td>
<td>8 kg (17.7 lb.)</td>
</tr>
</tbody>
</table>

Natural fibers required for netting and stitching required when “All natural netting and stitching” is specified in the Plan.
### TABLE 3885-3
PERMANENT BLANKET CRITERIA

<table>
<thead>
<tr>
<th>Category 6</th>
<th>Category 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw-Coconut 3S</td>
<td>Wood Fiber 3S</td>
</tr>
<tr>
<td>Min. weight per m² (yd²)</td>
<td>0.35 kg (0.64 lb.)</td>
</tr>
<tr>
<td>Fiber Length: 80% must be greater than</td>
<td>75 mm (3 inches)</td>
</tr>
<tr>
<td>Material</td>
<td>70% Straw and 30% Coconut Fibers</td>
</tr>
<tr>
<td>Netting &amp; Stitching Service Life</td>
<td>Longer than 36 months</td>
</tr>
<tr>
<td>Netting &amp; Stitching Material</td>
<td>Black UV Stabilized Polypropylene</td>
</tr>
</tbody>
</table>

**B-1 Material Fiber**

Each erosion control blanket shall consist of a uniform web of interlocking fibers. The blanket shall be of uniform thickness with the material fibers being evenly distributed over the entire area of the blanket. The blankets shall have sufficient porosity to shield the underlying soil surface from erosion and promote plant growth. All blankets shall be smolder resistant.

**B-2 Netting**

For Category 00 blankets, the netting shall start to break down within 6 weeks. For Category 1 blankets, the netting shall start to break down after 1 month with 80 percent breakdown occurring within 3 months. For Category 2 and 3 blankets, the netting shall contain sufficient UV stabilization for breakdown to occur within a normal growing season. For Category 4 and 5 blankets, the netting shall be UV stabilized to provide a service life of 2 to 3 years. For blankets designated as 2S, the fiber material shall be contained between an attached top and a bottom layer of netting.

All layers of netting or net-like material forming the 3-dimensional matrix of Category 6 and 7 blankets shall be UV stabilized to provide for permanent netting and vegetation reinforcement. The 3-dimensional...
matrix shall provide a minimum NRCS Vegetation Class E retardance and sediment trapping troughs.

B-3 Stitching
The material fiber in each blanket, except Category 00, shall be securely attached with stitching to the netting to prevent movement of the fiber in relation to the netting. For blankets consisting of 75 mm (3 inch) material fibers, the blanket shall be fastened together at a spacing not to exceed 50 mm (2 inches). For blankets consisting of 150 mm (6 inch) material fibers, the blanket shall be fastened together at a spacing not to exceed 100 mm (4 inches).

B-4 Anchors
Anchors for each category blanket shall be as defined in Table 3885-4.

<table>
<thead>
<tr>
<th>Blanket Category</th>
<th>Material</th>
<th>Type</th>
<th>Min. Bearing Width</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>00 &amp; 0</td>
<td>Biodegradable</td>
<td>Hook shaped stake</td>
<td>9.5 mm (0.375 in.) diameter</td>
<td>125 mm (5 inch)</td>
</tr>
<tr>
<td>1 &amp; 2</td>
<td>Steel Wire 11 Gauge</td>
<td>25 mm (1 inch)</td>
<td>100 mm (4 inch)</td>
<td></td>
</tr>
<tr>
<td>3 &amp; 4</td>
<td>Steel Wire 11 Gauge</td>
<td>25 mm (1 inch)</td>
<td>150 mm (6 inch)</td>
<td></td>
</tr>
<tr>
<td>5, 6, &amp; 7</td>
<td>Steel Wire 11 Gauge</td>
<td>25 mm (1 inch)</td>
<td>200 mm (8 inch)</td>
<td></td>
</tr>
</tbody>
</table>

3885.3 SAMPLING AND TESTING
Approved products for this specification are on file on the Mn/DOT web page under the Materials Engineering Section.
This Specification covers silt fence for use in retaining sediment. Installation procedures are to be in accordance with 2573. The following types are provided for specific uses:

**Standard Machine Sliced**
General use during site grading to keep sediment from moving off of the right-of-way and to protect critical areas. Can be used in ditch check applications.

**Heavy Duty**
Areas inaccessible to equipment due to space limitations, wet soils, steep slopes, etc. Must be hand installed.

**Super Duty**
Areas where extra strength and insurance is required for the protection of critical areas or traveling public due to long steep slopes next to and draining to the mainline, or stockpiles needing to be located near critical environmental areas.

**Preassembled**
Light duty applications are to protect temporary construction or to supplement the other types of silt fence.

Silt fence shall conform to Table 3886-1 and the following requirements.

**A Geotextile**
Geotextile shall be uniform in texture and appearance and shall have no defects, flaws, or tears that would affect its physical properties. It shall contain sufficient ultraviolet ray (U.V.) inhibitors and stabilizers to provide a minimum 2-year service life from outdoor exposure.

**B Pre-manufactured Materials**

- **B1 Super Duty**
The main support and strength shall conform to 2533, Precast Concrete Median Barrier.

- **B2 Preassembled**
Each post shall be securely fastened to the geotextile by a minimum of five gun staples 25 mm (1 inch) long that are also suitable for such a purpose. Stapling should be done at a diagonal angle to the threads of the geotextile fabric.
3886.2

C Posts
Standard metal T posts with a welded plate shall be used in conjunction with the machine sliced and heavy duty installations. Wooden posts used in conjunction with the preassembled silt fence shall have a sharpened end and shall protrude below the bottom of the geotextile to allow for a minimum of 457 mm (18 inch) embedment.

D Geotextile Fastners
D1 Zip Ties
Geotextile used in Machine Sliced and Heavy Duty applications shall be fastened to posts using plastic zip ties with a minimum tensile strength of 22 kg (50 pounds).

D2 Wire Ties
Geotextile used in Super Duty applications shall be fastened to anchor points using wire ties or plastic zip ties with a minimum tensile strength of 22 kg (50 pounds).

3886.3 SAMPLING AND TESTING
Geotextiles must be sampled and tested prior to use, when the amount to be installed is 300 m (1000 feet) or greater or in special circumstances at the request of the Engineer. In the presence of the Engineer, sampling shall be by random selection in the field at the rate of one swatch (sample) per ten rolls or fraction thereof. Swatches shall be a full roll width and at least 3 m (9 feet) long, discarding the first 1 m (3 feet) of fabric from the outside of the roll. Samples shall be available for testing at least 21 days prior to intended use.
TABLE 3886-1
SILT FENCE

<table>
<thead>
<tr>
<th>Description</th>
<th>Machine Sliced</th>
<th>Heavy Duty</th>
<th>Super Duty</th>
<th>Preassembled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine installed geotextile fastened to posts on-site.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand installed geotextile fastened to posts on-site.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-cast concrete median barriers placed end to end with geotextile fastened to front face of barriers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ready to install unit of geotextile attached to drivable posts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geotextile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Woven</td>
</tr>
<tr>
<td>Woven monofilament*</td>
</tr>
<tr>
<td>Woven monofilament*</td>
</tr>
<tr>
<td>Woven</td>
</tr>
<tr>
<td>Width</td>
</tr>
<tr>
<td>915 mm (36 inches)</td>
</tr>
<tr>
<td>915 mm (36 inches)</td>
</tr>
<tr>
<td>915 mm (36 inches)</td>
</tr>
<tr>
<td>915 mm (36 inches)</td>
</tr>
<tr>
<td>Grab Tensile ASTM D 4632 (machine direction)</td>
</tr>
<tr>
<td>59 kg (130 lb) min.</td>
</tr>
<tr>
<td>59 kg (130 lb) min.</td>
</tr>
<tr>
<td>59 kg (130 lb) min.</td>
</tr>
<tr>
<td>45 kg (100 lb) min.</td>
</tr>
<tr>
<td>Apparent Opening Size ASTM D 4751</td>
</tr>
<tr>
<td>0.60-0.425 mm (# 30-40 Sieve)</td>
</tr>
<tr>
<td>0.60-0.425 mm (# 30-40 Sieve)</td>
</tr>
<tr>
<td>0.60-0.425 mm (# 30-40 Sieve)</td>
</tr>
<tr>
<td>0.85-0.212 mm (# 20-70 Sieve)</td>
</tr>
<tr>
<td>U.V. Stability ASTM D 4355, 500 hrs.</td>
</tr>
<tr>
<td>70% min.</td>
</tr>
<tr>
<td>70% min.</td>
</tr>
<tr>
<td>70% min.</td>
</tr>
<tr>
<td>70% min.</td>
</tr>
<tr>
<td>Permeability (minimum) ASTM D 4491</td>
</tr>
<tr>
<td>1.0/sec</td>
</tr>
<tr>
<td>1.0/sec</td>
</tr>
<tr>
<td>1.0/sec</td>
</tr>
<tr>
<td>0.05/sec</td>
</tr>
<tr>
<td>Posts</td>
</tr>
<tr>
<td>N/A</td>
</tr>
<tr>
<td>Material</td>
</tr>
<tr>
<td>Steel T-Post with welded plate</td>
</tr>
<tr>
<td>Steel T-Post with welded plate</td>
</tr>
<tr>
<td>Wood</td>
</tr>
<tr>
<td>Min. Size</td>
</tr>
<tr>
<td>1.8 kg / m (1.26 lbs./ft)</td>
</tr>
<tr>
<td>1.8 kg / m (1.26 lbs./ft)</td>
</tr>
<tr>
<td>50 mm x 50 mm (2 x 2 inches)</td>
</tr>
<tr>
<td>Min. Length</td>
</tr>
<tr>
<td>1.5 m (5 feet)</td>
</tr>
<tr>
<td>1.5 m (5 feet)</td>
</tr>
<tr>
<td>1.5 m (5 feet)</td>
</tr>
<tr>
<td>Min. Embedment</td>
</tr>
<tr>
<td>610 mm (24 inches)</td>
</tr>
<tr>
<td>610 mm (24 inches)</td>
</tr>
<tr>
<td>458 mm (18 inches)</td>
</tr>
<tr>
<td>Max. Spacing</td>
</tr>
<tr>
<td>1.8 m (6 feet), 1.2 m (4 feet) for ditch checks</td>
</tr>
<tr>
<td>1.8 m (6 feet)</td>
</tr>
<tr>
<td>1.8 m (6 feet)</td>
</tr>
<tr>
<td>Geotextile Fastener to Post</td>
</tr>
<tr>
<td>Plastic Zip Ties-22 kg (50 lbs.) Tensile</td>
</tr>
<tr>
<td>Plastic Zip Ties-22 kg (50 lbs.) Tensile</td>
</tr>
<tr>
<td>Wire Tie or Plastic Zip Ties-22 kg (50 lbs) Tensile</td>
</tr>
<tr>
<td>Gun Staples 25 mm (1 inch) long</td>
</tr>
<tr>
<td>Min. Fasteners per post</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>1 tie at each individual barrier end</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

* No substitutions allowed, monofilament in both directions.
Flotation Silt Curtain

3887.1 SCOPe
This specification covers flotation silt curtain used for containing suspended sediment in an area of open water. The following types are provided for the specified uses:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still Water</td>
<td>Lakes or large bodies of water with little to no current</td>
</tr>
<tr>
<td>Moving Water</td>
<td>Streams and rivers with a current less than 2.1 m/s (7.0 feet/second)</td>
</tr>
<tr>
<td>Work Area</td>
<td>Moving or still water, used to confine a work area</td>
</tr>
</tbody>
</table>

3887.2 REQUIREMENTS
Floatation silt curtain shall be constructed of fabric fastened to a flotation carrier and weighted along the bottom edge. Depth of curtain shall be as indicated in the Plans. Depth of curtain shall refer to the dimension of the curtain fabric extending below the flotation, i.e. hanging in the water. The flotation silt curtain shall conform to Table 3887-1. Upon completion of the work the curtain shall be removed in a manner that will prevent re-suspension of sediment into the water.
### TABLE 3887-1
**FLOTATION SILT CURTAIN REQUIREMENTS**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Still Water</th>
<th>Moving Water &amp; Work Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Curtain Fabric Material Type</strong></td>
<td>Impermeable vinyl-nylon laminate</td>
<td>Impermeable vinyl-coated nylon</td>
</tr>
<tr>
<td>Mass per square meter (square yard)</td>
<td>0.6 kg (18 oz)</td>
<td>0.75 kg (22 oz)</td>
</tr>
<tr>
<td>Grab Tensile Strength ASTM D 4632 (B)</td>
<td>1.3 kN (300 lbs)</td>
<td>2.2 kN (500 lbs)</td>
</tr>
<tr>
<td>Depth of Curtain (A)</td>
<td>From 0.6 to 3 m (2-10 feet)</td>
<td>From 0.6 to 3 m (2-10 feet)</td>
</tr>
<tr>
<td>Flotation</td>
<td>150 mm (6 inches) diameter, Marine quality expanded polystyrene</td>
<td>200 mm (8 inches) diameter, Marine quality expanded polystyrene</td>
</tr>
<tr>
<td>Net Buoyancy, per meter (foot)</td>
<td>200 N (13 lbs)</td>
<td>300 N (20 lbs)</td>
</tr>
<tr>
<td>Top Load Carrying Components</td>
<td>Fabric Only</td>
<td>Fabric plus 8 mm (5/16 inch) galvanized steel cable 40.0 kN (9000 lb) min. break strength</td>
</tr>
<tr>
<td>Ballast, mass per meter (pound/foot), min.</td>
<td>1.0 kg (0.7 lb/foot) enclosed 6 mm (1/4 inch) galvanized chain</td>
<td>1.6 kg (1.1 lb/foot) enclosed 8 mm (5/16 inch) galvanized chain</td>
</tr>
<tr>
<td>Connection Between Sections</td>
<td>Laced grommets</td>
<td>Aluminum collar reinforced quick disconnects</td>
</tr>
</tbody>
</table>

(A) As specified in the Contract
(B) Minimum average roll value.

**3887.3 SAMPLING AND TESTING**

Material furnished under this Specification may be accepted on the basis of the manufacturer's guaranteed analysis. However, the Department reserves the right to sample, test, inspect, and accept or reject the materials based on its own tests.
Erosion Stabilization Mats

3888.1 SCOPE

This Specification covers permanent, long lived turf reinforcement mats to provide soil reinforcement for vegetation establishment in ditch bottoms, waterways, steep and engineered slopes, and shorelines where shear stresses are high or where there are highly erodible soils that have frequent runoff. Erosion stabilization mats shall be composed of UV stabilized, non-degradable, synthetic fibers, filaments, nettings, and/or wire mesh processed into three dimensional reinforcement matrices. Erosion stabilization mats shall provide sufficient thickness, strength, and void space to permit soil filling and retention and the development of vegetation within the matrix. All turf reinforcement mats shall be filled with topsoil, topsoil blends, or compost. To prevent temporary loss of topsoil media after placement, see 2575 and 3885. Various classes with different applications, varying in severity of shear stresses, are as follows:

<table>
<thead>
<tr>
<th>ESM Class</th>
<th>Application</th>
<th>Minimum Permissible Shear Stress (A) in channel applications -½ hr. Pa (pounds/sq. ft)</th>
<th>Minimum Tensile Strength (B) ASTM-D 6818</th>
<th>Matrix Composition (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Slopes and ditches</td>
<td>100 Pa (2.1 lbs/sq. ft)</td>
<td>1.82 kN/m (125 lbs/ft)</td>
<td>Nylon, Polypropylene, Polyolefin, or Polyester</td>
</tr>
<tr>
<td>2</td>
<td>Slopes and ditches</td>
<td>288 Pa (6 lbs/sq. ft)</td>
<td>2.19 kN/m (150 lbs/ft)</td>
<td>Nylon, Polypropylene, Polyolefin, or Polyester</td>
</tr>
<tr>
<td>3</td>
<td>Slopes and ditches</td>
<td>384 Pa (8 lbs/sq. ft)</td>
<td>2.55 kN/m (175 lbs/ft)</td>
<td>Nylon, Polypropylene, Polyolefin, or Polyester</td>
</tr>
<tr>
<td>4</td>
<td>Slopes and ditches</td>
<td>480 Pa (10 lbs/sq. ft.)</td>
<td>20 kN/m (1370 lbs/ft)</td>
<td>Nylon, Polypropylene, Polyolefin, or Polyester</td>
</tr>
<tr>
<td>5</td>
<td>Steep slope surface soil reinforcement</td>
<td></td>
<td>20 kN/m (1370 lbs/ft)</td>
<td>Nylon, Polypropylene, Polyolefin, or Polyester, bonded to twisted wire mesh (D)</td>
</tr>
</tbody>
</table>
(A) Sustained shear for minimum ½ hour vegetated with Retardance Class B.
(B) Minimum Average Roll Value of either direction.
(C) Minimum thickness of 6.4 mm (¼ inches), UV stability ASTM D4355 at 500 hours of 80 percent.
(D) Minimum 50-year design life.

3888.2 REQUIREMENTS

A General
Erosion stabilization mats are made of a three dimensional matrix of synthetic material and shall be continuously bonded at filament intersections. Filaments which are discontinuous or loosely held together by woven, unstitched, or glued netting will not be permitted.
All mats shall be soil filled. The mats shall have cells at least 10-19 mm (3/8 -3/4 inch) in depth to allow soil filling and retention.

B Materials and Dimensions
Material and dimension requirements will be as indicated in the Plans.

C Anchors, Staples, and Pins
The anchoring method and installation pattern used to link the Erosion Stabilization Mats to the soil surface shall be identified in the Plan. Where the anchoring method is not specified in the Plan, the following shall be used as directed by the Engineer:
1. Metal U-shaped, 11 gauge, 254 mm (10 inches) in length.
2. Metal pins should be at least 4.7 mm (3/16 inch) diameter steel with a 38 mm (1 ½ inch) steel washer at the head of the pin, 254 mm (10 inches) in length.
3. Welded 95 mm (3/8 inch) diameter rebar "T" stakes 305 mm (12 inches) in length.

3888.3 APPROVED MATERIALS
Approved products for this specification are on file on the Mn/DOT Web page under the Materials Engineering Section.

3888.4 SAMPLING AND TESTING
Material furnished under this specification may be accepted on the basis of the manufacturer's guaranteed analysis. However, the Department reserves the right to sample, test, inspect, and accept or reject the materials based on its own tests.

3889 Temporary Ditch Checks

3889.1 SCOPE
This Specification covers temporary ditch checks used for slowing water velocity and temporarily containing sediment in ditch bottoms.
3889.2 REQUIREMENTS

Temporary ditch checks shall conform to the requirements for the following types, as specified in the Contract.

A  Type 1: Sliced in Silt Fence

Type 1 ditch check shall meet the requirements of 3886-silt fence-machine sliced with a maximum 1.2 m (4 foot) post spacing.

B  Type 2: Bioroll

Type 2 ditch checks shall consist of 3987 Type 2 Storm Water Filter Logs.

C  Type 3: Bioroll Blanket System

Type 3 ditch checks shall consist of two components; Type 2 or 3 Storm Water Filter Log in accordance with 3897, staked on top of a Category 3, specification 3885 erosion control blanket. The blanket shall form a minimum width of 3.7 m (12 feet) perpendicular to the ditch gradient.

D  Type 4: BLANK

E  Type 5: Rock Weeper

Type 5 ditch checks shall be composed of a geotextile liner, coarse concrete aggregate, and riprap. The geotextile filter fabric liner shall be in accordance with 3733 Type IV. The coarse concrete aggregate forming the front half of the weeper shall be in accordance with 3137-1 CA-1. The riprap forming the back half of the weeper shall be in accordance with 3601, Class I and be composed of 100 percent crushed or quarry run material.

The rock weeper shall be created such that the side profile forms a triangle with 1:2 (V:H) slopes on both the front and back slopes. The coarse concrete aggregate shall be installed on the front half of the triangle with a 1:2 slope to a height of 0.6 m (2 feet). The riprap shall be installed on the back half of the triangular section.

F  Type 6: Geotextile Triangular Dike

Type 6 ditch checks shall be triangular shaped having a height of at least 200 mm – 250 mm (8-10 inches) in the center with equal sides and a 400 mm – 500 mm (16-20 inches) base. The triangular shaped inner material shall be urethane foam. The outer cover shall be a woven geotextile fabric placed around the inner material and allowed to extend beyond both sides of the triangle 0.61-0.91 m (2-3 feet). Length of each section shall be 0.91-2.1 m (3-7 feet). Standard length shall be 2.1 m (7 feet) unless otherwise indicated in the plans.

G  Type 7: Rock Check

Type 7 ditch checks shall be composed a geotextile liner and riprap. The geotextile filter fabric liner shall be in accordance with 3733 Type IV. The riprap shall be in accordance with 3601, Class I-IV, as
specified in the Contract, and be composed of 100 percent crushed or quarry run material. Riprap shall be configured in a trapezoidal shaped berm with respect to the side profile such that the bottom of the berm is approximately 1.5 m (5 feet) wide, the top of the berm is approximately 0.6 m (2 feet) wide, and the height of the berm is approximately 0.6 m (2 feet) deep.

3889.3 SAMPLING AND TESTING
Samples for testing shall be of such size and numbers as requested by the Engineer.

3890 Compost

3890.1 SCOPE
This Specification covers compost material used as a soil amendment for landscape planting or turf establishment purposes.

3890.2 REQUIREMENTS
Compost material furnished under this Specification shall consist of a natural humus product derived from the aerobic decomposition of organic wastes. The compost shall be considered mature and usable by Mn/DOT when 60 percent decomposition has been achieved as determined by an ignition-loss analysis and any one additional test method including the Solvita test of 5 or above. This shall mean that the compost product has no offensive smell, no identifiable organic materials, and will not reheat more than 11 °C (20 °F) degrees above ambient temperature. Compost must be produced by a process to further reduce pathogens (PFRP) and weed seeds, and process verified by fecal coliform or Salmonella sp. Tests, where applicable. Compost foreign particle restrictions up to 3% at 4 mm (0.16 inch) will apply to the shredded pieces from the plastic bags used to transport feedstocks to the composting facility, but will be considered acceptable if visible in the finished product. Biosolids as a compost additive or co-compost material shall be acceptable if product description and source is on file with Mn/DOT and meets all specifications for Grade 1 Compost.

Compost shall be registered for sale with the State of Minnesota. Additionally, the material shall meet the Minnesota Pollution Control Agency requirements for allowable levels of any inherent contaminants (7035.2836 Subp. 6 Sec. A), or the Code of Federal Regulations, Title 40, section 503.13(b)(3), amended for mercury. Compost must meet minimal chemical contaminant standards in order to be used in a Mn/DOT project. No material may be mixed into a compost that does
not comply with Minnesota Rules Chapter 7045 (Hazardous Waste). Compost used in Mn/DOT transportation systems is not allowed to exceed 10% of the Minnesota Pollution Control Agency’s Superfund residential soil cleanup guidelines, termed Soil Reference Values or SRVs (i.e. 10% of individual chemical or chemical mixture Hazard Index, Hazard Quotient, or acceptable cancer risk level). No chemical contaminant, including pesticides, can be present in concentrations that would result in toxic effects to soil organisms, plants, or animals which reside in or on the composted soil areas or use the treated area for food or shelter. At the time of delivery to the Project, the compost shall be in a condition considered safe for exposure to dusts during handling.

A Grade 1 Compost

Grade 1 compost for use in turf establishment shall be a nutrient rich type derived from the decomposition of animal derived material with a texture similar to a highly organic soil and meeting the following requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter Content</td>
<td>30%</td>
<td>----</td>
</tr>
<tr>
<td>C/N Ratio</td>
<td>6:1</td>
<td>20:1</td>
</tr>
<tr>
<td>NPK ratios(^a)</td>
<td>2:2:1</td>
<td>4:4:2</td>
</tr>
<tr>
<td>pH</td>
<td>5.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>35%</td>
<td>55%</td>
</tr>
<tr>
<td>Bulk Density kg/m(^3)/(lbs/cy. yd)</td>
<td>415 (700)</td>
<td>950 (1600)</td>
</tr>
<tr>
<td>Inert Material</td>
<td>----</td>
<td>3%</td>
</tr>
<tr>
<td>Bulk Density @ 4 mm</td>
<td>----</td>
<td>@ 4 mm</td>
</tr>
<tr>
<td>Soluble salts (mmho/cm)</td>
<td>----</td>
<td>10</td>
</tr>
<tr>
<td>Germination Test(^b)</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Screened Particle Size</td>
<td>----</td>
<td>10 mm</td>
</tr>
<tr>
<td>Contaminants</td>
<td>----</td>
<td>US EPA 503(^c)</td>
</tr>
</tbody>
</table>

\(^a\) To obtain the nitrogen, phosphorus or potassium levels specified, the compost may be fortified with commercial fertilizer.

\(^b\) Germination test must list the species of Cress or lettuce seed used.

\(^c\) or MPCA 7035.2836 Subp. 6 Sec. A.
**B  Grade 2 Compost**

Grade 2 compost for use as a landscape planting medium, shall be a humus rich type derived from the decomposition of leaves and yard wastes. Animal or poultry manure, at any stage of decomposition, shall not be acceptable. Texture shall be similar to a shredded peat and shall meet the following requirements:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter Content</td>
<td>30%</td>
<td>----</td>
</tr>
<tr>
<td>C/N Ratio</td>
<td>6:1</td>
<td>20:1</td>
</tr>
<tr>
<td>pH</td>
<td>5.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>35%</td>
<td>55%</td>
</tr>
<tr>
<td>Bulk Density $\text{kg/m}^3$ ($\text{lbs/cu.yd.}$)</td>
<td>415(700)</td>
<td>890(1500)</td>
</tr>
<tr>
<td>Inert Material $^a$</td>
<td>----</td>
<td>3%</td>
</tr>
<tr>
<td>Soluble salts (mmhos/cm)</td>
<td>----</td>
<td>10</td>
</tr>
<tr>
<td>Germination Test $^b$</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Screened Particle Size</td>
<td>----</td>
<td>19 mm</td>
</tr>
<tr>
<td>Contaminants</td>
<td>----</td>
<td>US EPA 503$^c$</td>
</tr>
</tbody>
</table>

$^a$ Includes plastic bag shreds

$^b$ Germination test must list the species of Cress or lettuce seed used.

$^c$ or MPCA 7035.2836 Subp. 6 Sec. A.

**C  Grade 3 Compost**

Grade 3 compost derived from a composite of up to 10 percent of animal derived material feedstock added to leaf and yard waste feedstock by weight, meeting all requirements of Grade 1 Compost.

**3890.3 APPROVED MATERIALS**

Vendors approved by the Department's Turf Establishment and Erosion Prevention Unit and on file on the web under the Materials Engineering Section meet this specification requirement.

**3890.4 SAMPLING AND TESTING**

Compost shall be tested and approved by the Engineer prior to delivery to the Project. Prior to the Engineer sampling the product, compost vendors must furnish certification that their compost has been chemically and biologically tested and found to meet the specification standards described above. When any federal or state chemical specific requirements are conflicting, the vendor shall meet the most stringent requirement. The Department also reserves the right to conduct bioassay testing of any material.
Prospective sources shall be indicated to the Engineer at least 1 month prior to delivery to the Project in order to allow adequate time for testing and approval of the material. Material from sources approved by the Agricultural Engineer may be accepted on the basis of a certificate of compliance according to 1603. In this case, certified test reports shall be furnished prior to delivery and acceptance to the Engineer and also to the Agricultural Engineer.

All testing shall be in accordance to current standard testing procedures of the University of Minnesota Soils Testing Laboratory, Soil Science Department, or equivalent.

3891

Storm Drain Inlet Protection

3891.1 SCOPE

This specification covers materials used for temporarily protecting storm drain inlets that are either constructed during the Project or exist prior to the Project, from sedimentation during construction activities. For purposes of this specification storm drain inlets are defined as manholes, catch basins, curb inlets and other drop type inlets that provide for the ingress of surface water into underground drainage systems.

3891.2 TYPES

Types of storm drain inlet protection to be provided shall be as follows:

Inlet protection to be utilized in median areas, field inlets and other areas where vegetation will ultimately be established.

Inlet protection to be utilized in and adjacent to streets, parking lots and other areas that will ultimately be paved.

3891.3 APPROVED MATERIALS

In addition to the Approved Products List, approved materials that can be furnished for use are as follows:

A  Rock Log

Rock logs shall meet the requirements of 3897.2 Type 7.

B  Compost Log

Compost logs shall meet the requirements of 3897.2 Type 5.

C  Sediment Control Inlet Hat

Sediment control inlet hats shall be a polyethylene hat-like structure covering the inlet with small weep holes on the side providing a filtering function of the storm water runoff and a large opening above the weep holes for emergency overflow.
D  Silt Fence Ring and Rock Filter Berm or Rock Log Combination

Silt fence shall meet the requirements of 3886 Type Heavy Duty. Silt fence shall be placed in a circular configuration around the inlet to form a minimum 1.5 m (5 foot) diameter zone of protection. Rock logs (3897.2 Type 7) shall line the outside toe of the silt fence. Rock Filter berms shall consist of 3882 Type 9 Mulch, at the Silt Fence toe, as indicated on the Plans.

E  Pop-up Head

Pop-up head inlet protection shall form a solid steel plate over the inlet casting or solid steel box that fits inside a grate assembly with the exception of a center cylindrical drain tube riser. The tube riser shall be fully extended when providing drainage functions and have holes that provide filtering capabilities. The tube riser shall be covered with a removable knit type geotextile that provides additional sediment filtering capabilities. The tube riser shall be able to be pushed down flat to the steel plate to allow construction vehicles to drive over it, facilitate cleanout, or to shut off drainage to the inlet.

F  Filter Bag Insert

Filter bag insets shall consist of a replaceable reinforced filter bag suspended from a retainer ring, or frame that fits within a grate or it shall consist of a geosynthetic filter bag suspended from a rebar or steel rods. The filter bag that is suspended from a frame shall be constructed of a polypropylene filter geotextile fabric with a minimum weight of 222 g/m² (4 ounce/square yard), a minimum flow rate of 5908 L/minute/m² (145 gallon/minute/square feet), a minimum permittivity of 2 per second, and designed for a minimum silt and debris capacity of 0.57 m² (2 cubic feet). The filter bag shall be reinforced with an outer polyester mesh fabric. The filter bag shall be suspended from a galvanized steel ring or frame utilizing a stainless steel band and locking clamp. The frame shall be designed with an overflow feature. Overflow capacity shall be at a minimum equal to the design flow capacity of the structure's grate opening.

When the filter bag insert is the type suspended from the grate the geosynthetic fabric shall meet 3886 for Machine Sliced and a minimum silt and debris capacity of 0.57 m² (2 cubic feet). All edges, seams shall be minimum double stitched. The Filter bag insert shall have an oval, edge heat sealed overflow 10 by 15 mm (4 by 6 inches) holes cut into all four panel sides.

G  BLANK

H  BLANK

I  BLANK
3891.3

K  Other

Devices approved by the Department's Erosion Control Engineering Unit and on file on the web under the Materials Engineering Section's Approved Products List can be furnished as meeting this specification requirement.

3891.4 REQUIREMENTS

Dimension requirements will be as indicated in the Plans.

3891.5 SAMPLING AND TESTING

Sampling and testing samples shall be furnished in the size and number directed by the Engineer.

3892

Temporary Down Drain

3892.1 SCOPE

This Specification covers material used as a temporary Down drain to convey drainage down a slope while turf is establishing.

3892.2 REQUIREMENTS

In the absence of plan specifications, Temporary Down drain shall consist of a 250 mm (10 inch) minimum diameter corrugated polyethylene tubing (PE). The corrugated polyethylene tubing shall be nonperforated and shall comply with AASHTO M 252. The Down drain shall be anchored with stakes. The stakes shall be nominal 50 x 50 mm (2 x 2 inch) cross-section, at least 1 m (3 feet) long, and with a pointed end. Maximum spacing between the stake installations shall be 2.5 m (8 feet).

3892.3 SAMPLING AND TESTING

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

3893

Sandbags

3893.1 SCOPE

This Specification covers material used for sandbags to dike off construction areas or to serve as temporary erosion control installations.

3893.2 REQUIREMENTS

Sandbags shall consist of a woven polypropylene fabric sewn together with double stitching. The polypropylene fabric shall meet or exceed the following:

- Grab Tensile Strength
  - ASTM D 4632 420 N, min.
- UV Stability
  - ASTM D 4355 70% min.
Overall size of the sandbag shall be at least 350 x 650 mm (14 x 26 inch).

3893.3 SAMPLING AND TESTING

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

Sediment Mat

3894.1 SCOPE

This Specification covers a sediment absorbing biodegradable mat temporarily placed in a stream bed to intercept and retain sediment caused by in-stream construction activities.

3894.2 REQUIREMENTS

The sediment mat shall consist of a flat pad that can be laid out singly or grouped together. The pad shall be composed of a bottom layer of burlap, a center core of wood excelsior fiber blanket and an upper layer of jute netting. The burlap shall be a construction grade 280 g (10 ounce) mass fabric. The wood excelsior fiber center core shall be approximately 25 mm (1 inch) thick and shall have a mass of at least 0.50 kg (1 pound) per m² (square yard). The jute netting shall be a construction grade having a mass of at least 0.50 kg (1 pound) per m² (square yard) with approximately 25 mm (1 inch) openings. The pad shall be stitched together along the edges and through the center to prevent movement of the layers in relation to each other. Overall size of each pad shall be approximately 1.2 x 3.0 m (4 x 10 feet) with an overall mass of approximately 11 kg (24 pounds).

3894.3 SAMPLING AND TESTING

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

Fiber Log

3895.1 SCOPE

This Specification covers fiber logs used to stabilize shorelines and to facilitate the establishment of vegetation.

3895.2 REQUIREMENTS

The fiber log shall consist of natural coconut fibers (coir) that have been compressed and stuffed into a netting. Dimensions of the log shall be approximately 300 mm (12 inches) in diameter. Mass of the log shall be no less than 11 kg/m (7.4 pounds per foot). The outer netting shall consist of coir yarn. Service life shall be a minimum of 5 years.
3895.3

3895.3 SAMPLING AND TESTING

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

3896

Soil and Root Additives

3896.1 SCOPE

This specification covers additives for improving soil or root stock to ease transplanting, stimulate growth and improve the health of plant stock or seed.

3896.2 REQUIREMENTS

Additives shall conform to the requirements for one or more of the following, as specified in the Contract:

A  Plant Hormones

Rooting hormone powder or liquid, used to stimulate rooting of plant cuttings, bare root stock and perennial plant material, shall contain known root hormones including any of the following: indole-3-butyric acid (IBA) indole acetic acid (IAA) or cytokinins. The inert ingredients shall not be harmful to the environment. Pre-mixed liquid forms must be handled and mixed according to the manufacturer's recommendations. This material may be tank mixed or pre-blended with hydrophilic polymers and endomycorrhizal inoculum.

B  Hydrophilic Polymers

Super-absorbent polymer or hydrophilic compound, used to modify physical characteristics of soils to manage soil air and water, shall be an organic and fully biodegradable cross-linked polymer or other hydroscopic compound with water-binding groups and shall consist of potassium polyacrylate/polyacrylamide copolymer, sugar alcohols, polysaccharides, humates, alpha-hydroxypropionic acid or other documented hydrophilic compound. The product shall have a minimum life span of 60 days in the soil. Application rate shall be in accordance to manufacturer's recommendations for new plantings. This material may be mixed or pre-blended with rooting hormones and mycorrhizal treatments.

C  Mycorrhizal Inoculum

C1  Endomycorrhizal Inoculum

Endomycorrhizal inoculum, microorganisms symbiotic with, and beneficial to plant roots, shall contain several species of Glomus that can be applied to the soil or base of a plant as a liquid, powder, or pellet. Minnesota origin of inocula is preferred. Additional endomycorrhizal species of Gigaspora, Scutellospora, Entrophospora, Acaulospora, or Sclerocystis may also be present. The Inoculum will not be rejected if ectomycorrhizal species of Pisolithus or Rhizopogon
are present. The inoculum shall have a defined live spore count and shall be applied according to the manufacturer's recommendations for new plantings. Antagonistic pathogens shall not be present above trace levels. This material may be mixed or pre-blended with hydrophilic polymers and rooting hormones.

C2  Ectomycorrhizal Inoculum

Ectomycorrhizal inoculum, microorganisms symbiotic with, and beneficial to plant roots, shall contain *Rhizopogon* and or other cold tolerant species that can be applied to the soil or base of a plant as a liquid, powder, or pellet. Minnesota origin of inocula is preferred. The inoculum shall have a defined live spore count and shall be applied according to the manufacturer's recommendations for new plantings. Antagonistic pathogens shall not be present above trace levels. This material may be mixed or pre-blended with hydrophilic polymers and rooting hormones.

3896.3 SAMPLING AND TESTING

Product data sheet, research tests and Material Safety Data Sheet shall be submitted to the Engineer for approval prior to delivery and use on the project.

3897  Filter Logs

3897.1 SCOPE

This specification covers filter logs used for slowing and filtering storm water runoff, and other water encountered on the Project.

3897.2 REQUIREMENTS

Filter logs shall conform to the requirements of the following types, as specified in the Contract.

**Type Straw Bioroll**

Straw Bioroll shall consist of grain straw free of seed bearing stalks of noxious grasses or weeds as defined by the rules and regulations of the Minnesota Department of Agriculture. Straw shall be encased in polypropylene netting that will photo degrade within 6 to 9 months. The netting shall have approximate openings of 13 mm x 13 mm (½ inch x ½ inch). The encased straw shall form a cylindrical log that is a minimum of 3 m (10 feet) long and 150-175 mm (6 – 7 inches) in diameter. Straw shall be packed into the net casing at a density between 32 to 64 kg/m³ (2 to 4 pounds/cubic feet).
Type Wood Fiber Bioroll

Wood Fiber Bioroll shall consist of excelsior fibers. Excelsior fibers shall be encased in a polypropylene netting that will photo degrade within 6 to 9 months. The netting shall have approximate openings of 13 mm x 13 mm (½ inch x ½ inch). The encased excelsior fibers shall form a cylindrical log that is a minimum of 3 m (10 feet) long and 150-175 mm (6 – 7 inches) in diameter. A minimum of 80 percent of the fiber material shall be 150 mm (6 inches) or longer. Excelsior fibers shall be packed into the net casing at a density between 22 to 58 kg/m³ (1.4 to 3.6 pound/cubic feet).

Type Compost Log

Compost Log shall consist of a blend of 30-40% weed free compost as per 3890 Grade 2 and 60-70% partially decomposed wood chips. The compost/wood blend material shall pass a 51 mm (2 inches) sieve with a minimum of 70% retained on the 10 mm (3/8 inch) sieve, in accordance with TMECC 02.02-B, "Sample Sieving for Aggregate Size Classification". The compost/wood chip blend shall be pneumatically shot into a geotextile cylindrical bag. The geotextile bag shall consist of a knitted material with openings of 10 mm (3/8 inches) and contain the compost/wood chip material while not limiting water infiltration. The encased compost shall form a cylindrical log that is a maximum of 55 m (180 feet) and approximately 200 mm (8 inches) in diameter.

Type Rock Log

All aggregate shall be washed before placed in a rock bag. Rock shall be supplied in accordance with 3137.2 Class D with a gradation in accordance with Table 3137-1 CA-1 through CA-5. The casing material for the rock shall be between 1.2 m (4 feet) and 3 m (10 feet) in length and between 100 mm (4 inches) and 150 mm (6 inches) in diameter when filled with rock. The casing material shall have a minimum grab tensile strength of 575 N (130 pounds) and a minimum Mullen Burst Strength of 1200 kPa (175 psi).

3897.3 SAMPLING AND TESTING

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

3898 Flocculants

3898.1 SCOPE

This specification covers naturally derived additives for coagulating dispersed clays, and reducing turbidity in storm water runoff prior to discharge to natural surface waters. The use of flocculants to settle out clay-sized particles allows for increased sediment trapping efficiency and is to be used as part of a designed storm water treatment system.
3898.2 REQUIREMENTS
Flocculants shall be environmentally benign, biodegradable, and consist of natural origin biopolymers to improve water quality and protect aquatic biota. The pH and temperature of the sediment laden storm water must be tested and be within the manufactures specified pH and temperature range. Adequate time for chemical reaction with clay-sized particles must be provided for in the field prior to discharge to a surface water, wetland, or identified water of concern.
Flocculants shall conform to the requirements as detailed by each type.
A Liquid
The flocculant shall be stored in a concentrated liquid state. A manufacture's label must be affixed to the container that lists the percent of concentration in the container and the application dose rate. All dose rate calculations must be verified by the Engineer prior to application to the treatment system.
B Flocculant Sock
The flocculant shall be in a gelatin-like state that is packaged in individual compartments of the encasing sock material. The encasing material shall allow water to flow through it such that the water to be treated comes in contact with the gelatin-like flocculant material.
The Flocculant Sock shall have attachment anchor cords or grommets as needed for use in pipes, sediment control filter systems, and ditch bottoms.
The Flocculant Sock shall at a minimum treat 945 m³ (250,000 gallons) of water flowing through it.
C Granular Floc
The flocculant shall be stored in a granulated state. A manufacture's label must be affixed to the bag or container that states the purity of the product and the application mixing rate. All dose rate calculations must be verified by the Engineer prior to application to the treatment system.
3898.3 SAMPLING AND TESTING
A certificate of compliance, and Material Safety Data Sheet shall be submitted to the Engineer for approval prior to delivery and use on the project.
Form Coating Material

3902.1 SCOPE
This Specification covers coating material that will prevent bonding between a form, dowel, or other object and concrete.

3902.2 REQUIREMENTS
The form coating material shall meet the following requirements and also be approved by the Concrete Engineer. The form coating material shall be a chemical release agent containing no ordinary lubrication oil, conventional form oil, fuel oil, or kerosene. The form coating material shall prevent bonding to concrete; shall not penetrate, stain, or leave a residual film on the concrete surface; and shall not attract dirt or other deleterious matter.

The form coating material shall be applied at a rate recommended by the manufacturer that will provide a smooth surface free of dusting action caused by reactions of the chemical release agent.

The flash point of the chemical release agent shall be not less than 65°C (149°F).

3902.3 SAMPLING AND TESTING
A Sampling
Samples for testing shall be of such size and numbers as required by the Schedule of Materials Control.

B Testing
Flash Point ............................................................. ASTM D 92

Water for Concrete and Mortar

3906.1 SCOPE
This Specification covers water for use in portland cement concrete and mortar.

3906.2 REQUIREMENTS
Water for use in mortar or concrete shall be subject to the approval of the Engineer. It shall not be salty or brackish and shall be reasonably clear and free from oil, acid, injurious alkali or vegetable matter.

When comparative tests are made with a water of known satisfactory quality, any indication of unsoundness, marked change in time of setting, or a reduction of more than 10 percent in mortar strength shall be sufficient cause for rejection of the water under test.

3906.3 SAMPLING AND TESTING
Samples for testing shall be as required by the Schedule of Materials Control. The quality of the water shall be determined in accordance with AASHTO T 26.
In sampling water for testing, care shall be taken that the containers are clean and that samples are representative.

3910
Rock Salt

3910.1 SCOPE
This Specification covers rock salt to be used as a deicer for road construction and maintenance purposes.

3910.2 REQUIREMENTS
The quality and grading of the salt shall conform to ASTM D 632 for Type 1, Grade 1 material. At the time of delivery to the Department, the salt shall not contain more than 1.5 percent moisture, and it shall be free flowing and free of lumps, aggregations and foreign matter.

3910.3 SAMPLING AND TESTING
A  Sampling
The Department reserves the right to sample and inspect the salt at the Contractor’s unloading and storage facilities or at the point of delivery to the Department.
B  Testing
The chemical analysis for determination of sodium chloride content shall be made in accordance with the Rapid Method of Test for Sodium Chloride, as published in the Annex to ASTM D 632.

3911
Calcium Chloride

3911.1 SCOPE
This Specification covers liquid and solid calcium chloride for use in dust control accelerating the hardening of concrete and other purposes.

3911.2 GENERAL REQUIREMENTS
Calcium chloride shall be in liquid or solid form, as specified in the Contract, and shall conform to AASHTO M 144 for the type and grade specified. Unless otherwise authorized, liquid calcium chloride shall contain a minimum of 38 percent, by mass (weight), anhydrous CaCl₂. The solution shall be clear and free of solid matter.
3911.3  

3911.3  SAMPLING AND TESTING  

A  Sampling  
Sampling shall be according to ASTM D 345. Calcium chloride shall be sampled at the rate of one 1 kg (2 pounds) sample of solid material and 0.5 L (1 pint) of liquid material for each shipment or lot. Sample containers shall be well sealed plastic jars.  

B  Testing  
Calcium chloride, CaCl\textsubscript{2} ................... Atomic Absorption Method (A)  
Alkali chlorides .........................................ASTM E 449

(A) Test Method on file in the Chemical Laboratory of the Office of Materials

3912  
Magnesium Chloride Solution  

3912.1  SCOPE  
This Specification covers magnesium chloride solution used for dust control.  

3912.2  REQUIREMENTS  
The magnesium chloride solution shall be water clear, thoroughly mixed, free from any solid matter or deleterious substances. The solution solids shall consist primarily of magnesium chloride.  

Chemical Composition  
Magnesium chloride, anhydrous, percent minimum .............. 28.0  
Sulfate, as SO\textsubscript{4}, percent maximum ............................................ 3.5  
Alkali chlorides, as NaCl, percent maximum .......................... 5.0  

3912.3  SAMPLING AND TESTING  

A  Sampling  
Magnesium chloride shall be sampled at the rate of 0.5 L (1 pint) sample per load. Sampling procedure shall be according to ASTM D 345. Sampling containers shall be well sealed plastic jars.  

B  Testing  
Magnesium chloride, MgCl\textsubscript{2} ....................ASTM E 449 Modified (A)  
Sulfate SO\textsubscript{4} .................................................Gravimetric precipitation with BaCl\textsubscript{2}  
Alkali chlorides .........................ASTM E 449 (or flame emission)

(A) Test Method on file in the Chemical Laboratory of the Office of Materials.
Concrete Treating Oil

3917.1 SCOPE
This Specification covers two types of mixtures to be applied as a protective coating on concrete. Unless otherwise specified, the type used shall be optional with the Contractor.

3917.2 REQUIREMENTS
A Type I
Type I concrete treating oil shall consist of a mixture of equal parts, by volume, of:
(a) Mineral spirits conforming to ASTM D 235.
(b) Neutral petroleum oil (plain) having a viscosity of 75-100 SUS at 38ºC (100ºF).
B Type II
Type II concrete treating oil shall consist of a mixture of boiled linseed oil and petroleum spirits conforming to AASHTO M 233.

3917.3 SAMPLING AND TESTING
A Sampling and testing boiled linseed oil.......ASTM D 260
B Tests for mineral spirits ...............................ASTM D 235
C Sampling petroleum products....................ASTM D 4057
D Viscosity.........................................................ASTM D 445
3973

Buried Cable Signs

3973.1 SCOPE

This Specification covers the buried cable signs used to mark the route of underground fiberoptic cables.

3973.2 REQUIREMENTS

Install the ground mounted signs to 3.8 kg/m (2.6 pounds per foot) galvanized steel fence posts that comply with 3401. Use stainless steel bands and fittings when installing the signal mounted signs to the RCS.

The aluminum signs shall comply with 3352, 2564, the Contract detail and with the Mn/DOT Standard Signs Manual. The sign is 150 mm wide x 300 mm high (6 x 12 inches), with black legend on a non-reflective yellow face and complies with Department standards. The Engineer must approve the sign design before they are procured by the contractor.

A  Buried Cable Sign

The sign is aluminum, 200 mm wide x 300 mm high (8 x 12 inches), with black legend silk screened on a yellow face, complying with the Mn/DOT Standard Signs Manuals.

The sign legend is:

CAUTION  (line 1)
BURIED FIBER  (line 2)
OPTIC CABLE  (line 3)
BEFORE DIGGING CALL  (line 4)
GOPHER STATE ONE CALL  (line 5)
612.454.0002  (line 6)
Mn/DOT LOGO  (line 7)

B  Legend Size

The legend size is: The first line has 40 mm (1.575 inch) yellow characters centered on a black 50 mm x 180 mm (2 x 7 inch) background. The second has 30 mm (1.18 inch) black characters, third and fourth 20 mm (¾ inch), fifth 15 mm (0.59 inch), and the sixth 25 mm (1.0 inch).

The logo is a 40 mm (1.575 inch) diameter circle with a white background. The blue letters "MINNESOTA DEPARTMENT OF TRANSPORTATION" are in margin of the circle. The left half of the logo inside the margin has a silhouette of the left one half of a coniferous tree on a green foreground. The right half of the logo inside the margin has a five point star silhouette inside a blue foreground.
3973.2

C Sign Placement

Place the signs less than 220 m (722 feet) apart, and at each change of direction, along the route of direct buried fiberoptic cable.

3973.3 TESTING ........................................................................................................ 2550

END