SECTION 727 - PAVEMENT MARKING MATERIALS

727-01 WHITE AND YELLOW THERMOPLASTIC REFLECTORIZED PAVEMENT MARKINGS

SCOPE. This specification covers the white and yellow thermoplastic reflectorized pavement striping material that is extruded, in a molten state, onto the pavement. Following a surface application of glass beads and upon cooling to normal pavement temperatures, the resultant marking is an adherent reflectorized stripe, of specified thickness and width, that is capable of resisting deformation by traffic.

GENERAL. Methods and requirements for applying thermoplastic markings shall be as specified in section 687, Thermoplastic Reflectorized Pavement Markings.

MATERIAL REQUIREMENTS

Thermoplastic Composition. The thermoplastic composition shall be specifically formulated for application at temperatures greater than 205°C. The components in the composition shall show no significant break-down, or deterioration at 246°C.

The binder component shall be formulated as a hydrocarbon resin; or it shall be formulated as a mixture of high boiling point monohydric primary alcohol and modified maleic resin; or the manufacturer may submit an optional binder formulation to the Materials Bureau for evaluation and approval. The pigment, beads and filler shall be uniformly dispersed in the binder resin.

The thermoplastic composition shall be free from all skins, dirt and foreign objects and shall comply with the following requirements:

<table>
<thead>
<tr>
<th>Component</th>
<th>% by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Yellow</td>
</tr>
<tr>
<td>Binder</td>
<td>17.0 min</td>
</tr>
<tr>
<td>Titanium Dioxide</td>
<td>10.0 min</td>
</tr>
<tr>
<td>Glass Beads</td>
<td>30-40</td>
</tr>
<tr>
<td>Calcium Carbonate &amp; Inert Fillers</td>
<td>43.0 max</td>
</tr>
<tr>
<td>Yellow Pigments</td>
<td>---</td>
</tr>
</tbody>
</table>

* Amount and type of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing the other composition requirements of this specification are met.

Physical Properties of Composition.

A. Color. White thermoplastic composition, as placed, shall be white, free from dirt or tint. The color of the white composition shall be defined by the color chip in the possession of the Materials Bureau.

Yellow thermoplastic composition, as placed, shall be yellow, free from dirt or tint and shall be a reasonable visual match to Munsell Book Notation 10YR8/14 (ASTM D1535).

B. Drying Time. When installed at 21°C, and in thickness between 3 mm and 5 mm, the composition shall be completely solid and shall show no damaging effect from traffic after ten (10) minutes.

C. Yellowness Index. White thermoplastic composition shall not exceed a yellowness index of 0.12 when tested in accordance with AASHTO Designation T-250.

D. Softening Point. The composition shall have a softening point of not less than 90°C when tested in accordance with ASTM E28.

E. Specific Gravity. The specific gravity of the composition as determined by a water displacement method of 25°C shall be between 1.8 and 2.2 (referred to water at 25°C).

Reflective Glass Spheres (Pre-mix and Drop-On). Reflective glass spheres for use in the composition and for drop-on shall conform to the following requirements:

The glass spheres shall be colorless; clean; transparent; free from milkiness or excessive air bubbles; and
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essentially clean from surface scoring or scratching. They shall be spherical in shape and at least 70% of the glass beads shall be true spheres when tested in accordance with ASTM D1155.

The refractive index of the spheres shall be a minimum of 1.50 as determined by the liquid immersion method at 25°C.

The silica content of the glass spheres shall not be less than 60%.

The crushing resistance of the spheres shall be as follows: A 18 kg dead weight, for 850 μm to 600 μm mesh spheres, shall be the average resistance when tested in accordance with ASTM D1213.

The glass spheres shall have the following grading when tested in accordance with ASTM D1214 (Note: Requests for optional gradations may be submitted to the Materials Bureau for evaluation and approval):

<table>
<thead>
<tr>
<th>Standard Sieve</th>
<th>Mass % Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>850 μm</td>
<td>100</td>
</tr>
<tr>
<td>600 μm</td>
<td>79-95</td>
</tr>
<tr>
<td>300 μm</td>
<td>15-60</td>
</tr>
<tr>
<td>180 μm</td>
<td>0-15</td>
</tr>
</tbody>
</table>

Glass spheres for drop-ons shall be treated with a moisture-proof coating.

Thermoplastic Primer. The thermoplastic primer shall be specifically designed to enhance the bond of thermoplastic pavement markings to asphalt cement and/or portland cement concrete pavements.

The primer shall be either a one-component or two-component, cold or hot applied material of the type recommended by the thermoplastic pavement marking manufacturer.

Thermoplastic primers shall conform to current Federal, State and Local air pollution regulations, including those for the control (emission) of volatile organic compounds (VOC) as established by the U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation.

PACKAGING AND SHIPPING. The thermoplastic composition shall be shipped to the job site in containers that are strong, substantial and capable of being sealed in a manner approved by the Department. The containers shall be plainly marked with the manufacturer's name and address, New York State specification designation, date of manufacture and batch number.

The reflective glass spheres for drop-on application shall be shipped in moisture resistant bags. Each bag shall be marked with the name and address of the manufacturer and the name and net weight of the material.

Thermoplastic primers shall be shipped in pails, drums, or other strong substantial containers. Each container shall be plainly marked with the name of the product, the name and address of the manufacturer, the date of manufacture, the quantity of material, and the date of expiration or shelf life. In addition, two-component primer containers shall be identified as "Part A" and "Part B". Primers shall be shipped to the job site accompanied with written instructions for use.

BASIS OF ACCEPTANCE. Thermoplastic material shall be accepted on the basis of sampling and inspection at the place of manufacture or in warehouse lots as determined by the Department. Samples submitted to the Materials Bureau shall be taken as directed by the Department. In addition, all samples shall be accompanied with the manufacturer's certified identification of the binder formulation (e.g. "formulated as a hydrocarbon resin"). Any unauthorized tampering or breaking of the seals on the containers between the time of sampling and delivery to the job site shall be cause for rejection of the material.

Reflective glass spheres may be accepted at the job site on the basis of the manufacturer's certification, or samples may be submitted to the Materials Bureau for testing.

Thermoplastic primers shall be accepted at the job site on the basis of the manufacturer's certification that they conform to the requirements of this specification.
727-02 WHITE AND YELLOW REMOVABLE REFLECTORIZED PAVEMENT MARKINGS

SCOPE. This specification covers white and yellow removable reflectorized pavement marking material.

GENERAL. Methods and requirements for applying removable reflectorized pavement markings shall be as specified in Section 619 Maintenance and Protection of Traffic.

MATERIAL REQUIREMENTS

General Requirements. Removable pavement markings shall consist of white and yellow preformed reflectorized tape or white and yellow, raised type, reflectorized markers.

Removable preformed reflectorized marking tape shall be composed of a pigmented plastic or polymeric film, on a reinforced conformable backing. A retroreflective layer of glass spheres shall be bonded to, or embedded in the top surface. The preformed marking shall be pre-coated on its bottom side with a pressure sensitive adhesive and shall be capable of adhering to bituminous or portland cement concrete surfaces without the use of heat, solvents or other means.

Removable raised type reflective markers shall be designed as single units, and consist of an acrylic plastic or another type of durable casing, containing one or two reflective faces. The marker casing shall be approximately square in shape and designed to provide maximum daytime delineation. The removable marker shall be adhered to bituminous or portland cement concrete surfaces using the adhesives and/or methods recommended by the manufacturer.

Physical Properties

A. Color. White removable markings, as placed, shall be white, free from dirt or tint. Yellow removable markings, as placed, shall be yellow, free from dirt or tint, and conform to Highway Color Tolerance Chart, PR#1 (U.S. Department of Transportation, Federal Highway Administration, December, 1972).

B. Size. Removable preformed marking tape shall be of the specified size and shape and conform to the applicable requirements of the M.U.T.C.D.

Removable raised type markers shall be fabricated to the following requirements:

1. Casing dimensions. The minimum casing dimensions shall be 100 mm x 100 mm x 19 mm.

2. Area of each reflective lens. The minimum area of the reflective lens shall be 245 mm².

C. Reflectance

1. White and Yellow Preformed Tape. Glass spheres for retro-reflectivity shall have a refractive index of not less than 1.50, as determined by the liquid immersion method at 25°C. The spheres shall be firmly bonded, or embedded in the surface of the marking tape.

   The quantity of glass spheres shall be such that white and yellow preformed markings have the following initial average reflectance values at 0.2° and 0.5° observation angles and 86.0° entrance angle as measured in accordance with the testing procedures of Federal Test Method Standard 370. The photometric quantity to be measured shall be specific luminance (SL) and it shall be expressed as millicandelas per square meter per lux.

<table>
<thead>
<tr>
<th>TABLE 727-02-1 PREFORMED TAPE REFLECTANCE REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Observation Angle</td>
</tr>
<tr>
<td>Specific Luminance, ((med·m²)1x⁻¹)</td>
</tr>
</tbody>
</table>
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2. White and Yellow Reflective Marker Lenses. White and yellow reflective lenses shall have the following initial average reflectance values, when measured with incident light parallel to the base of the marker, at an observation angle of 0.2° and entrance angles of 0° and 20°. The photometric quantity to be measured shall be specific intensity (SI) and it shall be expressed as millucandela per lux.

<table>
<thead>
<tr>
<th>TABLE 727-02-2 REFLECTIVE MARKER LENSES REFLECTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Entrance Angle</td>
</tr>
<tr>
<td>Specific Intensity (mcd/lx)</td>
</tr>
</tbody>
</table>

NOTES:
1. Observation Angle. Shall mean the angle at the reflector between the observer's line of sight and the direction of light incident on the reflector.
2. Entrance Angle. Shall mean the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of reflective marker.
3. Specific Intensity. Shall mean the luminous intensity (candelas) of returned light at the chosen observation and entrance angles for each lux of illumination at the reflector on a plane perpendicular to the incident light.
4. Photometric Test Procedure. The reflective marker to be tested shall be located with the center of the reflective lens at a distance of 1.5 m from a uniformly bright light source, having an effective diameter of 5.1 mm. The return of light shall be measured using an annular ring photocell (9.4 mm I.D. x 11.9 mm O.D.). The photocell shall be shielded to eliminate stray light. The distance from the light source center to the photocell center shall be 3.3 mm. If a test distance of other than 1.5 m is used, the source and receiver shall be modified in the same proportion as the test distance.

D. Removability. Preformed marking tapes and raised type markers shall be removable from bituminous and portland cement concrete pavements, intact or in substantially large pieces, either manually or by the use of a mechanical roll-up device, and without the use of heat, solvents, grinding or blasting. After removal, no permanent marks, scars or damage to the pavement surface shall result.

BASIS OF ACCEPTANCE. Removable marking materials shall be approved by the Materials Bureau. Detailed requirements and procedures for approval are available from the Materials Bureau. Approval of removable markings will be based on engineering analysis for conformance with this specification and controlled field testing prior to their use on a Department project. If the proposed marking meets the specification requirements and performs satisfactorily in the controlled field tests, the product will be placed on the Department's “Approved List” of materials.

In no case shall the appearance of a marking material on the Department's approved list release the Contractor from compliance with the requirements under “Construction Details” of this specification. Neither shall its approval be considered a warranty by the State of satisfactory performance.

Project acceptance will be based on the appearance of the marking material on the Department's “Approved List” of removable reflectorized pavement markings.

727-03 WHITE AND YELLOW EPOXY REFLECTORIZED PAVEMENT MARKINGS

SCOPE. This specification covers white and yellow epoxy reflectorized pavement striping material that is sprayed onto the pavement. Following a surface application of glass beads and upon drying, the resultant marking is a reflectorized stripe of specified thickness and width, that is capable of resisting deformation by traffic.

GENERAL. Methods and requirements for applying epoxy markings shall be as specified in Section 685, Epoxy Reflectorized Pavement Markings.
MATERIAL REQUIREMENTS

Epoxy Material Composition. The epoxy resin composition shall be specifically formulated for use as a pavement marking material and for hot-spray application at elevated temperatures. The type and amounts of epoxy resins and curing agents shall be at the option of the manufacturer, providing the other composition and physical requirements of this specification are met.

The epoxy marking material shall be two-component (Part A and Part B), 100% solids type system formulated and designed to provide a simple volumetric mixing ratio (e.g. two volumes of Part A to one volume of Part B).

The epoxy marking material shall be supplied as either a regular-dry or a slow-dry material. Regular-dry may be used for all marking patterns. Slow-dry material is intended for marking hatchlines, edgelines, and other marking patterns located out of the general path of traffic.

A. Part A. Part A of either white or yellow shall conform to the following requirements:

<table>
<thead>
<tr>
<th>MARKING COLOR</th>
<th>MATERIAL (ASTM REF., TYPE)</th>
<th>PERCENT WEIGHT OF PART A</th>
<th>Pigment</th>
<th>Epoxy Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Titanium Dioxide (D476, II)</td>
<td>18 Minimum</td>
<td>75 to 82</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>Medium Chrome Yellow (D211, Type III)</td>
<td>23 Minimum</td>
<td>70 to 77</td>
<td></td>
</tr>
</tbody>
</table>

ASTM D2371 shall be used to determine the pigment content of Part A, except toluene shall be substituted for benzene in the extraction mixture. No extender pigments are permitted. The white pigment, upon analysis, shall contain a minimum of 16.5% TiO₂ (100% purity). The yellow pigment, upon analysis, shall contain a minimum of 20% PbCrO₄ (100% purity).

The epoxy content of the epoxy resin in Part A will be tested in accordance with ASTM D1652 and calculated as the weight per epoxy equivalent (WPE) for both white and yellow. The epoxy content will be determined on a pigment free basis. The epoxy content (WPE) shall meet a target value provided by the manufacturer and approved by the Director, Materials Bureau. A ±50 tolerance will be applied to the target value to establish the acceptance range.

B. Part B. The amine value of Part B shall be tested in accordance with ASTM D2074 to determine its total amine value. The manufacturer may specify an alternate test method for determining the amine value subject to the approval of the Director, Materials Bureau. The total amine shall meet a target value provided by the manufacturer and approved by the Director, Materials Bureau. A ±50 tolerance will be applied to the target value to establish the acceptance range.

Physical Properties of Mixed Components (Part A and Part B). Unless otherwise noted, all samples are to be prepared tested at an ambient temperature of 23 ± 2°C.

A. Color. The white epoxy composition shall be an approximate visual color match to Munsell Book Notation N 9.5/0 (ASTM D1535) when viewed under North Standard Daylight.

The yellow epoxy composition shall be within the following chromaticity coordinate limits.

<table>
<thead>
<tr>
<th>TABLE 727-03-1 CHROMATICITY COORDINATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>x</td>
</tr>
<tr>
<td>y</td>
</tr>
</tbody>
</table>

Chromaticity coordinate testing shall be performed in accordance with ASTM E1347 using a color spectrophotometer with a 45° circumferential illumination/0° viewing geometry, illuminant C, and 2° standard observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm.
with a wavelength interval and spectral bandpass of 10 nm. The sample port aperture shall be 32 mm.

Yellow epoxy samples that are within the chromaticity coordinate limits but which visually are determined to significantly deviate from the color of normal quality assurance samples shall be compared to a visual color standard. Yellow epoxy samples shall be an approximate visual color match to Munsell Book Notation 10YR 8/14 (ASTM D1535) when viewed under North Standard Daylight.

Test specimens shall be prepared by applying the epoxy at a 0.38 mm ± 0.02 mm wet film thickness (without glass spheres) to a test panel consisting of a smooth rigid material, a smooth paper chart, smooth cardboard, or other suitable material and allowing the specimens to dry for a minimum 24 hours prior to testing.

**B. Directional Reflectance.** The directional reflectance (represented by CIE tristimulus value Y) of the white and the yellow epoxy composition shall be a minimum 84% and 54%, respectively, relative to a white standard.

Testing shall be performed in accordance with ASTM E1347 using a color spectrophotometer with a 45° circumferential illumination/0° viewing geometry, illuminant C, and 2° standard observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength interval and spectral bandpass of 10 nm. The sample port aperture shall be 32 mm.

The test specimens shall be prepared by applying the epoxy composition (without glass spheres) to black and white contrast panels (Leneta Form 5C or equivalent) to produce a wet film thickness of 0.38 mm ± 0.02 mm. The test specimens shall be allowed to dry for a minimum of 24 hours prior to testing.

**C. Drying Time (Laboratory).** When tested in accordance with ASTM D711 as modified below, regular-dry epoxy marking material shall reach a no-pick-up time in 30 minutes or less. Under these same test conditions, slow-dry epoxy marking material shall reach a no-pick-up time in 60 minutes or less. A Bird Applicator or other suitable instrument shall be used to spread a nominal 0.38 ± 0.02 mm thick wet film. Reflective glass spheres shall be immediately dropped onto the epoxy film at a rate of 3 kg/L.

**D. Drying Time (Field).** When installed at 25°C at the specified wet film thickness and reflectorized with glass spheres, regular-dry and slow-dry epoxy markings shall reach a no-track condition in approximately 30 minutes, and 60 minutes, respectively.

Dry to "no-tracking" shall be considered as the condition where no visual deposition of the epoxy marking to the pavement surface is observed when viewed from a distance of 15 m, after a passenger car is passed over the line.

**E. Hardness.** The epoxy composition when tested in accordance with ASTM D2240 shall have a Shore D hardness of between 75 and 100. Samples shall be allowed to cure for not less than 72 hours nor more than 96 hours prior to testing.

**F. Infrared Spectrophotometer Analysis (ASTM D2621).** Samples of Part A and Part B shall be analyzed by infrared spectrography. The spectrum of each component shall be a reasonable match to the spectrum of the original formulation accepted by the Materials Bureau for the Department of Transportation Approved List of Materials.

**Reflective Glass Spheres.** Reflective glass spheres for drop-on application shall conform to the following requirements:

The glass spheres shall be colorless, clean, transparent, free from milkiness or excessive air bubbles, and essentially clean from surface scarring or scratching. They shall be spherical in shape and at least 70% of the glass beads shall be true spheres when tested in accordance with ASTM D1155, Procedure A.

The refractive index of the spheres shall be a minimum of 1.50 as determined by the liquid immersion method at 25°C.

The silica content of the glass spheres shall not be less than 60%.

The glass spheres shall have the following gradation when tested in accordance with ASTM D1214.
The reflective glass spheres shall be treated with either a moisture-resistant coating or with a dual purpose type coating (moisture-resistant and adherence). The treated glass spheres shall flow freely from the dispensing equipment at any time when surface and atmospheric conditions are satisfactory for marking operations.

PACKAGING, SHIPMENT AND MARKING

**Epoxy.** Epoxy pavement marking materials shall be shipped to the job site in strong, substantial containers. Individual containers shall be plainly marked with the following information:

- Name of Product
- Item Number
- Lot Number
- Batch Number
- Test Number
- Date of Manufacture
- Date of Expiration of Acceptance (6 months from date of manufacture)
- The Statement (as appropriate): “Part A - Contains Pigment and Epoxy Resin,” or “Part B- Contains Catalyst”
- Quantity
- Mixing Proportions, Application Temperature and Instructions
- Safety Information
- Manufacturer’s Name and Address

**Reflective Glass Spheres.** Reflective glass spheres shall be shipped in moisture resistant bags or boxes. Each bag or box shall be marked with the name and address of the manufacturer, the brand name or product code of the glass sphere, the lot/batch number, the date of manufacture (mm/yy), and net weight of the material.

**BASIS OF ACCEPTANCE.** Only epoxy pavement marking materials from manufacturers appearing on the Department's Approved List shall be considered for acceptance. Details for obtaining Approved List status are available from the Materials Bureau.

Epoxy pavement marking materials will be sampled and tested in accordance with the procedural directives of the Materials Bureau. Samples will be taken at the manufacturing location and considered for acceptance in stock lot quantities.

Department red and green metal security seals will be placed on containers of pavement marking materials that meet specifications. The colored metal security seals serve as the evidence of acceptance for epoxy material delivered to the job site.

All acceptances of uninstalled epoxy marking material shall expire six (6) months after the date of manufacture.

Reflective glass spheres may be accepted at the job site on the basis of the manufacturer's certification, or they may be submitted to the Materials Bureau for testing.
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727-04 WHITE AND YELLOW PREFORMED REFLECTORIZED PAVEMENT MARKINGS

SCOPE. This specification covers the white and yellow preformed pavement stripes that are applied to the pavement, resulting in a marking that is capable of resisting deformation by traffic.

GENERAL. Methods and requirements for applying preformed markings are specified in Section 688, Preformed Reflectorized Pavement Markings. White and yellow preformed markings shall be composed of a mixture of plastics or polymeric materials, resins, pigments, and reflective glass and/or ceramic spheres that are uniformly distributed throughout the thickness of the material. In addition, a reflective layer of glass and/or ceramic spheres shall be bonded to, or embedded in the top surface.

The preformed markings shall be pre-coated, on its bottom side, with a pressure sensitive adhesive for adherence to bituminous or portland cement concrete surfaces.

The finished preformed marking material shall be of the specified dimension and shape, of good appearance, and free of cracks or other defects. The edges shall be clean cut and well defined. The material shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting or shrinkage.

When properly applied, the preformed markings shall be capable of molding itself to the contours, breaks and faults of bituminous or portland cement concrete surfaces; and shall show no significant tearing, roll-back, lifting or other signs of poor adhesion.

PHYSICAL PROPERTIES

Color. White preformed pavement markings, as placed, shall be white, free from dirt or tint. The color of the white marking shall be defined by the color chip in the possession of the Materials Bureau.

Yellow preformed pavement markings, as placed, shall be yellow, free from dirt or tint and shall be a reasonable visual match to Munsell Book Notation 10YR 8/14 (ASTM D1535).

Thickness. Preformed pavement marking material shall be a uniform film having a minimum thickness of 1.5 mm, or it shall be a patterned type material having a minimum thickness of 0.5 mm at the thinnest portions and a minimum thickness of 1.5 mm at the thickest portions of the patterned cross-section. The patterned top surface shall have approximately 50% of the surface area raised, and its design shall provide immediate and continuing retroreflection.

Reflective Glass and Ceramic Spheres. Glass and ceramic spheres for use in the preformed marking composition and for surface application shall have a refractive index of not less than 1.50, as determined by the liquid immersion method at 25°C.

Friction Resistance. The surface of the preformed marking material, with reflective glass and/or ceramic beads, shall provide a minimum friction resistance value of 45 BPN when tested in accordance with ASTM E303.

Tensile Strength. Preformed pavement marking material shall have a minimum tensile strength of 275 kPa when tested in accordance with ASTM D638M. Test specimens shall be Type M11 prepared by die cutting with Die C as specified in ASTM D412, Test Method A. The testing machine shall operate at a speed of 5 mm per minute, and tests shall be conducted at an ambient temperature of 23 ± 2°C. For calculating the tensile strength of patterned type material, the thickness measurements shall be taken in the thinnest portions of the cross-sectional area.

Elongation. Preformed pavement marking material shall have a minimum elongation of 15% when tested in accordance with ASTM D638M, and under the conditions as specified for "e. Tensile Strength." The chain extensometer shall be a Tinius Olsen Model R-2-1.
Plastic Pull Test. A 25 mm x 150 mm test specimen shall support a dead weight of 1.8 kg for not less than 5 minutes. Tests shall be conducted at ambient temperature of 23 ± 2°C.

Primer. Primer or adhesive activators shall be of the type recommended by the manufacturer of the preformed marking material. All primers and adhesives shall conform to Federal, State, and Local regulations for the emission of volatile organic compounds (VOC).

PACKAGING AND SHIPMENT. Preformed reflectorized pavement marking and primer materials shall be shipped and packaged in accordance with commercially accepted standards. The following information shall be plainly marked on each container or on the shipping invoice: the name of the product, the name and address of the manufacturer, the quantity of material, the date of manufacture, and the date of expiration or the shelf life.

BASIS OF ACCEPTANCE. White and yellow preformed reflectorized pavement markings and primer materials shall be approved by the Materials Bureau. Detailed requirements and procedures for approval are available from the Materials Bureau.

Approval of preformed markings will be based on laboratory analysis and field testing prior to their use on a Department project. If the proposed marking passes the requirements for laboratory analysis and initial field tests and it is considered acceptable by the Director, Materials Bureau, the product will be placed on the Department’s “Approved List” of materials.

Project acceptance will be based on the appearance of the marking and primer material on the Department’s approved list of preformed reflectorized pavement markings.

727-05 GLASS BEADS FOR REFLECTORIZED PAVEMENT MARKING PAINTS

SCOPE. This specification covers reflectorizing glass beads for application to traffic zone paints for the production of a reflective surface.

GENERAL. Methods and requirements for the application of glass beads shall be as specified in 640, Reflectorized Pavement Marking Paints, of these specifications.

MATERIAL REQUIREMENTS. The beads shall be glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering. The beads shall be colorless, clean, transparent, free from milkiness or excessive air bubbles, and essentially free from surface scarring or scratching. They shall be spherical in shape and at least 70% of the glass beads shall be true spheres.

The silica content of the glass beads shall not be less than 60%.

The beads shall have a refractive index between 1.50 and 1.65 when tested by the liquid immersion method at 25°C.

The spheres shall meet the following gradation:

<table>
<thead>
<tr>
<th>Standard Sieve</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 850 μm; Retained 600 μm</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>Passing 600 μm; Retained 300 μm</td>
<td>30%</td>
<td>75%</td>
</tr>
<tr>
<td>Passing 300 μm; Retained 180 μm</td>
<td>9%</td>
<td>32%</td>
</tr>
<tr>
<td>Passing 180 μm</td>
<td>0%</td>
<td>10%</td>
</tr>
</tbody>
</table>

The beads shall show no tendency to absorb moisture in storage and shall remain free of clusters and hard lumps. They shall flow freely, and to the satisfaction of the Engineer, from the dispensing equipment at any time when surface and atmospheric conditions are satisfactory for painting.

The glass beads shall be packed in waterproof plastic lined burlap or plastic lined paper bags. Each bag shall be marked with the name and address of the manufacturer and the name and net weight of the material.

TESTING. The properties indicated above shall be determined in accordance with the following methods of test:
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A. Sphericity. Irregularly shaped particles (out-of-round) shall be tested in accordance with ASTM D1155.

B. Gradation. Tested in accordance with ASTM D1214.

C. Moisture Resistance. The spheres shall pass the following moisture resistance test:

Place one kilogram of spheres in a washed cotton bag, having a thread count of approximately 8 per square centimeter (warp and woof) and immerse the bag in a container of water for 30 seconds. Remove the bag and force excess water from the sample by squeezing the bag. Suspend and allow to drain for two hours at room temperature (23 ± 2°C). Then, mix the sample in the bag by shaking thoroughly. Transfer sample slowly to a clean, dry glass funnel having a stem 100 mm in length, with a 9.5 mm inside diameter stem entrance opening and a minimum exit opening of 6.4 mm. The entire sample shall flow freely through the funnel without stoppage. When first introduced into the funnel, if the spheres clog, it is permissible to lightly tap the funnel to initiate the flow.

BASIS OF ACCEPTANCE. Application for approval of Glass Beads for use in Reflectorized Pavement Marking Paints shall be submitted to the Materials Bureau by the manufacturer, accompanied by one 27 kg bag sample of the product.

Upon approval by the Materials Bureau, the name of the product will be placed on an “approved list” of Glass Beads for Use in Reflectorized Pavement Marking Paints. This product may then be accepted on the basis of the brand name labeled on the container.

SECTION 728 — COMPRESSIVE LOAD TRANSMITTING DEVICES

728-01 RUBBER IMPREGNATED WOVEN COTTON-POLYESTER FABRIC

SCOPE. This specification covers the material requirements, tests and basis of acceptance for rubber impregnated, woven, cotton-polyester fabric.

MATERIAL REQUIREMENTS. Rubber impregnated woven cotton-polyester fabric shall be composed of multiple layers of prestressed cotton-polyester duck with a minimum mass of 0.25 kg/m², impregnated and bound with high quality rubber compound, containing rot and mildew inhibitors and anti-oxidants. The duck warp count shall be 50±1 threads per 25 mm and the filling count shall be 40±2 threads per 25 mm. Each thread shall contain 2 yarns. The material shall contain 64 plies per 25 mm. The number of piles in the furnished material shall be such as to produce the specified thickness.

TEST. This material shall exhibit a maximum load deflection of 10% at 6.9 MPa when tested in accordance with MIL-C-882.

BASIS OF ACCEPTANCE. This material will be accepted on the basis of the manufacturer’s certification of compliance with these specification requirements.

728-02 RUBBER IMPREGNATED RANDOM FIBER PAD

SCOPE. This specification covers the material requirements, tests and basis of acceptance for rubber impregnated random fiber pads.

MATERIAL REQUIREMENTS. Rubber impregnated random fiber pad shall be composed of a high quality elastomer with a random distribution of non-asbestos fibers.

BASIS OF ACCEPTANCE. Rubber impregnated random fiber pad shall be accepted under an Approved List.
728-03 PLAIN RUBBER PAD

**SCOPE.** This specification covers the material requirements, tests and basis of acceptance for plain rubber pads.

**MATERIAL REQUIREMENTS.** Plain rubber vertical load transmitting devices shall contain only polychloroprene as the raw elastomer polymer. The physical properties of the cured material shall comply with ASTM D2000 Line Call Out M2BC514A14B34. The rubber pads shall be cast in a mold under pressure and heat, or may be furnished to Department projects if they have been carefully cut from a larger piece of fully molded material. Shape factors of each device, i.e., net load area divided by the area free to bulge, must exceed twelve (12).

**TEST.** One plain rubber pad sample per size shall be submitted by the Engineer to the Materials Bureau for destructive test.

**BASIS OF ACCEPTANCE.** The presence of the appropriate form, validated by the Materials Bureau, shall constitute evidence of acceptability at the job site for plain rubber pads.

728-04 SHEET LEAD

**SCOPE.** This specification covers the material requirements and basis of acceptance for sheet lead.

**MATERIAL REQUIREMENTS.** Sheet lead shall be lead plate of nominal 3 mm thickness, meeting the standard specification for Pig Lead, ASTM B29.

**BASIS OF ACCEPTANCE.** This material shall be accepted on the basis of a manufacturer's certification of compliance with this specification.

728-05 (VACANT)

728-06 SHEET GASKET (TREATED BOTH SIDES)

**SCOPE.** This specification covers the material requirements for sheet gasket, treated both sides with a parting agent to prevent adhesion to working surfaces. This material is used as a bond breaker and sliding surface in bridge construction.

**MATERIAL REQUIREMENTS.** The sheet gasket shall have a nominal 1.6 mm thickness and shall be treated on both sides with a parting agent. The material shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water absorption, maximum</td>
<td>C642</td>
<td>6.7%</td>
</tr>
<tr>
<td>Coefficient of static friction, maximum</td>
<td>D1894</td>
<td>0.36</td>
</tr>
<tr>
<td>Coefficient of kinetic friction, maximum</td>
<td>D1894</td>
<td>0.24</td>
</tr>
<tr>
<td>Tensile strength, MPa, min., in the weakest direction</td>
<td>F152, Type 2</td>
<td>8.3</td>
</tr>
</tbody>
</table>

**BASIS OF ACCEPTANCE.** Application for approval of sheet gasket (treated both sides) shall be submitted to the Director, Materials Bureau. Upon approval, the name and manufacturer of the product shall be placed on the Department's Approved List.

SECTION 729 (VACANT)
§730-01

SECTION 730 - SIGNS AND DELINEATORS

730-01 ALUMINUM SIGN PANELS

SCOPE. These specifications cover aluminum sign panels used as the prepared surface backing in the application of reflective sheeting for location markers, delineators and traffic signs.

MATERIAL REQUIREMENTS. The panel material shall be either Aluminum Alloy 6061-T6, 5154-H38, 5052-H38 or 3004-H38 and shall conform to the requirements of material specification §715-04, Wrought Aluminum.

FABRICATION

Preparation of Panel Surface for Reflective Sheeting. The surface preparation of panels for the application of Reflective Sheetig, §730-05, shall be performed by Method I or Method II, in strict accordance with the recommendations of the manufacturer of the reflective sheeting.

A. Method I

1. Cleaning (Vapor or Alkaline cleaning)

   a. Vapor Cleaning. By total immersion of the sheeting or sign panel in a saturated vapor of trichlorethylene or perchlorethylene. Trademark printing shall be removed with lacquer thinner. Follow with a thorough rinse.

   b. Alkaline Cleaning. Sheeting shall be immersed in a tank containing alkaline solutions, controlled and titrated to the solution manufacturer's specifications. Immersion time shall depend upon the amount of soil present and the gage of the metal. Follow with a thorough rinse.

   NOTE: After cleaning and rinsing and prior to etching, the aluminum sheeting shall be checked with a "Water Break Test" as follows: If the metal is clean, water will completely cover the surface with no breaks. Whenever water breaks, oil is present and the plate shall be re-cleaned until all traces of oil disappear. The surface near the edges shall be examined with extreme care for presence of oil.

2. Etching (Use Acid or Alkaline Etch)

   a. Acid Etch. Etch in a 6% to 8% phosphoric acid solution at 38°C. Rinse thoroughly with running cold water followed by hot water tank rinse.

   b. Alkaline Etch. Etch the pre-cleaned aluminum surface in alkaline etching material that is controlled by titration, use time, temperature and concentration specified by the solution manufacturer. Rinse thoroughly, remove smut with an acidic chromium compound type solution as specified by the solution manufacturer and then thoroughly rinse.

B. Method II

Cleaning and Etching. Use a chemical conversion treatment in accordance with the requirements of Military Specification MIL-C-5541A, Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys, or later addenda. Following the etching and rinsing, panels shall be dried by a forced hot air dryer or by immersion for one minute, in circulating hot water at 82°C and allowed to air dry.

Application of Reflective Sheeting. The metal shall not be handled between all cleaning operations and applications of the reflective sheeting except by device or clean canvas gloves.

Immediately prior to the application of the reflective sheeting, the aluminum panel shall be prepared as specified in Method I or Method II. The reflective sheeting shall be adhered to the aluminum panel by the vacuum applicator process or mechanical process in strict accordance with the recommendations of the manufacturer of the reflective sheeting.
§730-02

BASIS OF ACCEPTANCE. Aluminum panels may be accepted on the basis of the manufacturer’s certification that his/her product conforms to all of the above specifications. However, the Department reserves the right to conduct tests, upon aluminum panels supplied. When tests are to be made, all test samples without reflective sheeting applied shall be submitted to the Materials Bureau. The number of samples shall comprise approximately one percent of the number of panels. Each sample shall contain a minimum area of 0.1 m² for each thickness of panel used. Failure of the samples to meet all the requirements of the above specifications shall be cause for rejection of the aluminum panels represented by such samples.

730-02 PLYWOOD SIGN PANELS

SCOPE. These specifications cover plywood sign panels used in the construction of temporary and permanent guide signs.

GENERAL. Plywood sign panels for signs shall conform to the requirements for high density overlay as set forth in Product Standard PS 1-66-Soft Plywood, Construction and Industrial, for Douglas Fir Plywood and all amendments thereto as established through the United States Department of Commerce. The plywood panels shall be high density overlay, exterior type plywood, 5 ply and B-B grade or better. Inner plies shall be B grade veneers or better.

MATERIAL REQUIREMENTS. The thickness of the plywood sign panels and plywood battens shall be 19 mm. The edges of all plywood used in sign panels or battens shall be painted with two coats of approved black paint. The overlay faces, on both sides, shall be black in color, hard, smooth and of such quality that further finishing by paint or varnish is not required. Panels shall consist of a cellulose-fibre or sheets, in which not less than 40 percent by weight of the laminate shall be a thermo-setting resin of the phenol or melamine type. The resin-impregnated material shall not be less than 0.2286 mm thick and shall weigh at least 29 kg/100m² of single face, including both resin and fibre. The resin impregnation shall be sufficient to attach the surfacing material to the plywood. The bond shall be equal in performance to the glue lines between the sheets of veneer which make up the plywood.

Panel Preparation for Reflective Sheeting. In preparing the sign panel for material specification §730-05, Reflective Sheeting, the entire portion of the overlay surface to be covered, shall first be given a light, firm abrasion with steel wool (medium to fine grade) saturated with xylol, V.M.&P. Naphtha or similar commercial solvent. The surface shall then be wiped clean and dry. An alternate method of panel pre-treatment, which consists of a solvent wipe, immediately followed by vapor degreasing (tri-chloroethylene) for a minimum period of six (6) minutes may be used. After panel preparation, the edges of all panels and battens shall be painted with two coats of approved black paint. Panel and batten surfaces to be glued shall be slightly roughened with waterproof adhesive prior to assembly.

Each plywood shall be grade-marked and certified with the standards adopted by the Douglas Fir Plywood Association.

BASIS OF ACCEPTANCE. Plywood sign panels may be accepted upon the manufacturer’s certification that its product conforms to all of the above detailed specifications. However, the Department reserves the right to conduct tests on the plywood panels submitted. When tests are to be made, all test samples without reflective sheeting applied shall be submitted to the Materials Bureau. The number of test samples shall comprise one percent of the contract quantity and each sample shall have a minimum surface area of 0.1 m². Failure of the samples to meet all the requirements of the above specifications shall be cause for rejection of the plywood sign panels represented by such samples.

730-03 and 730-04 (VACANT)
§730-05

730-05 REFLECTIVE SHEETING

SCOPE. These specifications cover reflective sheeting for use in the fabrication of highway and construction signs, delineators and other traffic control devices.

GENERAL. The reflective sheeting supplied shall be colored, flexible, weather resistant and shall have a smooth outer surface. If the reflective sheeting contains spherical lens elements, the lens elements shall be embedded within a transparent plastic, so as to produce a smooth, flat outer surface. All sheeting shall be of good appearance, free from ragged edges, cracks, scales, blisters, or other defects.

The back of the reflective sheeting shall be protected by a removable liner and shall include a precoated pressure sensitive or a heat activated adhesive, either of which may be applied without necessity of additional adhesive tack coats on the reflective sheeting or application surface.

Reflective sheeting shall be one of the following classes:

Class A (Materials Designation 730-05.01). A medium intensity reflective sheeting often referred to as engineer grade. It is recommended for highway signs, except where high reflectivity is required, and for construction barricades, panels and other work zone devices.

Class B (Materials Designation 730-05.02). A high intensity reflective sheeting often referred to as high intensity. It is recommended for highway signs, construction signs, delineators, and other work zone devices.

Class C (Materials Designation 730-05.03). A super-high intensity reflective sheeting recommended for delineators, construction barricades and vertical panels. This material is not recommended for highway or construction zone sign faces.

Class D (Materials Designation 730-05.04). A fluorescent orange colored sheeting with reflective properties similar to Class B high intensity. This sheeting is only recommended for use on orange colored construction signs, and for orange on construction barricades, vertical panels, and other work zone devices with rigid substrates, when a high level of conspicuity or visibility is needed.

MATERIAL REQUIREMENTS. Reflective sheeting shall meet the following requirements.

Class A. Class A reflective sheeting shall conform to the requirements of AASHTO M 268, Type I.

Class B. Class B reflective sheeting shall conform to the requirements of AASHTO M 268, Type III.

Class C. Class C reflective sheeting shall conform to the requirements of AASHTO M 268, Type V.

Class D. Class D fluorescent orange reflective sheeting shall conform to the requirements of AASHTO M 268, with the following modifications.

A. Coefficient of Retroreflection (RA). The coefficient of retroreflection shall meet or exceed the reflectivity requirements indicated in Table 730-05-1.

<table>
<thead>
<tr>
<th>Observation Angle (°)</th>
<th>Entrance Angle (°)</th>
<th>Minimum Rₐ (cd/lx/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>-4</td>
<td>100.0</td>
</tr>
<tr>
<td>0.2</td>
<td>+30</td>
<td>34.0</td>
</tr>
<tr>
<td>0.5</td>
<td>-4</td>
<td>64.0</td>
</tr>
<tr>
<td>0.5</td>
<td>+30</td>
<td>22.0</td>
</tr>
</tbody>
</table>

B. Daytime Color. The color shall conform to the requirements for luminance factor, maximum spectral radiance factor (peak reflectance), and color specification limits indicated in Table 730-05-2. Color measurements shall be determined in accordance with ASTM E991, using instrumentation which...
§730-05

has circumferential viewing (illumination). Calculations shall be performed in accordance with ASTM E308 for the CIE 1931 2° standard observer.

### TABLE 730-05-2 FLUORESCENT ORANGE COLOR REQUIREMENTS

<table>
<thead>
<tr>
<th>Luminance Factor (Y Percent)</th>
<th>Maximum Spectral Radiance Factor (%)</th>
<th>Color Specification Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. Max.</td>
<td>Minimum</td>
<td>1</td>
</tr>
<tr>
<td>30.0 —</td>
<td>110.0</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.583</td>
</tr>
</tbody>
</table>

**NOTE:**
1. Four pairs of chromaticity coordinates determine acceptable color in terms of the CIE, 1931 Standard Colorimetric System measured with Standard Illuminant D65.

**C. Artificial Weathering.** After 1500 hours of artificial weathering performed in accordance with ASTM G 26, Method A, using a Type B weatherometer, the following requirements shall be met:
- The minimum coefficient of retroreflection shall be 55.0 cd/lx/m2 at 0.2 degree observation angle; -4 degree entrance angle.
- The luminance factor (Y Percent) shall be from 20.0 to 45.0.
- The maximum spectral radiance factor (peak reflectance) shall not be less than 60.0 percent.
- The color specification limits shall conform to the requirements shown above in **Class D, B. Daytime Color.**

**FABRICATION.** The reflective sheeting shall be so fabricated as to allow easy cutting to specified sizes and shapes.

The sheeting surface shall be solvent resistant and shall permit solvent cleaning. All solvents used for cleaning operations shall be as recommended by the sheeting manufacturer and shall comply to all Federal, State and Local air quality regulations.

To assure uniform appearance and brilliance under both night and daytime conditions, the reflective sheeting shall be cut, matched and positioned on the prepared sign panel or other substrate in strict accordance with the recommendations of the sheeting manufacturer. Backgrounds, characters, delineators, etc., shall be coated and/or edge sealed in accordance with the recommendations of the sheeting manufacturer. When performed, coating operations shall be done in a workmanlike manner so as to create an even, clear, uniform coat which shall be free of streaks, drops or other defects which might affect reflectivity.

Reflective sheeting shall be furnished in both rolls and sheets. Rolls shall be packed individually and contain not more than four splices per 46 m linear measurement. Cut sheets shall be packaged flat and in such a manner as to minimize any damage or defacement that may occur to the sheeting during shipment or storage. The sheeting surface shall be capable of being readily processed and be compatible with recommended transparent and opaque process inks. The finished sheeting surface shall show no loss of the color with normal handling, cutting and application.

**TESTING.** Outdoor test specimen panels shall include both unprocessed reflective sheeting and reflective sheeting processed with the manufacturer’s recommended transparent and opaque inks. Class A and Class B reflective sheetings shall be exposed outdoors on a test deck for a minimum two year continuous time period. Class D reflective sheeting shall be exposed outdoors on a test deck for a minimum one year continuous time period. Outdoor exposure testing will not be required for Class C reflective sheeting.

Outdoor testing shall consist of exposing reflective sheeting test specimen panels, facing south, and inclined at an angle of 45° from a horizontal position. The test deck facility shall be located in a climate similar to that in which the material is intended to be used, or at a site approved by the Materials Bureau. Testing shall be performed by an independent testing agency or in conjunction with the National Transportation Product Evaluation Program (NTPEP).
§730-05

Following the specified outdoor exposure time period, all weathered test panels of reflective sheeting shall meet the following performance requirements. The sheeting on the test panels shall show no appreciable adhesion loss, cracking, blistering, crazing, dimensional change, or color change. The minimum percent retained coefficient of retroreflection (RA) shall be as specified below when compared to a control unexposed specimen counterpart. The control specimen reflectivity values (RA) shall be measured at the start of outdoor exposure testing. Measurements shall be taken at 0.2 degree observation angle; -4 degree entrance angle.

<table>
<thead>
<tr>
<th>TABLE 730-05-3 MINIMUM PERCENT RETAINED COEFFICIENT OF RETROREFLECTION (R,)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A (Materials Designation 730-05.01)</td>
</tr>
<tr>
<td>Class B (Materials Designation 730-05.02)</td>
</tr>
<tr>
<td>Class D (Materials Designation 730-05.04)</td>
</tr>
</tbody>
</table>

**BASIS OF ACCEPTANCE.** Class A, Class B, and Class D reflective sheetings shall be approved by the Materials Bureau. Approvals will be based upon independent laboratory analysis and outdoor exposure testing conducted in accordance with this specification. If the reflective sheeting passes the requirements for laboratory and outdoor exposure testing, the product will then be placed on the Department’s “Approved List” of materials. Detailed requirements and procedures for approval are available from the Materials Bureau.

Project acceptance of Class A, Class B, and Class D reflective sheetings will be based on the appearance of the sheeting material on the Department’s “Approved List” of reflective sheeting materials, and the manufacturer’s certification of compliance to this specification.

Project acceptance of Class C reflective sheeting will be based on manufacturer’s certification of compliance to this specification.

730-06 THRU 730-08 (VACANT)

730-09 TUBULAR MARKERS

**SCOPE.** This specification covers the material, fabrication, and performance requirements for tubular markers.

**MATERIAL REQUIREMENTS.** Tubular markers shall be orange in color with a minimum height of 915 mm and a minimum outside diameter of 64 mm. Tubular markers shall be tubular in cross section maintaining either a round or elliptical shape over the entire length. The base and/or any non-flexible portion of the marker shall not extend more than 50 mm above the pavement surface.

The markers shall have two horizontal circumferential stripes of white reflective sheeting a minimum of 75 mm wide. The top edge of the upper band shall be a maximum of 50 mm from the top edge of the marker. The space between shall not exceed 150 mm. Reflective sheeting shall conform to §730-05 Reflective Sheeting, Class B (Materials Designation 730-05.02) or Class C (Materials Designation 730-05.03).

The sheeting shall be bonded to the post with a precoated pressure sensitive adhesive or a tack free heat activated adhesive. Mechanical fasteners to bond reflective sheeting to the post will not be allowed.

The bonding system used to fasten the marker to the pavement shall be any fast setting chemical compound, mastic-type material, or mechanical fastener capable of fixing the tubular marker to either concrete or asphalt pavement. The bonding system shall not present a hazard to traffic if the tubular marker or base unit becomes unfixed from the pavement.
§730-10

TESTING. Tubular markers shall meet the requirements in the procedural directives of the Materials Bureau.

BASIS OF ACCEPTANCE. Application for approval of tubular markers shall be submitted to the Materials Bureau. The procedural directives outlining detailed requirements and procedures for approval are available from the Materials Bureau. Upon approval the name of the tubular marker will be placed on an Approved List.

Project acceptance will be based on the manufacturer's name and type of tubular marker appearing on the Department's Approved List titled 'Tubular Markers.'

730-10 ACRYLIC PLASTIC REFLEX REFLECTORS

SCOPE. This specification covers acrylic plastic prismatic reflectors for delineators.

MATERIAL REQUIREMENTS

Delineator Reflector Lens. Delineator reflectors shall consist of a clear and transparent acrylic plastic face, herein referred to as the lens, with a heat plastic or plastic coated foil back fused to the lens under heat and pressure around the entire perimeter of the lens, and the central mounting hole, to from a unit permanently sealed against dust, water, and water vapor. The lens shall consist of a smooth front surface, free from projections or indentation, other than a central mounting hole and identification, with a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the reflector.

Definitions and Optical Requirements

A. Entrance Angle. Shall mean the angle at the reflector between the direction of light incident on it and the direction of reflector axis.

B. Observation Angle. Shall mean the angle at the reflector between observers line of sight and direction of light incident on the reflector.

C. Specific Intensity. Shall mean luminous intensity (candela) returned at the chosen observation angle by a reflector for each lux of illumination at the reflector.

Optical Test Procedure. The reflex reflector to be tested shall be located at a distance of 30.5 m from a single uniformly bright light source having an effective diameter of 50 mm the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photo-electric photometer having a minimum sensitivity of 1 x 10^{-6} lux per scale division.

The photometer shall have a receiver aperture 13 mm diameter shielded to eliminate stray light. The distance from light source center to aperture center shall be 53.1 mm for 1/10 degree observation angle, and 175 mm for 1/5 degree observation angle.

If a test distance other than 30.5 m is used, the source and aperture dimensions and the distance between source and aperture shall be modified accordingly.

Seal Test. Submerge 50 samples in water bath at room temperature. Subject the submerged samples to a vacuum of 127 mm gage for five minutes. Restore atmospheric pressure and leave sample submerged for five minutes, then examine the samples for water intake. Evidence of moisture or water intake on more than two (2) samples shall be cause for rejection of the lot represented by the samples.

Heat Resistance. Three reflectors shall be tested for four hours in a circulating air oven at 79.5 ± 2°C. The test specimens shall be placed in a horizontal position on a grid or perforated shell permitting free air circulation. At the conclusion of the test the samples shall be removed from the oven and permitted to cool to room temperature. The samples after exposure to heat shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.
TABLE 730-10-1 OPTICAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Observation Angle Degrees</th>
<th>Entrance Angle Degrees</th>
<th>Specific Intensity Candela/lux</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Crystal</td>
</tr>
<tr>
<td>1/10</td>
<td>0</td>
<td>11.1</td>
</tr>
<tr>
<td>1/10</td>
<td>20</td>
<td>4.4</td>
</tr>
<tr>
<td>1/2</td>
<td>0</td>
<td>1.9</td>
</tr>
<tr>
<td>1/2</td>
<td>20</td>
<td>0.7</td>
</tr>
</tbody>
</table>

NOTE: Failure of reflectors to equal or exceed the minimum specific intensity value shall constitute failure of the reflector being tested; failure of more than 2 reflectors out of 50 begin subjected to test shall constitute failure to the lot represented by the samples. The specific intensity of delineator reflectors shall meet the above noted values, regardless of reflector orientation.

BASIS OF ACCEPTANCE. Acrylic plastic reflex reflectors will be accepted on the basis of the manufacturer's certification that their product conforms to all of the above detailed specifications. However, when the Department requires that tests be made, samples shall be submitted to the Materials Bureau. Fifty-three (53) samples will be selected at random from each shipment received from the reflector manufacturer. Each shipment may contain more than one lot. These samples shall be tested as specified above. Failure of the samples to meet all the requirements of the above specifications shall be cause for rejection of delineators represented by such samples.

730-11 REFLECTORIZED SHEETING SIGN CHARACTERS (TYPE III)

SCOPE. These specifications cover the material requirements for Type III reflectorized sheeting sign characters.

MATERIAL REQUIREMENTS. Type III characters shall consist of white reflective sheeting meeting the requirements of §730-05, Reflective Sheeting, Materials Designation 730-05.02 (Class B).

The reflective sheeting shall be applied to sheet aluminum with mechanical equipment in a manner specified by the sheeting manufacturer. The base material for demountable characters shall be made of sheet aluminum alloy 6061-T6 or 3003-M14 treated with applicable requirements of §730-01, Aluminum Sign Panels.

Characters up to and including 300 mm in height shall be fabricated from 1.0 mm thick sheet aluminum. Sheet aluminum 1.6 mm thick shall be used for characters over 300 mm in height.

Completed characters shall be dip-coated or edge sealed as specified by the sheeting manufacturer.

Character units shall be securely fastened to the sign background with aluminum or stainless steel screws, or pull-through blind rivets. Spacing of screws or rivets shall be determined by character size and shape but in no case shall be more than 200 mm on center.

BASIS OF ACCEPTANCE AND TESTS. Type III characters may be accepted on the basis of the manufacturer's certification that its product conforms to all of the above specifications. This certificate shall include the source or sources of all materials. However, when the Department requires that tests be made, samples for testing by the Materials Bureau shall be taken by a representative of the Department as follows:

Two (2) percent or a minimum of five (5) characters (whichever is the greater) for each size character used.

Two (2) percent or a minimum of 0.6 m of border (whichever is greater) for each width of border used.

These samples are to be tested as specified for §730-01 and 730-05. Failure of samples to meet all the requirements of the above specifications shall be cause for rejection.
730-12 REFLECTORIZED SHEETING AND SIGN CHARACTERS (TYPE IV)

SCOPE. These specifications cover the material requirements for Type IV, reflectorized sheeting sign characters.

MATERIAL REQUIREMENTS. Type IV characters shall consist of cutout reflective sheeting material meeting the requirements of §730-05, Reflective Sheeting, Materials Designation 730-05.02 (Class B).

Characters or borders shall be applied directly to clean, dust-free reflective sheeting background panels. Characters or borders shall be applied mechanically with equipment and in a manner specified by the sheeting manufacturer. Borders shall be cut neatly and butt-joined at corners and panel joints.

After the sign has been completed the entire sign face area shall be clear coated (sprayed or dipped) and/or edge sealed with a clear coating as specified by the sheeting manufacturer.

BASIS OF ACCEPTANCE. The requirements of §730-11 shall apply.

730-13 REFLECTORIZED SHEETING SIGN CHARACTERS (TYPE V)

SCOPE. These specifications cover the material requirements for Type V reflectorized sheeting sign characters.

MATERIAL REQUIREMENTS. Type V characters shall consist of a painted, screened, or reverse-screened application of paint, paste, or transparent color of a type and in a manner recommended by the manufacturer of the reflective material.

Reflective material used for reverse-screened signs shall meet the requirements of §730-05, Reflective Sheeting, Materials Designation 730-05.02 (Class B). Characters shall meet the optical requirements of 730-05.02. Panels shall be clear coated and/or edge sealed with a clear coating as specified by the sheeting manufacturer.

BASIS OF ACCEPTANCE. The requirements of §730-11 shall apply.

730-14 REFLECTORIZED SHEETING SIGN CHARACTERS (TYPE VI)

SCOPE. These specifications cover the material requirement for Type VI reflectorized sheeting sign characters.

MATERIAL REQUIREMENTS. Type VI characters shall consist of embossed aluminum frames meeting the requirements of Types I and II characters of §730-10. When reflective characters are specified, they shall meet the reflective requirements and finish of Type III characters. When non-reflective characters are specified, they shall be prepared in strict accordance with cleaning and etching requirements of §730-01, Aluminum Sign Panels. After preparation, frames shall be coated with one coat of gloss baked enamel per Federal Standard TT-E-489.

BASIS OF ACCEPTANCE. The requirements of §730-11 shall apply.

730-15 THRU 730-19 (VACANT)

730-20 SIGN POSTS AND FOOTINGS

SCOPE. These specifications cover the material requirements for Sign Posts and Footings.

MATERIAL REQUIREMENTS. Steel posts for ground mounted signs shall meet the requirements of §715-01, Structural Steel, except that ASTM A1 or rerolled axle steel may be used for small angle posts and ASTM A36, A242, A441, A572, Grade 345 and A588 steel may be used for posts and slip-impact bases as shown on the plans or standard sheets. All steel posts after fabrication (punching, drilling, etc.)
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shall be galvanized in accordance with the applicable requirements of §719-01, Galvanized Coatings and Repair Methods.

   Posts used with slip-impact base and hinge assemblies must be of weldable quality.
   Welding shall be in accordance with the provisions of section “Fabrication,” in the New York State Steel Construction Manual.

Galvanized Material Repair.  All damage to the galvanized surfaces due to handling, shipment, erection, etc., shall be repaired as described in §719-01

Aluminum Posts.  Aluminum posts shall meet the requirements of §715-04, Wrought Aluminum, and shall be fabricated of alloys 6061-T6.  Welding shall be in conformance with applicable provisions and general recommendations of the latest edition of the American Welding Society’s “Standard Specifications for Welded Highway and Railway Bridges.”  All aluminum welding shall be performed in the shop using an inert gas metal arc welding process.  Welders shall be qualified in accordance with the latest edition of the ASME Boiler and Pressure Vessel Codes, 6 IX, Welding Qualification, Part B.

   Dirt, grease, lubricants or other foreign materials in areas to be welded shall be removed by cleaning with a solvent or by vapor degreasing.  Preheating for welding is permissible up to a temperature of 200°C for a period not to exceed 30 minutes.
   Any porosity, craters, cracks or undercutting shall be cause for rejection.  Defective welds may be repaired by chipping or machining out defective material and rewelding.
   Field welding will not be allowed.
   The portions of the posts that will be in contact with the concrete shall be coated with a zinc coated primer, and the primer shall be thoroughly dry before the concrete is placed.

Embedded Footings.  Embedded footings for signs with metal posts shall be constructed of Class A Concrete without reinforcement.  If the sign footings are precast, the concrete shall meet the requirements of Class A Concrete in section 501, Portland Cement Concrete—General, except that the requirements for inspection facilities, automated batching controls and recordation do not apply.  The batching, mixing and curing methods, and the inspection facilities shall meet the approval of the Department or its representative.  The Contractor may submit, for approval by Director, Materials Bureau, a mix at least equivalent to the specified Class A Concrete, with a minimum cement content of 340 kg/m³.

Wood Posts.  Wood posts shall comply with the requirements of §712-14 Stress Graded Timber and Lumber.  Using the clean wood properties of ASTM D2555, the bending stress (Modulus of Rupture) shall not be less than 28 MPa.  They shall be surfaced four sides and shall be of the dimension shown on the plans before surfacing.  Surface dried redwood, red cedar, cypress or black locust may be used untreated.  Other lumber including Douglas fir, pine, oak, birch, maple and beech may be used but shall be pressure treated in accordance with §708-31, Wood Preservatives-Water Borne.

   The requirements for inspections contained in §712-14 and §708-31 are waived and the material will be accepted upon certification of the manufacturer.
   A Roadside Delineator, Type IV shall be included with each post.

Slip-Impact Base and Hinge Assemblies.  Slip-impact base and hinge assemblies shall be fabricated as shown on the standards sheets.  In general, these assemblies will only be used where signs cannot be located behind existing guide rail and where it is impractical to provide guide rail solely for sign protection.

   Post types 1-8 placed behind guide rail will not require slip-impact bases.

BASIS OF ACCEPTANCE.  Acceptance shall be based on the manufacturer’s certification that its product conforms to these specifications.
730-21 FLEXIBLE DELINEATOR POSTS

SCOPE. This specification covers the material, fabrication, and performance requirements for flexible delineator posts.

MATERIAL REQUIREMENTS. Flexible delineator posts shall be supplied with reflective sheeting of a size and color as required by the contract documents. The color of the posts shall match the color of the reflective sheeting unless otherwise specified in the contract documents. Where double unit reflectors are specified, elongated reflective sheeting may be substituted as in accordance with the New York State Manual of Uniform Traffic Control Devices.

Reflective sheeting shall be fabricated of a material conforming to the requirements of §730-05 Reflective Sheeting, Class B or Class C. Sheetig shall be applied in accordance with the sheeting manufacturer's written instructions.

TESTING. Flexible delineator posts shall meet the requirements in the procedural directives of the Materials Bureau.

BASIS OF ACCEPTANCE. Application for approval of flexible delineator posts shall be submitted to the Materials Bureau. The procedural directives outlining detailed requirements and procedures for approval are available from the Materials Bureau. Upon approval the name of the flexible delineator post will be placed on an Approved List.

Project acceptance will be based on the manufacturer's name and type of flexible delineator post appearing on the Department's Approved List titled 'Flexible Delineator Posts.'

730-22 STIFFENERS, OVERHEAD BRACKETS AND MISCELLANEOUS HARDWARE

SCOPE. These specifications cover the material requirements for stiffeners, overhead brackets and miscellaneous hardware used for signs.

MATERIAL REQUIREMENTS

Aluminum Components. Horizontal sign panel stiffeners (Z bars) and overhead panel brackets shall be fabricated of aluminum alloy 6061-T6.

Other miscellaneous hardware including vertical stiffeners, bolts, nuts, washers, screws, rivets, pull-type lockbolts and serrated or knob stem blind rivets shall be fabricated of the materials and in the manner shown on the plans or standard sheets and shall meet the requirements of §715-04, Wrought Aluminum.

Components designated as Alloy 2024-T4 shall be given a Type 205 coating in accordance with §719-02, Aluminum Anodic Coatings.

Certification, Sampling, Testing and Inspection of aluminum components shall be handled as noted in §715-04.

Steel Components. Steel bolts, nuts and washers referenced to this specification shall conform to the requirements of Table 730-22-1 unless otherwise specified.

Bolts, nuts and washers to be used in contact with aluminum shall be coated with cadmium or cadmium/tin combination.

All cadmium and cadmium/tin coatings shall be given a chromate treatment in or with an aqueous solution of salts, acids or both to produce a protective chromate coating. The chromate coating shall be distinctly colored iridescent yellow to bronze for cadmium. Cadmium/tin coatings, when given this iridescent chromate treatment, may remain silver colored. Usual chromic and nitric acid bright dips are not chromate treatments.
### TABLE 730-22-1 STEEL FASTENERS

<table>
<thead>
<tr>
<th>CLASS</th>
<th>BOLT SIZE (ASTM F568)</th>
<th>ALLOWABLE NUTS¹ (ASTM A563M)</th>
<th>BOLT, NUTS &amp; WASHER COATING SYSTEMS²</th>
<th>PLAIN WASHER</th>
<th>PREVAILING TORQUE HEX NUTS AND HEX FLANGE NUTS³</th>
<th>LOCK WASHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>M5 TO M36 M42 TO M100</td>
<td>5 - H1 5 - HH</td>
<td>P OR Z</td>
<td>P OR Z</td>
<td>&lt; M12, use ANSI B18.22M, soft</td>
<td>CLASS 5.9 or 10</td>
</tr>
<tr>
<td>8.8</td>
<td>M16 TO M36 M42 TO M100</td>
<td>9 - H2 12 - H2 9 - HH 12 - HH</td>
<td>P Z P</td>
<td>Z</td>
<td>&gt; M12, use ASTM F436M IFI 542 or ANSI B18.22M, hard only</td>
<td>CLASS 5.9 or 10</td>
</tr>
<tr>
<td>10.9</td>
<td>M5 TO M36 M42 TO M100</td>
<td>10 - H1 12 - HH</td>
<td>P P OR Z</td>
<td></td>
<td>CLASS 9 or 10</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. Class of nut (5.9, 10 and 12):
   - H1: ANSI B18.2.4.1M hex nut, style 1
   - H2: ANSI B18.2.4.2M hex nut, style 2
   - HH: ANSI B18.2.4.6M heavy hex nut
2. P > M9.5: ASTM B695, class 50, type 1
   - P ≤ M9.5: ASTM B695, class 40, type 1, cadmium coating
     - ASTM B696, class 8, type 2
     - ASTM B766, class 12, type 2, cadmium/tin coating
     - ASTM B635, class 8, type 2
3. Z > M9.5: ASTM A153, class C
   - Z ≤ M9.5: ASTM A153, class D

**BASIS OF ACCEPTANCE.** Acceptance will be based on the manufacturer's certification that its product conforms to these specifications.

### 730-23 FIBERGLASS REINFORCED PLASTIC SIGN PANELS

**SCOPE.** This specification covers the material requirements for fiberglass reinforced plastic for use as a sign panel substrate.

**GENERAL.** The fiberglass reinforced plastic sign panel shall be fiberglass reinforced thermoset polyester laminate. The panel shall be acrylic modified and UV stabilized for outdoor weatherability. The panel shall be stabilized so as not to release migrating constituents (i.e., solvents, monomers, etc.) over time, and shall contain no residual release agents on the surface of the laminate that will interfere with any subsequent bonding operations. The panel shall not contain visible cracks, pinholes, foreign inclusions, or surface wrinkles that would affect implied performance, alter the specific dimensions of the panel or otherwise affect its serviceability.

**MATERIALS REQUIREMENTS

**Physical Requirements.** The fiberglass reinforced plastic sign panel materials shall conform to the physical requirements in Table 730-23-1:
TABLE 730-23-1 PHYSICAL REQUIREMENTS FOR FRP SIGN PANELS

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>ASTM TEST METHOD</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>D638</td>
<td>69 MPa</td>
</tr>
<tr>
<td>Tensile Modulus</td>
<td>D638</td>
<td>8274 MPa</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>138 MPa</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>D790</td>
<td>8274 MPa</td>
</tr>
<tr>
<td>Compression Strength</td>
<td>D695</td>
<td>221 MPa</td>
</tr>
<tr>
<td>Compression Modulus</td>
<td>D695</td>
<td>9653 MPa</td>
</tr>
<tr>
<td>Punch Shear</td>
<td>D732</td>
<td>90 MPa</td>
</tr>
<tr>
<td>Weatherability — Grade II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>D3841</td>
<td>26</td>
</tr>
</tbody>
</table>

Panel Flatness Test. Panel flatness shall be determined by supporting a 760 mm by 760 mm panel at two opposite corners, the maximum deflection measured diagonally, parallel and perpendicular to the panel by lines drawn through the center of the panel, shall not exceed 13 mm. The panel shall then be supported in a like manner in an oven for 48 hours at 82°C. The maximum deflection shall again be measured as previously noted, and shall not exceed 13 mm. All measurements shall be made when the panels are at ambient temperature. The fiberglass reinforced plastic panel shall have a maximum Coefficient of Thermal Expansion of 3.24 mm/mm°C and maintain its strength and impact resistance qualities over a temperature range of -54°C to 100°C.

Application of Reflective Sheeting. The reflective sheeting shall be adhered to the fiberglass reinforced plastic panel in strict accordance with the recommendations of the manufacturer of the reflective sheeting.

BASIS OF ACCEPTANCE. Application for approval of fiberglass reinforced plastic sign panel by the producer shall be submitted to the Materials Bureau accompanied by a 7.5 m² sample of the product. Upon approval by the Materials Bureau, the name of the product will be placed on the Department's Approved List entitled "Fiberglass Reinforced Plastic Sign Panels 730-23.

730-24 TYPE A SIGN SUPPORTS

SCOPE. This specification covers the material and fabrication requirements for breakaway supports used for roadside signs.

MATERIAL, FABRICATION AND PERFORMANCE REQUIREMENTS. Post material, fabrication and performance requirements shall be in accordance with the standard sheets, the appropriate Materials Details and the procedural directives of the Materials Bureau.

BASIS OF ACCEPTANCE. Type A Sign Supports shown on the standard sheets shall be accepted based on the manufacturer's certification that its product conforms to these specifications and the appropriate standard sheets.

All other Type A Sign Supports will be accepted on the basis of their listing on the Department's Approved List of Type A Sign Supports. In addition, the manufacturer or supplier shall provide two copies of the approved Materials Details through the Contractor to the Engineer as part of the evidence of acceptability for the material at least ten days prior to the use of the product.
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730-25 - TYPE B SIGN POSTS

SCOPE. This specification covers the material requirements for Type B Sign Posts and Rustic Type B Sign Posts. These sign posts shall be equipped with breakaway bases and hinge assemblies per §730-26, Breakaway Bases and Hinge Assemblies, if installed at a location subject to vehicle impact.

MATERIALS AND FABRICATION REQUIREMENTS

Steel Sign Posts. Steel for sign posts and attachements to or components of sign posts shall be ASTM A36M, A242M, A572M Grade 345 and A588M and shall conform to §715-01 Structural Steel. Rustic Type B Sign Posts shall be ungalvanized weathering steel, ASTM A588M or A242M, meeting the requirements of §715-01 Structural Steel.

Sign posts, except Rustic Type B Sign Posts, shall be galvanized after fabrication (punching, drilling, welding, cutting, etc.) in accordance with §719-01, Galvanized Coatings and Repair Methods. Damage to galvanized surfaces of steel posts due to handling, shipment, erection, etc. shall be repaired as described in Repair of §719-01, when directed by the Engineer.

Sign posts with breakaway bases shall be of weldable quality, and all welding shall be in accordance with the provisions of the section on 'Fabrication' of the New York State Steel Construction Manual.

FABRICATION. Sign posts shall be fabricated as indicated on the standard sheets. Breakaway bases shall conform to the requirements of §730-26, Breakaway Bases and Hinge Assemblies.

BASIS OF ACCEPTANCE. Acceptance shall be based on the manufacturer's certification that the product conforms to these specifications.

730-26 BREAKAWAY BASES AND HINGE ASSEMBLIES

SCOPE. This specification covers the material and fabrication requirements for bi-directional and omni-directional breakaway bases and hinge assemblies for use on Type B Sign Posts and for use on Rustic Type B Sign Posts.

Bi-Directional Breakaway Bases and Hinge Assemblies are intended for use when the expected impact angle is within 30 degrees of the axis of the base from the front and rear.

Omni-Directional Breakaway Bases and Hinge Assemblies are intended for use whenever the expected impact angle may be greater than 30 degrees, measured as described above.

MATERIAL AND FABRICATION REQUIREMENTS. Breakaway bases and hinge assemblies shown on standard sheets shall satisfy the following requirements:

Steel for breakaway bases and hinge assemblies shall be A-36M, A242M, A572M Grade 345, A588M and shall meet the requirements of §715-01, Structural Steel. Steel shall be of weldable quality. Fasteners shall be of the size and shape shown on the Standard Sheets and meet the requirements of §730-22, Stiffeners, Overhead Brackets and Miscellaneous Hardware. Breakaway bases and hinge assemblies shall be galvanized in accordance with §719-01, Galvanized Coatings and Repair Methods, after the base is welded to the post. Welding shall be in accordance with the provisions of the section on 'Fabrication' of the 'New York State Steel Construction Manual.' Fabrication details shall be in accordance with the standard sheets.

Breakaway bases and hinge assemblies for use in conjunction with rustic sign posts shall meet the above requirements with the following exceptions:

- The upper slip base plate and attached post shall be ungalvanized weathering steel, ASTM A588M or A242M, meeting the requirements of §715-01, Structural Steel. The lower slip base plate, and the attached stub portion of the post, shall be galvanized steel. The remainder of the slip base shall be as shown on the contract drawings.

- When used on one-way, divided roadways, the back flange hinge plate shall be ungalvanized A588M or A242M steel installed as shown on the contract drawings. When used on two-way,
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undivided roadways, the back flange hinge plate shall meet the requirements, below, of the front flange hinge plate.

- The front flange hinge plate shall be galvanized steel, except that an additional galvanized steel flat washer meeting the requirements of ASTM F436M shall be installed on all four bolts between the post and the hinge plate to assure proper slippage.

Weathered Brown Guide Rail Paint meeting the requirements of §708-24 shall be used to paint all exposed galvanized surfaces, except in the vicinity of the slots in the hinge plates.

**BASIS OF ACCEPTANCE.** Breakaway bases and hinge assemblies fabricated as shown on the standard sheets shall be accepted based on the manufacturer's certification that the complete assembly conforms to these specifications.

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**730-27 PERMANENT VARIABLE MESSAGE SIGNS**

**SCOPE.** This specification gives minimum material, fabrication, fatigue and strength requirements of variable message signs for permanent installation. Other requirements are in the Contract Documents.

Within this specification, "overhead" shall mean to be mounted over the traveled way, or what the plans indicate will become the traveled way.

**MATERIAL REQUIREMENTS**

**Housing.** The enclosure housing shall be constructed of aluminum alloy 3003-H14, 6061-T6, 5154-H38 or as specified on approved shop drawings. The minimum thickness shall be 3.2 mm. Seams shall be continuously welded by an inert gas process only in the shop.

The housing shall be completely sealed to prevent the entry of water, insects, dust, dirt and corrosion. Neoprene gaskets shall be utilized as necessary.

Readily-available, changeable filtration devices shall be provided at drain holes and at all points where forced air enters the enclosure.

All hinged access panels and windows shall be equipped with hold-open devices which shall not release accidentally or by the action of wind. The hold-open devices shall not interfere with the operation of the display, nor with the repair or replacement of user serviceable components.

**Stiffeners, Hardware and Mounting Brackets.** Hardware, framing members and mounting brackets shall meet the requirements of §730-22, unless indicated otherwise on the manufacturer's shop drawings approved by the Engineer.

Framing structural members shall be made of aluminum alloy 6061-T6 or an approved equivalent. All hardware shall be corrosion-resistant steel or protected from corrosion by suitable plating. Fasteners for securing access panels shall be captive.

**MANUFACTURING**

**General.** Fabrication shall be such that performance will not be impaired after the equipment has been subjected to shock and vibration caused by normal installation, transportation and maintenance handling. Particular attention shall be given to neatness and thoroughness of soldering, wiring, welding, plating, riveting, finishes and machine operations. All parts shall be free from burrs and sharp edges or any other defect that could make the part or equipment unsatisfactory for the operation or function intended in this specification.

Modules shall be designed such that major portions may easily be replaced. Modules of unlike functions shall be mechanically keyed to prevent insertion into the wrong socket or connector. All modules and assemblies shall be clearly identified with name, model number, serial number and any other pertinent information required to facilitate equipment maintenance. They shall be readily accessible for inspection and maintenance, using simple hand-held tools and standard meters.
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Housing. The sign enclosure including doors and access panels shall be designed and constructed so as to present a clean, neat appearance; be smooth with exterior corners rounded; be weatherproof and vandal-resistant; and be free of burrs, blemishes and unspecified holes.

Drainage holes shall be drilled near each corner of the base of the enclosure.

The enclosure shall have internal lighting sufficient for all maintenance activity requirements of the VMS and 120 volt power receptacles every 3 m mounted on the rear interior panels.

If the variable message sign is designated as "walk-in," then its access door shall be a minimum of 610 mm wide X 1520 mm high.

Environmental

A. Temperature. Internal temperature shall be continuously monitored whenever electric power is applied to the sign. The internal temperature of the enclosure shall be reported to the local and central controller upon request. Ventilation shall be automatically turned on and off at internal temperatures specified in the Proposal. Exhaust and intake ports shall be protected by filter screens against moisture, dust and insect intrusion. The ventilation system shall be sufficient to circulate three times the volume of air inside the enclosure per minute. Multiple fans or blowers shall be used to provide the specified venting and shall be located within the enclosure to minimize heat stratification.

B. Adverse Conditions. The equipment shall meet all of its specified functions during and after subjection to any combination of the following conditions:

1. Ambient Temperature. Range of -30°C to +62°C.
2. Temperature Shock. 17°C per hour, during which the relative humidity shall not exceed 95%.
3. Relative Humidity Range. 0 to 95% over the temperature range of 4°C to 43°C.

C. Ambient Light. The variable message sign shall be equipped with light sensors so that the display shall be able to automatically adapt its level of light output to maintain readability under varying ambient light conditions. There shall be a minimum of eight (8) levels of dimming, linearly spaced from nighttime to daylight brightness. The sign's automatic dimming control shall be overridable by central control. The dimming circuitry shall automatically compensate for variations in the AC line voltage to maintain the light output constant for the selected brightness level.

The levels of lighting shall produce luminance measured on the optic axis, as follows:

1. Daylight. A minimum of 14 candela per pixule for typical daylight environment.
2. Nighttime. Between 1.5 and 2 candela per pixule for nighttime environment.

Electrical Protection. The equipment shall contain readily-accessible, normally resettable or replaceable circuit protection devices (such as circuit breakers or fuses) for equipment and power source protection.

Electronic Components. All components shall be UL listed. All printed circuit boards shall be FR4 or G10 fiberglass epoxy material, with 20oz. copper, double-sided with plated through-holes.

All etched connector fingers are to be plated with a minimum thickness of 2.5 μm (100 micro-inches) of gold over nickel.

Board connectors that are not an integral part of the printed circuit are to be plated with a minimum thickness of 0.38 μm (15 micro-inches) of gold over nickel.

Sign Face. In order to increase contrast, the pixules shall be arranged on a black, non-glossy background. All electronic components visible from outside the sign shall be of black color or coated with black, non-glossy paint.
The front of the sign shall be enclosed by a protective, weathertight face, 6 mm thick.
Variable spacing between letters shall approximate the recommended spacing for 460 mm Series E sign text found in the Federal Highway Administration Standard Alphabets for Highway Signs.

DESIGN CRITERIA

All Permanent Variable Message Signs. The equipment shall be designed such that the failure of one part shall not cause the failure of any other part. In the event of a power failure of 500 milliseconds or less, proper operation of the equipment shall commence after restoration of power, without creating false information.

Shop drawings and calculations that show the sign's ability to withstand the design loads shall be submitted to the Traffic Engineering and Highway Safety Division for approval, and shall be signed by a Professional Engineer licensed and registered to practice in New York State. If the drawings and calculations are approved by the Department, the manufacturer will be notified, and the manufacturer's name and drawing numbers will be placed on the Approved List.

Approved shop drawings shall be submitted to the Engineer prior to delivery of any variable message signs. The Contractor shall develop and deliver shop drawings signed by a licensed New York State Professional Engineer which illustrate in detail, how to mount and connect the variable message sign enclosure to the structure shown on the Plans.

All variable message signs covered by this specification shall be designed to withstand the following loads, combined in groups in accordance with the latest A.A.S.H.T.O. Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Each member and connection shall be designed for the maximum stress of all the different combinations, with the allowable stress increased as indicated in the A.A.S.H.T.O. Group Loading table. Unless noted otherwise, "Ice" load in the table shall mean "Ice and Snow loads simultaneously."

A. Dead Load. The weight of the variable message sign including all components, plus consideration of loads imposed during maintenance.

B. Live Load. Variable message signs designated as "walk-in," or otherwise intended to support personnel in service, shall be designed to support a live load of 4.8 kPa applied to the service platform.

C. Ice Load. The ice load shall be 145 Pa, unless historical accretion data for the location the variable message sign will be installed, the slope of a panel, or shielding hoods and the like indicate a different load. This load shall be considered on individual panels and the members and connections supporting only one panel. The load on members and connections supporting more than one panel shall be designed to support an ice load on:

1. The one end panel, and
2. Either the front or back panel, after considering panel slope and/or shielding hoods, which produces the largest load in the member or connection.

D. Snow Load. The snow load shall be 1.9 kPa, unless historical accretion data for the location the variable message sign will be installed, or the shape of a panel indicate that a different load is appropriate. This load shall be applied to the top panel and any hood or other nearly horizontal projection.


1. Individual nonhorizontal panels. Panels, members and connections carrying loads from
only one nonhorizontal panel shall be designed for 100% of the Base Wind Load acting normal to the panel along with 20% of the Base Wind Load acting transverse to the panel.

2. **Adjacent nonhorizontal panels.** Panels, members and connections carrying wind loads from two adjacent, nonhorizontal panels perpendicular to each other shall be designed to withstand a wind load acting on both panels. For the purposes of determining direction of forces, the term "paramount" refers to the panel contributing the greatest load, and the adjacent panel termed the "adjoining" panel. If it is not clear which panel will contribute the greatest load, then analyze with one panel assumed to be paramount, and the adjacent one adjoining, then do a separate analysis with the roles reversed. The center of action of the wind loads shall be the centroid of the panel on which it acts. The magnitude of the components shall be:

a. **Normal to the paramount panel.** 100% of the Base Wind Load on the paramount panel, plus 30% of the base wind load on the adjoining panel;

b. **Transverse to the paramount panel.** 20% of the Base Wind Load on the paramount panel, plus 60% of the base wind load on the adjoining panel.

Members and connections carrying wind loads from adjacent, nonhorizontal panels at angles other than perpendicular to each other shall be designed to withstand an appropriate wind load coming from the direction producing the greatest stress in the member or connection.

**Overhead Permanent Variable Message Signs.** Variable message signs to be mounted over a traveled way, or what the plans indicate will become a traveled way, shall be designed for the fatigue loads and using the allowable stresses in NYSDOT Design Specifications for Overhead Sign Structures Carrying Variable Message Signs October 1998, section 11, with all current updates. With regard to article 11.7, the natural wind gust and the truck-induced blast limit-state-equivalent static loads shall be considered separately.

**DELIVERY AND INSTALLATION**

The contractor shall deliver, store, handle, and install all materials and equipment in such a manner as not to degrade quality, serviceability or appearance. Material to be stored shall be stored in a clean and dry location free from construction dust, precipitation, and condensing moisture. Any part of the equipment damaged during transportation, handling, or installation shall be repaired, or if determined by the Engineer as unfit for use in the finished work, shall be removed from the site and replaced by the Contractor at no additional cost.

All materials shall be delivered and stored in the manufacturer's original unopened protective packages and protected against soiling, physical damage, or wetting, before and during installation. Unloading and unpacking of all materials shall be done in a manner to prevent misalignment or damage.

The installation shall be performed by factory certified personnel. Installation shall be complete in all respects, including all framing and all related fastenings and anchors required for a complete installation. Equipment shall be placed in accordance with the general arrangement as shown on the Drawings. The general arrangement may be modified only as required to suit specific equipment. Modifications shall not affect the design of components. Layout dimensions as shown on the Drawings may be modified to improve operating efficiency.

**MARKING.** The contract number, pay-item number, and month and year of installation shall be marked using permanent ink, paint, or stamping into the wall. Characters shall be 25-45 mm high, horizontal when the variable message sign is in its final position, and be located in the following locations:

- The end panel of the vms, so as to be visible from the shoulder closest to the variable message sign.
- On the inside of a "walk-in" variable message sign, near the middle of the panel opposite the door.
Also, the manufacturer's name, product name, model number, serial number, and city and state or province of manufacture shall be permanently marked on the outside and an easily accessible location inside the variable message sign.

These markings shall not be visible when viewing the front of the variable message sign straight-on.

TESTS

Design Approval. In order to get on the Approved list, design approval tests shall be conducted by the fabricator on one (1) or more samples of each equipment type, as approved by the Traffic Engineering and Highway Safety Director, to determine if the design of the equipment meets the requirements of this specification. In the case of standard product line equipment, the Traffic Engineering and Highway Safety Director may waive the design approval tests if:
   - The manufacturer's written specifications (functional and environmental) are equal to or better than those specified in the contract documents and the manufacturer so states in writing; or
   - The manufacturer provides certification by an independent testing laboratory that these design approval tests have been previously satisfactorily completed.

Performance. If specified in the Contract Documents, each variable message sign shall pass these performance tests both alone and fully integrated in the system:
   - Factory Tests
   - Installation Tests
   - Pre-Acceptance Tests
   - Project Acceptance Tests

A complete list of all equipment and system tests to be performed, including the testing plan and detailed testing procedures for each type of equipment, shall be submitted to the Engineer for approval. Test procedures shall be in accordance with the manufacturer's recommendations and shall demonstrate all functional requirements.

A minimum of two (2) weeks written notification will be provided for the witnessing of all testing, after approval of the testing plan and the appropriate testing procedures.

If a unit has been modified as a result of a test failure, a report shall be prepared and delivered to the Engineer prior to re-testing of the equipment. The report shall describe the nature of the failure and the corrective action taken. If the Engineer determines that a failure pattern exists, then design and construction modifications shall be made to all equipment without additional cost to the State or extension of the contract period. The Engineer will forward copies of the reports of modifications to the Regional Traffic and Safety Engineer, and to the Materials Bureau.

Rejected equipment may be offered again for retest provided all non-compliances have been corrected and retested by the Contractor. The contractor shall submit evidence that the sign(s) have passed, to the Engineer with the request and the schedule to re-witness the performance tests.

BASIS OF ACCEPTANCE. Variable message signs will be accepted based on the following:
   - The manufacturer's name, product name or model number, and drawing number and date, appearing on the Department's Approved List.
   - Submission of approved shop drawings, for each different variable message sign supplied.
   - Manufacturer's written certification of compliance to these specifications and the approved shop drawings.
   - If required by the Engineer or the approved shop drawings, submission of mill certifications for structural materials.
   - Passing all performance tests in the specification.

Final inspection and acceptance of equipment shall be made after installation at the locations specified on the plans.