Specification for

Wet Retroreflective Removable Pavement Markings

Used In Work Zones

3M™ Stamark™ Wet Reflective Removable Tape

Series 710

April 2009

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March 2009

1.0 General Description

1.1 This work shall consist of furnishing, installing, removing or obliterating pavement markings in work zones in accordance with this provision and in reasonably close conformity with the dimensions and lines shown on the plans or established by the Engineer.

2.0 Materials - General

2.1 The preformed patterned markings shall consist of white or yellow films with clear microcrystalline ceramic beads incorporated to provide immediate and continuing retroreflection during both wet and dry conditions. This film shall be manufactured without the use of lead chromate pigments or other similar, lead-containing chemicals.

2.2 The quality of the pavement marking shall be such that the performance requirements for the marking shall be met.

2.3 The markings shall be precoated with a pressure sensitive adhesive and shall be capable of being adhered to Asphalt concrete or Portland cement concrete at temperatures as low as 50°F (10°C) in accordance with the manufacturer's recommendations.

2.4 When stored in a cool dry area indoors, the materials shall be suitable for use for one year after the date of purchase.

3.0 Classification

3.1 The removable retroreflective pavement marking tape must be designed and constructed in such a manner that it can be readily removed when the markings are no longer applicable. The tape shall be capable of performing for the duration of a normal construction season and shall then be capable of being removed intact or in large pieces. The tape shall be wet and dry reflective throughout its useful life. (A normal construction season is defined as the time after the last snowplowing in the spring and before the first snowplowing in the fall/winter. In non-snow removal locations, a normal construction season is limited to the calendar year at the time of installation. Removable pavement markings for work zones are not intended for multi-year applications.)

4.0 Requirements

Composition: The retroreflective pliant polymer pavement markings shall consist of a mixture of high-quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of microcrystalline ceramic beads bonded to a durable polyurethane topcoat surface. The patterned surface shall have approximately 20% ± 10% of the surface area raised and presenting a near vertical face (ß angle of 0° to 60°) to traffic from any direction. (See diagram below.) The channels between the raised areas shall be substantially free of exposed beads or particles.

β

Retroreflectance: The white and yellow markings shall have the initial expected retroreflectance values as shown in Table 1 under dry, wet, and rainy conditions. The photometric quantity to be measured shall be coefficient of retroreflected luminance (RL) and shall be expressed as millicandelas per square foot per foot-candle [(mcd • ft-2) • fc-1]. The metric equivalent shall be expressed as millicandelas per square meter per lux [(mcd • m-2) • lx-1].

Retroreflectance values shall be measured under dry conditions in accordance with the testing procedures of ASTM D4061.

Retroreflectance values shall be measured under wet conditions in accordance with ASTM E2176 or ASTM E2177. Wet retroreflectance values measured under a “condition of continuous wetting” (simulated rain) shall be in accordance with ASTM E2176, and to reduce variability between measurements, test method shall be performed in controlled laboratory environment while the marking is positioned with a 3 to 5 degree lateral slope. A wetting agent shall be used to improve wetting of the pavement marking by the water. It is recommended that a 0.1% by volume liquid soap solution be used. Measurements shall be reported as an average for each roll tested, in a minimum of three locations.

Wet retroreflectance values measured under a “condition of wetness” shall be in accordance with ASTM E2177, and the test may be performed with the marking installed on the road. New markings shall be tested using a wetting agent, as previously described. Laboratory measurements shall be performed using a 3 to 5 degree lateral slope. Measurements shall be reported as an average for each roll tested, in a minimum of three locations

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##### Table 1

**Expected Initial RL under dry, wet, and rainy conditions**

WHITE Dry Wet & Rainy

Entrance Angle 88.76° 88.76°

Observation Angle 1.05° 1.05°

Retroreflected Luminance 500 250

RL [(mcd • m-2) • lx-1]

YELLOW Dry Wet & Rainy

Entrance Angle 88.76° 88.76°

Observation Angle 1.05° 1.05°

Retroreflected Luminance 300 200

RL [(mcd • m-2) • lx-1]

Note: The test instrument shall use an Entrance Angle of 88.76° and Observation Angle of 1.05°which represent a simulated driver viewing geometry at a 30 meter distance.

Beads: Index of Refraction: All “dry-performing” microcrystalline ceramic beads bonded to the polyurethane-coated, patterned surface of the material shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method. All “wet-performing” microcrystalline ceramic beads bonded to the polyurethane-coated, patterned surface of the material shall have a minimum index of refraction of 2.30 when tested using the liquid oil immersion method. The glass beads mixed into the pliant polymer shall have a minimum index of refraction of 1.5 when tested by the liquid oil immersion method.

**Testing Procedure For Refractive Index of Beads By Liquid Immersion**

Equipment Required:

1. Microscope (minimum 100X magnification)

2. Light source - preferably sodium light or other monochromatic source, but not absolutely essential

3. Refractive index liquids\*

4. Microscope slide and slide cover

5. Mortar and pestle

\*Available from R.P. Cargille Laboratories, Inc., Cedar Grove, NJ.

Procedure:

1. Using the mortar and pestle, crush a few representative beads and place a few of these crushed particles on a microscope slide.

2. Place a drop of a refractive index liquid, with an index as close to that of the glass as can be estimated, on the particles.

3. Cover the slide with a microscope slide cover and view the crushed particles by transmitted light normal to the slide surface (illuminated from the bottom).

4. Adjust the microscope mirror to allow a minimum light intensity for viewing. This is particularly important if sodium light is not used.

5 Bring a relatively flat and transparent particle into focus.

6. By slightly raising and lowering the objective (microscope tube), look for one or both of the following:

1. Becke Line - This light line will appear to move either into

the particle or away from it. In general, if the objective is

raised, the line will move toward the material of higher

refractive index; if the objective is lowered, the line will

move toward the material of lower index.

1. Variation in Particle Brightness - When raising the object

from a sharp focus, the particle will appear to get brighter

or darker than the surrounding field. If it becomes

brighter, the glass has a higher refractive index than the

liquid. If it becomes darker, the glass has a lower

refractive index than the liquid. In both cases, the

opposite will be true if the object is lowered.

7. This test can be used to confirm that the beads are above or below a specified index. It can also be used to give an accurate determination of the index (± 0.001). This is done by using several refractive index liquids until a match or near match of indices occurs. The index of the glass will equal that of the liquid when no Becke line and no variation in bead brightness can be observed.

The size and quality of the beads shall be such that the performance requirements for the retroreflective pliant polymer shall be met.

Acid Resistance: The beads shall show resistance to corrosion of their surface after exposure to a 1% solution (by weight) of sulfuric acid. The 1% acid solution shall be made by adding 5.7cc of concentrated acid into 1000cc of distilled water. CAUTION: Always add the concentrated acid into the water, not the reverse. The test shall be performed as follows:

Take a 1-inch x 2-inch sample, adhere it to the bottom of a glass tray and place just enough acid solution to completely immerse the sample. Cover the tray with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution (do not rinse, touch or otherwise disturb the bead surfaces) and dry the sample while adhered to the glass tray in a 150° F. (66° C.) oven for approximately 15 minutes.

Microscopic examination (20X) shall show no more than 15% of the beads having a formation of a very distinct opaque white (corroded) layer on their entire surface.

Color: The preformed markings shall consist of white and yellow films with pigments selected and blended to conform to standard highway colors.

Removability: The pavement markings shall be removable from Asphalt concrete and Portland cement concrete intact or in large pieces, at temperatures above freezing without the use of heat, solvents, grinding or blasting without permanently scarring the roadway surface.

Skid Resistance: The patterned surface of the retroreflective pliant polymer shall provide an initial average skid resistance value of 45 BPN when tested according to ASTM E303 except values shall be taken in one direction and then at a 45° angle from that direction. These two values shall then be averaged to find the skid resistance of the patterned surface.

Patchability: The pavement marking material shall be capable of use for patching worn areas of the same type in accordance with manufacturer’s instructions.

Thickness: The patterned material without adhesive shall have a minimum caliper of 0.075 inches (1.651mm) at the thickest portion of the patterned cross-section and a minimum caliper of 0.020 inches (.508mm) at the thinnest portion of the cross-section.

.020 in.

.075 in.

5.0 Installation

5.1 Pavement markings in work zones shall be placed in accordance with the following provisions:

5.1.1 At the end of each day's work, pavement markings shall be in place on each paving lift that is open to normal traffic flow. Materials requiring removal shall be specified above, and marking configurations shall be in accordance with the Manual on Uniform Traffic Control Devices.

5.1.2 The pavement markings shall be maintained and replaced by the Contractor without additional compensation until they have served their purpose, at which time the contractor will be required to remove them.

5.1.3 Pavement markings shall be applied to clean, dry surfaces in accordance with the manufacturer's installation instructions or a method approved by the Engineer.

6.0 Method of Measurement

6.1 Linear pavement markings will be measured in linear feet complete-in-place for the width specified.

6.2 Removal or obliteration of pavement markings in construction work zones will not be measured for payment, but shall be considered incidental to the work.

7.0 Basis of Payment

7.1 Retroreflective pavement markings will be paid for at the contract unit price, which price shall be full compensation for cleaning and preparing the pavement surface, for furnishing and placing all materials, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

7.2 Payment will be made under:

7.2.1 Pay Item Pay Unit

Pavement Markings, linear (width) Linear Foot