

Specification for Durable, All Weather,
Preformed, Patterned Pavement Markings

3M™ Stamark™ High Performance All Weather Tape Series 380AW

March 2016

(SP380AW)

Market Test Specification For Durable, All Weather, Preformed, Patterned Pavement Markings

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I. **Description**

This work shall consist of furnishing and installing retroreflective preformed patterned pavement markings in accordance with this provision and in reasonably close conformance to the dimensions and lines shown on the plans or established by the engineer.

II. **Materials - General**

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 any intentional use of lead chromate pigments or other similar, lead-containing chemicals.

Preformed words and symbols shall conform to the applicable shapes and sizes as outlined in the "Manual on Uniform Traffic Control Devices for Streets and Highways."

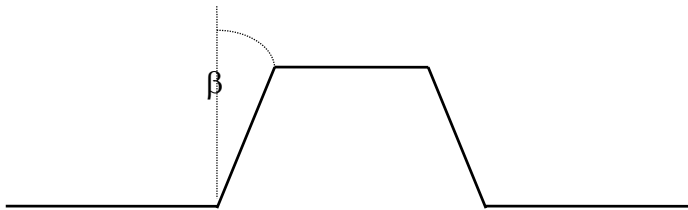
The preformed markings shall have a pre-coated pressure sensitive adhesive, and shall be capable of being adhered to properly prepared asphalt cement concrete and Portland cement concrete, when installed according to the manufacturer's application requirements. The preformed markings shall conform to pavement contours by the action of traffic. The pavement markings shall be capable of application on new, asphalt cement concrete wearing courses during the paving operation in accordance with the manufacturer's instructions. After application, the markings shall be immediately ready for traffic. The bidder shall identify proper surface preparation adhesives (where necessary) to be applied at the time of application, all equipment necessary for proper application, and requirements for application that help assure effective product performance. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's requirements.

III. Classification

The markings shall be highly durable and retroreflective pliant polymer materials designed for longitudinal and word/symbol markings subjected to high traffic volumes and severe wear conditions such as shear action from crossover or encroachment on typical longitudinal configurations such as edge lines and lane lines. The markings shall be capable of providing retroreflection during both wet and dry conditions.

IV. 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 40% \pm 15% of the surface area raised, or 40% \pm 10% of the total pavement marking volume raised, and presenting a near vertical face (β 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.



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 (R_L) and shall be expressed as millicandelas per square foot per foot-candle [$\text{mcd}/\text{ft}^2/\text{fc}$]. The metric equivalent shall be expressed as millicandelas per square meter per lux [$\text{mcd}/\text{m}^2/\text{lx}$].

Retroreflectance values shall be measured under dry conditions in accordance with the testing procedures of ASTM E1710.

Initial retroreflectance values shall be measured under wet conditions in accordance with ASTM E2832-12 or ASTM E2177 prior to installation. Wet retroreflectance values measured under a “condition of continuous wetting” (simulated rain) shall be in accordance with ASTM E2832-12. Wet retroreflectance values measured under a “condition of wetness” (wet recovery) shall be in accordance with ASTM E2177. To reduce variability between measurements, the test method shall be performed in a 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 required 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.

In-service wet retroreflectance values measured under a standard condition of continuous wetting shall be in accordance with ASTM E2832-12, and the test may be performed with the marking installed on the road. Measurements in the field shall not be made where both the cross slope and grade are less than 0.5 percent, or where the water submerges the test specimen. Newly installed markings shall be tested using a wetting agent, as previously described.

Table 1. Minimum Retroreflectivity Values

| Color | White | | Yellow | |
|--|-------------------|---|-------------------|---|
| | Dry ASTM E1710 | Wet & Rainy ASTM E2832-12 or ASTM E2177 | Dry ASTM E1710 | Wet & Rainy ASTM E2832-12 or ASTM E2177 |
| Entrance Angle ¹ | 88.76° | 88.76° | 88.76° | 88.76° |
| Observation Angle ¹ | 1.05° | 1.05° | 1.05° | 1.05° |
| Coefficient of Retroreflected Luminance [mcd/m ² /lux] | 500 | 250 | 300 | 200 |

Notes: Coefficients of retroreflected luminance when measured under ASTM E2177 will be higher than when measured under ASTM E2832-12. Stated minimum values shall be met using either test method.

English R_L : Millicandelas per square foot per foot-candle [(mcd/ft²)/fc]

Metric R_L : Millicandelas per square meter per lux [(mcd/m²)/lx]

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.

¹ Entrance Angle 88.76° and Observation Angle 1.05° represent a simulated driver viewing geometry at a 30 meter distance.

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:
 - a. 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.
 - b. 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:

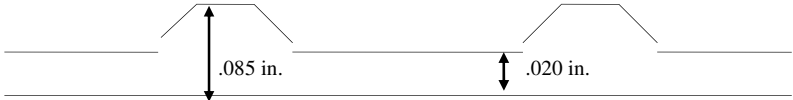
Take a 1-inch x 2-inch sample, adhere it to the bottom of a glass tray and place just enough acid solution to completely immerse the sample. Cover the tray with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution (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.

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.

Thickness: The patterned material without adhesive shall have a minimum caliper of 0.085 inches (2.159mm) 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.



V. Warranty

The manufacturer shall warrant that white and yellow pavement marking material sold for this application in the United States and Canada will remain effective for its intended use under normal traffic conditions and meet the minimum retained coefficient of dry retroreflection value of 100 millicandelas per foot squared per foot-candle (in accordance with ASTM E1710), subject to the following provisions:

**Table 2
Warranty Periods**

| Application* | Dry Retroreflectivity Warranty Period |
|-----------------------|--|
| Longitudinal Markings | 4 years |
| Symbols and Legends | 2 years |

*Applications in mountainous, heavy snowfall areas above 5,000 ft. (1,500m) are not covered by this warranty.

If the pavement markings are applied in accordance with all the manufacturer's application requirements and fail during the warranty period, fail to adhere to the roadway, or fail due to complete wear-through during the warranty period shown above (from the date of installation), the manufacturer's sole responsibility and purchaser's and user's exclusive remedy shall be:

Manufacturer will provide the replacement materials that will restore the pavement marking retroreflectivity values to warranty levels or greater.

Conditions

Such failure must be solely the result of design or manufacturing defects in the pavement marking material and not of outside causes such as improper installation or substrate failure. Failure to follow required application procedures will void this warranty.

Damage to pavement markings caused by snow removal equipment is not covered under this warranty.

A visual night inspection must be made with a manufacturer's representative and a customer representative present to identify areas of the installation which appear to be below the minimum dry retained reflectance values of 100 millicandelas per foot squared per foot-candle. Areas which appear to be below the minimum retained reflectance value shall be identified as "zones of measurement." To qualify for material replacement, follow the steps below:

Sampling and Testing Procedure for Determining Initial and Retained Coefficients of Retroreflected Luminance for Manufacturer's Warranty Purposes

Step 1: A visual night inspection must be made with a Manufacturer's representative and a customer representative present to identify areas of interest which appear to be below the specified minimum retained reflectance values. Areas of interest which appear to be below the minimum retained reflectance value shall be identified as potential zones of investigation

(“Zone of Investigation”). To qualify for a warranty claim, a Zone of Investigation must be at least 360 feet (108 meters) in road length, and shall consist of either edge lines, center lines or lane lines, but not in combination.

Step 2: Within each Zone of Investigation, reflectance measurements must be taken at specified measurement sections. The measurement procedure varies based on the total length of the Zone of Investigation, as described below.

a. Zone of Investigation Measuring 360 Feet (108 m) to 1,080 Feet (324 m) in Length

For continuous lines, reflectance measurements must be made at approximately 20 ft. (6 m) intervals throughout the Zone of Investigation. For skip lines, two measurements must be taken at two random locations on each skip throughout the Zone of Investigation.

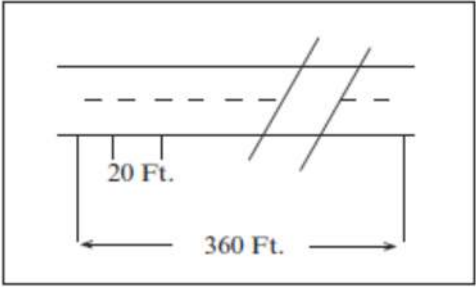


Figure 1

b. Zone of Investigation Measuring 1,080 Feet (324 m) to 6 Miles (9.6 km) in Road Length

A minimum of three measurement sections must be specified within the Zone of Investigation. Each measurement section must be at least 360ft in road length. The start point, the midpoint and the end point of the Zone of Investigation must be included in a measurement section, as shown in Figure 2. A minimum of 18 measurements must be made at each measurement section. For continuous lines, reflectance measurements must be made at 20-foot (6 m) intervals throughout each measurement section. For skip lines, two measurements must be taken at two random locations on each skip in the measurement sections.

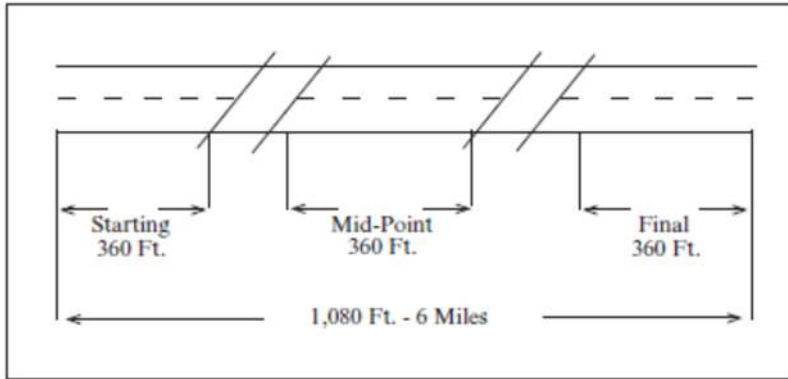


Figure 2: Measure every 20 ft. on continuous lines or 2 measurements per skip for each measurement section.

c. Zone of Investigation Greater than 6 Miles in Road Length

Each 3-mile (4.8 kilometers) interval throughout the Zone of Investigation must include at least one measurement section. In each measurement section, a minimum of 18 measurements must be made. The start point and the end point of the Zone of Investigation must be a part of a measurement section. For continuous lines, reflectance measurements must be made at 20-foot (6 m) intervals throughout each measurement section. For skip lines, two measurements must be taken at two random locations on each skip in the measurement sections.

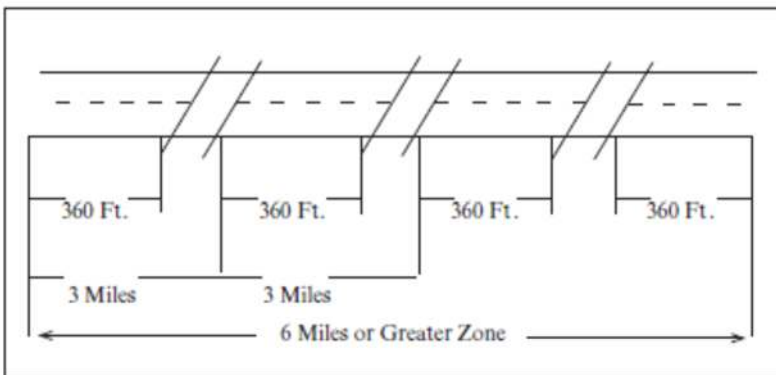


Figure 3: Measure every 20 ft. on continuous lines or 2 measurements per skip for each measurement section.

Step 3: All reflectance measurements made at the checkpoints shall be made on a clean, dry surface at a minimum temperature of 40° F (4° C). The test instrument shall use an Entrance Angle of 88.76° and an Observation Angle 1.05° which represent a simulated driver viewing geometry at a 30 meter distance.

Step 4: All reflectance measurements within the Zone of Investigation must be averaged to determine if the minimum retained retroreflectance values have been met.

VI. Installation

The markings shall be applied in accordance with the manufacturer’s installation instructions. Marking configurations shall be in accordance with the “Manual on Uniform Traffic Control Devices.”

In snow removal states, the markings should preferably be inlaid in the fresh surface during final rolling of the mat, or grooved into existing pavement surfaces in accordance with the manufacturer’s installation instructions. These markings can also be overlaid on new or existing pavement surfaces in accordance with the manufacturer’s installation instructions.

VII. Contract Units and Basis For Payment

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

Retroreflective preformed pavement markings will be paid for at the contract unit price, which 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.

Payment will be made under:

| <u>Pay Item</u> | <u>Pay Unit</u> |
|--|-----------------|
| Preformed Pavement Marking, Linear (width) | Linear Foot |
| Preformed Pavement Marking, Words/Symbols | Each |