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# METHOD OF TESTING FOR SPECIFICATION COMPLIANCE OF NON-REFLECTIVE AND RETROREFLECTIVE PAVEMENT MARKERS

**CAUTION:** Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Part 2 Section 8 of this method. It is the responsibility of whoever uses this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

## SCOPE

The following methods in the two parts of this test describe the testing procedures to be used for determining specification compliance for non-reflective and reflective pavement markers.

The non-reflective pavement marker portion of this test method is divided into the following parts:

1. Identification and Workmanship
2. Bond Strength
3. Glaze Thickness
4. Hardness
5. Luminance Factor
6. Yellowness Index
7. Color
8. Compressive Strength
9. Water Absorption

The reflective pavement marker portion of this test method is divided into the following parts:

1. Identification and Workmanship
2. Bond Strength
3. Compressive Strength
4. Water Soak Resistance
5. Color
6. Retroreflectance
7. Steel Wool Abrasion
8. Safety and Health

## PART 1. NON-REFLECTIVE PAVEMENT MARKERS

### 1. IDENTIFICATION AND WORKMANSHIP

Use visual inspection and appropriate measurements to determine if the markers are the type and have the color, shape, dimensions, tolerances, characteristic, and finish specified.

### 2. BOND STRENGTH

#### A. APPARATUS

1. Tensile testing machine with a capacity of at least 45 kN and a rate capability of 22 kN/min.

2. Bond strength test fixture as shown in Figure 1.

3. Supply of 51-mm diameter steel test plugs 55-mm long, sandblasted on one end, and with a threaded hole in the other end. A plug made from 6061 aluminum of the same dimensions may also be used.

4. Plastic gloves.

5. Paper cups, several sizes.

6. Supply of wooden tongue depressors.

7. Epoxy adhesive. Adhesive that meets the requirements in the Standard Specifications, Section 95-2.04 or 2.05 has been found to be satisfactory.

B. PROCEDURE

1. Condition test equipment, pavement markers, and adhesive at 21°C to 25°C for a minimum of four hours before testing.

2. Place a small amount of epoxy adhesive on the center of the bottom surface of the marker, and spread over an area approximately two inches in diameter. Place a thin layer of adhesive on the sandblasted surface of the plug and press down firmly onto the center of the bottom surface of the marker with a slight twisting motion. Using a tongue depressor with a squared end, carefully remove any adhesive which extrudes from under the plug. Cure the assembly for 48 hours at 25°C.

3. At the end of the 48-hour curing period, determine the bond strength using the tensile testing machine. Use the bond strength test fixture shown in Figure 1. The fixture is designed to provide uniform load distribution and can be adapted to most standard test machines. A reflective marker is shown under test in Figure 1.

4. Report results in MPa:
Bond strength (MPa) = Total Force/ Bond Area of Test Plug

FIGURE 1

## 3. GLAZE THICKNESS

A. APPARATUS

1. Microscope of at least 25 power with a calibrated reticule.

2. Hammer.

3. Power sander.

4. Supply of Eriochrome Black T (black dye).

5. Hydrofluoric acid, 48 %, See Hazard in Part 2, Section 8.

B. PROCEDURE

1. Use hammer to break pavement marker into fragments small enough to be viewed under a compound microscope and select a fragment, preferably wedge shaped with a tapered edge, for test. The area selected for measurement must be at least 6 millimeters from the edge of marker. Grind the glazed tapered edge smooth and flat using a power

sander with fine textured abrasive belt. In most cases the edges of the glaze will then be clearly delineated when viewed through the microscope, and no further preparation of the specimen will be necessary. When the glaze is not sharply defined, or for referee method purposes, use the following procedure to prepare the specimen for test.

2. Etch the area which has been ground smooth and flat with hydrofluoric acid for approximately thirty seconds. Wash thoroughly and dry. Apply a drop of Eriochrome Black T (black dye) to the etched surface; let stand for ten seconds and wipe off the excess stain. The body of the marker will absorb the dye, leaving glaze unmarked and well defined.

3. Mount specimen under microscope and measure glaze thickness with calibrated reticule using a minimum magnification of twenty-five. Proper lighting is important.

## 4. HARDNESS

### A. APPARATUS

Moh's scale of relative hardness pencils, #6 orthoclase.

### B. PROCEDURE

Moh Hardness: Determine the Moh hardness of the glazed surface of the marker relative to the mineral orthoclase, which has a hardness of 6. Using moderate hand pressure, it must not be possible to scratch the glazed surface of the marker with orthoclase.

## 5. LUMINANCE FACTOR

### A. APPARATUS

Spectrophotometer with 45/0 (0/45) geometry.

### B. PROCEDURE

Test the top of the convex glazed surface of the pavement markers in accordance with ASTM Designation: E 1349. Measure with CIE Illuminant C and 1931 CIE 2 degree standard observer. Report Daytime luminance factor, Y %.

## 6. YELLOWNESS INDEX

### A. APPARATUS

Spectrophotometer described in Section 5, A of this specification.

### B. PROCEDURE

Test the glazed surface of the white marker in accordance with ASTM Designation: E 313.

## 7. COLOR-YELLOW

### A. APPARATUS

Spectrophotometer described in Section 5, A of this specification.

### B. PROCEDURE

1. On the top surface of the marker, measure the chromaticity coordinates (x,y) with CIE Illuminant C and 1931 CIE 2 degree standard observer.

2. Plot the coordinates on a CIE 1931 Standard Colorimetric System graph. They should fall within a box whose corner points are defined by the four pairs of chromaticity coordinates below.

| x | y |
|---|---|
| 0.451 | 0.458 |
| 0.481 | 0.429 |
| 0.545 | 0.464 |
| 0.495 | 0.500 |

### 8. COMPRESSIVE STRENGTH

A. APPARATUS

1. Compression testing machine with a capacity of at least 22 kN and a rate capability of 5-mm per minute.

2. Steel ring, 25-mm high, 75-mm internal diameter and a 6-mm wall.

3. Solid metal plug, 25.4 mm in diameter and 25-mm high.

4. Protective eye glasses or shield.

B. PROCEDURE

1. Place the steel ring in the testing machine and center the marker base down upon the ring.

2. Center the solid metal plug on top of the marker.

3. At a rate of 5-mm per minute, apply the load necessary to break the marker. Use protective eyeglasses or shield. Report the load in kN.

### 9. WATER ABSORPTION

Test in accordance with ASTM Designation: C 373 with the following exception. Specimens selected for the water absorption test shall be whole markers and the glaze shall not be removed.

## PART 2. RETROREFLECTIVE PAVEMENT MARKERS

### 1. IDENTIFICATION AND WORKMANSHIP

Same as Part 1.

### 2. BOND STRENGTH

Same as Part 1.

### 3. COMPRESSIVE STRENGTH

A. APPARATUS

Same as Part 1, Section 8.

B. PROCEDURE

Same as Part 1, Section 8. In addition to the 8.9 kN minimum load specified in the California Standard Specifications, failure of a marker shall also consist of, (1) significant deformation of the marker at a load of less than 8.9 kN or, (2) significant delamination of the shell and the filler material regardless of the load required to break the marker.

NOTE: Significant deformation is defined as more than 3 mm.

### 4. WATER SOAK RESISTANCE

Immerse pavement markers in water, maintained at (35° ± 3°C) for 48 hours. Then remove from water and immediately examine the marker for any delamination or loss of retroreflectance as determined in accordance with Section 6, Retroreflectance.

### 5. COLOR

Use visual comparison with a previously approved reference marker to determine that the color(s) of the reflectors when illuminated are as specified.

### 6. RETROREFLECTANCE

A. APPARATUS

1. Reflex photometer with power supply, output meter, appropriate color filters, goniometer, pavement marker mount, and miscellaneous fixtures, as needed.

2. Reference reflective pavement marker to determine the specific intensity of the reference reflective marker, see the calibration procedure in Sections A and B of the following procedure.

B. PROCEDURE

1. Remove the reference marker to be used from its protective storage and place it in the photometer on the pavement marker fixture at the 1.52-meter test distance and 0° entrance angle.

2. Set the output meter to approximately the specific intensity of the reference marker.

3. Remove reference marker and push Relative button "on". Replace reference marker and using the rear (nearest to the light source) adjustable iris, set the output meter to the reading indicated on marker. Remove and replace reference marker a few times to check placement and meter settings. The meter will now indicate the specific intensity of the markers to be tested as a direct reading.

   a. Reference reflective marker calibration procedure (Clear Reflector).

      (1) Open both irises to full open position.

      (2). Set the marker fixture aside and, leaving all settings as is, remove the photocell assembly from its normal position near the lamp end of the Photometer and mount it on the goniometer at the 1.52-meter distance, 0° entrance angle, using the fixture supplied for this purpose. Record the meter reading.

      (3) Return the photocell to its normal position, remove the goniometer and replace the marker fixture, leaving the lamp settings as is.

      (4) Push the Reference button "on". The meter should now read zero. Place the marker on the fixture and record the reading. Calculate the specific intensity ($S_x$) of the marker using the equation:

$$S_x = (R/C)\, D^2$$

Where:

R = meter reading of the reflector

C = meter reading of the photocell

D = test distance

   b. Reference reflective marker calibration procedure (Color Reflector)

      1. Follow the same procedure outlined in Calibration Procedure (Clear Reflector) (Section A) with the following exceptions:

      a. In paragraph 2, place a filter of the proper color in front of the photocell.

      b. In paragraph 4, if the reflector and the photocell are read at the same distance (D) the specific intensity ($S_x$) is calculated using the equation:

$$S_x = (R/C)\, D^2K$$

Where:

K = Transmission Factor of the color filter.

   c. Special Note: If it is necessary to determine the reflectance of a single or several markers for

which there is no "Standard" available, a "Standard" of approximately the same size and specific intensity can be used in conjunction with the following equation and previously discussed procedures to calculate the unknown markers' specific intensity ($S_x$):

$$S_x = S_r (X/R)$$

Where:

$S_r$ = known specific intensity of the "Standard' reflector.

X = meter reading of the unknown reflector

R = meter reading of the "Standard" reflector.

## 7. STEEL WOOL ABRASION PROCEDURE

### A. APPARATUS

1. Number 3, course steel wool.

2. Abrasion apparatus that can apply a 22-kg load to a 25-mm diameter steel plug. It would allow the operator to pass the pad back and forth over the lens surface, see Figure 2.

FIGURE 2

### B. PROCEDURE

1. Measure the retroreflectance of the lens surface to be tested in accordance of Part 2, Section 6.

2. Form a 25-mm diameter flat pad with the steel wool. Place the steel wool pad on the reflector lens. Apply a load of 22 kg and rub the entire lens surface 100 times. Change the steel wool pad after testing each marker.

3. Measure the retroreflectance of the abraded surface.

NOTE: On two color units the red lens may not be abrasion resistant and if so should not be abraded.

## 8. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual.

Hazards: Hydrofluoric acid is highly corrosive. It is highly irritating to the skin (a burn might not be visible or painful immediately) and the respiratory tract. Read the directions and precautions on the label before using. Wear protective clothing and equipment. Store in a cool, ventilated location. Hydrofluoric acid will react with water or steam to produce poisonous and corrosive fumes.

**REFERENCES:**

ASTM Designation: C 373
ASTM Designation: D 2240
ASTM Designation: E 1349
ASTM Designation: E 313
California Test 660
Caltrans Laboratory Safety Manual

End of Test
(California Test 669 contains 6 pages)