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DIVISION OF ENGINEERING SERVICES
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METHOD OF TEST FOR NON-REFLECTIVE AND RETRO-REFLECTIVE 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 15 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.

A. SCOPE

The following procedures describe the testing for determining specification compliance for non-reflective and retro-reflective pavement markers.

The nonreflective 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. Daytime Luminance Factor
6. Yellowness Index
7. Color-Yellow
8. Compressive Strength
9. Water Absorption
10. Artificial Weathering

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

11. Compressive Strength
12. Water Soak Resistance
13. Retro-reflectance
14. Steel Wool Abrasion
15. Safety and Health

B. REFERENCES

- California Test 660 — Evaluating Color by Means of Chromaticity Coordinates
ASTM C 373 — Water Absorption, Bulk Density, Apparent Porosity and Apparent Specific Gravity of Fired White Ware Products
ASTM E 313 — Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates
ASTM G 155 — Operating Xenon ARC Light Apparatus for Exposure of Non-Metallic Materials
Caltrans Laboratory Safety Manual, Standard Specifications

NONREFLECTIVE PAVEMENT MARKERS

PART 1. IDENTIFICATION AND WORKMANSHIP

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

PART 2. BOND STRENGTH

1A. APPARATUS

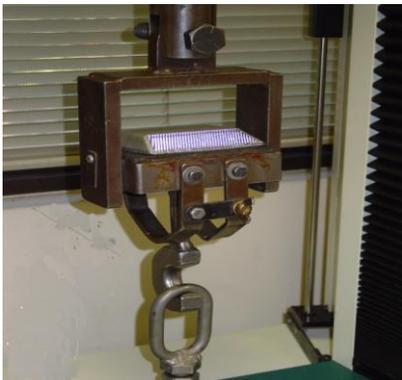
1. Tensile testing machine with a capacity of at least 10,000 pounds-force and a rate capability of 5,000 pounds per min.
2. Bond strength test fixture as shown in Figure 1.
3. Two-inch diameter aluminum test plugs, 2-¼ inch long, sandblasted on one end, and with a threaded hole in the other end.
4. A hook welded to a threaded rod. This is screwed into the test plug and the hook connects to the tensile testing machine.
5. Plastic gloves.
6. Paper cups, several sizes.
7. Wooden tongue depressors.
8. Epoxy adhesive

1B. PROCEDURE

1. Condition test equipment, pavement markers, and adhesive at 23°C ± 2°C for a minimum of four hours before testing.
2. Place a small amount of mixed epoxy adhesive on the center of the bottom surface of the marker and spread over an area approximately 2 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 that extrudes from under the plug. Cure the assembly for 48 hrs at 25°C.
3. At the end of the 48 hr 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 psi:

Bond strength (psi) = Total force / Bond area of test plug.

FIGURE 1



PART 3. GLAZE THICKNESS

3A. APPARATUS

1. Microscope with a power of at least 25 times and a calibrated reticule.
2. Hammer.
3. Power sander with a fine textured abrasive belt.
4. Supply of Eriochrome Black T (black dye).
5. Hydrofluoric acid, 48 %

3B. 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 $\frac{1}{4}$ inch from the edge of marker. Grind the glazed tapered edge smooth and flat using the power sander. 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 that has been ground smooth and flat with hydrofluoric acid for approximately 30 s. See hazard statement in Part 15 and read Safety Data Sheet for hydrofluoric acid. Wear appropriate personal protective equipment. Rinse thoroughly and dry. Apply a drop of Eriochrome Black T (black dye) to the etched surface; let stand for 10 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 25x.

PART 4. HARDNESS

4A. APPARATUS

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

4B. 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.

PART 5. DAYTIME LUMINANCE FACTOR

5A. PROCEDURE

Test the top of the convex surface of the pavement marker in accordance with California Test 660. Report daytime luminance factor, Y (%).

PART 6. YELLOWNESS INDEX

6A. PROCEDURE

Test the top of the convex surface of the white pavement marker in accordance with California Test 660. Report the yellowness index.

PART 7. COLOR-YELLOW

7A. PROCEDURE

1. Measure the chromaticity coordinates (x, y) of the top surface of the marker in accordance with California Test 660.
2. Plot the coordinates on a chromaticity diagram in accordance with the 1931 CIE Standard Colorimetric System. They should fall within a box whose corner points are defined by the four pairs of chromaticity coordinates below.

\bar{x}	\bar{y}
0.451	0.458
0.481	0.429
0.545	0.464
0.495	0.500

PART 8. COMPRESSIVE STRENGTH

8A. APPARATUS

1. Compression testing machine with a capacity of at least 5,000 pounds.
2. Steel ring, 1 inch high, 3 inches internal diameter and a $\frac{1}{4}$ inch wall.
3. Solid metal plug, 1 inch in diameter and 1 inch high.
4. Protective eyeglasses or shield.

8B. 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 0.2 inches per min, apply the load necessary to break the marker. Use protective eyeglasses and shield. Report the load in pounds-force.

PART 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 10. ARTIFICIAL WEATHERING

10A. APPARATUS

Xenon Arc light apparatus, meeting the requirements in ASTM Designation: G 155. Use the light and condensate cycle described in Cycle 1 of Table X3.1.

10B. PROCEDURE

1. Measure the initial yellowness index on the top surface of the white marker according to Part 6 of this test method.
2. Expose the top surface of the marker for 500 hrs in the Xenon Arc apparatus.
3. Measure and record the yellowness index of the top surface of the marker after exposure.

RETROREFLECTIVE PAVEMENT MARKERS

Identification, workmanship and bond strength are performed as for non-reflective markers, Part 1 and 2 of this method.

PART 11. COMPRESSIVE STRENGTH

11A. PROCEDURE

1. Test in accordance with Part 8, non-reflective pavement markers.
2. In addition to the 2,000 pounds-force minimum load specified in the Standard Specifications, failure of a marker could also consist of:
 - a. Significant deformation (greater than $\frac{1}{8}$ inch) of the marker at a load of less than 2,000 pound-force.
 - b. Significant delamination of the shell and the filler material regardless of the load required to break the marker.

PART 12. WATER SOAK RESISTANCE

12A. APPARATUS

Apparatus to hold water and markers for conditioning at 35°C.

12B. PROCEDURE

1. Immerse pavement markers in the water bath, maintained at $(35^{\circ} \pm 3^{\circ}\text{C})$ for 48 hrs.
2. Remove from water and immediately examine the marker for any delamination or otherwise deleterious effects.
3. Measure the retroreflectance in accordance with Part 13 of this test method. Any significant loss of reflectance shall be cause for rejection.

PART 13. RETROREFLECTANCE

13A. 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 13B-4.A and B of the following procedure.

13B. 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 5 foot 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.
4. Place markers to be tested in the photometer and record the specific intensity.

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 5 foot 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 (colored 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:

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

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

PART 14. STEEL WOOL ABRASION PROCEDURE

14A. APPARATUS

1. Number 3 course steel wool.
2. Abrasion apparatus that can apply a 50-pound load to a 1-inch diameter steel plug. It would allow the operator to pass the steel wool pad back and forth over the lens surface, see Figure 2.

FIGURE 2



14B. PROCEDURE

1. Measure the retroreflectance of the lens surface to be tested in accordance with Part 13 of this test method.
2. Form a 1-inch diameter flat pad with the steel wool. Place the steel wool pad on the reflector lens. Apply a load of 50 pounds to the steel wool pad and rub the entire lens surface 100 times. Change the steel wool pad after testing each marker.
3. Wipe off any dust from the lens and 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.

PART 15. SAFETY AND HEALTH

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, tester must be knowledgeable about safe laboratory practices hazards and exposure, chemical procurement and storage and personal protective apparel and equipment.

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.

Caltrans Laboratory Safety Manual is available at:

<http://dot.ca.gov/>

**End of Text
(California Test 669 contains 8 pages)**