
Standard Method of Test for Detectable Warning Systems

AASHTO Designation: T 388-22¹

Technically Revised: 2022

Technical Subcommittee: 4d, Safety Devices



**American Association of State Highway and Transportation Officials
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INTRODUCTION

The use of detectable warning systems at curb cuts and vehicular ways is mandated as part of the Americans with Disabilities Act. These detectable warning systems are subject to a variety of environmental conditions that can lead to material degradation and reduction in performance. In extreme cases, degradation may occur such that the detectable warning systems become a hazard to pedestrians—for example, by becoming a tripping or slip hazard.

This method provides a protocol for testing the durability of detectable warning systems in a repeatable manner. Laboratory exposures and evaluation tests were developed to simulate the types of damage and degradation anticipated in service. Exposures are conducted cyclically to allow for effects of combined interaction of the simulated environmental exposures.

Nondestructive evaluation tests are conducted both before and after exposures to provide comparative values. Destructive evaluation tests are conducted after the exposures.

The primary objective of this test method is to provide a repeatable set of tests that can be conducted specifically to evaluate durability of detectable warning systems. Each test is suitable for use with any type of detectable warning system, regardless of the material composition or method of attachment. Specimens are attached to concrete slabs to provide a test of the detectable warning system/sidewalk system. Data produced following this method is anticipated to be used for purposes of determining product durability and product comparison.

1. SCOPE

1.1. This method of test covers the specimen fabrication, testing protocols, and laboratory-accelerated weathering of detectable warning systems for the purposes of evaluating durability. This method of test covers the following categories:

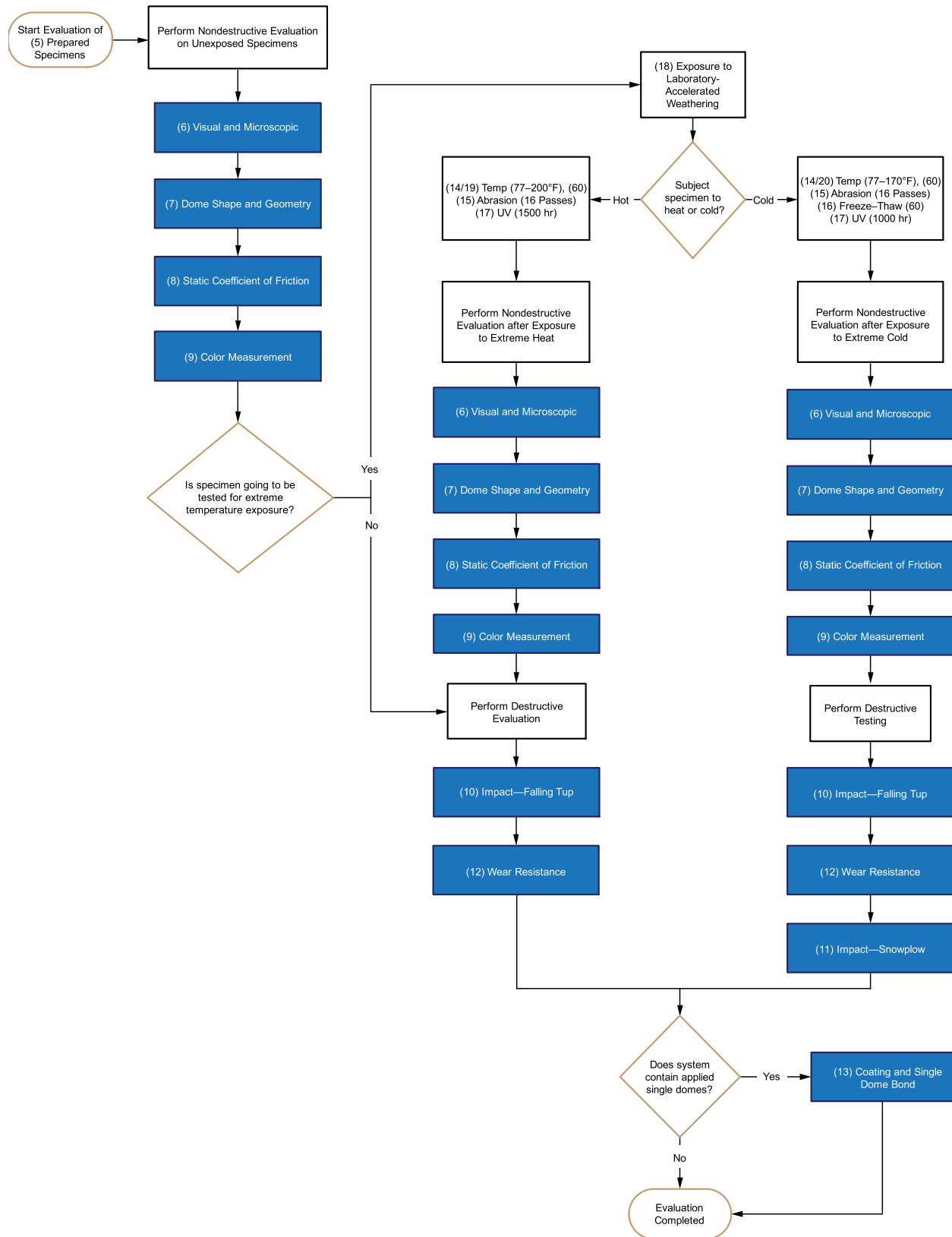
1.1.1. *Non-Destructive Evaluation Tests:*

- Visual and Microscopic Evaluation (Section 6)
- Dome Shape and Geometry Measurement (Section 7)
- Static Coefficient of Friction Measurement, Dry and Wet (Section 8)
- Color Measurement (Section 9)

1.1.2. *Destructive Evaluation Tests:*

- Resistance to Impact from Falling Tup (Section 10)
- Resistant to Impact from Simulated Snowplow Blade (*Cold Exposure*) (Section 11)
- Wear Resistance (Section 12)
- Coating and Single Dome Bond Strength (*Systems with Coatings or Surface-Applied Single Domes*) (Section 13)

- 1.1.3. *Laboratory-Accelerated Weathering—Exposure Regime (Hot and Cold Exposure Categories):*
- High Temperature Thermal Cycling (Section 14)
 - Abrasion Exposure (Section 15)
 - Freeze–Thaw Durability (*Cold Exposure Applications only*) (Section 16)
 - Ultraviolet Light Exposure (Section 17)
- 1.1.4. Figure 1 illustrates the suite of tests that are available to evaluate the durability of detectable warning systems.



Note: Numbers in parentheses indicate the section where the evaluation is explained.

Figure 1—Flowchart for Detectable Warning Systems

- 1.2. The values stated in SI units are to be regarded as the standard.
- 1.3. *This standard method of test may involve hazardous materials, operations, and equipment. It does not purport to address all safety problems associated with its use. It is the responsibility of the user of this standard practice to establish the appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*
- 1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of [R 18](#) are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with [R 18](#) alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of [R 18](#) or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:

- [M 339M/M 339](#), Thermometers Used in the Testing of Construction Materials
- [R 18](#), Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- [R 39](#), Making and Curing Concrete Test Specimens in the Laboratory
- [T 22M/T 22](#), Compressive Strength of Cylindrical Concrete Specimens
- [T 119M/T 119](#), Slump of Hydraulic Cement Concrete
- [T 152](#), Air Content of Freshly Mixed Concrete by the Pressure Method

2.2. ASTM Standards:

- [D1056](#), Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber
- [D2244](#), Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
- [D4541](#), Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
- [E1](#), Standard Specification for ASTM Liquid in Glass Thermometers
- [E18](#), Standard Test Methods for Rockwell Hardness of Metallic Materials
- [E230/E230M](#), Standard Specification for Temperature Electromotive Force (emf) Tables for Standardized Thermocouples
- [E2877](#), Standard Guide for Digital Contact Thermometers
- [G151](#), Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
- [G154](#), Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

2.3. Federal Regulation:

- *Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines*, July 23, 2004, United States Access Board.

2.4. International Electrotechnical Commission Standard:

- IEC 60584 1: 2013 Thermocouples Part 1: EMF Specifications and Tolerances

3. TERMINOLOGY

3.1. Definitions:

- 3.1.1. *cast-in-place*—a detectable warning system that is cast into plastic concrete.
- 3.1.2. *surface applied*—a detectable warning system that is applied to the surface of cured concrete.
- 3.1.3. *exposure regime*—a series of tests subjecting the detectable warning system specimens to simulated environmental exposure, including high-temperature thermal cycling, abrasion, freeze–thaw, and ultraviolet light.
- 3.1.4. *evaluation test*—tests evaluating the performance of the detectable warning systems. These tests include visual and microscopic evaluation, dome shape and geometry measurement, dry and wet static coefficient of friction measurement, color measurement, resistance to impact from falling tup, resistance to impact from simulated snowplow blade, wear resistance, and bond strength tests.
- 3.1.5. *non-destructive evaluation test*—evaluation tests that do not require any destruction of the sample. These tests are visual and microscopic evaluation, dome shape and geometry measurement, dry and wet static coefficient of friction measurement, and color measurement.
- 3.1.6. *destructive evaluation test*—evaluation tests that involve partial destruction of the sample. These tests include resistance to impact from falling tup, resistance to impact from simulated snowplow blade, wear resistance, and bond strength tests.
- 3.1.7. *hot exposure category*—a category indicating a set of exposure conditions intended to simulate exterior environments with hot summer weather and with little to no freezing weather during the winter.
- 3.1.8. *cold exposure category*—a category indicating a set of exposure conditions intended to simulate exterior environments with slightly cooler summer weather and with freezing weather during the winter.
- 3.1.9. *irradiance*—a measure of power flux. For this method, irradiance is measured over a narrow bandwidth of the peak wavelength for the ultraviolet lights used.
- 3.1.10. *dome*—the truncated dome on the detectable warning system.
- 3.1.11. *field*—the space between the domes on the detectable warning system. The field is level with the surrounding concrete.
- 3.1.12. *surface-applied single dome*—a single truncated dome that is adhered to a concrete substrate as part of an array of separately applied domes composing a detectable warning system.

4. SIGNIFICANCE AND USE

- 4.1. This test method is intended to evaluate durability of detectable warning systems that are attached to concrete slabs.
- 4.2. Results obtained are intended to provide data that can be used to determine and compare the durability of detectable warning system products.

5. FABRICATION OF TEST SPECIMENS

- 5.1. Test specimens consist of nominally 0.6-by-0.6-m (2-by-2-ft) areas of the detectable warning system applied to concrete slabs following manufacturer's instructions.
- 5.2. *Number of Specimens:*
- 5.2.1. Two specimens of each type of detectable warning system are required for exposure and evaluation testing.
- 5.2.2. If required, an additional specimen can be fabricated for additional destructive evaluation testing of the unexposed specimen.
- 5.3. *Detectable Warning Systems:*
- 5.3.1. A sufficient number of units of each type of detectable warning system is required to cover a nominal area of 0.6 m by 0.6 m (2 ft by 2 ft) for at least two, or more if required, test specimens.
- 5.3.1.1. If the smallest available unit of the detectable warning system undergoing testing is larger than 0.6 m by 0.6 m (2 ft by 2 ft), cut the detectable warning system to produce a nominally 0.6-m-by-0.6-m (2-ft-by-2-ft) sample. Report the fact that the samples were cut as a deviation from the test method during each subsequent test method. Consider the potential effect of this cut on system performance when selecting domes for evaluation tests.
- 5.3.2. Any required method of attachment, including bolts, anchors, adhesives, or other attachment mechanisms.
- 5.4. *Cement Concrete Slabs ("Slabs"):*
- 5.4.1. The slabs for use in the method shall be made in accordance with the applicable requirements of [R 39](#).
- 5.4.2. Slabs shall measure a minimum of 0.86 m by 0.86 m by 0.1 m high (34 in. by 34 in. by 4 in. high).
- 5.4.3. Slabs shall be reinforced with a minimum 6 by 6—W6 by W6 welded wire reinforcing supported on 13-mm ($\frac{1}{2}$ -in.) bolsters.
- Note 1**—It has been found to be useful to place additional reinforcing bars around the perimeter of the sample. Additional or supplementary reinforcement is optional.
- 5.4.4. *The cement concrete mix used to fabricate the slabs shall meet the following specifications:*
- 5.4.4.1. 359 kg of Type I portland cement per m^3 of concrete (605 lb/yd³).
- 5.4.4.2. Maximum aggregate size of 19 mm ($\frac{3}{4}$ in.).
- 5.4.4.3. Slump of 100 to 150 mm (4 to 6 in.) when tested according to [T 119M/T 119](#).
- 5.4.4.4. Minimum compressive strength of 24 MPa (3,500 psi) at 14 days when tested according to [T 22M/ T22](#).
- 5.4.4.5. Five to 8 percent entrained air when tested according to [T 152](#).

- 5.4.5. The slabs shall be fabricated with thermocouples placed according to Section 14, “High-Temperature Thermal Cycling.” These thermocouples can be cast into the slab, or can be installed after curing of the slab.

Note 2—It has been found useful to cast lifting inserts into the concrete slabs near the edges to facilitate moving the slabs during the testing process.

- 5.5. *For cast-in-place detectable warning systems:*

- 5.5.1. Fill an appropriately sized form with plastic cement concrete, strike off the surface, consolidate with a hand vibrator, finish to an even surface with floats, and set the detectable warning system in the concrete according to manufacturer’s instructions while the concrete is still plastic.

- 5.5.2. Center the detectable warning system in the form, leaving a uniform concrete border on all sides of the detectable warning system.

- 5.5.3. Edge finish around the perimeter of the form.

- 5.5.4. Do not edge finish around the perimeter of the detectable warning system.

- 5.5.5. The final finish shall be done with a wooden float, leaving an even surface. Steel trowels shall not be permitted. After the water sheen has disappeared, the surface shall be given a final finish by brushing with a whitewash brush.

- 5.5.6. Moist cure the concrete according to [R 39](#) for a minimum of 14 days.

- 5.5.7. Provide a unique marking to the slab for future identification. Ensure the marking is able to sustain the laboratory-accelerated weathering exposure regime (Note 3).

- 5.6. *For surface-applied detectable warning systems:*

- 5.6.1. Fill an appropriately sized form with concrete, strike off the surface, consolidate with a hand vibrator, and finish to an even surface with floats.

- 5.6.2. Finish the concrete in the area to receive the detectable warning system as directed by the manufacturer’s instructions.

- 5.6.3. Moist cure the concrete according to [R 39](#) for a minimum of 14 days.

- 5.6.4. Apply the detectable warning system to the cured concrete slabs according to the manufacturer’s instructions.

- 5.6.5. Provide a unique marking to the slab for future identification (Note 3).

Note 3—A permanent-ink marker has been found suitable for providing markings on the specimens. It is recommended that both the top surface and side of the detectable warning system specimen be marked.

NON-DESTRUCTIVE EVALUATION TESTS

6. VISUAL AND MICROSCOPIC EVALUATION

- 6.1. *Scope:*

6.1.1. This test method covers visual and microscopic evaluation of detectable warning systems. Visual and microscopic evaluation provide a method to determine the effects of laboratory-accelerated weathering on detectable warning system specimens that are not readily measured with other standard tests.

6.2. *Summary of Test Method:*

6.2.1. This test method describes how to conduct a visual and microscopic evaluation of detectable warning systems.

6.3. *Significance and Use:*

6.3.1. Visual and microscopic evaluation provides a means to evaluate any degradation of a detectable warning system as a result of laboratory-accelerated weathering. Visual and microscopic evaluation is intended to be carried out prior to laboratory weathering and upon completion of the weathering, prior to any further evaluation.

6.4. *Apparatus*—A hand lens or portable microscope, capable of magnifications of 10X to 30X.

6.5. *Procedure:*

6.5.1. Visually examine each test specimen for any defects or unusual features, which may include cracks, dents, divots, discolorations, or other features. Also examine the specimens for irregularities in the attachment of the detectable warning system to the slab, such as debonding or displacement of the detectable warning system. Some defects or features may not be apparent on an unexposed specimen, but may become apparent as a result of the test exposures. (See Appendix X1 for additional information regarding types of degradation.)

6.5.2. Examine the overall specimen from a sufficient distance to observe the entire specimen at once.

6.5.3. Examine the specimen from a distance of 15 to 45 cm (6 to 18 in.) from several angles to ensure that all features are observed.

6.5.4. Identify observed features with a contrasting marker and document the locations for future reference.

6.5.5. Photograph the sample. Take one overall photograph of the sample and the concrete. Additional close-up photographs of any particular features that are observed are recommended.

6.5.6. Select two areas, each approximately 2.5 cm by 2.5 cm (1 in. by 1 in.), for microscopic examination. Examine these areas with a hand lens or microscope, with magnifications of 10X to 30X.

6.5.7. Record a micrograph of each area for future reference.

6.5.8. Document the areas examined in the project notes and record any observations.

Note 4—For some detectable warning systems, applying dye or ink to the areas examined, then rapidly removing excess from the surface, is a good way to highlight microcracks and other surface features.

Note 5—If multiple people will be carrying out the visual and microscopic examinations, it is helpful if all observers conduct examinations together on at least one sample and compare their observations to ensure that similar results are produced.

6.6. *Report the following:*

- 6.6.1. Exposure level, if any, prior to the visual and microscopic examination;
- 6.6.2. Description of defects and features observed visually and location on the specimen;
- 6.6.3. Description of defects and features observed microscopically and location on the specimen; and
- 6.6.4. Any changes from prior evaluations of the same specimen, if applicable.

7. DOME SHAPE AND GEOMETRY MEASUREMENT

7.1. *Scope:*

- 7.1.1. This test method covers the measurement of dome shape and geometry of detectable warning systems. The Americans with Disabilities Act Accessibility Guidelines (ADAAG) provides geometric recommendations for the domes and dome spacing of detectable warning systems. This evaluation is intended to provide a basis for quantifying potential changes in dome shape and geometry as the result of laboratory-accelerated weathering.

7.2. *Summary of Test Method:*

- 7.2.1. This method is used to measure the geometry of the domes on a detectable warning system, and to compare the measured values to a specification or to another sample.

7.3. *Apparatus:*

- 7.3.1. Calipers, either dial or digital, 250-mm (6-in.) span.
- 7.3.2. *Depth Gauge*—The depth gauge consists of a gauge plate and a dial gauge. The gauge plate shall be a flat square plate, measuring a minimum of 75 mm by 75 mm (3 in. by 3 in.), with a hole in the center for a dial gauge. The dial gauge shall have a minimum travel of 12 mm (0.5 in.), measure to a precision of 0.25 mm (0.01 in.), and have a tapered measuring point that does not penetrate the detectable warning system surface.

7.4. *Calibration:*

- 7.4.1. Zero calipers in a closed position.
- 7.4.2. Zero the depth gauge against a flat surface.

7.5. *Procedure:*

- 7.5.1. Use the calipers to measure the dome base (bottom) diameter, dome top diameter, and the base-to-base spacing of nearest domes. Figure 2 provides a schematic of the measurements to be made, and the current ADAAG recommendation. Measure these values on four different domes. Mark the domes measured on a data sheet.

Note 6—For the purposes of this evaluation test, the diameter of the top and base (bottom) of some domes is not clearly delineated from the sides. In these cases, the measurement should be taken from the location that most closely appears to be the point of greatest change in the curvature of the dome.

- 7.5.2. The depth gauge is used to measure dome heights. Place the gauge plate over four domes and measure the distance between the gauge plate and the main surface of the field (see Note 7). Measure the depth of four different areas. Mark the locations measured on a data sheet.

Note 7—For the purposes of this evaluation test, the measured height of the dome includes any texture or any features that may provide static coefficient of friction on the top surface of the dome. For specimens with features on the field, such as discrete conical features regularly arranged on the field, the tapered measuring point of the dial gauge will measure the flat area of the field. Therefore, the measurement may include surface features on the dome tops, but not on the field.

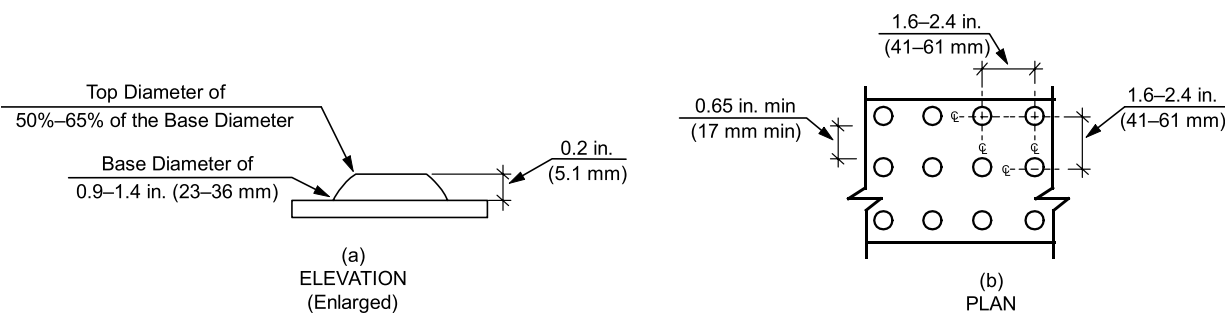


Figure 2—ADAAG Dome Dimensions²

- 7.6. *Calculation of Results:*
- 7.6.1. Calculate the center-to-center spacing by adding one dome base diameter to the base-to-base spacing of nearest domes.
- 7.7. *Report the following:*
- 7.7.1. The dome base (bottom) diameter, dome top diameter, base-to-base spacing, calculated center-to-center spacing, and dome height for each location measured; and
- 7.7.2. For exposed specimens, calculate the change in dimensions from those obtained on the unexposed specimen.

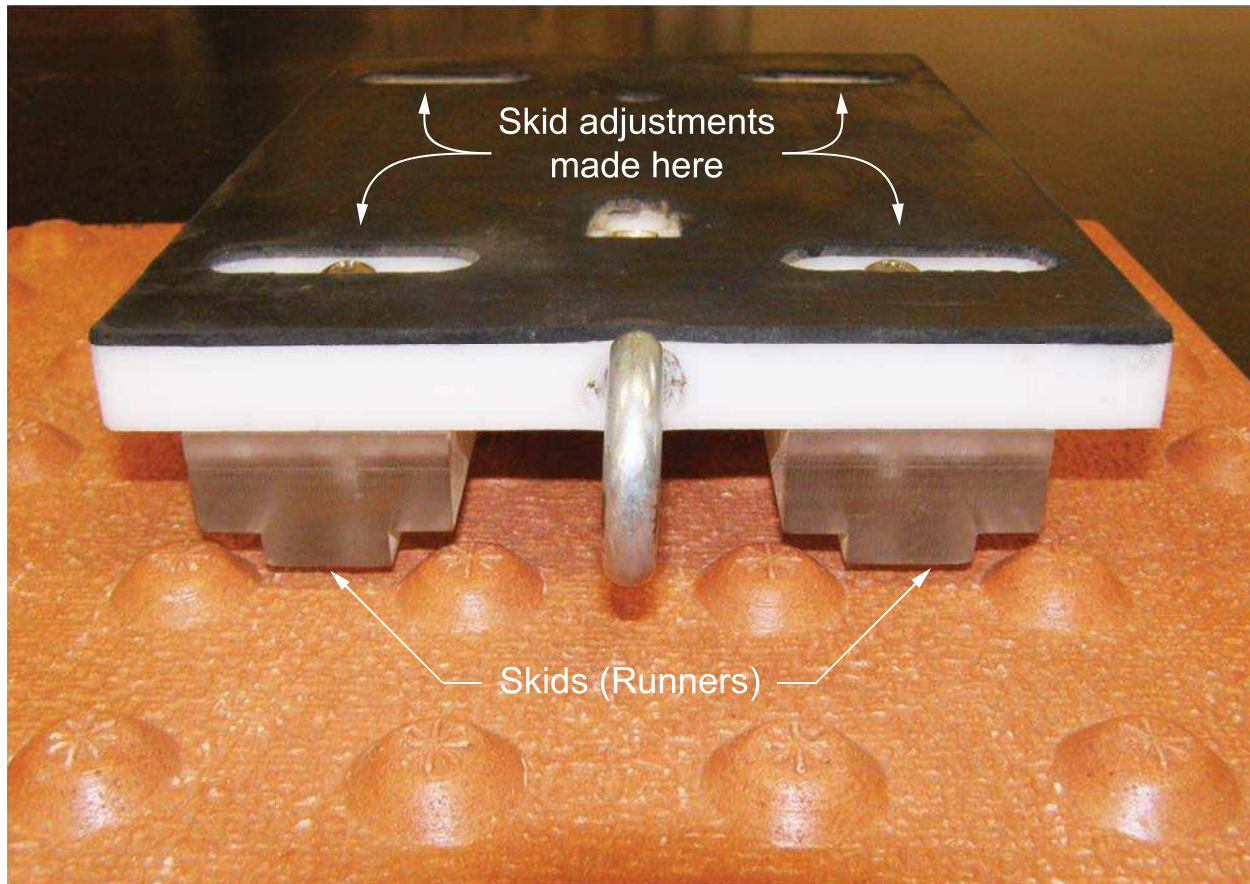
8.

STATIC COEFFICIENT OF FRICTION MEASUREMENT

- 8.1. *Scope:*
- 8.1.1. This test method covers the measurement of static coefficient of friction of detectable warning systems under both wet and dry conditions. In use, detectable warning systems are placed as outdoor walking surfaces, often on inclined planes. Consequently, the surface must be resistant to slip. This method is applicable for use in evaluating the dry and wet static coefficient of friction of detectable warning systems as part of a laboratory testing program.
- 8.2. *Summary of Test Method:*
- 8.2.1. This method evaluates the dry and wet static coefficient of friction of detectable warning systems that have and have not been exposed to the laboratory-accelerated weathering. Static coefficient of friction is determined by the horizontal force required to move the sled assembly from a position of rest on the detectable warning system.
- 8.3. *Significance and Use:*
- 8.3.1. This evaluation method is intended to measure the dry and wet static coefficient of friction of detectable warning systems that are cast or surface applied into concrete.

8.4. *Apparatus*—The sled assembly consists of a plate, feet, a pull chain, and a force gauge. Two sleds are required; one to be used for each of the wet and dry conditions.

8.4.1. *Static Coefficient of Friction Sled*—A photo of the static coefficient of friction sled is shown in Figure 3.



Note: Skids (runners) are adjustable to test between and on top of the domes. The 1/8-in. thick Neolite® heel material is attached to the bottom of the skids with contact adhesive (not visible in photo).

Figure 3—Neolite® Sled Assembly, Static Coefficient of Friction

8.4.1.1. *Feet*—Two feet are used on the sled. Two assemblies are used, constructed from 200- by 200- by 19-mm (8- by 8- by 3/4-in.) 6061-T6 aluminum plate, with two adjustable skids (runners) measuring 19 mm by 150 mm (3/4 in. by 6 in.) of sufficient height to clear the domes. The skids need to be adjustable to permit testing between as well as on top of the domes. The 3-mm (1/8-in.) thick Neolite® is attached to the adjustable skids with contact adhesive. An example of a Neolite® Sled Assembly is shown in Figure 3. Sections 8.4.1.2 through 8.4.1.5 detail how to prepare the sled assembly feet before use.

8.4.1.2. Remove sheen from the Neolite® surface prior to initial use. Place a sheet of 400 grit wet or dry silicon carbide paper (attached to a flat surface, such as a piece of float glass) on a flat and stable surface and sand Neolite® or approved equal material by moving the assembly once across the sandpaper towards the operator for a distance of about 100 mm (4 in.) while applying 67–89 N (15–20 lbf) to the assembly.

- 8.4.1.3. Remove the sled assembly and brush off any accumulated dust from the silicon carbide paper and sled assembly using a dry brush; brush to be such that it effectively removes the dust but causes no damage to the silicon carbide paper or the Neolite® on the sled assembly.
- 8.4.1.4. Rotate the sled 90 degrees clockwise and sand the Neolite® again with the same procedure (one single pull towards the operator followed by removing the dust is considered one stroke).
- 8.4.1.5. Repeat sanding in this fashion, rotating the sled assembly by 90 degrees clockwise and brushing off the dust each time between strokes, for a total of eight strokes. Eight strokes equal one resurfacing cycle. Continue sanding the Neolite® or approved equal until all the sheen (glossy surface produced during the manufacturing process) is removed, usually no more than 500 strokes.
- 8.4.1.6. *Standard Tile*—Standard tiles are those that were manufactured under controlled conditions and assigned a unique identifying number; they are available from the Tile Council of North America.
- 8.4.1.7. *Pull Chain*—A rigid chain, for example, fabricated of metal links, is used to pull the sled with the force gauge.
- 8.4.1.8. *Force Gauge*—A digital or analog force gauge meeting the following requirements shall be used to measure the pull force on the sled plate:
- Minimum capacity: 50 N (11 lbf)
 - Precision: 0.1 N (0.02 lbf)
 - Peak hold function
- 8.4.1.9. *Mass (Weight)*—A weight meeting the following requirements shall be used to provide the force on the sled plate:
- 8.4.1.9.1. Cylindrical (approximately 150 mm (6 in.) in diameter and approximately 100 mm (4 in. tall)) or of rectangular dimensions with the base measuring approximately 100 mm by 150 mm (4 in. by 6 in.)
- 8.4.1.9.2. Mass (Weight), 11 kg (25 lb)
- 8.5. *Dry Calibration:*
- 8.5.1. Condition test feet and test specimen for at least 24 h in an atmosphere maintained at $21 \pm 6^{\circ}\text{C}$ ($70 \pm 10^{\circ}\text{F}$). The thermometer for measuring the temperature of the test equipment and specimens shall meet the requirements of [M 339M/M 339](#) with a temperature range of at least 14 to 28°C (57.2 to 82.4°F) and an accuracy of $\pm 1.5^{\circ}\text{C}$ ($\pm 2.7^{\circ}\text{F}$) (see Note 8).
- Note 8**—Thermometer types suitable for use include [ASTM E1](#) mercury thermometers; [ASTM E2877](#) digital metal stem thermometer; dial gauge metal stem thermometer; [ASTM E230/E230M](#) thermocouple thermometer, Type T, any Class, Types J or K, Special Class; or IEC 60584 thermocouple thermometer, Type T, any Class, Type J or K, Class 1.
- 8.5.2. Zero the force gauge with the pull chain attached. Calibrate the static coefficient of friction mass (weight) by hanging the static coefficient of friction sled assembly vertically from the force gauge. Record this measurement as the static coefficient of friction mass (weight).
- 8.5.3. Calibrate the Neolite® Sled Assembly surface with the standard tile each time the test is performed.

- 8.5.3.1. Use a clean soft paper towel to remove any remaining dust or debris from the surface of the Neolite® test pads before calibrating. For uses other than the initial use, resurface the sled assembly with 400 grit wet or dry silicon carbide paper, four cycles.
- 8.5.3.2. Determine the total mass (weight), W , of the 11-kg (25-lb) mass (weight) plus the Neolite® Sled Assembly.
- 8.5.3.3. Clean the standard tile with a renovator.
- 8.5.3.4. Place the Neolite® Sled Assembly and the 11kg (25 lb) mass (weight) on the standard tile surface. Using a dynamometer, determine the force required to set the test assembly in motion.
- 8.5.3.5. Record the highest reading.
- 8.5.3.6. Make a total of four pulls, each perpendicular to the previous pull, taken at 0-, 90-, 180-, and 270-degree orientations. Calculate the dry calibration factor as follows:

$$X = 0.86 - \frac{R}{N \times W} \quad (I)$$

where:

X = dry calibration factor,

R = sum of the four recorded dry force readings, kg (lb),

N = number of pulls (4), and

W = Mass (weight) of sled assembly plus 11kg (25 lb) mass (weight), kg (lb).

Note 9—The 0.86 factor is the static coefficient of friction value as determined by the Tile Council of North America for the standard tile (see Section 8.4.1.7).

8.6. *Dry Procedure:*

- 8.6.1. Test the surface in the as-received condition.
- 8.6.2. One static coefficient of friction measurement is defined as the average of four sled assembly readings, taken at 0-, 90-, 180-, and 270-degree orientations.
- 8.6.3. Before each measurement, prepare the sled assembly feet as directed in Section 8.5.3.1.
- 8.6.4. Connect the force gauge to the sled assembly base by the pull chain.
- 8.6.5. Prepare the sled assembly for taking readings on the domes and on the field according to the procedure given below. Use the mass (weight) to press the sled assembly on to the surface.
 - 8.6.5.1. Before placing 11-kg (25-lb) mass (weight) on the Neolite® Sled Assembly, insure that the force gauge is horizontally and vertically centered with the Neolite® Sled Assembly and stabilized to minimize any off-center (horizontal/vertical axis) forces once sled is put into motion.
 - 8.6.5.2. Place the 11-kg (25-lb) mass (weight) sled assembly with Neolite® material attached on the test surface. Using a dynamometer, determine the force required to set the sled assembly in motion.
 - 8.6.5.3. To perform one reading on the domes, align the sled assembly feet in the channels of the sled assembly to center each on the top of a dome. Place the sled assembly on top of the dome surface.
 - 8.6.5.4. To perform one reading on the field, keep the feet aligned in the same orientation as used for the dome reading. Place the feet of the sled assembly in the spaces between the domes. Leave space between the feet and the domes in the direction of the desired pull direction.

- 8.6.6. Pull the force gauge horizontally, aligned with the longitudinal axis of the sled assembly base. Increase the pull force gradually until the sled assembly moves.
- 8.6.7. Record the maximum pull force reached on the force gauge.
- 8.6.8. Repeat steps in Sections 8.6.5 through 8.6.7 three times for each measurement, rotating the sled assembly 90 degrees each time, for a total of four readings.
- 8.6.9. Take four sets of measurements of the static coefficient of friction: two locations on the domes and two locations on the field of the specimen.

8.7. *Wet Calibration:*

- 8.7.1. Immerse the Neolite® portion of the sled assembly in water for a minimum of 5 min after resurfacing the sled in accordance with Section 8.5.3.1.
- 8.7.2. Calibrate the sled assembly surface each time the test is performed. Repeat the procedure in accordance with Sections 8.5.3.1 through 8.5.3.4 except saturate the surface with distilled water and repeat the calibration with the surface wet, keeping the surface saturated.
- 8.7.3. Calculate the wet calibration factor as follows:

$$X_w = 0.51 - \frac{R_w}{N \times W} \quad (2)$$

where:

X_w = wet calibration factor,

R_w = sum of the four recorded wet force readings, kg (lb),

N = number of pulls (4), and

W = Mass (weight) of heel assembly plus 11 kg (25 lb) weight, kg (lb).

Note 10—The 0.51 factor is the static coefficient of friction value as determined by the Tile Council of North America for the standard tile (see Section 8.4.1.7).

8.8. *Wet Test Procedure:*

- 8.8.1. Repeat the procedure in accordance with Section 8.7.2.
- 8.8.2. Record all readings.

8.9. *Calculation of Results:*

- 8.9.1. Calculate the static coefficient of friction separately for dry and wet measurements.
- 8.9.2. Determine the coefficient of friction (COF) for each reading as follows:

$$F = \left(\frac{R}{N \times W} \right) + X \quad (3)$$

where:

F = static coefficient of friction,

R = sum of the four recorded force readings, kg (lb),

N = number of pulls (4), and

X = calibration factor,

W = Mass (weight) of sled assembly plus 11 kg (25 lb) mass (weight), kg (lb).

- 8.9.3. Average the four coefficient of friction readings for each set of measurements.
Note 11—The coefficient of friction is typically between 0 and 1, but in some cases may exceed 1.
- 8.10. *Report:*
- 8.10.1. Report each measurement obtained for the domes and the field in both dry and wet conditions.
- 8.10.2. Report the average of the measurements for the domes and the average of the measurements for the field separately for dry and wet conditions.
- 8.10.3. For unexposed specimens, compare these numbers to values provided in any governing specification, if values are available in the specification.
- 8.10.4. For exposed specimens, compare these numbers to those obtained on the unexposed specimen.

9. COLOR MEASUREMENT

- 9.1. *Scope:*
- 9.1.1. This test method covers the measurement of color and color change of detectable warning systems. Exposure to environmental conditions, such as ultraviolet light and abrasion, may fade the color of the detectable warning system.
- 9.1.2. The *Americans with Disabilities Act Accessibility Guidelines* discuss the need for color contrast between the detectable warning system and the surrounding pavement. Certain materials may experience color fading or color change upon exposure to the environment. Measurement of color and evaluation of color change are used as tools to evaluate potential changes in color contrast of the detectable warning system and surrounding pavement.
- 9.2. *Summary of Test Method:*
- 9.2.1. This method describes the measurement of color of detectable warning systems and the calculation of color difference after laboratory-accelerated weathering.
- 9.3. *Significance and Use:*
- 9.3.1. This test method is intended to evaluate color and color change of detectable warning systems that are cast into concrete.
- 9.4. *Apparatus*—An apparatus with a standard illuminant suitable for measuring color in the Commission Internationale de l’Eclairage Lab (CIELAB) system.
- 9.5. *Procedure:*
- 9.5.1. Calibrate the instrument according to the manufacturer’s instructions prior to making color measurements. The instrument should be suitable for measuring the color of the field, and the measuring head should be sized accordingly.
- 9.5.2. If measuring color for the first time on a particular specimen, select ten dome locations and ten field locations for color measurement. The locations should be selected to be representative of the typical condition of the specimen; no locations with unusual markings (ink markings, scuff marks, or excess concrete on the surface) should be selected. The locations should be selected randomly

and be well distributed over the surface of the specimen. Note the locations for future comparative measurement.

Note 12—An instrument with a small measuring head that can fit between the domes has been found to produce more repeatable measurements on the field. If the instrument cannot make good contact with the surface being measured, ambient lighting conditions have a significant effect on the values obtained.

9.5.3. If measuring color on a specimen previously measured, measure the color on the same ten domes and ten field locations. Use the same instrument as used previously.

9.5.4. Select a standard illuminant, observer, and aperture. If this is not the original measurement on the specimen, use the same instrumental conditions as before.

Note 13—A D65 standard illuminant and a 2-degree standard observer have been found to be suitable, although other illuminants and observers may be suitable. An 8-mm (0.31-in.) aperture has been found to be suitable. Other apertures, no larger than the top diameter of the dome, may also be suitable.

9.5.5. Measure the color using the instrument, and record the data.

Note 14—Because the surface roughness of many detectable warning systems is high, variations in the color measured in the ten locations is expected. For this reason, an average is calculated and used in the calculation of color difference.

9.6. *Calculation of Results:*

9.6.1. Calculate the average L^* , a^* , and b^* values of the domes and field separately by averaging the ten measurements. This is the average color reading for the specimen. Domes and field are calculated and reported separately.

9.6.2. Calculate color difference between current reading and previous reading using the following equations. Always use the average of the ten measurements as the reading. Color difference is calculated based on the difference between the averages of one set of ten readings and another set previously measured on the same specimen, rather than as the difference between one set of readings and a standard.

9.6.2.1. Change in lightness: $\Delta L^* = L^*2 - L^*1$, where L^*2 is the current reading, and L^*1 is the previous reading.

9.6.2.2. Change in redness/greenness: $\Delta a^* = a^*2 - a^*1$, where a^*2 is the current reading, and a^*1 is the previous reading.

9.6.2.3. Change in yellowness/blueness: $\Delta b^* = b^*2 - b^*1$, where b^*2 is the current reading, and b^*1 is the previous reading.

$$\text{Total color difference: } \Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (4)$$

Note 15—Total color difference, ΔE , is generally considered suitable for measuring color difference, although other color difference values, ΔL^* , Δa^* , or Δb^* , may be useful for determining color fade of detectable warning systems and compliance with applicable regulations.

9.7. *Report the following:*

9.7.1. The sample identification assigned;

9.7.2. Type, manufacturer, and, if known, lot number of the detectable warning system(s) tested;