

SSPC: The Society for Protective Coatings

PAINT APPLICATION SPECIFICATION NO. 9

Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages

1. Scope

1.1 This standard describes procedures to measure the thickness of dry, homogeneous coatings applied on cementitious surfaces using commercially available ultrasonic coating thickness gages. These procedures are intended to supplement manufacturers' operating instructions for the manual operation of the gages and are not intended to replace them.

1.2 The procedures for calibration, adjustment, and general use of using ultrasonic coating thickness gages are described in ASTM D 6132 and the gage manufacturer's instructions. This document focuses on the correct method for taking measurements.

1.3 Current ultrasound technology may not be capable of accurately measuring the DFT of some coatings (see Notes 8.1 and 8.2).

2. Description

2.1 The procedures described in this standard include criteria for determining the number of measurements, location of measurements, and whether the dry film thickness (DFT) of the coating conforms to project specifications.

2.2 Description of Gages: Ultrasonic gages use a transducer in the probe to send pulses into the coating and measure the time taken by that pulse to return to the probe tip to calculate coating thickness (see Note 8.3).

2.3 DEFINITIONS

2.3.1 Gage Reading: A single reading at one point.

2.3.2 Spot Measurement: The average of at least three gage readings made within a 15 cm (6 inch) diameter circle.

2.3.3 Structure: A unit composed of one or more connected concrete members. It is possible for a single concrete shape (beam, pipe, channel, etc.) to be considered a structure if it is painted in a shop.

2.3.4 Homogeneous: of the same or similar in composition or structure. In this standard, the term "homogeneous coating"

refers to a coating of uniform composition throughout that does not contain large, solid particles such as sand.

2.3.5 Calibration: The controlled and documented process of measuring traceable calibration standards and verifying that the results are within the stated accuracy of the gage. Calibrations are typically performed by the gage manufacturer or by a qualified laboratory in a controlled environment using a documented process. The standards used in the calibration are such that the combined uncertainties of the resultant measurement are less than the stated accuracy of the gage.

2.3.6 Verification: An accuracy check performed by the user using known reference standards.

2.3.7 Adjustment: The act of aligning the gage's thickness readings to match those of a known sample in order to improve the accuracy of the gage on a specific surface or in a specific portion of its measurement range.

3. References

3.1 The latest issue, revision, or amendment of the referenced standards in effect on the date of invitation to bid shall govern, unless otherwise specified. Standards marked with an asterisk (*) are referenced only in the Notes, which are not requirements of this standard.

3.2 If there is a conflict between the requirements of any of the cited referenced standards and this standard, the requirements of this standard shall prevail.

3.3 ASTM INTERNATIONAL STANDARDS¹

* D 4138	Standard Test Methods for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive, Cross-Sectioning Means
D 6132	Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Gage

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Standards are available online from <http://www.astm.org>.

- * **D 7091** Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
- * **SSPC-PA 2** Measurement of Dry Coating Thickness with Magnetic Gages

4. Gage Requirements

The ultrasonic gage shall be capable of measuring the thickness of a coating over a cementitious substrate. To qualify under this standard, the gage shall have a minimum accuracy within $\pm 10\%$. All gages shall be calibrated and adjusted following the manufacturer's instructions and be in accordance with ASTM D 6132.

5. Measurement Procedures

5.1 Verify that the gage will provide accurate readings over the coating to be measured, using the procedure in Note 8.2.

5.2 SPOT MEASUREMENT: Repeated gage readings, even at points close together, usually differ due to surface irregularities of the coating and the substrate (see Notes 8.4 and 8.5). Therefore, a minimum of three (3) gage readings shall be made for each spot measurement of the coating. For each new gage reading, move the probe to a new location within the 15 cm (6 inch) diameter circle defining the spot. Each gage reading shall be at least 5 cm (2 inches) from the other gage readings. Discard any single unusually high or low gage reading that cannot be repeated consistently. Take the average of the acceptable gage readings as the spot measurement (see Note 8.6).

5.3 NUMBER OF MEASUREMENTS: Make five (5) separate spot measurements (average of the gage readings, see Section 5.2) spaced arbitrarily over each 10 m² (108 ft²) area to be measured unless otherwise specified. The five spot measurements shall be made for each 10 m² (108 ft²) of area as follows:

5.3.1 For structures not exceeding 30 m² (323 ft²) in area, each 10 m² (108 ft²) (or increment thereof) area shall be measured.

5.3.2 For structures not exceeding 100 m² (1,076 ft²) in area, three 10 m² (108 ft²) (or increment thereof) areas shall be arbitrarily selected by the inspector and measured.

5.3.3 For structures exceeding 100 m² (1,076 ft²) in area, the first 100 m² (1,076 ft²) shall be measured as stated in Section 5.3.2 and for each additional 100 m² (1,076 ft²) of area (or increment thereof), one 10 m² (108 ft²) area shall be arbitrarily selected by the inspector and measured.

5.3.4 If the dry film thickness for any 10 m² (108 ft²) area or increment thereof (see Sections 5.3.1, 5.3.2 and 5.3.3) is not in compliance with the requirements of Section 6, additional measurements shall be made to isolate the non-conforming area, and each 10 m² (108 ft²) area painted during that work shift shall be measured.

5.4 SPECIFYING THICKNESS: Both a maximum and a minimum thickness are customarily specified for the coating. If a maximum thickness value is not specified, (as in Restriction Level 4 of Table 1) the specified thickness shall be the minimum and there shall be no maximum.

Table 1
Restriction Levels
Coating Thickness on Concrete

Thickness	Spot Reading	Area Reading
Level 1		
Minimum	As specified	As specified
Maximum	As specified	As specified
Level 2		
Minimum	As specified	As specified
Maximum	125% of maximum	As specified
Level 3		
Minimum	75% of minimum	As specified
Maximum	125% of maximum	As specified
Level 4		
Minimum	75% of minimum	As specified
Maximum	Unrestricted	Unrestricted

6. CONFORMANCE TO SPECIFIED THICKNESS

6.1 Thickness Restriction Levels: Table 1 provides four thickness restriction levels. Level 1 is the most restrictive and does not allow for any deviation of spot or area measurements from the specified minimum and maximum thickness, while Level 4 is the least restrictive. The owner shall specify the dry film thickness restriction level for a given project. There is no restriction on individual gauge readings provided that the spot readings and the average for the area conform to the requirements given in Table 1.

6.2 Minimum Thickness: The average of the spot measurements for each 10 m² (108 ft²) area shall not be less than the specified minimum thickness in Table 1. No single spot measurement in any area shall be less than the specified minimum thickness in Table 1. If the average of the spot measurements for a given area meets or exceeds the specified minimum thickness, but one or more spot measurements is less than the specified minimum thickness, additional measurements shall be made to define the non-conforming area (see Appendix 1 and Note 8.7).

6.3 Maximum Thickness: The average of the spot measurements for each 10 m² (108 ft²) area shall not be more than the specified maximum thickness stated in Table 1. Although no single spot measurement in any 10 m² (108 ft²) area shall be more than 125% of the specified maximum thickness stated in Table 1, it is permissible for any single gage reading to over-run by a greater amount. If the average of the spot measurements for a given 10 m² (108 ft²) area meets or falls below the specified maximum thickness, but one or more spot measurements is more than the specified maximum thickness, additional measurements shall be made as specified to define the non-conforming area (see Appendix 1).

7. Disclaimer

7.1 While every precaution is taken to ensure that all information furnished in SSPC standards is as accurate, complete and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, coatings or methods specified therein, or of the standard itself.

7.2 This standard does not attempt to address problems concerning safety associated with its use. The user of this standard, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all governmental regulations.

8. Notes

Notes are not requirements of this standard.

8.1 PROBLEM COATINGS: Ultrasonic gages are not recommended for certain coatings, such as mortars, that are heavily filled with aggregate. Similarly, an acrylic floor coating may contain flakes that were broadcast across the wet coating, creating a non-homogeneous medium whose thickness is difficult to determine accurately with ultrasonic gages. If thickness readings are suspect, they can be verified using destructive means per ASTM D 4138 (see Note 8.8).

8.2 DETERMINING COATING SUITABILITY FOR DFT MEASUREMENT USING ULTRASONIC TECHNOLOGY: To determine if it is possible to accurately measure coatings described in Note 8.1 using an ultrasonic gage, apply the coating to a smooth steel panel. Verify the measurement accuracy of an SSPC-PA 2, Type 2 electronic gage for use on ferrous substrates per manufacturer's instructions. Measure the coating DFT on the steel test panel using the Type 2 electronic gage, and record the results. The procedures for measurement using magnetic gages are described in ASTM D 7091. Next, verify the measurement accuracy of the ultrasonic gage using the manufacturer's instructions, and measure the DFT on the same test panel. Compare the results of the Type 2 electronic gage with readings taken by the ultrasonic gage. The readings should be within the combined tolerances of both instruments. If repeatable readings fall outside this tolerance, follow the manufacturer's instructions to perform an adjustment to the ultrasonic gage. If repeatable measurements still cannot be obtained, alternative methods of determining DFT should be used (see Note 8.8).

8.3 MEASUREMENT RANGE: Ultrasonic thickness gages can measure polymer coating thicknesses from approximately 8 µm to 15 mm (0.3 to 600 mils). The upper limit depends on the acoustical properties of the material being measured and the transducer in the probe.

8.4 REPEATABILITY: Ultrasonic gages are sensitive to small irregularities of the coating surface or of the concrete surface directly below the probe center. Repeated gage readings on a rough surface, even at points very close together, frequently differ considerably, particularly for thin films over a rough surface with a high profile.

8.5 VARIATION IN THICKNESS (75% of MINIMUM): In any measurement there is a level of uncertainty. Two individuals using the same ultrasonic gage will not necessarily record the exact same number for a given spot measurement using the same 15 cm (6 inch) diameter circle. To allow for this variation, an individual spot measurement is permitted to be below the specified minimum thickness as long as other spots in the 10 m² (108 ft²) area are high enough to make the average thickness meet or exceed the specified minimum thickness.

8.6 COUPLANT: It is recommended that the couplant be removed from the coating after making a spot measurement, especially if an additional coat is to be applied.

8.7 CORRECTING LOW THICKNESS: Non-conforming areas should be corrected as specified.

8.8 DESTRUCTIVE TESTING: A paint inspection gage (sometimes called a Tooke or PIG gage) can give DFT measurements, but it cuts through the coating, so each measurement site must be repaired. The procedures for measurement using destructive gages are described in ASTM D 4138. The job specification should stipulate the number and location of areas to be tested by destructive means.

APPENDIX 1 - Numerical Example of Average Thickness Measurement

Appendix 1 does not form a mandatory part of this standard.

The following numerical example is presented as an illustration of Section 5.

Suppose this structure is 30 m² (323 ft²) in area. The owner requires Restriction Level 4, 75% minimum, no maximum. Mentally divide the surface into three equal parts, each being about 10 m² (108 ft²).

Part A - 10 m² (108 ft²)
Part B - 10 m² (108 ft²)
Part C - 10 m² (108 ft²)

First, measure the coating thickness on Part A. This involves at least 15 readings of the thickness gage (see Figure A1). Assume the specification requires 640 μ m (25 mils) minimum thickness. The average thickness for area A is then the average of the five spot measurements made on area A, namely 660 μ m (26 mils).

Spot 1	640 μ m	25 mils
Spot 2	770	30
Spot 3	540	21
Spot 4	770	30
Spot 5	580	23
Avg.	660 μ m	26 mils

Considering the U.S. Customary Measurements: The average, 26 mils, exceeds the specified minimum of 25 mils and thus satisfies the specification. Next, determine if the lowest spot measurement, 21 mils, is within 75% of the specified minimum thickness. Seventy-five percent of 25 mils is 19 mils ($0.75 \times 25 = 19$). Although 21 mils is below the specified minimum, it is still within 75 percent of it, so the specification is satisfied.

There are individual gage readings of 15 mils at spot 5 and 18 mils at spot 3, both of which are clearly less than 19 mils. This is allowed because only the average of the three readings (i.e. the spot measurement) must be greater than

or equal to 19 mils. Because the owner required Level 4, no maximum DFT was specified.

Considering Metric Measurements: The average, 660 μ m, exceeds the specified minimum of 640 μ m and thus satisfies the specification. Next, determine if the lowest spot measurement, 540 μ m, is within 75% of the specified minimum thickness. Seventy-five percent of 640 μ m is 480 μ m ($0.75 \times 640 = 480$). Although 540 μ m is below the specified minimum, it is still within 75% of it, so the specification is satisfied.

There are individual gage readings of 380 μ m at spot 5 and 460 μ m at spot 3, both of which are clearly less than 480 μ m. This is allowed because only the average of the three readings (i.e., the spot measurement) must be greater than or equal to 480 μ m. Because the owner required Level 4, no maximum DFT was specified.

Since the structure used in this example is about 30 m² (322 ft²), the procedure used to measure the film thickness of part A must be applied to both part B and part C. The measured thickness of part B must exceed the 640 μ m (25 mils) specified minimum, as must the thickness of part C.

To monitor the thickness of this entire 30 m² (322 ft²) structure, at least 45 individual gage readings must be taken, from which 15 spot measurements are calculated. The five spot measurements from each 10 m² (108 ft²) part of the structure are used to calculate the thickness of that part.

Figure A1 – Part “A” of Structure (Area Approximately 10 m² [~100 ft²])

