

SSPC: The Society for Protective Coatings Paint Application Standard No. 2

Procedure for Determining Conformance to Dry Coating Thickness Requirements

1. SCOPE

1.1 This standard describes a procedure for determining shop or field conformance to a specified coating dry film thickness (DFT) range on ferrous and non-ferrous metal substrates using two types of nondestructive coating thickness gages (Type 1, magnetic pull-off; and Type 2, electronic) described in ASTM D7091.¹

1.2 This standard defines a procedure to determine whether coatings conform to the minimum and the maximum thickness specified. See Note 12.1 for an example of a possible modification when measuring dry film thickness on overcoated surfaces.

1.3 This document contains the following non-mandatory appendices:

- Appendix 1 - Numerical Example of Average Thickness Measurement and Illustration of the Procedure for Determining the Magnitude of a Nonconforming Area
- Appendix 2 - Methods for Measuring Dry Film Thickness on Steel Beams (Girders)
- Appendix 3 - Methods for Measuring Dry Film Thickness for a Laydown of Beams, Structural Steel, and Miscellaneous Parts after Shop Coating
- Appendix 4 - Method for Measuring Dry Film Thickness on Coated Steel Test Panels
- Appendix 5 - Method for Measuring Dry Film Thickness of Thin Coatings on Coated Steel Test Panels that Have Been Abrasive Blast Cleaned
- Appendix 6 - Method for Measuring the Dry Film Thickness of Coatings on Edges
- Appendix 7 - Method for Measuring Dry Film Thickness on Coated Steel Pipe Exterior
- Appendix 8 - Examples of the Adjustment of Type 2 Gages Using Shims
- Appendix 9 - Precaution Regarding Use of the Standard for Coating Failure Investigations
- Appendix 10 -- Procedure for Obtaining a Greater Population of Thickness Measurements Using Type 2 Gage Continuous Read/Scanning Probe Technology

1.5 Units of Measure: This standard makes use of both the ASTM SI 10, "American National Standard for Metric Practice" International System Units (SI) and U.S. Customary units. The measurements are not exact equivalents; therefore, each system must be used independently of the other.

2. REFERENCED STANDARDS

2.1 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.

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

2.3 ASTM International

ASTM D7091 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

2.4 SSPC: The Society for Protective Coatings

*** PA Guide 11** Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating

3. DEFINITIONS

3.1 Gage Reading: A single instrument reading.

3.2 Spot Measurement: The average of three, or at least three gage readings made within a 4-cm (approximately [~]1.5-in) diameter circle.

Discussion: Acquisition of more than three gage readings within a spot is permitted. Any unusually high or low gage readings that are not repeated consistently are discarded. The average of the acceptable gage readings is the spot measurement.

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. For referenced ASTM standards visit the ASTM website <<https://www.astm.org>> For Annual Book of ASTM Standards volume information, or to review the scope of an ASTM standard, refer to the standard's Document Summary page on the ASTM website.

3.3 Area Measurement: The average of five spot measurements obtained over each 10 m² (~100 ft²) area of coated surface, or portion thereof.

3.4 Certified Standards: Coated or plated metal plates (containing an uncoated plate for zero reference) with assigned values traceable to a national metrology institution. Also, uncoated shims of flat plastic sheet with assigned values traceable to a national metrology institution.

4. DESCRIPTION OF GAGES

4.1 Gage Types: The gage type is determined by the operating principle employed in measuring the thickness and is not determined by the mode of data readout, i.e. digital or analog.

4.2 Type 1 – Magnetic Pull-Off Gages: For magnetic pull-off gages, a permanent magnet is brought into direct contact with the coated surface. The force necessary to pull the magnet from the surface is measured and interpreted as the coating thickness value on an analog dial (scale) on the gage. Less force is required to remove the magnet from a thick coating. The gage scale is non-linear.

4.3 Type 2 – Electronic Gages: An electronic gage uses electronic circuitry to convert a reference signal into coating thickness.

5. CALIBRATION, VERIFICATION OF ACCURACY AND ADJUSTMENT

5.1 Three operational steps are necessary to ensure accurate coating thickness measurement: calibration, verification of accuracy and adjustment. These steps shall be completed before taking coating thickness measurements to determine conformance to a specified coating thickness range. Verification of accuracy shall be performed using certified standards. Type 2 gage adjustment to compensate for characteristics including (but not limited to) substrate metallurgy, geometry, thickness/thinness and roughness shall be performed using certified shims. The measured shims commonly supplied with Type 2 gages are also acceptable for gage adjustment.

5.2 Gages shall be calibrated by the equipment manufacturer, their authorized agent or an accredited calibration laboratory. A test certificate or other documentation showing traceability to a national metrology institution is required. There is no standard time interval for re-calibration, nor is one absolutely required. Calibration intervals are usually established based upon experience and the work environment, or when specified. A one-year calibration interval is a typical starting point suggested by gage manufacturers.

5.3 To guard against measuring with an inaccurate gage, gage accuracy shall be verified at a minimum of the beginning and end of each work shift according to the procedures

described in ASTM D 7091 or the gage manufacturer's instructions. The user is advised to verify gage accuracy during measurement acquisition (e.g., hourly) when a large number of measurements are being obtained. If the gage is dropped or suspected of giving erroneous readings during the work shift, its accuracy shall be rechecked.

5.4 Record the serial number of the gage, the reference standard used, the stated thickness of the reference standard as well as the measured thickness value obtained, and the method used to verify gage accuracy. If the same gage, reference standard, and method of verification are used throughout a job, they need to be recorded only once. The stated value of the standard and the measured value must be recorded each time accuracy is verified.

5.5 If the gage fails the post-measurement accuracy verification check, all measurements acquired since the last accuracy verification check are suspect. In the event of physical damage, wear, or high usage, or after an established calibration interval, the gage shall be rechecked for accuracy of measurement. If the gage is not measuring accurately, it shall not be used until it is repaired and/or recalibrated (usually by the gage manufacturer).

5.6 A Type 1 gage that does not meet the manufacturer's stated accuracy (when verified on certified standards) cannot be adjusted to correct for the out-of-tolerance condition and shall not be used until it is repaired and/or re-calibrated (typically by the gage manufacturer). Any manual adjustment of these gages will limit the DFT range for which the gage will provide accurate readings; therefore, adjustment of the gage is not permitted. Furthermore, the application of a single "correction value" representing the full range of the gage to compensate for a gage that is not measuring accurately is not appropriate, since the gage scale is non-linear.

6. MEASUREMENT PROCEDURE – TYPE 1 GAGES

6.1 Verify Type 1 gage accuracy using certified coated metal plates having at least one thickness value within the expected range of use. Unless explicitly approved by the gage manufacturer, certified shims of plastic or of non-magnetic metals that are acceptable for verifying the accuracy of Type 2 (electronic) gages shall not be used for verifying the accuracy of Type 1 gages.

6.2 In order to compensate for any effect of the substrate itself and surface roughness, obtain one reading from the bare, prepared substrate at each of a minimum of ten (10) arbitrarily spaced locations and calculate the average value. This value represents the effect of the substrate/surface roughness on a coating thickness gage. This average value is the base metal reading (BMR).

6.3 Measure the DFT of the coating at the number of spots specified in Section 8.

6.4 Subtract the BMR from the gage reading to obtain the thickness of the coating.

7. MEASUREMENT PROCEDURE – TYPE 2 GAGES

7.1 The manufacturers of Type 2 (electronic) gages prescribe different methods of adjustment to measure dry film thickness over roughened surfaces. Adjust the gage according to the manufacturer's instructions using one of the methods described in ASTM D 7091 or Appendix 8 of this standard.

7.2 Measure the DFT of the coating at the number of spots specified in Section 8.

8. REQUIRED NUMBER OF MEASUREMENTS FOR CONFORMANCE TO A THICKNESS SPECIFICATION

8.1 Number of Measurements: Repeated gage readings, even at points close together, often differ due to small surface irregularities of the coating and the substrate. 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 4-cm (approximately [~]1.5-in) diameter circle defining the spot. Discard any unusually high or low gage readings that are not repeated consistently. The average of the acceptable gage readings is the spot measurement.

8.2 Unless otherwise specified in the procurement documents (project specification), an area measurement is obtained by taking five (5) separate spot measurements (average of the gage readings described in Section 8.1) randomly spaced throughout each 10-m² (~100 ft²) area to be measured and representative of the coated surface. The five spot measurements shall be made for each 10-m² (~100 ft²) area as follows:

8.2.1 For areas of coating not exceeding 30 m² (~300 ft²) arbitrarily select and measure each 10-m² (~100 ft²) area.

8.2.2 For areas of coating greater than 30 m² (~300 ft²) and not exceeding 100 m² (~1,000 ft²), arbitrarily select and measure three 10-m² (~100 ft²) areas.

8.2.3 For areas of coating exceeding 100 m² (~1,000 ft²), arbitrarily select and measure the first 100 m² (~1,000 ft²) as stated in Section 8.2.2. For each additional 100 m² (~1,000 ft²) coated area (or increment thereof), arbitrarily select and measure one additional 10-m² (~100 ft²) area.

8.3 Nonconforming Areas: If the coating thickness for any 10-m² (~100 ft²) area is not in compliance with the contract documents, the procedure described here shall be followed to assess the magnitude of the nonconforming thickness.

8.3.1 Determine the spot DFT at 1.5-meter (5-foot) intervals in eight equally spaced directions radiating outward from the nonconforming 10-m² (100-ft²) area.

If there is no place to measure in a given direction, then no measurement in that direction is necessary. Acquire spot measurements in each direction (up to the maximum surface area coated during the work shift) until two consecutive conforming spot measurements are acquired in that direction or until no additional measurements are possible. Acceptable spot measurements are defined by the minimum and maximum values in the contract documents. No allowance is made for variant spot measurements, as is the practice when determining the area DFT. An illustration of this procedure is shown in Figure A1.2.

8.3.1.1 On complex structures or in other cases where making spot measurements at 1.5-meter (5-foot) intervals is not practical, spot measurements shall be performed on repeating structural units or elements of structural units. This method shall be used when the largest dimension of the unit is less than 3 meters (~10 feet). Make spot measurements on repeating structural units or elements of structural units until two consecutive units in each direction are conforming or until there are no more units to test.

8.3.2 Non-compliant areas shall be demarcated using removable chalk or other specified marking material and documented. All of the area within 1.5 meters (5 feet) of any non-compliant spot measurement shall be designated as non-compliant. For a given measurement direction or unit measurement, any compliant area or unit preceding a non-compliant area or unit shall be designated as suspect, and as such is subject to re-inspection after corrective measures are performed (see Note 12.2).

8.3.3 Appendices 2 through 7 and Appendix 10 provide specifiers with optional alternatives for defining the area size as well as the number and frequency of spot measurements to include in project specifications as appropriate for the size and shape of the item or structure to be coated.

9. CONFORMANCE TO SPECIFIED THICKNESS

9.1 A minimum and a maximum thickness are normally specified for each layer of coating. If a single thickness value is specified and the coating manufacturer does not provide a recommended range of thickness, then the minimum and maximum thickness for each coating layer shall be $\pm 20\%$ of the stated value.

9.2 Table 1 provides five 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 5 is the least restrictive. Depending on the coating type and the prevailing service environment, the specifier selects the dry film thickness restriction level for a given project. If no restriction level is specified, then Level 3 is the default. It is possible to specify a maximum thickness threshold for Level 5 Spot or Area measurements for some generic product types and service environments.

TABLE 1
COATING THICKNESS RESTRICTION LEVELS

Thickness	Gage Reading	Spot Measurement	Area Measurement
Level 1			
Minimum	Unrestricted	As specified	As specified
Maximum	Unrestricted	As specified	As specified
Level 2			
Minimum	Unrestricted	As specified	As specified
Maximum	Unrestricted	120% of maximum	As specified
Level 3 (default)			
Minimum	Unrestricted	80% of minimum	As specified
Maximum	Unrestricted	120% of maximum	As specified
Level 4			
Minimum	Unrestricted	80% of minimum	As specified
Maximum	Unrestricted	150% of maximum	As specified
Level 5			
Minimum	Unrestricted	80% of minimum	As specified
Maximum	Unrestricted	Unrestricted	Unrestricted

9.3 For the purpose of final acceptance of the total dry film thickness, the cumulative thickness of all coating layers shall be no less than the cumulative minimum specified thickness and no greater than the cumulative maximum specified thickness.

10. Report

The following items shall be reported:

10.1 The type of instrument used, including manufacturer, model number, serial number and date of calibration.

10.2 The type of certified standard used to verify gage accuracy, including manufacturer, model number, serial number and thickness value(s).

10.3 The thickness of the measured shim(s) used to adjust a Type 2 gage.

10.4 The average BMR (if appropriate).

10.5 The spot and area measurements.

10.6 The gage operator and date of measurement acquisition.

11. Disclaimer

11.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications 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 specification or standard itself.

11.2 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.

12. Notes

Notes are not requirements of this standard.

12.1 Overcoating: Maintenance painting often involves application of a new coating over an existing coating system. It can be very difficult to accurately measure the DFT of this newly applied coating using non-destructive methods. First, access to the profile is not available, compromising the accuracy of the BMR or the adjustment of a Type 2 gage. Second, unevenness in the DFT of the existing coating necessitates careful mapping of the "before and after" DFT readings. This unevenness also adds to the statistical variation in trying to establish a base DFT reading to be subtracted from the final DFT.

A paint inspection gage (sometimes called a Tooke or PIG gage) will give accurate DFT measurements, but it requires that an incision be made through the coating (overcoat only or total system), so each measurement site will require repair.

A practical approach to monitoring DFT (when overcoating) is to compute the DFT using wet film thickness (WFT) readings, the percent volume solids of the coating being applied, and any thinner addition as shown here.

$$\begin{aligned} \text{DFT} &= \text{Measured WFT} \times \% \text{ Volume Solids,} \\ &\quad \text{or} \\ \text{DFT} &= \text{Measured WFT} \times \% \text{ volume solids} \\ &\quad \div (100\% + \% \text{ thinner added}) \end{aligned}$$