SSPC-PA 2-2022
Approved April 12, 2022

Procedure for Determining Conformance to Dry Coating Thickness Requirements

Procedure for Determining Conformance to Dry Coating Thickness Requirements

This AMPP standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he or she has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard. Nothing contained in this AMPP standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by Letters Patent, or as indemnifying or protecting anyone against liability for infringement of Letters Patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. AMPP assumes no responsibility for the interpretation or use of this standard by other parties and accepts responsibility for only those official AMPP interpretations issued by AMPP in accordance with its governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

Users of this AMPP standard are responsible for reviewing appropriate health, safety, environmental, and regulatory documents and for determining their applicability in relation to this standard prior to its use. This AMPP standard may not necessarily address all potential health and safety problems or environmental hazards associated with the use of materials, equipment, and/or operations detailed or referred to within this standard. Users of this AMPP standard are also responsible for establishing appropriate health, safety, and environmental protection practices, in consultation with appropriate regulatory authorities, if necessary, to achieve compliance with any existing applicable regulatory requirements prior to the use of this standard.

CAUTIONARY NOTICE: AMPP standards are subject to periodic review and may be revised or withdrawn at any time in accordance with AMPP technical committee procedures. AMPP requires that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication and subsequently from the date of each reaffirmation or revision. The user is cautioned to obtain the latest edition. Purchasers of AMPP standards may receive current information on all standards and other AMPP/NACE/SSPC publications by contacting AMPP Customer Support, 15835 Park Ten Place, Houston, Texas 77084-5145 (Tel: +1 281-228-6200, email: customersupport@ampp.org).

Document History
2022-04-12: Revised by SSPC C.3.2
2015-01-26: Revised by SSPC C.3.2
2012-05-01: Revised by SSPC C.3.2
2004-05-04: Revised by SSPC C.3.2
1996-06-01: Revised by SSPC C.3.2
1982-11-01: Revised by SSPC C.3.2
1973-09-01: Issued by SSPC C.3.2, Film Thickness Measurement

AMPP values your input. To provide feedback on this standard, please contact: standards@ampp.org

Procedure for Determining Conformance to Dry Coating Thickness Requirements

Figures

Tables

Section 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 11.1 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. Appendices 2, 3, 4, 5, 6, 7, 10, and 11 become mandatory when invoked by the project specification or if the contractor or laboratory has agreed in writing to comply with their provisions.

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 on Plate, Beams, and Pipe Spools Using Type 2 Gage Continuous Read/Scanning Technology
Appendix 11	Method for Measuring the Thickness of Intumescent (Fireproofing) Coatings Applied to Load-Bearing Structural Steel Members, Fire Divisions, Pipework, and Vessels/Tanks

1.4 **Units of Measure**: This standard makes use of both the ASTM SI 10 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. Also, a tilde (~) is used to indicate approximation.

Section 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.

[1]

2.3 AMPP/SSPC Standard, www.ampp.org

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

2.4 ASTM International Standards, www.astm.org

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

IEEE/ASTM SI 10 American National Standard for Metric Practice

2.5 International Organization for Standardization Standard,[(2)] http://www.iso.org/

*** ISO 19840** Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces

2.6 U.S. Military Specification, https://quicksearch.dla.mil/qsSearch.aspx

*** MIL-PRF-23236** Coating Systems for Ship Structures

Section 3: Definitions

3.1 **Gage Reading**: A single instrument reading.

3.2 **Spot Measurement**: The average of three gage readings made within a ~4-cm (~1.5-inch) 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.

3.3 **Scanning Batch Measurement**: The mean of a minimum of 12 DFT readings and up to 24 readings, without lifting the probe from the coated surface (definition applies to Appendix 10 only).

3.4 **Area Measurement**: The average of five spot measurements obtained over each ~10 m^2 (~100 ft^2) area of coated surface, or portion thereof.

3.5 **Scanning Area Measurement**: The sample mean of five (or as otherwise defined in Appendix 10) scanning batch measurements obtained over each ~10 m^2 (~100 ft^2) area of coated surface, or portion thereof (definition applies to Appendix 10 only).

3.6 **Certified Standards**: Coated or plated metal plates (accompanied by 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.

Section 4: Description of Gages

4.1 **Gage Types**: The gage type is determined by the operating principle employed in measuring the coating 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.

(2)

4.3 **Type 2 – Electronic Gages**: An electronic gage uses electronic circuitry to convert a reference signal into coating thickness. Some electronic gages are equipped with scanning technology.

Section 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, 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 by procurement documents or by the gage user's quality system. 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 D7091 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.

Section 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.

Section 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 and areas specified in Section 8.

NOTE: Gages that employ "place and remove" technology or scanning technology may be used to carry out the procedure outlined in Section 8.

Section 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 gage readings shall be acquired for each spot measurement of the coating. For each new gage reading, move the probe to a new location within a ~4-cm (~1.5-in) diameter circle defining the spot. When scanning technology is used, move the probe in a circular motion within a ~4 cm (~1.5 in) diameter area that defines the spot, without lifting the probe from the surface. 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 acquiring five separate spot measurements (average of the gage readings described in Section 8.1) randomly spaced throughout each ~10-m^2 (~100 ft^2) area to be measured and representative of the coated surface. The five spot measurements shall be made for each ~10-m^2 (~100 ft^2) area as follows:

8.2.1 For areas of coating not exceeding ~30 m^2 (~300 ft^2) arbitrarily select and measure each ~10-m^2 (~100 ft^2) area.

8.2.2 For areas of coating greater than ~30 m^2 (~300 ft^2) and not exceeding ~100 m^2 (~1,000 ft^2), arbitrarily select and measure three ~10-m^2 (~100 ft^2) areas.

8.2.3 For areas of coating exceeding ~100 m^2 (~1,000 ft^2), arbitrarily select and measure the first ~100 m^2 (~1,000 ft^2) as stated in Section 8.2.2. For each additional ~100 m^2 (~1,000 ft^2) coated area (or increment thereof), arbitrarily select and measure one additional ~10-m^2 (~100 ft^2) area.

NOTE: Alternate coating thickness measurement frequencies for plate, beams, and pipe using gages equipped with continuous read/scanning technology are provided in Appendix 10.

8.3 **Nonconforming Areas**: If the coating thickness for any ~10-m^2 (~100 ft^2) 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-m (~5-ft) intervals in eight equally spaced directions radiating outward from the nonconforming ~10-m^2 (~100 ft^2) 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 acquiring spot measurements at ~1.5-m (~5-ft) 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 m (~10 ft). Acquire 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 marking materials and shall be documented. All of the area within ~1.5 m (~5 ft) 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 11.2).

8.4 Appendices 2 through 7 and Appendices 10 and 11 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.

Section 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 ± 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.

Section 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.

Section 11: Notes

Notes are not requirements of this standard.

11.1 **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.

$$\text{DFT} = \text{Measured WFT} \times \% \text{ Volume Solids},$$

or

$$\text{DFT} = \text{Measured WFT} \times \% \text{ volume solids} \div (100\% + \% \text{ thinner added})$$

If the DFT of the existing coating is not too uneven or eroded, the average DFT of the existing coating can be measured per this standard to establish a base DFT. This base DFT can then be subtracted from the total DFT to isolate the thickness of the overcoat(s).

11.2 **Correcting for Low or High Thickness**: The specifier should specifically state the methodology to correct the applied and cured film for low or high thickness. If this information is not contained in the specification, then the coating manufacturer's instructions should be followed.

Appendix 1
Numerical Example of Average Thickness Measurement and Illustration of the Procedure for Determining the Magnitude of a Nonconforming Area (Nonmandatory)

Appendix 1 is not a mandatory part of this standard.

Example Using SI Units:

The following numerical example is presented as an illustration of Section 8. The example is based on a Level 3 Restriction (default).

Suppose the coated area is ~30 m^2 in area. Divide the area into three equal parts, each being ~10 m^2.

Part A - ~10 m^2
Part B - ~10 m^2
Part C - ~10 m^2

First, measure the coating thickness on Part A. This involves at least 15 gage readings with a Type 1 or Type 2 device (see Figure A1). Assume the specification calls for 64 µm minimum thickness. The coating thickness for area A is then the average of the five spot measurements made on area A, namely 67 µm.

Spot 1	64 µm
Spot 2	75 µm
Spot 3	53 µm
Spot 4	75 µm
Spot 5	66 µm
Average	67 µm

The average, 67 µm, exceeds the specified minimum of 64 µm and thus satisfies the specification. Next, determine if the lowest spot measurement, 53 µm, is within 80% of the specified minimum thickness (based on Coating Thickness Restriction Level 3, or the default). Eighty percent of 64 µm is 51 µm (0.80 × 64 = 51). Although a measurement of 53 µm is below the specified minimum, it is still within 80% of that minimum, so the specification is satisfied. There are individual gage readings of 47 µm at Spot 5 and 45 µm at Spot 3, both of which are clearly less than 51 µm. This is allowed because only the average of the three readings (i.e., the spot measurement) must be greater than or equal to 51 µm.

Since the structure used in this example is ~30 m^2, 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 64 µm specified minimum, as must the thickness of part C.

To monitor the thickness of this entire ~30-m^2 structure, at least 45 individual gage readings must be taken, from which 15 spot measurements are calculated. The five spot measurements from each ~10- m^2 part of the structure are used to calculate the thickness of that part.

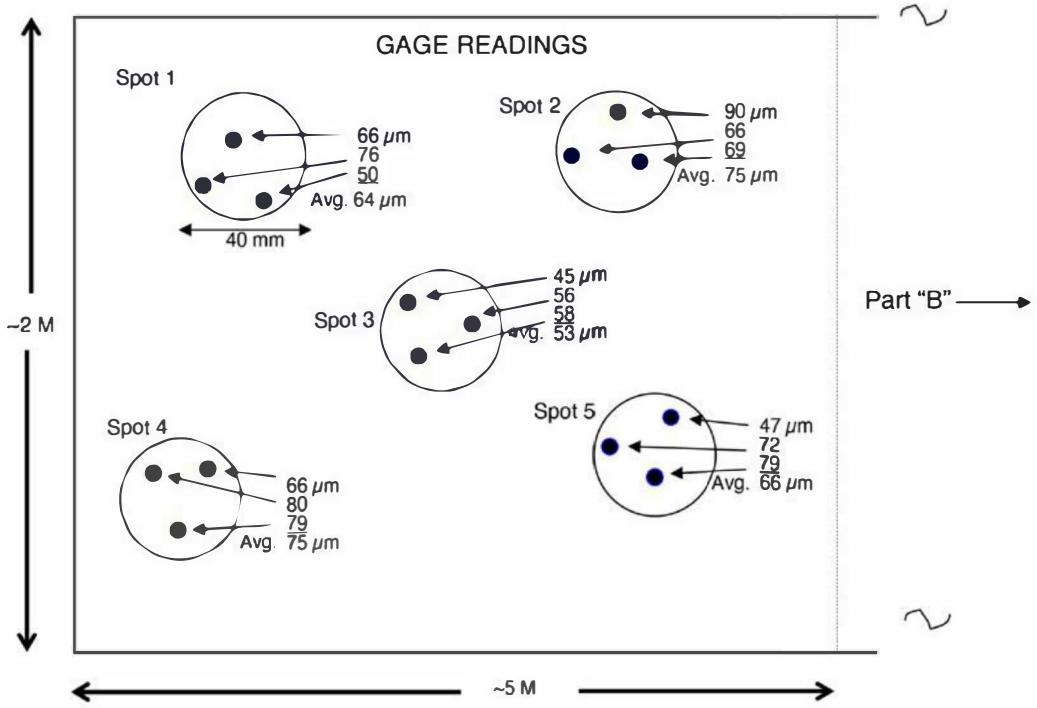

Figure A1 (metric): Part "A" of Structure (area is ~10 m²).

Example Using U.S. Customary Units

Suppose the coated area is ~300 ft² in area. Divide the area into three equal parts, each being ~100 ft².

Part A - ~100 ft²
Part B - ~100 ft²
Part C - ~100 ft²

First, measure the coating thickness on Part A. This involves at least 15 gage readings with a Type 1 or Type 2 device (see Figure A1.1). Assume the specification calls for 2.5 mils minimum thickness. The coating thickness for area A is then the average of the five spot measurements made on area A, namely 2.6 mils.

Spot 1 2.5 mils
Spot 2 2.9 mils
Spot 3 2.1 mils
Spot 4 2.9 mils
Spot 5 2.6 mils
Average 2.6 mils

The average, 2.6 mils, exceeds the specified minimum of 2.5 mils and thus satisfies the specification. Next, determine if the lowest spot measurement, 2.1 mils, is within 80% of the specified minimum thickness (based on Coating Thickness Restriction Level 3, or the default). Eighty percent of 2.5 mils is 2.0 mils (0.80 × 2.5 = 2.0). Although 2.1 mils is below the specified minimum, it is still within 80 percent of that minimum, so the specification is satisfied. There are individual gage readings of 1.8 mils at Spot 3 and 1.8 mils at Spot 5, both of which are clearly less than 2.0 mils. This is allowed because only the average of the three readings (i.e., the spot measurement) must be greater than or equal to 2.0 mils.

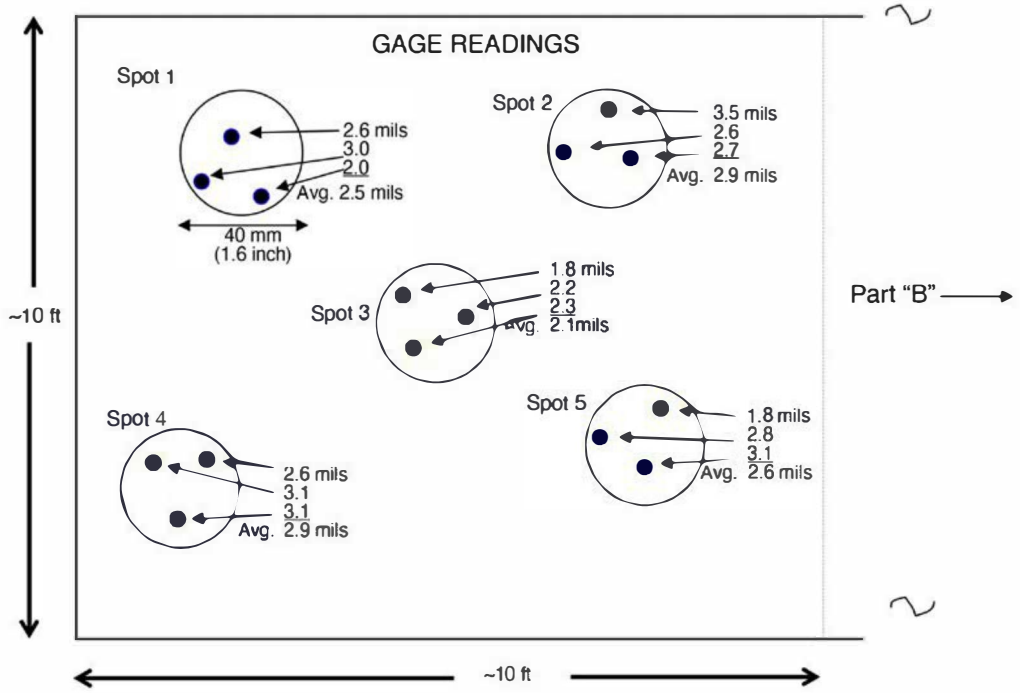

Figure A1 (U.S. Custom): Part "A" of Structure (area is ~100 ft2).

Figure A1.2 illustrates the procedure described in Section 8.3 of this standard for determining the magnitude of the nonconforming thickness.

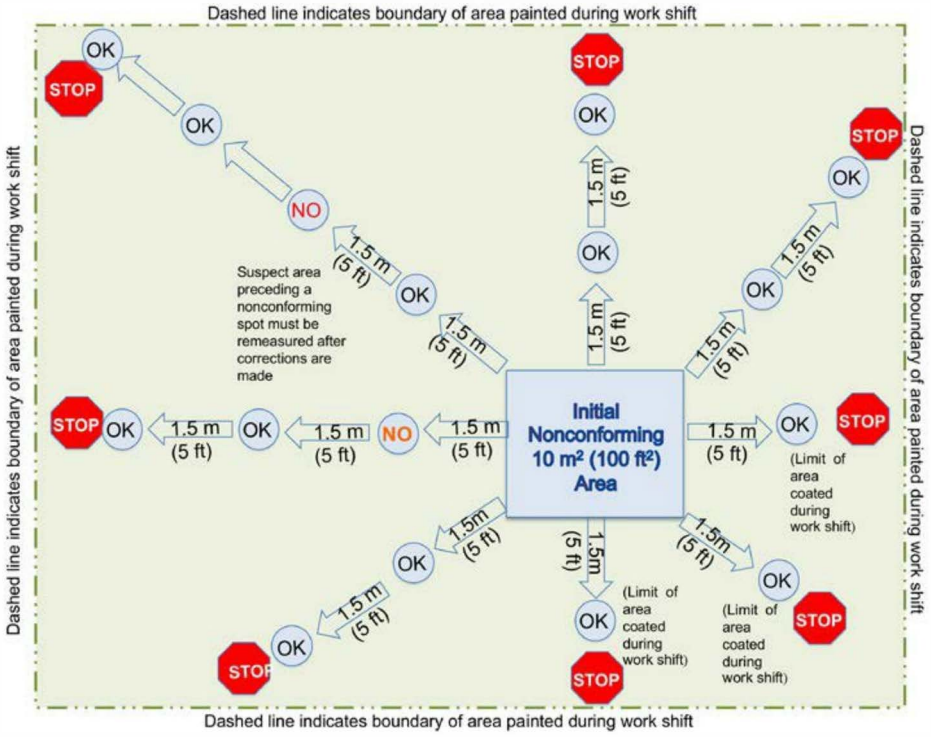

Figure A1.2: Determining Extent of Nonconforming Areas (all measurements are approximate)

Appendix 2
Methods for Measuring Dry Film Thickness on Steel Beams (Girders) (Nonmandatory)

Appendix 2 is not a mandatory part of this standard, but it provides two sample protocols for measuring DFT on beams and girders. Appendix 2 may be invoked by contract documents and therefore is written in mandatory language. This Appendix becomes mandatory when it is invoked by specification, or the contractor has agreed in writing to comply with the provisions herein.

A2.1 A challenge for the painter in coating steel beams or girders is providing the same uniform thickness over high and low vertical surfaces as over horizontal surfaces. On a beam, there are proportionately more edges that tend to have low dry film thickness (DFT) and inside corners that tend to have high DFT compared to the center of the flat surfaces. Each painter usually develops a pattern of work for a specific task. Hence, the DFT on the underside of the top flange, for example, may be consistently on the high side or the low side of the target DFT. This type of error is easy to detect and correct. Random errors pose a more difficult problem. Gross errors where the paint is obviously too thin or too thick must be corrected and are beyond the scope of this standard.

The number of spot measurements in these protocols may far exceed the "5 spot measurement per ~10 m^2 (~100 ft^2)" required in the standard. The full DFT determination, described in Section A2.2, provides a very thorough inspection of the beam. The sample DFT determination, described in Section A3.4, allows for fewer spot measurements. The user does not have to require a full DFT determination for every beam in the structure. For example, the requirement may be for a full DFT determination on one beam out of ten, or a sample DFT determination on one beam out of five, or a combination of full and sample DFT determinations. Note that for existing structures, the top side of the top flange (Surface 1) may not be accessible for measuring coating thickness.

A beam has twelve different surfaces as shown in Figure A2. Any one of these surfaces may have a DFT outside the specified range, and hence, shall be measured. If the thickness of the flange is less than ~25 mm (~1 in), the contracting parties may choose not to measure the DFT on the toe, i.e., surfaces 2, 6, 8, and 12 of Figure A2. As an informal initial survey, the inspector may want to check for uniformity of DFT across each surface. Is the DFT of the flange near the fillet the same as near the toe? Is the DFT uniform across the web? The inspector must be sure to use a gage that is not susceptible to edge effects. Follow the gage manufacturer's instructions when measuring the edges.

A2.2 **Full DFT Determination of a Beam**: Divide the beam or girder into five equal sections along its length. Identify the 12 surfaces of the beam as shown in Figure A2 for each section. For tall beams, where the height of the beam is ~90 cm (~36 in) or more, divide the web in half along the length of the beam. For the full DFT determination, each half of the web is considered a separate surface. Take one spot measurement (as defined in Section 8.1) on surface 1 in each of the five sections. The location of the surface 1 measurement within a section is arbitrarily chosen by the inspector in each of the five sections. The average of these five spot measurements is the DFT of surface 1. Repeat for the other 11 surfaces (7 surfaces if the toe is not measured; 14 surfaces for tall beams). The data can be reported in a format shown in Table A2.1.

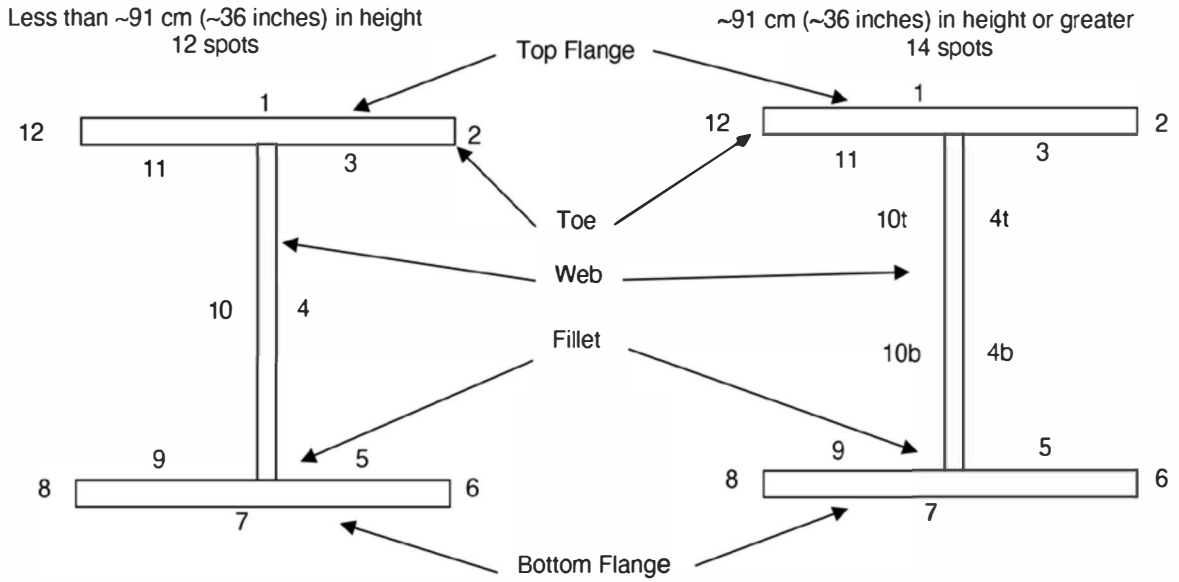

Figure A2: The Surfaces of a Steel Beam.

Table A2.1
Datasheet for Recording Spot Measurements and
Average DFT Values for the 12 Surfaces of a Beam or Girder

Spot Measurements of DFT on Beam # _____

Surface[A, B]	Section 1	Section 2	Section 3	Section 4	Section 5	Average
1						
2						
3						
4						
4t						
4b						
5						
6						
7						
8						
9						
10						
10t						
10b						
11						
12						
(A) (B)						

Table A2.2
Number of Spot Measurements Needed
On Each Surface of a Beam for a Full or a Representative DFT Determination

	Number of Spot Measurements per Surface	
Length of Beam	**Full DFT Determination[A]**	**Representative DFT Determination**
Less than ~6 m (~20 ft)	5	2
From ~6 to 18 m (~20 to 60 ft)	5	3
Over ~18 m (~60 ft)	5	NA

[A]

A2.3 If Coating Thickness Restriction Level 3 is invoked by the specification (or if no Restriction Level is invoked by the specification), then no single spot measurement can be less than 80% of the specified minimum DFT, and no single spot measurement can be more than 120% of the specified maximum DFT. The average value for each surface must conform to the specified DFT. (There will be only eight average values if the DFT of the toe is not measured; there may be as many as 14 average values for beams greater than ~90 cm (~36 in) in height.)

A2.4 **Representative DFT Determination of a Beam**: In lieu of a full DFT determination of each beam, the job specification may require only a representative DFT determination for selected beams less than ~18 m (~60 ft) long. For a representative DFT determination, the web of beams greater than ~90 cm (~36 in) in height is not split.

A2.4.1 If Coating Thickness Restriction Level 3 is invoked by the specification (or if no Restriction Level is invoked by the specification), then no single spot measurement can be less than 80% of the specified minimum DFT, and no single spot measurement can be more than 120% of the specified maximum DFT. The average value for each surface must conform to the specified DFT. (There will be only eight average values if the DFT of the toe is not measured; there may be as many as 14 average values for beams greater than ~90 cm (~36 in) in height.)

A2.4.2 Beams less than ~6 m (~20 ft) in length: For beams less than ~6 m (~20 ft) in length, take two spot measurements, randomly distributed, on each of the 12 surfaces (8 surfaces if the toe is not measured) of the beam as defined in Figure A2. Each spot measurement must conform to the specified DFT.

A2.4.3 Beams ~6 m (~20 ft) up to ~18 m (~60 ft) in length: For beams ~6 m (~20 ft) up to ~18 m (~60 ft) in length, take three spot measurements, randomly distributed, on each of the 12 surfaces (8 surfaces if the toe is not measured) of the beam as defined in Figure A2. Each spot measurement must conform to the specified DFT.

A2.5 **Non-Conformance**: If any spot measurement falls outside the specified range, additional measurements may be made to define the non-conforming area.

A2.6 **Restricted Access**: If the beam is situated such that one or more of the surfaces are not accessible, take measurements on each accessible surface in accordance with Section A2.2 or Section A2.4 through A2.4.2, as specified.

A2.7 **Attachments**: Stiffeners and other attachments to a beam should be arbitrarily measured.

Appendix 3
Methods for Measuring Dry Film Thickness for a Laydown of Beams, Structural Steel, and Miscellaneous Parts after Shop Coating
(Nonmandatory)

Appendix 3 is not a mandatory part of this standard, but it provides two sample protocols for measuring DFT for a laydown. Appendix 3 may be invoked by contract documents and therefore is written in mandatory language. This Appendix becomes mandatory when it is invoked by specification, or the contractor has agreed in writing to comply with the provisions herein.

A3.1 **Definition**: A "laydown" is a group of steel members laid down to be painted in one shift by one painter. Discussion: For inspection of a laydown, first make a visual survey to detect areas with obvious defects, such as poor coverage, and correct as necessary. As an informal initial survey, the inspector may want to check for uniformity of DFT across each surface.

A3.2 **Full DFT Determination**

A3.2.1 Beam (Girder): Follow the procedure described in Section A2.2.

A3.2.2 Miscellaneous Parts: Take one spot measurement (as defined in Section 8.1) on each surface of the part. If the part has fewer than five surfaces, take multiple spot measurements on the larger surfaces to bring the total to five. If the total area of the part is over ~10 m2 (~100 ft2), take 5 spot measurements randomly distributed over the part for each ~10 m2 (~100 ft2) or fraction thereof.

A3.3 If Coating Thickness Restriction Level 3 is invoked by the specification (or if no Restriction Level is invoked by the specification), then no single spot measurement can be less than 80% of the specified minimum DFT, and no single spot measurement can be more than 120% of the specified maximum DFT. The average value of the spot measurements on each surface must conform to the specified DFT. If there is only a single spot measurement on a surface, it must conform to the specified DFT.

A3.4 **Representative DFT Determination**: In lieu of a full DFT determination of each painted piece as described in Section A2.2, the job specification may require only a representative DFT determination for selected pieces.

A3.4.1 Beams less than ~6 m (~20 ft) in length: Follow the procedure described in Section A2.4.1.

A3.4.2 Beams greater than ~6 m (~20 ft) up to ~18 m (~60 ft) in length: Follow the procedure described in Section A2.4.2.

A3.4.3 Miscellaneous parts: For a miscellaneous part, take three spot measurements, randomly distributed on the part. Each spot measurement must conform to the specified DFT.

A3.5 **Non-Conformance**: If any spot measurement falls outside the specified range, additional measurements may be made to define the non-conforming area.

A3.6 **Restricted Access**: If a beam or miscellaneous part is situated such that one or more of the surfaces are not accessible, take measurements on each accessible surface in accordance with Section A2.2 or Section A2.4, as specified.

A3.7 **Number of Beams or Parts to Measure**: In a laydown, the number of beams or parts to receive a full DFT determination and the number to have a representative DFT determination can be specified. For example, do a full DFT determination on a piece painted near the beginning of the shift, near the middle of the shift, and near the end of the shift in accordance with Section A3.2, and perform a representative DFT determination on every third piece in accordance with Section A3.4.

A3.8 **Attachments**: Stiffeners and other attachments to a beam shall be arbitrarily measured.

Appendix 4
Method for Measuring Dry Film Thickness on Coated Steel Test Panels (Nonmandatory)

Appendix 4 is not a mandatory part of this standard, but it provides a sample protocol for measuring DFT on coated steel test panels. Appendix 4 may be invoked by contract documents and therefore is written in mandatory language. This Appendix becomes mandatory when it is invoked by specification or the laboratory has agreed to, in writing comply with the provisions herein.

A4.1 **Panel Size**: The test panel shall have a minimum area of ~116 cm^2 (~18 in^2) and a maximum area of ~930 cm^2 (~144 in^2); e.g., minimum ~7.5 x 15 cm (~3 x 6 in) and maximum ~30 x 30 cm (~12 x 12 in).

A4.2 **Procedure**: Use a Type 2 electronic gage. Obtain two spot measurements from the top third, the middle third, and the bottom third of the test panel. Readings shall be taken at least ~12 mm (~ 1/2 inch) from any edge and ~25 mm (~ 1 in) from any other spot measurements. Discard any unusually high or low gage reading that cannot be repeated consistently. The DFT of the test panel is the average of the six acceptable spot measurements.

A4.3 **Minimum Thickness**: The average of the acceptable spot measurements shall be no less than the specified minimum thickness. No single spot measurement shall be less than 80% of the specified minimum.

A4.4 **Maximum Thickness**: The average of the acceptable spot measurements shall be no more than the specified maximum thickness. No single spot measurement shall be more than 120% of the specified maximum.

A4.5 **Rejection**: If a spot measurement is less than 80% of the specified minimum DFT or exceeds 120% of the specified maximum DFT, additional measurements may be made to reevaluate the DFT on the area of the test panel near the low or high spot measurement. If the additional measurements indicate the DFT in the disputed area of the panel to be below the minimum or above the maximum allowable DFT, the panel shall be rejected.

Appendix 5
Method for Measuring Dry Film Thickness of Thin Coatings on Coated Steel Test Panels That Have Been Abrasive Blast Cleaned (Nonmandatory)

Appendix 5 is not a mandatory part of this standard, but it provides a sample protocol for measuring DFT of thin coatings on coated steel test panels that had been abrasive blast cleaned. Appendix 5 may be invoked by contract documents and therefore is written in mandatory language. This Appendix becomes mandatory when it is invoked by specification, or the laboratory has agreed in writing to comply with the provisions herein.

A5.1 For the purposes of this standard, a coating is defined as thin if the dry film thickness (DFT) is about 25 micrometers (1 mil) or less. Because the DFT is the same order as the statistical fluctuations of a DFT gage on bare blast cleaned steel, many gage readings must be taken to get a meaningful average.

A5.2 **Panel Size**: The test panel shall have a minimum area of ~116 cm^2 (~18 in^2) and a maximum area of ~930 cm^2 (~144 in^2); e.g., minimum ~7.5 x 15 cm (~3 x 6 in) and maximum ~30 x 30 cm (~12 x 12 in).

A5.3 **Procedure**: Use a properly adjusted Type 2 electronic gage. Obtain ten gage readings randomly distributed in the top third of the panel. Compute the mean (average) and standard deviation of these ten readings. Similarly, take ten readings from the middle third and ten readings from the bottom third of the test panel and compute their means and standard deviations. Readings shall be taken at least ~12 mm (~1/2 in) from any edge and ~25 mm (~1 in) from any other gage reading. Discard any unusually high or low gage reading, i.e., a reading that is more than three standard deviations from the mean. The DFT of the test panel is the average of the three means.

A5.4 **Minimum Thickness**: The average of the means shall be no less than the specified minimum thickness. No single mean shall be less than 80% of the specified minimum.

A5.5 **Maximum Thickness**: The average of the means shall be no more than the specified maximum thickness. No single mean shall be more than 120% of the specified maximum.

Appendix 6
Method for Measuring the Dry Film Thickness of Coatings on Edges with Type 2 Gages (Nonmandatory)

Appendix 6 is not a mandatory part of this standard, but it provides a sample protocol for measuring DFT of coatings on edges. Appendix 6 may be invoked by contract documents and therefore is written in mandatory language. This Appendix becomes mandatory when it is invoked by specification, or the contractor has agreed in writing to comply with the provisions herein.

A6.1 Type 2 gage manufacturers offer a variety of probe configurations, some of which are less affected by proximity to edges and are designed to better measure the thickness of coatings on edges. The user should consult the gage manufacturer's instructions before measuring coating thickness on edges. SSPC-PA Guide 11 describes the use of coatings with edge-retentive properties and references a method (MIL-PRF-23236D) for assessing edge retention properties of coatings.

A6.2 Prior to measurement of coating thickness on edges, the gage and probe should be verified for accuracy by placing a thin, flexible shim onto the prepared, uncoated edge. Adjustments to the gage may or may not be required. This procedure also verifies that the probe configuration will accommodate the edge configuration prior to coating thickness data acquisition.

A6.3 Obtain a minimum of three gage readings within ~4 cm (~1.5 in) of the coated edge. The average of the gage readings is considered a spot measurement. The number of spot measurements along the edge will vary depending on the total length of the coated edge.

Appendix 7
Method for Measuring Dry Film Thickness on Coated Steel Pipe Exterior (Nonmandatory)

Appendix 7 is not a mandatory part of this standard, but it provides a sample protocol for measuring DFT on the exterior of coated pipe. Appendix 7 may be invoked by contract documents and therefore is written in mandatory language. This Appendix becomes mandatory when it is invoked by specification, or the contractor has agreed in writing to comply with the provisions herein.

A7.1 Pipe sections that are loaded onto a cart or rack are considered a complete unit, as opposed to a single joint of pipe. The total number of spot and area measurements is based on the total square footage of pipe on the cart or rack. The square footage can be calculated as shown in the example below:

- Circumference of pipe = pi (π) × diameter
- Area = (length of each pipe × circumference) × no. of pipe sections on cart or rack

Example (U.S. Units):
- 10 pieces of 48 in long × 9 in diameter pipe = 4 ft × (3.14 x 0.75 ft) = 9.4 ft^2 area per pipe section.
- 9.4 ft^2 per pipe section × 10 pipe sections = 94 ft^2 total coated area

Since the total area is less than 100 ft^2, 5 spots (each spot is a minimum of 3 gage readings) are measured, according to Section 8.2.1.

A7.2 **Pipe DFT Frequency Factors**: Some carts may contain multiple small pipe sections, resulting in a total coated surface area in excess of 100 ft². In such cases, the specifier may require additional spot measurements, due to a large number of items on the cart. Using Section 8.2.1 of this standard, five readings are required for the first 100 ft² of coated pipe. In addition, the owner or contractor may specify one of the Pipe DFT Frequency Factors shown here. Based on the example in Section A7.1, if "Pipe DFT Frequency Factor 4" was invoked, 20 spot measurements would be acquired (5 spots [for the first 100 ft²] x 4 frequency factor). In such a case, more of the items on the cart are measured, giving a better sampling to determine compliance.

Example (U.S. Customary Units) if total coated area exceeds 100 ft² and Frequency Factor 2 is invoked:

- Total coated square footage on a cart = 175 ft²
- Section 8.2.1 requires 2 sets of 5 spot measurements (5 spots on each of two 100-square foot areas) = 10 spot measurements.
- Pipe DFT Frequency Factor of 2 × 10 spots = 20 spot measurements

A7.2.1 Pipe DFT Frequency Factor 2 = (length of each pipe × circumference) × no. of pipe sections on cart or rack = (number of spot measurements) × 2

A7.2.2 Pipe DFT Frequency Factor 3 = (length of each pipe x circumference) × no. of pipe sections on cart or rack = (number of spot measurements) × 3

A7.2.3 Pipe DFT Frequency Factor 4 = (length of each pipe x circumference) × no. of pipe sections on cart or rack = (number of spot measurements) × 4

A7.2.4 Pipe DFT Frequency Factor 5 = (length of each pipe x circumference) × no. of pipe sections on cart or rack = (number of spot measurements) × 5

A7.2.5 Pipe DFT Frequency Factor 6 = (length of each pipe x circumference) × no. of pipe sections on cart or rack = (number of spot measurements) × 6

A7.3 **Measurements On Individual Pipe Spools**: Pipe spools that are not loaded onto a rack or cart are measured individually. The number and locations of spot measurements are based on Table A7. Three sets of four circumferential spot measurements should be obtained on pipe spools less than ~3 m (~10 feet) in length.

Table A7
Number and Locations of Spot Measurements – Pipe Spools

Pipe Diameter	Circumferential Spot Measurements	Interval Spacing
Up to ~30 cm (~12 in)	4 evenly spaced	~3 m (~10 feet) apart
~36-60 cm (~14 to 24 inches)	6 evenly spaced	~3 m (~10 feet) apart
Greater than ~60 cm (~24 inches)	8 evenly spaced	~3 m (~10 feet) apart

A7.4 A challenge for the painter in coating fabricated pipe spools is providing a uniform thickness throughout the entire surface. On a fabricated pipe spool, there are potentially valves, flanges, and elbows that tend to have low or high DFT compared to the straight run section. Painters may develop a pattern of work for a specific task. Hence, the DFT on the flange and valves may be consistently on the high side or the low side of the target DFT. This type of error is easy to detect and correct. Random errors pose a more difficult problem. Gross errors where the paint is obviously too thin or too thick must be corrected and are beyond the scope of this standard.

The number of spot measurements in this protocol may far exceed the "5 spot measurements per ~10 m² (~100 ft²)" required in the standard. The full DFT determination, described in Table A7, provides a very thorough inspection of a joint of pipe. The DFT determination, described in Section A7.1, may allow for fewer spot measurements. The user does not have to require a full DFT determination for every joint of pipe. For example, the requirement may be for a full DFT determination on one pipe out of ten, or a sample DFT determination on one pipe out of five, or a combination of full and sample DFT determinations.

Appendix 8
Examples of the Adjustment of Type 2 Gages Using Shims
(Nonmandatory)

Appendix 8 does not form a mandatory part of this standard, but it provides examples of how to adjust Type 2 gages using certified shims or measured shims on roughened (e.g., abrasive blast cleaned) surfaces. This example describes a method of adjustment to improve the effectiveness of a Type 2 (electronic) gage on a blast cleaned or otherwise roughened surface. Blast cleaning is used throughout this example, but these methods are applicable to other types of surface preparation. A less uniform surface, such as partially rusted hand tool cleaned steel, may require more gage readings to achieve a satisfactory level of statistical significance. Since gage operation differs among manufacturers, follow the manufacturer's instructions for adjustment of a particular gage.

A Type 2 gage needs to be adjusted to account for the profile of the substrate in order to read the coating thickness directly. Type 2 gages equipped with double pole probes may provide greater measuring precision on rough surfaces compared to single pole probes.

A portion of the substrate, after blast cleaning but prior to coating, can be used to adjust the gage. Alternatively, an uncoated test panel, blast cleaned at the time the structure was blast cleaned and having a profile representative of the structure can be used to adjust the gage provided the test panel is of material with similar magnetic properties and geometry as the substrate to be measured. If this is not available, then a correction value can be applied to a smooth surface adjustment as described in A8.3.

Three adjustment techniques can be used depending on the capability and features of the gage to be used for the inspection. Note that due to the statistical variation produced by a roughened surface, individual readings taken using these three methods may not perfectly agree.

The first two examples describe adjustment and verification to one or more shims. When shims are used, resultant gage measurements are less accurate and must be recalculated. For example, if the accuracy of a properly calibrated gage is ± 2% and the thickness of a shim is accurate to within ± 3%, the combined tolerance of the gage and the shim will be ± 4% as given by the sum of squares formula:

$$\sqrt{2^2 + 3^2} = 3.6055 \approx 4\%$$

For the gage to be in agreement with the shim, the average thickness measured by the gage must be within ±4% of the shim's thickness. If the average thickness measured on a 250-micrometer (µm) (10-mil) shim is between 240 µm (9.6 mils) and 260 µm (10.4 mils), the gage is properly adjusted. The minimum of 240 is 250 minus 4% of 250 (9.6 is 10 minus 4% of 10); the maximum of 260 is 250 plus 4% of 250 (10.4 is 10 plus 4% of 10). [4% of 250 is 10; 4% of 10 is 0.4.]

A8.1 **Single-Point Adjustment**: This example uses a single shim value at or close to the thickness to be measured. The thickness range over which this adjustment achieves the required accuracy will vary with gage design.

Assuming that the coating thickness to be measured is 100 µm (4.0 mils), then a shim of approximately 100 µm (4.0 mils) or slightly greater should be used to adjust the gage. The shim is placed on an area of the substrate that has been blast cleaned to the required standards, or on a blasted test coupon with a similar surface profile. The average of 10 readings on the shim is sufficient to allow for the statistical variation in the blast profile.

A8.2 **Two-Point Adjustment**: This example uses two shim values, one above and one below the expected film thickness to be measured. It should be noted that not all film thickness gages can be adjusted in this manner.

Assuming that the coating thickness to be measured is 100 µm (4.0 mils), then shims of 250 µm (10.0 mils) and 50 µm (2.0 mils) are appropriate for setting the upper and lower values on the scale of the gage.

As protective coatings are normally applied to blast cleaned metal surfaces, a statistical approach is required to obtain a typical value for the adjustment. Ten readings on a shim are sufficient to establish a reliable average value for that shim on the roughened surface. Following the manufacturer's instructions, the gage is adjusted so that the actual shim thickness is then used to set the gage.

This procedure should be repeated for both the upper and lower shim values.

The average of 10 readings on an intermediate shim, approximately 100 µm (4.0 mils) thick in the case described here, will confirm that the gage has been adjusted correctly. It is acceptable for the average reading to be within ± 4% of the shim thickness.

This method ensures that the gage reads the thickness of the coating over the peaks of the profile.

A8.3 **Smooth Surface Adjustment**: If access to the bare blast cleaned substrate is not available because the coating already covers it, a smooth surface can be used to adjust the gage. Adjust the gage on a smooth surface according to the manufacturer's instructions. Alternatively, it may be possible to adjust some Type 2 gages through the coating already applied to an abrasive blast cleaned substrate (may be necessary if no uncoated substrate exists). This procedure should be performed according to the manufacturer's instructions.

Readings taken on the blast-cleaned substrate will be higher than the true value by an amount dependent on the surface profile and the gage probe design. For most applications, a correction value of 25 µm (1.0 mil) is generally applicable. Note that this value is not related to the actual surface profile measurement. This correction value must be subtracted from each gage reading to correct for the effect of the profile. The resulting corrected reading represents the thickness of the coating over the peak.

For fine profiles, the correction value may be as low as 10 µm (0.4 mils) but for coarse profiles it could be as high as 40 µm (1.6 mils). Table A8 gives approximate correction values to be used when a blast-cleaned surface is not available to adjust the gage.

Table A8
Typical Gage Correction Values Using ISO 8503 Profile Grades
(Source: ISO 19840)

ISO 8503 Profile Grade	Correction Value (mil)	Correction Value (µm)
Fine	0.4	10
Medium	1.0	25
Coarse	1.6	40

The use of coated standards to adjust gages means that a correction value must be applied to readings as the coated standards make use of smooth substrate surfaces.

Appendix 9
Precaution Regarding Use of the Standard for Coating Failure Investigations (Nonmandatory)

Appendix 9 is not a mandatory part of this standard and is included to offer cautionary information if this standard is being used for coating failure investigations. During a coating failure investigation, coating thickness measurements may be acquired from failing and non-failing areas based on observed patterns of failure and not acquired using the methods described in Sections 8.2.1 through 8.2.3. Acquiring coating thickness measurements using the denoted sections may incur higher costs than acquiring readings solely in areas of failing and adjacent areas of non-failing coatings. ASTM D7091 does not address frequency of measurements and therefore may be a more appropriate reference standard for this application.

Appendix 10
Procedure for Obtaining a Greater Population of Thickness Measurements on Large, Flat Plate, Beams, and Pipe Spools Using Type 2 Gage Continuous-Read/Scanning Technology
(Nonmandatory)

A10.0 Scope

Appendix 10 is not a mandatory part of this standard, but it provides a protocol for measuring the dry film thickness (DFT) of coatings on large, flat plate, beams, and pipe spools with Type 2 (electronic) gages utilizing scanning technology. Appendix 10 may be invoked by contract documents and therefore is written in mandatory language. Appendix becomes mandatory when it is invoked by specification, or the contractor has agreed in writing to comply with the provisions herein. Statistical analysis of data suggests that greater precision of DFT measurements can be achieved by obtaining a greater population of measurements over a larger area using the scanning method over the traditional "place & remove probe" frequency described in Section 8 of this standard. Also, scanning technology enables an operator to collect a greater number of DFT measurements in a shorter period than the traditional method described in Section 8. Due to the increased number of measurements being collected, better indication of the sample mean can be obtained through increased precision.

A10.2 Procedure

A10.2.1 The procedures for gage calibration, verification of accuracy, and adjustment described in Section 5 of this standard shall be completed prior to acquisition of coating thickness readings described in this Appendix.

A10.2.2 Obtaining Scanning Batch Measurements on Plate: Using a Type 2 gage set to the continuous-read mode, traverse the probe across the surface of a coating (see Figure A10.2) at the rate necessary to acquire a minimum of 12 readings (up to 24 readings) before lifting the probe. While more than 24 readings may be acquired during the scan, research has indicated that there is little improvement in the statistical validity of the data set with additional readings beyond 24. Any unusually high or low gage readings in a scan batch that are not repeated consistently (outliers) may be discarded. Record the mean of the acceptable scanning gage readings (Scanning Batch Measurement), as well as highest and lowest readings (after discarding outliers, if applicable). The standard deviation may also be reported if required.

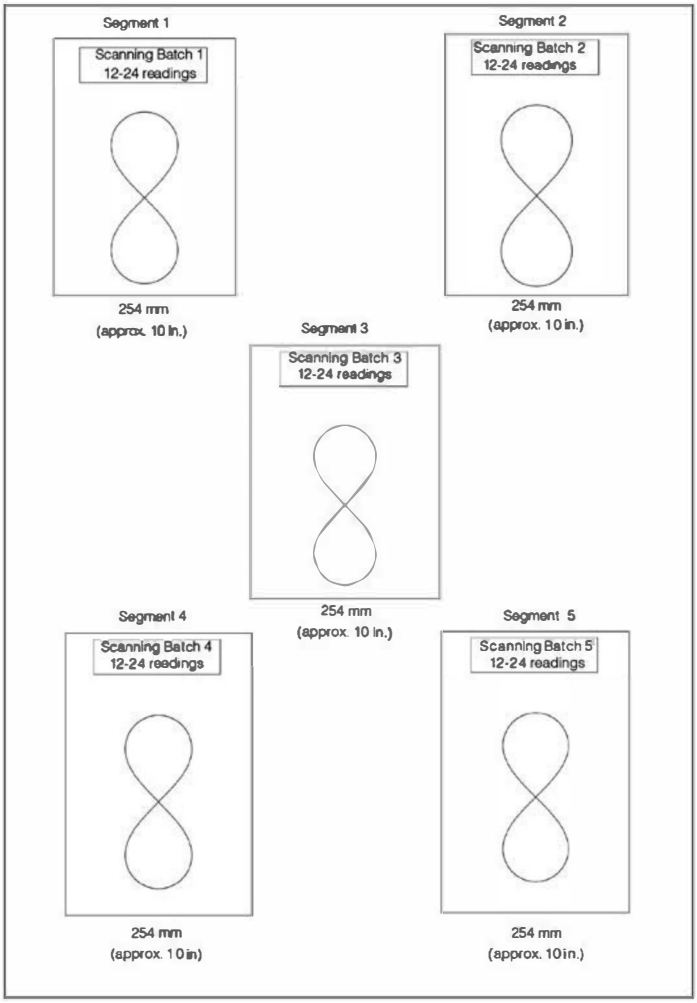

Figure A10.2: Obtaining Scanning Batch Measurements on 2 x 5m² Plate

A10.2.3 Obtaining Scanning Area Measurements on Plate: Repeat the procedure described in A10.2.2 in four additional ~645 cm² (~100 in²) segments (total of five segments) over each ~10 m² (~100 ft²) area of coated surface, or portion thereof (see Figure A10.2). The Coating Thickness Restriction Table (Table 1) in Section 9 of this standard is used to verify conformance to the coating thickness specified in the contract documents. The "Spot Measurement" column in Section 9, Table 1 shall be referenced for the Segment Measurements.

A10.2.4 Calculating the Scanning Area Measurement: Calculate the total mean of the five scanning batch measurements obtained over each ~10 m² (~100 ft²) area of coated surface, or portion thereof and record the information. The Coating Thickness Restriction Table (Table 1) in Section 9 of this standard is used to verify conformance to the coating thickness specified in the contract documents. The "Area Measurement" column in Section 9, Table 1 shall be referenced for the Scanned Area Measurements.

A10.3 **Obtaining Scanning Batch Measurements on Beams**: Divide the beam or girder into five equal sections along its length. Identify the 12 surfaces of the beam as shown in Figure A2 for each section. For tall beams,

where the height of the beam is ~90 cm (~36 in) or more, divide the web in half along the length of the beam. For the full DFT determination, each half of the web is considered a separate surface. Take one scanning batch measurement on surface 1 in each of the five sections. Scan measurements within a section shall run the length of the section in each of the five sections, see Figures A10.3.2 and A10.3.3. The mean of these five scanning batch measurements is the DFT of the measured surface. Repeat for the other 11 surfaces (7 surfaces if the toe is not measured; 14 surfaces for tall beams). See Appendix 2 for additional information on beam surfaces.

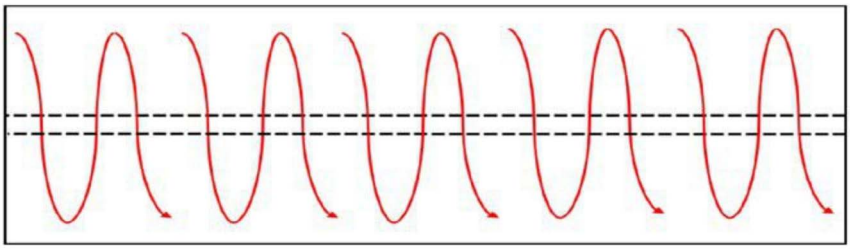

Figure A10.3.1: Scanning Batch DFT Measurements on an I-Beam (Top View)

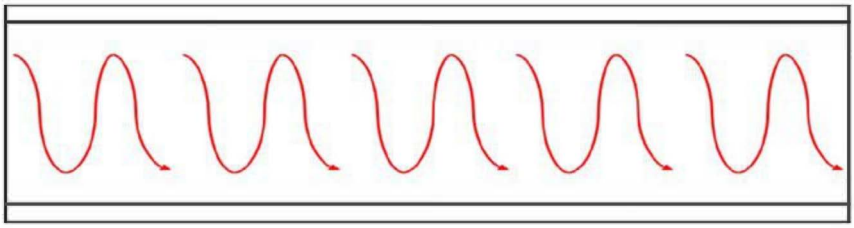

Figure A10.3.2: Scanning Batch DFT Measurements on an I-Beam (Profile View—No Toe Measurements, Less than ~90 cm [~36 in] in Height)

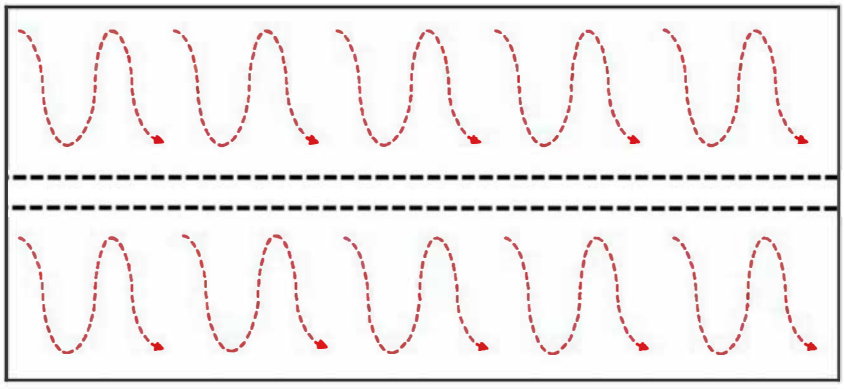

Figure A10.3.3: Scanning Batch DFT Measurements on an I-Beam (Top View/Bottom-Side Toe Measurments)

A10.4 If Coating Thickness Restriction Level 3 is invoked by the specification (or if no Restriction Level is invoked by the specification), then no single scanning batch measurement sample mean can be less than 80% of the specified minimum DFT, and no single scanning batch measurement sample mean can be more than 120% of the specified maximum DFT. The sample mean of each surface must conform to the specified DFT. There will be only eight sample mean values if the DFT of the toe is not measured, and there may be as many as 14 sample mean values for beams greater than ~90 cm (~36 in) in height.

A10.5 **Representative DFT Determination of a Beam**: In lieu of a full DFT determination of each beam, the job specification may require only a representative DFT determination for selected beams less than ~18 m (~60 ft) long. For a representative DFT determination, the web of beams greater than ~90 cm (~36 in) in height is not split.

A10.5.1 For beams less than ~6 m (~20 ft) in length, take two scanning batch measurements, randomly distributed, along the length of each of the 12 surfaces (8 surfaces if the toe is not measured) of the beam. Each scanning batch sample mean must conform to the specified DFT.

A10.5.2 For beams ~6 m (~20 ft) up to 18 m (~60 ft) in length, take three scanning batch measurements, randomly distributed, along the length of each of the 12 surfaces (8 surfaces if the toe is not measured) of the beam. Each scanning batch sample mean must conform to the specified DFT.

A10.6 Table A10.1 summarizes the requirements of Section A10.3 through A10.5.

Table A10.1
Number of Scanning Batch Measurements Needed
on Each Surface of a Beam for a Full or a Representative DFT Determination

	Number of Scanning Batch Measurements per Surface	
Length of Beam	**Full DFT Determination[A]**	**Representative DFT Determination**
Less than ~6 m (~20 ft)	5	2
From ~6 to 18 m (~20 to 60 ft)	5	3
Over ~18 m (~60 ft)	5	NA

[A]

A10.7 **Attachments**: Stiffeners and other attachments should be arbitrarily measured.

A10.8 **Non-conformance**: If any scanning batch measurement sample mean falls outside the specified range, additional scanning batch measurements may be made to define the non-conforming area.

A10.9 **Restricted Access**: If the beam is situated such that one or more of the surfaces are not accessible, take scanning batch measurements on each accessible surface.

A10.10 **Obtaining Scanning Batch Measurements on Pipe Spools**: Using a Type 2 gage set to the continuous-read mode, traverse the probe longitudinally across the surface of a coating as shown in Figures A10.10.1 through A10.10.3 at the rate necessary to acquire a minimum of 12 readings (up to 24 readings) before lifting the probe. Any unusually high or low gage readings in a scan batch that are not repeated consistently (outliers) may be discarded. Record the mean of the acceptable scanning gage readings (Scanning Batch Measurement), as well as highest and lowest readings (after discarding outliers, if applicable). The standard deviation may also be reported if required.

A10.11 **Obtain Scanning Area Measurements**: Repeat the procedure described in A10.10 in additional locations spaced evenly around the pipe circumference, at the same location along the pipe. The number of evenly spaced locations shall be in accordance with Table A10.2. Then obtain four more circumferential sets of scanning batch measurements (total of 5 segments) along the coated length of the pipe at ~3 m (~10 ft) intervals. See Figures A10.10.1 through A10.10.3. Note that only 3 of 5 segments are shown in Figures A10.10.1 through A10.10.3. The average of all the scanning batch measurements shall be considered the scanning area measurement. The Coating Thickness Restriction Table (Table 1) in Section 9 of this standard is used to verify conformance to the coating thickness specified in the contract documents. The "Spot Measurement" column in Section 9, Table 1 shall be referenced for the Scanning Batch Measurements.

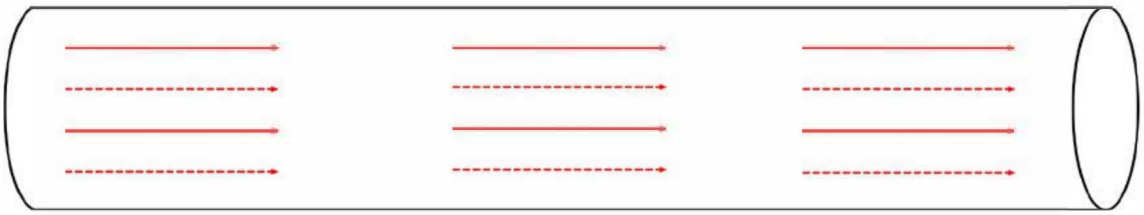

Figure A10.10.1: Four evenly spaced scanning batch measurements on a pipe diameter up to ~30 cm (~12 in) and greater than ~3 m (~10 ft) in length. Each arrow in the above diagram represents one circumferential scanning batch. Dotted arrows represent opposite side of pipe.

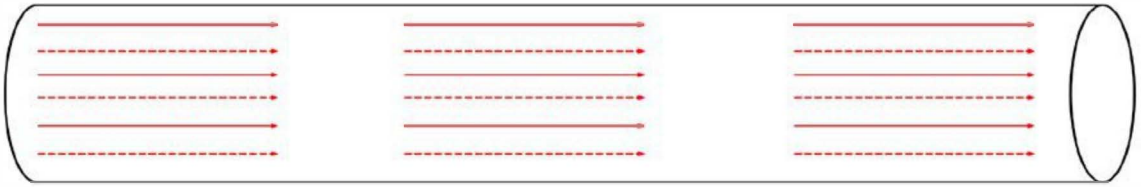

Figure A10.10.2: Six evenly spaced scanning batch measurements on a pipe diameter ~36-60 cm (~14 to 24 in) () and greater than ~3 m (~10 ft) in length. Each arrow in the above diagram represents one circumferential scanning batch. Dotted arrows represent opposite side of pipe.

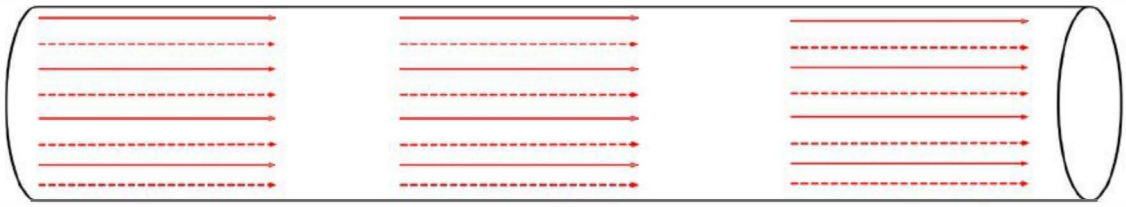

Figure A10.10.3: Eight evenly spaced scanning batch measurements on a pipe diameter greater than ~60 cm (~24 in) and greater than ~3 m (~10 ft) in length. Each arrow in the above diagram represents one circumferential scanning batch. Dotted arrows represent opposite side of pipe.

A10.12 Table A10.2 summarizes the requirements of Section A10.10 through A10.11.

Table A10.2
Number and Locations of Scanning Batch and Area Measurements –
Pipe Spools Longer Than ~3 M (~10 FT)

Pipe Diameter	Circumferential Scanning Batch Measurements	Interval Spacing for Scanning Area Measurements
Up to ~30 cm (~12 in)	4 evenly spaced	~3 m (~10 ft) apart
~30-60 cm (~14 to 24 in)	6 evenly spaced	~3 m (~10 ft) apart
Greater than ~60 cm (~24 in)	8 evenly spaced	~3 m (~10 ft) apart

Appendix 11
Method for Measuring the Thickness of Intumescent (Fireproofing) and Cryogenic Spill Protection Coatings Applied to Load-Bearing Structural Steel Members, Fire Divisions, Pipework, and Vessels/Tanks
(Nonmandatory)

A11.1 **Scope**: Appendix 11 is not a mandatory part of the SSPC-PA 2 standard, but it provides a protocol for measuring the dry film thickness (DFT) of intumescent fireproofing and cryogenic spill protection (CSP) systems applied to steel, such as structural steel members, girders, hollow steel sections, vessels, tanks, firewalls; and to reinforced steel plate, such as decks and bulkheads. Given the critical service that these systems provide, and the wide range of dry film thickness requirements specified, the frequency and acceptability of measurements varies significantly from those in the body of SSPC-PA 2. Appendix 11 may be invoked by contract documents and therefore is written in mandatory language.

Fireproofing and CSP systems serve a critical life safety role, as well as asset and environmental protection, whether for hydrocarbon processing facilities, terminals, offshore structures, or for commercial and residential buildings. Extensive third-party testing is performed on all fireproofing products to evaluate their thermal protection properties (insulation performance), for both cellulosic and hydrocarbon fires, on various steel shapes and section factors, within a range of limiting temperatures, and according to the designed purpose (load-bearing or non-load-bearing) of a steel structure. Third-party testing is performed according to industry standards such as those listed in Section A11.2, for example, ASTM E119 and E1529; BS 476-20 and 476-21; EN 13381-8; ISO 834-10, ISO 22899-1, ISO 20088; ANSI/UL 263, and ANSI/UL1709. For each intumescent coating, a minimum DFT is certified according to a specific testing standard, fire exposure, section factor, and fire rating. The certified DFT will provide the amount of insulation required to limit the rise of the steel member's core temperature and to reduce the amount of heat transfer through the intumescent coating, according to the certification parameters. An intumescent coating, if applied at too low of a thickness, presents a risk of a premature failure in a fire scenario. There are a number of coatings with certified DFTs that could exceed 25 mm (984 mils), depending on exposure design requirements of the system. However, typical thick-film intumescent coating applications range between 4 mm (157 mils) and 13 mm (511 mils), with thin-film intumescent coating materials typically applied between 2 mm (75 mils) and 8 mm (315 mils).

A11.2 Referenced Standards

A11.2.1 The latest issue, revision, or amendment of the referenced standards in effect on the date of invitation to bid shall govern unless otherwise specified.

A11.2.2 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.

A11.2.3 ASTM International, www.astm.org

ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E1529-1 Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies

A11.2.4 British Standards Institute[3] www.bsigroup.com

BS 476-20 Fire tests on building materials and structures – Part 20 Method for determination of the fire resistance of elements of construction (general principles)
BS 476-21 Fire Resistance Test to Building Material – Loadbearing elements
BS 13381-8 Test methods for determining the contribution to the fire resistance of structural members – Part 8 – Applied reactive protection to steel

A11.2.5 European Standard www.en-standard.eu/

EN 13381-8 Test methods for determining the contribution to the fire resistance of structural members – Part 8 – Applied reactive protection to steel

[3]

A11.2.6 International Organization for Standardization www.iso.org

ISO 834-10 Fire resistance tests – Elements of building construction – Part 10: Specific requirements to determine the contribution of applied fire protection materials to structural steel elements

ISO 12944-7 Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 7: Execution and supervision of paint work

ISO 12944-8 Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 8: Development of specifications for new work and maintenance

ISO 20088 Determination of the resistance to cryogenic spillage of insulation materials - Part 1 – Liquid phase and Part 3 – High pressure jet release

ISO 22899-1 Determination of the resistance to jet fires of passive fire protection materials – Part 1 General requirements

A11.2.7 Underwriters Laboratories[4] https://www.ul.com

ANSI/UL 263 Standard for Fire Tests of Building Construction and Materials

ANSI/UL1709 Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel

A11.3 Definitions

Cellulosic Fire: A fire in which the fuel source does not contain hydrocarbons, but materials common to the construction of commercial and residential buildings.

Circumference Measurement: The average of the total gage readings around the circumference of an open or closed profile steel member, within a linear path not to exceed 15 cm (6 in.) wide. Measurements may include spot readings, if applicable. Only measurements taken on steel member sides protected with PFP/CSP systems are included in circumference measurements. Refer to Figures A11.1 and A11.2.

Cryogenic Spill: an unintended release of a cryogenic liquid, typically around -162 °C (-260 °F) and lower, either in the form of spray, immersion, splash and or vapor.

Equipment Measurement: The average of the gage readings, and spot measurements if applicable, on each vessel, tank, and other equipment types.

Fire Rating: The amount of time that a fireproofed steel member must be thermally protected to a specific fire exposure, according to an industry standard.

Fireproofing: As it pertains to SSPC-PA 2, Appendix 11, is an intumescent coating that reacts with direct flame impingement, or radiant heat, to form an insulative char to limit the rise of the steel member's core temperature and to reduce the amount of heat transfer from the fire into the steel. Intumescent coatings are included in a general classification of fire protection materials known as passive fire protection (PFP).

Fire Exposure: a description of the expected fuel source of a given fire, being either cellulosic or hydrocarbon. Hydrocarbon fire exposures are further classified as pool fire or jet fire. A portion, or all, of a hydrocarbon fire rating may include jet fire exposure.

Gage Reading: A single instrument reading.

Hydrocarbon Fire: A fire in which the fuel source is hydrocarbon, such as petroleum and natural gas.

Limiting Temperature: The maximum, or highest, temperature which the fireproofed steel member must not exceed during the specified fire rating. For CSP systems, it is the minimum, or lowest, temperature steel must not exceed during a cryogenic spill. Often CSP systems will include a required fire rating, therefore resulting in both a minimum and maximum limiting temperature.

[4]

Jet Fire: An ignited pressurized hydrocarbon fuel source.

Member Measurement: The average of circumference measurements for open and closed profiles shown in Figures A11.1 and A11.2.

Panel Measurement: The average of the gage readings, and spot readings if applicable, on flat, corrugated, or contoured steel plate, as illustrated in Figure A11.3, which are typically used for the construction of decks, bulkheads, and firewalls.

Pool Fire: An ignited hydrocarbon fuel source that is not pressurized.

Section Factor: The cross-section unit area, or mass, of a given steel member in relationship with its surface area which may be exposed to flame impingement or radiant heat. Section factor calculations are used to determine the rate of heat absorption of a given steel member within a specified fire rating.

Spot Measurement (PFP/CSP Systems): As it pertains to SSPC-PA 2, Appendix 11, is the average of at least three gage readings made within a 15-cm (6-inch) diameter circle.

Thick-Film: Plural component intumescent coating systems designed and tested for hydrocarbon fire exposure, such as fires that occur in refineries, chemical plants, and on offshore structures, where the fuel source is hydrocarbon-based.

Thin-Film: Intumescent coatings, both single and plural component, designed and tested for cellulosic fire exposure, such as fires that occur in commercial and residential buildings, where the fuel source is not hydrocarbon-based. Dry film thickness requirements are typically less than thick-film intumescent coatings but can be equivalent, depending on the type of intumescent coating and fire rating.

A11.4 Dry Film Thickness Specification Parameters

A11.4.1 Table A11.1 contains three fireproofing thickness restriction Levels. The specifier may select the fireproofing thickness restriction level for a given project. If no restriction level is specified, then Level 1 is the default.

Table A11.1
Fireproofing Thickness Restriction Levels

Specified DFT Range for Individual Gage Readings included in Equipment, Member, and Panel Measurements	<4 mm (157 mils)	>4 mm (157 mils) ≤8 mm (315 mils)	>8 mm (315 mils) ≤13 mm (512 mils)	>13 mm (512 mils)
Level 1 (default)				
Minimum	As specified	As specified	As specified	As specified
Maximum	150%	140%	130%	120%
Level 2				
Minimum	90%	90%	90%	90%
Maximum	150%	140%	130%	120%
Level 3				
Minimum	85%	85%	85%	85%
Maximum	150%	140%	130%	120%

A11.4.2 The dry film thickness is deemed to comply with SSPC-PA 2, Appendix 11, when the equipment measurement, member measurement, or panel measurement is at least equal to the specified DFT and does not exceed the maximum specified DFT thickness restriction level specified in Table A11.1.

A11.5 Preparation for Inspection

A11.5.1 Prior to the application of the fireproofing and or CSP system, at minimum, an inspector must have access to the project specification, technical data sheet for each coating within the system specified, the fireproofing and or CSP product application manual, manufacturer's material take-off document stating DFT requirements for each steel member size to be coated, and applicable third-party fireproofing and or CSP certificate, or excerpt of document, illustrating and or describing the system components of the certified system. Inspector shall have the latest revisions of each document and confirm that the fireproofing and or CSP certification has not expired.

A11.5.2 The applicable certification for the specified fireproofing and or CSP system shall be reviewed to confirm if reinforcement, such as a non-metallic mesh or square galvanized wire, is required. If required, the specific reinforcement, the location within the total dry film thickness where it must be installed, and the reinforcement overlap requirements shall be identified.

A11.5.3 The maximum allowable DFT must be confirmed in writing from the manufacturer's technical authority and or from the certification document. If the maximum allowable DFT is less than the specified maximum level selected in Table A11.1, then the intumescent coating certification restriction shall be followed.

A11.5.4 The procedures for gage calibration, verification of accuracy, and adjustment described in Section 5 of this standard shall be completed prior to acquisition of fireproofing thickness readings described in this appendix. In addition, proper procedure for verifying the accuracy of the specific instrument being used for DFT readings on outside corners of square and rectangular hollow sections, circular hollow sections, and on edges, such as flange tips, to obtain the most accurate measurement shall be confirmed.

A11.5.5 Compatibility of the gage probe with the anticipated thickness of the fireproofing and or CSP system shall be verified. Further verification of accuracy and adjustments shall be performed with the selected probe prior to measuring fireproofing thicknesses. If deemed necessary, destructive DFT readings may be taken using a depth gauge, followed by repair of the system.

A11.5.6 Reference area(s), representative of the project as a whole, should be created in accordance with ISO 12944 - parts 7 and 8 to establish an acceptable standard of finish prior to commencement of the project. This may be stated as a requirement within contract documents. Consideration of acceptance shall include finish texture and film build uniformity across the surface of the steel. Excessively textured finishes or poor film build uniformity across the surface of the steel that would interfere with dry film build readings or result in vast variation of dry film measurements outside the specified restriction level stated in Table A11.1, shall not be acceptable.

A11.6 DFT Inspection Procedures

A11.6.1 The application and repairs of fireproofing and CSP coating systems shall be carried out in accordance with the manufacturer's written instructions, typically stated within technical data sheets and in intumescent coating application manuals.

A11.6.2 The DFT requirements for the primer, if included in the fireproofing or CSP system, shall be verified in accordance with the standard procedures described in SSPC-PA 2.

A11.6.3 The DFT requirements for the finish coat, if included in the fireproofing or CSP system, shall be verified by taking wet film thickness (WFT) readings to ensure the specified dry film thickness is achieved, taking into consideration the initial volume solids of the coating and the addition of any reducer. No finish coat shall be applied until the specified minimum required DFT of the fireproofing or CSP coating has been achieved according to A11.4.2.

A11.6.4 Regardless of total unit areas fireproofed, the coating thickness on each steel member must be measured.

A11.6.5 The specific locations of the DFT gage readings are based on the steel member shapes listed in Table A11.2 and illustrated in Figures A11.1 through A11.3. The distance between gage readings is specified in Table A11.2 according to the shape and size of the steel member.

Table A11.2
Dry Film Thickness Measurements on Steel Members

Steel Member Shape	Location of Gage DFT Readings[A]
Open profile members, such as Girders, I-Sections, Tee Sections, Channels, and Angles.[B] (Fig. A11.1)	Girder and I-Section Outer Flanges: • One gage reading in the center of each flange tip • One gage reading in the center of the outer flange face if the width is ≤20 cm (8 in) wide • Flange widths measuring between >20 cm (8 in) and 30 cm (12 in) shall have two gage readings with equal spacing between flange tips and each gage reading • Flange widths >30 cm (12 in) shall have one gage reading per 10 cm (4 in) with equal spacing between each flange tip and each gage reading Girder and I-Section Inner Flanges: • Inner flange shall have one gage reading 5 cm (2 in) from the flange tip and one gage reading 5 cm (2 in) from the web • Inner flange widths measuring greater than 20 cm (8 in) shall also include one additional gage reading per 10 cm (4 in), with equal spacing, between the web and flange tip and each gage reading Girder and I-Section Web (both sides): • Webs ≤36 cm (14 in) in depth shall have one gage reading 5 cm (2 in) from each flange and one in the center of the width of the web • For webs >36 cm (>14 in), one gage reading within 5 cm (2 in) from each flange and one additional gage reading, equally spaced, for every 13 cm (5 in) across the width of the web Tees: • Web depths >20 cm (8 in) shall follow same guidance as I-sections • Web depths ≤20 cm (8 in) shall have one gage reading in the center of each face • Web tip shall be measured as a flange tip Angles: • One gage reading taken near the center of each face Channels: • For web depths >20 cm (9 in) one gage reading in the center of each flange tip • Both outer and inner flange faces shall have one gage reading in the center • Web depths >20 cm (9 in) shall follow same guidance as I-sections for measuring the web • Each outside corner shall be measured within each circumference measurement • Web depths ≤20 cm (9 in) shall have one gage reading in the center of each face
Closed Profile Members: Circular Hollow Sections, Vessels, and Tanks (Fig. A11.2)	• A minimum of four gage readings, equally spaced, around the circumference of hollow sections • The distance between gage readings, with equal spacing, around the circumference shall not exceed 10 cm (4 in) • Circumference gage reading locations shall be rotated by approximately 45° between subsequent circumference gage reading locations to avoid consistent linear gage readings along the length of a circular hollow section • Tanks, vessels, offshore structures, and other equipment types: 1 gage reading, no less than 1 meter (40 in) apart, taken over the entire coated surface. Measurements shall include gage reading with 5 cm (2 in) from edges, if applicable.
Closed Profile Members: Rectangular and Square Hollow Sections (Fig. A11.2)	• One gage reading on the center of each face measuring ≤20 cm (8 in) • Two gage readings, with equal spacing, between each corner and each gage reading on each face measuring between >20 cm (8 in) and 30 cm (12 in) • Face widths >30 cm (12 in) shall have one gage reading per 10 cm (4 in), with equal spacing, between each corner and each gage reading on each face • Each outside corner shall be measured within each circumference measurement
Steel Panels, such as Firewalls, Decks, and Bulkheads (Fig. A11.3)	Entire fireproofed surface: • Gage readings within 5 cm (2 in) from edges, around the parameter, no greater than 60 cm (24 in) apart • Gage readings across the coated surface, no greater than 60 cm (24 in) apart
[A] [B]	

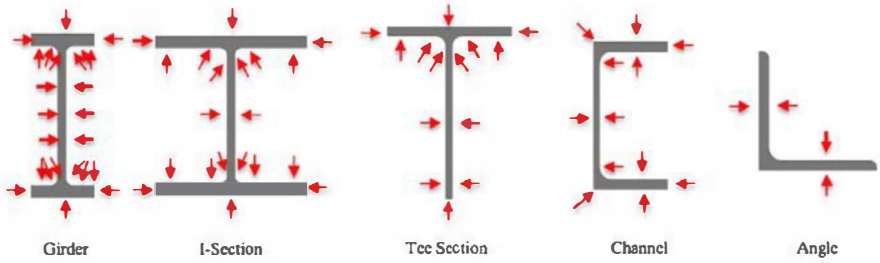

Figure A11.1: Open Profile Steel Members

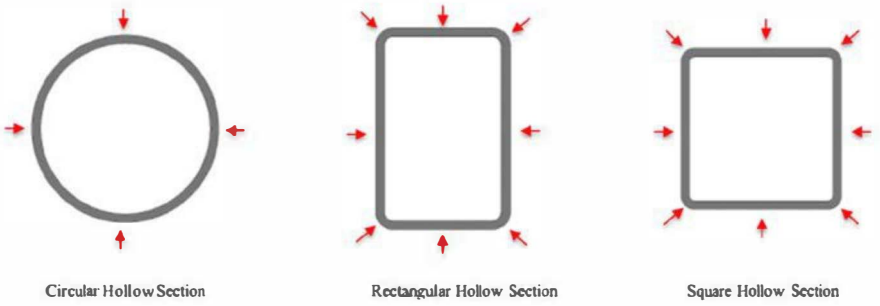

Figure A11.2 Closed Profile Steel Members

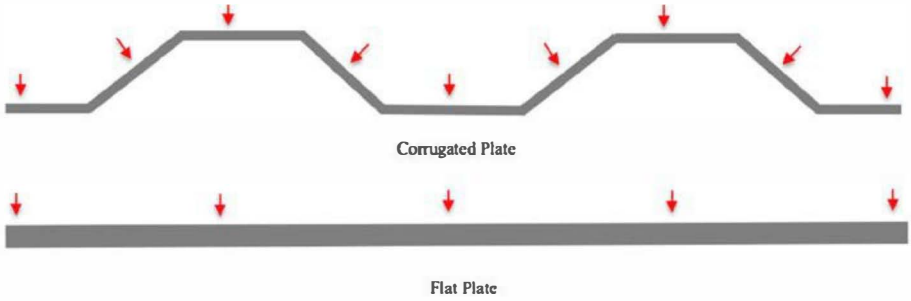

Figure A11.3 Steel Plates. Arrows indicate potential locations for taking measurements on corrugated and flat plates. Measurements are not required at every arrow.

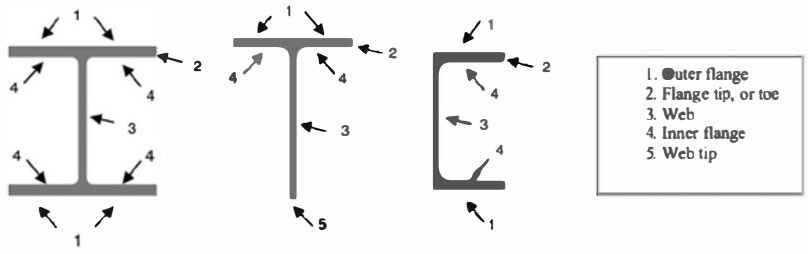

Figure A11.4 Component Names of Girders, I-sections, Tee Sections, and Channels

A11.6.6 The distance between circumference readings, along the length on open and closed steel profile members, shall not exceed 60 cm (24 in). The distance between gage readings on panels shall not exceed 60 cm (24 in). The distance between gage readings on equipment, such as tanks, vessels, and superstructures, shall not exceed 1 meter (40 in).

A11.6.7 Each flange tip within each circumference measurement on I-sections, girders, channels (web depths >20 cm [9 in]), and tees (web depths >20 cm [8 in]), shall have one gage reading. If the flange thickness is too small or it is not within the capabilities of the DFT instrument, then a gage reading shall be taken on both the accessible outer and accessible inner flange, as close to the flange tip as the gage will allow, but not to exceed 4 cm (1.5 in) from each flange tip.

A11.6.8 For steel members specified to have fireproofing applied on limited sides or areas, such as on a 3-sided beam or within a block out area, circumference and member measurements shall only consist of gage measurements, and spot measurements if applicable, on protected sides.

A11.6.9 When performing gage readings on open and closed profile steel members, no two adjacent circumference measurements should fall below 100% of the specified DFT. Three consecutive circumference measurements, adjacent to each other, shall not fall below 100% of the specified DFT. Additional material shall be applied to non-conforming area to achieve, at minimum, the specified DFT.

A11.6.10 When performing gage readings on equipment and panels, no two adjacent gage readings should fall below 100% of the specified DFT. Three consecutive gage readings along a linear path, in any direction, shall not fall below 100% of the specified DFT. Additional material shall be applied to non-conforming area to achieve, at minimum, the specified DFT.

A11.6.11 Areas measuring above the maximum DFT allowed for a given certification shall be repaired according to manufacturer's written instructions. Following the repair, the member, equipment, or panel measurements shall be carried out to confirm conformance according to the specified coating restriction level in Table A11.1.

A11.6.12 Gage readings or spot measurements, as defined in this appendix, shall be taken on any isolated area (areas outside the range of DFT measurement locations described in section A11.6.7) which appear to be below 85% of the specified dry film thickness, regardless of location, including corners and toes of flanges. DFT measurements within these isolated areas are to be considered independent and not to be included within circumference, equipment, and panel measurements. For isolated areas below 85% of the specified DFT, additional material shall be applied to the non-conforming area to achieve, at minimum, the specified DFT.

A11.6.13 In locations where space does not permit the use of Type 2 DFT gages, WFT readings shall be taken to ensure that the specified DFT is achieved. The initial volume solids of the coating, the addition of any solvent, and shrinkage that occurs during the curing process (typically in the range of 2% to 5% for plural-component intumescent coatings), shall be considered when measuring the WFT. The final DFT for single-component intumescent coatings are determined by its percentage of volume solids, which must be confirmed within the technical data sheet.

A11.6.14 WFT and DFT readings taken by applicators during the application process for the purpose of achieving the specified DFT are not required to be included in official inspection reports. There are no restrictions on the location or the number of gage readings that may be taken by applicators. Tape, stickers, and markings made on coated surfaces shall not leave any residue, such as a glue or wax, which may compromise adhesion of subsequent coating layers applied.

A11.6.15 For structural steel members that are not typical of commercially produced shapes and sizes, gage readings shall be taken within 5 cm (2 in) from edges, the distance between gage readings within the circumference measurements shall not exceed 13 cm (5 in), the distance between circumference measurements shall not exceed 60 cm (24 in).

A11.7 Conflict Resolution

A11.7.1 For member, equipment, or panel measurements above the specified DFT thickness restriction level, owner representative approval may be obtained for acceptance if the average is below the maximum allowable DFT, according to the intumescent coating certification.

A11.7.2 Application of all fireproofing and CSP systems shall comply with the industry standard in which the system was tested and certified. If there is a conflict between the requirements of this standard and the third-party industry certification specified, the requirements of the certification shall prevail.

A11.7.3 If there is a conflict between the written application requirements of the specified system and this standard, the manufacturer's written application requirements shall prevail, provided the minimum specified DFT is achieved.

A11.8 Reporting

In addition to standard application coating inspection requirements, report:

- The fireproofing or cryogenic spill protection system materials specified, along with batch dates
- Include documents listed in A11.5.1 and A11.5.3
- The certification being followed and include the certificate which defines the system configuration listed in A11.5.2
- The reference area location, in accordance with A11.5.6
- The DFT measurements of the primer, if included in the specified system
- The member, equipment, or panel measurements, along with the minimum and maximum dry film thickness for each fireproofed steel member
- The WFT readings for members described in A11.6.13, along with the percentage of solvent reduction and solvent type, if any
- The reinforcement commercial product name, the depth or DFT range in which it was installed within the system, along with the overlap measurements (if required per Section A11.5.2)
- The WFT measurements of the finish coat, if included in the specified system
- All conflicts described in Section A11.7