SPC-PA 2, Measurement of Dry Coating Thickness with Magnetic Gages, is among the most widely used SSPC standards. The latest revision became available last summer. There is no drastic change in the way dry film thickness (DFT) has traditionally been measured, since the “meat” of the 2004 revision is the same as the 1996 revision. But there are changes that should help specifiers and contractors alike. As is the case with all SSPC standards, this revision of PA 2 went through the consensus process, ultimately being approved by the Unit Committee, the Group Committee, the Standards Review Committee, and the Board of Governors. The diverse strongly opinionated positions of the members of each of these bodies resulted in much wailing and gnashing of teeth until workable compromises were formulated. This article will identify differences between the 2004 revision and the 1996 revision.

**New Appendices**

The most noticeable change in PA 2 is the addition of four new appendices. The committee recognized that the existing PA 2 was fine for large flat surfaces, but concerns about other shapes and sizes prompted the creation of these new appendices. In SSPC standards, appendices are not mandatory. However, these new appendices to PA 2 were written in such a way that they can easily be specified, thereby making them mandatory, if they are applicable to a particular job. The new appendices cover where and how many measurements should be taken.

**Appendix 3, Measuring DFT on Steel Beams**

A appendix 3, Methods for Measuring Dry Film Thickness on Steel Beams (Girders), provides two sample procedures for measuring DFT on beams and girders. Painters develop a pattern when painting shapes, and it is important to check that the underside of the top flange, for example, has the same DFT as the middle of the web. Because of the painter’s methods, one or two surfaces of a beam may be consistently out of conformance with the DFT specification; hence, every surface must be independently measured.

The procedures described in this appendix were first developed by a task group consisting of representatives from paint shops and inspection companies working in collaboration with the American Institute of Steel Construction (AISC). The methods for measuring DFT on beams and girders as used by these various groups were blended into a version that was useable by all. The document was then fine-tuned through input from the unit and group committees.
The two procedures for measuring DFT on beams are: 1) a full DFT determination that takes many measurements to thoroughly measure the beam; 2) a sample DFT determination that is less stringent. The specifier can choose the desired level of thoroughness based on how critical the job is and/or how much confidence there is in the painting contractor.

The surfaces of the beam are numbered as in Fig. 1 on p. 44. Spot measurements (average of three gage readings) are taken on each accessible surface. The exact number of spots depends on the size of the beam. As has been the case with PA 2, a single spot measurement may be only 80% of the minimum specified DFT as long as the average of the spot measurements is at least the specified minimum. Similarly, a single spot may not exceed 120% of the maximum specified DFT.

Appendix 4, Measuring DFT for Shop-Coated Pieces

Appendix 4, Methods for Measuring Dry Film Thickness for a Laydown of Beams, Structural Steel, and Miscellaneous Parts After Shop Coating, is similar to Appendix 3 except that the pieces are painted in a shop. The method used to measure DFT on beams and girders painted in a shop is the same as that described in Appendix 3. But Appendix 4 also addresses miscellaneous parts coated during a single shift by one painter.

A full DFT determination on a miscellaneous part requires at least five spot measurements. If the part has more than five surfaces, a spot measurement must be made on each surface. A sample DFT determination is less stringent and requires only three spot measurements per part. Based on the nature of the job, the specifier can specify the frequency of each type of determination. For example, one can specify 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; and a sample DFT determination on every third piece.

### Appendix 5, Measuring DFT on Coated Steel Test Panels

A appendix 5, Measuring Dry Film Thickness on Coated Steel Test Panels, describes a procedure for preparing test panels, usually in a laboratory. This method requires a Type 2 electronic gage, which labs use regularly, rather than a Type 1 pull-off gage. Since the area of the average test panel is very small compared to a structure, the number of gage readings is specified and no mention is made in Appendix 5 of averaging three gage readings to get a spot measurement. A total of six gage readings is made on each panel, two readings each in the top third, the middle third, and the bottom third of the panel. Each gage reading must conform to the 80% of minimum/120% of maximum rule. The average of the six gage readings is the DFT of the test panel and must conform to the specification.

### Appendix 6, Measuring DFT of Thin Coatings on Blast-Cleaned Test Panels

A appendix 6, Measuring Dry Film Thickness of Thin Coatings on Coated Steel Test Panels that Had Been Abrasive Blast Cleaned, describes a procedure to be used when Appendix 5 is not applicable, for example, when preparing test panels coated with a zinc-rich pre-construction primer. For coatings less than 1 mil (25 μm) thick, the DFT is the same order as the statistical fluctuations of a DFT gage on bare blast cleaned steel; hence, many measurements must be taken to get a meaningful average. On each third of the panel, ten gage readings are averaged to get a mean value. Each mean must follow the 80% of minimum/120% of maximum rule. The average of the three means is the DFT of the test panel and must conform to the specification.

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**Measuring Large Structures**

One of the few substantive changes in the 2004 revision of PA 2 is the procedure for dealing with a non-conforming area when measuring large structures. As before, only one 100 ft² (10 m²) area needs to be measured in each 1000 ft² (100 m²). The previous version of PA 2 stipulated the following for a non-con-
forming area: “additional measurements must be made to isolate the non-conforming area.” Added to that sentence in this latest version is: “and each 100 ft² (10 m²) area painted during that work shift shall be measured.” The reasoning behind this change is that finding one non-conforming area indicates that something went wrong during that work shift. Therefore, there is no way of knowing how many other areas are non-conforming unless they are all measured.

Gage Accuracy
As technology advanced, the accuracy of DFT gages improved to the point that electronic gages and most “banana” gages are accurate to within a few percent. To reflect this technological advance, for a gage to qualify under PA 2, the gage must have an accuracy within ± 5% or, for thin coatings, within ±0.1 mil (2.5 µm). The previous accuracy limit was ±10%. The effect of tightening this limit is to prohibit the use of pencil style pull-off gages under PA 2, since the most accurate pencil gages have a ± 10% limit on accuracy. As explained in a note in PA 2, in those instances where a pencil gage is the only practical way of measuring DFT, the contracting parties can agree to use them.

Calibration, Verification of Accuracy, and Adjustment
The new version of PA 2 has an expanded “Definitions” section. Clear distinctions are made among calibration, verification of accuracy (verification of internal calibration), and adjustment for a given profile. Gages are calibrated by the manufacturer or a qualified laboratory in a controlled environment using a documented procedure so that the gage will accurately measure known standards. Calibration of a gage may involve replacing the probe tip, replacing the spring or magnet, repairing electronic circuitry, etc.

The user needs only to verify that the gage is properly calibrated by measuring known standards. If a gage is out of calibration (not to be confused with out of adjustment), it may read a 5-mil (125 µm) standard correctly but not a 10-mil (250 µm) standard. If the DFT is expected to be around 7 mils (175 µm), there is no guarantee that the gage will give an accurate reading. A user may be able to adjust the gage to read both the 5-mil (125-µm) and the 10-mil (250-µm) standards accurately. In this case, the gage can be used with confidence to measure DFT between these limits. If major adjustments are necessary for every DFT range, it would be prudent to return the gage to the manufacturer for calibration.
Manufacturers often recommend returning the gage to them each year for re-certification, but this is not a requirement of PA 2. To quote PA 2, “There is no standard time interval for re-calibration, nor is one required.” Yearly factory recalibration may be a requirement of some other standard, such as A NSI Z540-1 or ISO 9000. As long as the gage reads known standards accurately, there is no need, according to PA 2, to send it back to the factory. For example, in the railcar industry, a single gage may be used to make several hundred measurements each day. The tip may wear out in six months, and the gage will require factory service and re-calibration. If a gage is used only sporadically, it may remain calibrated for many years.

PA 2 does require (as in the 1996 revision) that the accuracy of the gage be checked at the beginning and at the end of each work shift. Further accuracy checks are suggested if the gage is dropped or the readings become suspicious or erratic.

Gages are adjusted by the user to improve their accuracy in a specific circumstance. For example, when measuring DFT on a blast-cleaned surface, most electronic gages have a means of correcting for the effect of blast profile so that the individual gage readings represent the thickness of the paint above the profile peaks. The act of pushing buttons or turning dials so that the gage readings are automatically corrected for a given profile is adjustment, not calibration.

**Names of Gage Types**

Whereas Type 1 pull-off gages used to be divided into Type 1A and Type 1B depending on the type of spring mechanism, the new PA 2 does not make a distinction between banana gages and pencil gages and calls them all simply Type 1—Pull-Off Gages.

What PA 2 had referred to as constant pressure probe gages are now called Type 2—Electronic Gages. This terminology is consistent with ASTM D 1186 and with common usage.

Appendix 2, Examples of the Adjustment of Type 2 Gages Using Shims, has been modified to incorporate the current terminology, and has been expanded to include single point, two point, and smooth surface calibration adjustment. This appendix is meant only to supplement the gage manufacturers’ written instructions for adjustment of their gages.

**Overcoating**

A new note was added to PA 2 describing some of the options for measuring DFT when overcoating. Varying thickness of the existing coating makes accurate measurement of the newly applied
coating very difficult. Measurement of DFT with a destructive gage requires repair at every measurement site. If the existing coating is fairly uniform, the DFT of the additional coat(s) can be found by subtracting the “before” and “after” total DFTs.

The Myth of Maximum Thickness and Other Thoughts About PA 2

For the great majority of field painting projects, the application of the 2004 revision of PA 2 will be indistinguishable from the 1996 revision. Three closely spaced gage readings still comprise a spot measurement. At least five spot measurements are still required for every 100 ft² (10 m²), except for large structures. The average of the spot measurements is still “THE DFT” of the structure and must meet the specification. However, certain aspects of PA 2 are not uniformly understood, most importantly, maximum thickness.

Contrary to some scuttlebutt, PA 2 does not require nor did it ever require that a maximum DFT be specified. However, with many of the coatings used today, it is good practice to specify a maximum thickness. The maximum thickness should be stated explicitly in the job specification; for example, “The maximum dry film thickness shall be 10.0 mils.” A DFT statement may read: “The coating shall be applied at a dry film thickness of 2 to 4 mils.” This range is usually obtained from the manufacturer’s technical data sheet. This is the target that the painter is shooting for. Economic factors, along with flow characteristics of the coating, usually control excessive film build, so a better way to specify minimum DFT is with a single number; for example, “The minimum dry film thickness shall be 2.0 mils.” Depending on the environment, the coating may still perform satisfactorily.
at thicknesses up to 10 or 12 mils (250 or 300 µm). The 4 mils (100 µm) is not necessarily meant to be the maximum allowable thickness. If 4 mils is the maximum thickness allowed, the specification should read, “a minimum of 2.0 mils and a maximum of 4.0 mils.” The maximum should be stated explicitly as a maximum. The specified maximum DFT should be that thickness above which adverse performance characteristics appear, such as mudcracking, embrittlement, solvent retention, loss of adhesion, cohesive splitting, etc. Manufacturers’ literature may be consulted to determine the maximum thickness allowable under specific circumstances.

If a job specification calls for DFT from 2.0 to 4.0 mils (50–100 µm), every painter alive will at some point exceed 4.0 mils. There will be inside corners, tops of beams that the painter cannot even see, insides of box assemblies, etc. that will exceed the 4.0-mil maximum. The inspector will be constantly issuing variances, or else the painter will quit in disgust. If a particular coating is so sensitive to excessive thickness that it will not function properly slightly above the specified range, say by 0.3 mils (7.5 µm), no one will specify it.

Conclusion
The two technical changes in the body of the 2004 revision of PA 2 that might affect how a job is conducted are: 1) the contracting parties must agree to allow the use of pencil style pull-off gages; 2) if a non-conformance is found when coating a very large structure, each 100 ft² (10 m²) area painted during that work shift must be measured. The procedures given in the new appendices may be specified, thereupon making them mandatory for measuring beams and girders, for measuring pieces painted during a laydown in the shop, or for measuring test panels.

Ray Weaver is a technical advisor at SSPC. He can be reached at 412-281-2331, ext. 226, or weaver@sspc.org.