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Designation: ~~D7091 – 12~~ D7091 – 13

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[1]

This standard is issued under the fixed designation D7091; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice describes the use of magnetic and eddy current gages for dry film thickness measurement. This practice is intended to supplement the ~~manufacturers'~~manufacturers' instructions for the manual operation of the gages and is not intended to replace them. It includes definitions of key terms, reference documents, the significance and use of the practice, the advantages and limitations of coating thickness gages, and a description of test specimens. It describes the methods and recommended frequency for verifying the accuracy of gages and for adjusting ~~(optimizing)~~ the equipment and lists the reporting recommendations.

1.2 These procedures are not applicable to coatings that will be readily deformed under the load of the measuring gages/probes, as the gage probe must be placed directly on the coating surface to obtain a reading. Provisions for measuring on soft or tacky coatings are described in 5.7.

1.3 Coating thickness can be measured using a variety of gages. These gages are categorized as "magnetic pull-off" and "electronic." They use a sensing probe or magnet to measure the gap (distance) between the base metal and the probe. This measured distance is displayed as coating thickness by the gages.

1.4 Coating thickness can vary widely across a surface. As a result, obtaining single-point measurements may not accurately represent the actual coating system thickness. SSPC-PA2 prescribes a frequency of coating thickness measurement based on the size of the area coated. A frequency of measurement for coated steel beams (girders) and coated test panels is also provided in the appendices to ~~SSPC-PA2.~~ SSPC-PA 2. The governing specification is responsible for providing the user with the minimum and the maximum coating thickness for each layer, and for the total coating system.

1.5 The values stated in ~~SI~~inch-pound units are to be regarded as ~~the standard. The values given in parentheses are for information only.~~standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*:[2]

D609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products

D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels

D1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting

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[1] This practice is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

Current edition approved ~~April 1, 2012~~Nov. 1, 2013. Published ~~April 2012~~December 2013. Originally approved in 2005. Last previous edition approved in ~~2005~~2012 as ~~D7091~~D7091 – 12.~~– 05.~~ DOI: ~~10.1520/D7091-12.~~10.1520/D7091-13.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

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2.2 *SSPC Standard:*[3]

SSPC-PA 2 Procedure for Determining Conformance to Dry Coating Thickness Requirements

2.3 *ISO Standard:*[4]

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

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[3] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA ~~15222-4656. (see www.sspc.org)~~15222-4656, http://www.sspc.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *accuracy, n*—the measure of the magnitude of error between the result of a measurement and the true thickness of the item being measured.

3.1.1.1 *Discussion*—

An accuracy statement predicts the ability of a coating thickness gage to measure the true thickness of a coating to be measured. Accuracy statements provide the performance capability across the full functional measurement range of the gage. Accuracy statements frequently include a fixed portion that remains constant across the measurement range, plus a variable portion that is related to the measurement result for a particular thickness.

3.1.2 ~~*adjustment,*~~ *adjustment (optimization), n*—the physical act of aligning a gage's thickness readings to match those of a known thickness sample (removal of bias), in order to improve the accuracy of the gage on a specific surface or within a specific portion of its measurement range.

3.1.2.1 *Discussion*—

An adjustment will affect the outcome of subsequent readings. ~~Also known as "optimization."~~

3.1.3 *base metal reading (BMR), n*—a measurement obtained on the uncoated substrate using a coating thickness gage.

3.1.3.1 *Discussion*—

The BMR is the determined effect of substrate roughness on a coating thickness gage that is caused by the manufacturing process (for example, castings) or surface profile (roughness)-producing operations (for example, power tool cleaning, abrasive blast cleaning, etc.). Non-compensation for the base metal effect can result in an overstatement of the true thickness of the coating.

3.1.4 *calibration, n*—the high-level, controlled and documented process of obtaining measurements on traceable calibration standards over the full operating range of the gage, then making the necessary gage adjustments (as required) to correct any out-of-tolerance conditions.

3.1.4.1 *Discussion*—

Calibration of coating thickness gages is performed by the equipment manufacturer, ~~an~~their authorized agent, or by an ~~authorized, trained~~ accredited calibration laboratory in a controlled environment using a documented process. The outcome of the calibration process is to restore/realign the gage to meet/exceed the manufacturer's stated accuracy.

3.1.5 *certification, n*—documentation of the state of condition of the gage, which can (but not required by definition) be accompanied by corrective action (such as adjustment or calibration, or both, or the replacement of components) necessary to correct any out-of-tolerance conditions.

3.1.6 *coating thickness standard, n*—coated or plated metal plates, or uncoated shims of flat sheet, with assigned values traceable to a National Metrology Institution.

3.1.6.1 *Discussion*—

In the case of the eddy current principle, the coating and shim material must be non-metallic, whereas in the case of the magnetic induction and the Hall-effect methods the material must be nonmagnetic.

3.1.7 *compensation value, n*—generating a verifiable value, which is deducted from a measured value read from the gage, to correct for any surface conditions (that is, base metal effect).

3.1.8 *dry film thickness, n*—the thickness of a coating (or coating layers) as measured from the surface of the substrate.

3.1.8.1 *Discussion*—

If the surface of the substrate is roughened, the dry film thickness is considered the thickness of the coating or coating layers above the peaks of ~~a~~the surface profile.

3.1.9 *ferrous, n*—containing iron.

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3.1.9.1 *Discussion—*

Describes a magnetic material such as carbon steel. That material may also be known as ferromagnetic.

3.1.10 *gage (gauge), n*—an instrument for measuring quantity, or an instrument for testing.

3.1.10.1 *Discussion—*

In this practice, the term "gage" refers to an instrument for quantifying coating thickness.

3.1.11 *manufacturer's specifications, n*—a statement or set of statements that describes the performance characteristics of the gage under a given set of conditions.

3.1.11.1 *Discussion—*

~~Manufacturer's~~Manufacturer's specifications typically include the range of measurement, accuracy statement, operating temperature range, power source, dimensions and weight, and conformance to industry standards.

3.1.12 ~~*measurement,*~~ *measurement (reading), n*—the value obtained when placing the probe of a thickness gage in contact with a surface.

3.1.13 *micrometer (micron), n*—one one-thousandth of a millimeter ~~(0.001 mm);~~[0.001 mm]; 25.4 microns = 1 mil.

3.1.14 *mil, n*—~~an~~ a U.S. term referring to the imperial unit of ~~measure;~~ measure of one one-thousandth of an inch ~~(0.001 in.);~~ [0.001 in.] referred to elsewhere in the world as "one thou;" 1 mil = 25.4 microns.

3.1.15 *nonconductive, n*—a material that is unable to conduct electricity.

3.1.16 *non-ferrous metal, n*—a nonmagnetic metal or metal alloy (for example, copper, aluminum or brass).

3.1.17 *reference sample, n*—a coated or uncoated metal specimen of the same material and geometry as the specific measuring application used to adjust and/or verify the accuracy of a coating thickness measuring gage for a specific project.

3.1.17.1 *Discussion—*

A coated reference sample may or may not have thickness values traceable to a National Metrology Institution. However, the reference sample should be marked with the stated value and the degree of accuracy. The coating thickness of the sample should be close to the user's coating thickness measurement requirement.

3.1.18 ~~*shims,*~~ *shims (foils), n*—strips of flat sheet, with the thickness stated or referenced in some form, ~~that~~which can be used to adjust a Type 2 coating thickness gage in the intended range of use over the surface of the representative substrate material.

3.1.18.1 *Discussion—*

Other uses with Type 2 gages include: placement over soft coatings to obtain thickness measurements without the gage probe depressing the coating film, and verification of gage operation. ~~Also known as "foils."~~

3.1.19 *substrate, n*—the base material, the type of surface, or the component that is being coated.

NOTE 1—This practice addresses only metal substrates.

3.1.20 *surface profile, n*—surface texture generated during the manufacturing process (for example, casting), or the peak-to-valley depth generated by some power tools and by abrasive blast cleaning operations.

3.1.21 *Type 1 (pull-off) gage, n*—a magnetic pull-off instrument that measures the dry film thickness of nonmagnetic coatings over a ferrous metal base.

3.1.21.1 *Discussion—*

For Type 1 gages, a probe containing 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 a scale or display on the gage. Less force is required to remove the magnet from a thick coating. The scale is nonlinear. ~~Also known as "pull-off gage."~~

3.1.22 *Type 2 (electronic) gage, n*—an electronic instrument that uses electronic circuitry and (but not limited to) the magnetic induction, Hall-effect or eddy current principles, or a combination of a magnetic and eddy current principles, to convert a reference signal into a coating thickness reading.

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