



Designation: D7091 – 20

Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non- Ferrous Metals¹

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' 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 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-PA 2 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-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 units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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, Coatings and Related Products on Test Panels

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

2.2 SSPC Standard:³

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

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 Dec. 1, 2020. Published December 2020. Originally approved in 2005. Last previous edition approved in 2013 as D7091 – 13. DOI: 10.1520/D7091-20.

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.

³ Available from Society for Protective Coatings (SSPC), 800 Trumbull Dr., Pittsburgh, PA 15205, <http://www.sspc.org>.

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

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 (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.

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, their authorized agent, or by an 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 the surface profile.

3.1.9 *ferrous, n*—containing iron.

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 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 (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]; 25.4 microns = 1 mil.

3.1.14 *mil, n*—a U.S. term referring to the imperial unit of measure of one one-thousandth of an inch [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 (foils), n*—strips of flat sheet, with the thickness stated or referenced in some form, which can be used to

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

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.

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.

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.

3.1.22.1 *Discussion*—The probe of a Type 2 gage remains on the surface during the measurement process.

3.1.23 *verification of accuracy, n*—obtaining measurements on coating thickness standards, comprising of at least one thickness value close to the expected coating thickness, prior to gage use for the purpose of determining the ability of the coating thickness gage to produce thickness results within the gage manufacturer's stated accuracy.

4. Significance and Use

4.1 This practice describes three operational steps necessary to ensure accurate coating thickness measurement: calibration, verification and adjustment of coating thickness measuring gages, as well as proper methods for obtaining coating thickness measurements on both ferrous and non-ferrous metal substrates.

4.2 Many specifications for commercial and industrial coatings projects stipulate a minimum and a maximum dry film thickness for each layer in a coating system. Additionally, most manufacturers of high performance coatings will warranty coating systems based upon, in part, achieving the proper thickness of each layer and the total coating system. Even if a project specification is not provided, the coating manufacturer's recommendations published on product data sheets can become the governing document(s). Equipment manufacturers produce nondestructive coating thickness testing gages that are used to measure the cumulative or individual thickness of the coating layers, after they are dry. The manufacturers provide

information for the adjustment and use of these gages, normally in the form of operating instructions. The user of this equipment must be knowledgeable in the proper operation of these devices, including methods for verifying the accuracy of the equipment prior to, during and after use as well as measurement procedures.

5. Principles, Advantages, and Limitations of Gages

5.1 Type 1 magnetic pull-off gages employ an attraction principle and a static (non-time varying) magnetic field. These mechanical instruments measure the force required to pull a permanent magnet from a coated ferrous metal substrate. The magnetic force of attraction to the steel substrate beneath the coating is opposed by a spring or coil. Tension is applied to the spring/coil until the magnetic attraction to the steel is overcome. The gage must be placed directly on the coated surface to obtain a measurement. The force holding the permanent magnet to the ferrous base is inversely proportional to the thickness of the coating layer(s) between the magnet and the ferrous substrate. For example, a thin coating applied to a ferrous substrate will require greater spring tension to pull the magnet off than will a thicker coating, since the magnet is closer to the ferrous substrate with the thinner coating. This inverse relationship is reflected on the nonlinear gage scale. Most Type 1 magnetic pull-off gages do not require a power source (for example, batteries). The manufacturer's stated accuracy is typically 5 to 10 % of the reading.

5.2 Type 1 magnetic pull-off gages are susceptible to vibrations, which may cause the magnet to release from the coated substrate prematurely, yielding a false high value. The manually operated gages may be susceptible to human error caused by inadvertently turning the dial wheel past the point at which the magnet pulls from the surface, yielding a false low measurement. Type 1 gages should not be used on soft or tacky coatings, as the magnet may adhere to the coating causing false low measurements, or coating materials may dry on the magnet causing false high measurements. The exposed magnet may attract metal filings, which can contaminate the magnet and cause false high measurements. Type 1 gages cannot be used to measure the thickness of coatings applied to non-ferrous metal substrates. The manufacturer's specifications will contain a temperature operating range. Use of the gage outside of this range may generate false coating thickness measurements and may damage the instrument.

5.3 Type 2 gages are instruments that employ a measuring probe and the magnetic induction, Hall-effect or eddy current measurement principle in conjunction with electronic microprocessors to produce a coating thickness measurement. The gage probe must be placed directly (in a perpendicular position) on the coated surface to obtain a measurement.

5.3.1 For gages measuring on ferrous substrates, the magnetic induction or Hall-effect principles are used to measure a change in magnetic field strength within their probes to produce a coating thickness measurement. These gages determine the effect on the magnetic field generated by the probe due to the proximity of the substrate.

5.3.2 For gages measuring on non-ferrous metals, the gage probe coil is energized by alternating current that induces eddy

currents in the metal substrate. The eddy currents in turn create a secondary magnetic field within the substrate. The characteristics of this secondary field are dependent upon the distance between the probe and the basis metal. This distance (gap) is measured by the probe and shown on the gage display as the thickness (microns or mils) of the intervening coating. Note that gages/probes for measuring coating thickness on non-ferrous metals should not be used to measure coating thickness on ferrous surfaces, even though a reading may be displayed.

5.4 Type 2 gages are available with integral or separate (wired or wireless) probes, and they can be used to measure coating thickness on ferrous or non-ferrous metal substrates, or both, depending on the probes supported by the particular gage platform. The thickness of the coating is displayed digitally. In general, access to tight areas is easier with Type 2 gages, especially those equipped with separate or remote probes. Type 2 gages are available with memory, measurement batching, statistical analysis packages and data download/print-out. The manufacturer's stated accuracy is typically 1 to 3 % of the reading.

5.5 Instruments using either a magnetic or eddy current principle measure total film thickness only. In multi-layer coating systems the thickness of each layer must be measured after it is applied. Even then, the thickness of the measured layer is the cumulative thickness of that layer and all layers beneath it, down to the base metal.

5.5.1 Some instruments employ both principles and may be capable of measuring the individual thickness of two layers such as paint over zinc (duplex coating) on steel.

5.6 Most electronic coating thickness measuring gages can be verified for accuracy using coating thickness standards. Gages that cannot be adjusted by the user should be returned to the manufacturer or their authorized agent for calibration if the readings obtained on the coating thickness standards are outside of the combined accuracy of the standard and the manufacturer's stated gage accuracy.

5.6.1 Gage operation should be verified on a prepared, uncoated substrate having the same composition, shape and surface profile to which the coating will be applied to, for the intended range of use. If necessary, the gage should be adjusted as described in 7.4.

5.7 Type 2 gages should not be used directly on soft or tacky coatings, unless expressly designed for this application, as the pressure on the probe can indent the coating yielding false low measurements, or coating materials may contaminate the probe yielding false high measurements. A shim of known thickness can be placed on top of the soft/tacky coating film and a measurement of the coating thickness obtained by subtracting the shim thickness from the total measurement of the shim and the coating. Note that some Type 2 gages can be programmed to automatically deduct the shim thickness (known as "zero offset"). Type 2 gages may be sensitive (to some degree) to substrate effects including, but not limited to edges, corners and holes in the substrate, as well as substrate thickness. The manufacturer's specifications will contain a temperature operating range. Use of the gage or the probe outside of this range

may generate false coating thickness measurements and may damage the instrument.

5.8 Coating thickness measurement accuracy can also be affected by, but is not limited to, the factors listed below. Consult the instrument manufacturer for details on the specific effects of these factors and how they are addressed by the instrument.

5.8.1 *Curvature*—The influence of curvature varies considerably with the make and type of instrument but often becomes more pronounced as the radius of curvature decreases.

5.8.2 *Foreign Particles*—Instruments of all types must make physical contact with the test surface and are, therefore, sensitive to foreign material that prevents intimate contact between probe and coating surface. Both the test surface and instrument probe should be kept free of foreign material.

5.8.3 *Stray Magnetic Fields*—Strong stray magnetic fields, such as are produced by various types of electrical equipment, can seriously interfere with the operation of instruments based on magnetic principles.

5.8.4 *Metal-filled Coatings*—Instruments may produce erroneous results depending on the type and amount of metal in the coating film.

5.8.5 *Electrical Properties of the Basis Metal*—Eddy current measurements are affected by the electrical conductivity of the base metal, which itself is often affected by heat treatments. Instruments and probes are available that compensate for base material influence thus automatically avoiding such errors.

5.8.6 *Pressure*—The pressure with which the probe is applied to the test specimen affects the instrument readings and should therefore be kept constant.

6. Test Specimen

6.1 The test specimen can be the coated structure or component/part on which the thickness is to be evaluated, or can be test panels of similar surface profile, shape, thickness, composition and magnetic properties on which it is desired to measure the coating thickness.

NOTE 2—Applicable test panel description and surface preparation methods are given in Practices D609 and D1730.

NOTE 3—Coatings should be applied in accordance with Practices D823 or as agreed upon between the contracting parties.

NOTE 4—Test panels may be fabricated from thin gage materials and special consideration for gage adjustment may be required.

7. Frequency and Methods for Verifying the Accuracy and for Adjusting a Coating Thickness Gage

7.1 Three operational steps are necessary to ensure accurate coating thickness measurement: calibration, verification of accuracy, and adjustment.

7.2 *Calibration*—Calibration of coating thickness gages is performed by the equipment manufacturer, their authorized agent, or by an accredited calibration laboratory in a controlled environment using a documented process. A Certificate of Calibration showing traceability to a National Metrology Institute can be issued. There is no standard time interval for re-calibration, nor is one absolutely required, but a calibration interval can be established based on experience and the work environment. A one-year calibration interval is a typical frequency suggested by many gage manufacturers.

7.3 Verification of Accuracy—Before use, each instrument's calibration accuracy shall be verified by the user in accordance with the instructions of the manufacturer, employing suitable coating thickness standards and, if necessary, any deficiencies found shall be corrected. The gage should be verified for accuracy in the intended range of use. Also, the probe should be examined for cleanliness before verifying the accuracy and before obtaining coating thickness measurements.

7.3.1 If the gage readings obtained during verification are outside the combined accuracy of the coating thickness standard and the manufacturer's stated gage accuracy, the gage should be returned to the manufacturer or their authorized agent for repair and calibration.

7.3.2 For example, if the gage accuracy is $\pm 5\%$ and the standards accuracy is $\pm 5\%$, then the combined accuracy of the gage and the standard will be $\pm 7\%$ as given by the sum of the squares formula:

$$\sqrt{5^2 + 5^2} = 7.071 \text{ or approximately } 7\% \quad (1)$$

7.3.2.1 For the gage to be in agreement with the standard, the average thickness measured by the gage must be within $\pm 7\%$ of the standard's thickness. If the average thickness measured on a $254\text{ }\mu\text{m}$ [10 mil] standard is between $236\text{ }\mu\text{m}$ [9.3 mils] and $272\text{ }\mu\text{m}$ [10.7 mils], the gage is properly adjusted. The minimum value of $236\text{ }\mu\text{m}$ is calculated as $254\text{ }\mu\text{m}$ minus 7% of $254\text{ }\mu\text{m}$ [9.3 mils is 10 mils minus 7% of 10 mils]; the maximum of $272\text{ }\mu\text{m}$ is $254\text{ }\mu\text{m}$ plus 7% of $254\text{ }\mu\text{m}$ [10.7 mils is 10 mils plus 7% of 10 mils]. Otherwise the accuracy of the gage is suspect.

7.3.3 Unless explicitly permitted by the gage manufacturer, shims of plastic or of non-magnetic metals which are acceptable for verifying the accuracy of Type 2 (electronic) gages are not used for verifying the accuracy of Type 1 (pull-off) gages.

7.3.4 Since Type 1 gages are verified for accuracy using smooth-surfaced standards (or using a smooth zero plate), a compensation value may be required if the substrate to be coated is different from the standard (such as, but not limited to, curvature or composition) or roughened from the manufacturing process (for example, casting) or from abrasive blast cleaning. This is known as a Base Metal Reading or BMR. The BMR is the effect of substrate (for example, surface profile) on a coating thickness gage. The user obtains a minimum of ten (10) readings on the prepared, uncoated substrate. The arithmetic mean of these values becomes the Base Metal Reading. The BMR is deducted from the coating thickness values in order to report the thickness of the coating layer(s) over the surface profile.

7.4 Adjustment—Many instruments can be adjusted by the user in order to improve their accuracy on a specific surface or within a specific portion of its measurement range. In most instances it should only be necessary to check zero on the uncoated substrate and begin measuring. However the effects of properties of the substrate (composition, magnetic properties, shape, surface profile, edge effects) and coating (composition, mass, surface texture), as well as ambient and surface temperatures, may require adjustments to be made to the instrument. Follow the manufacturer's instructions.

7.4.1 The user should never adjust Type 1 coating thickness gages.

7.4.2 Most Type 2 gages can be adjusted using either a one-point or a two-point procedure.

7.4.2.1 Adjustment of Type 2 Gages Using a One-Point Procedure—A one-point adjustment involves fixing the instrument's calibration curve at one point after taking several readings on a single coating thickness standard or reference sample. Adjusting to zero on an uncoated sample of the test specimen is the simplest form of a one-point adjustment. If the user elects to perform a one-point adjustment procedure to a known thickness, a reference sample representing the target range of gage use should be selected and a measurement taken. No adjustment is necessary if the value displayed by the gage is within the combined accuracy of the reference sample and the manufacturer's stated gage accuracy (see 7.3.2). If the gage reading is outside of the combined accuracy of reference sample and the manufacturer's stated gage accuracy, then the user should carefully follow the gage manufacturer's instructions for proper adjustment, as the actual step-by-step procedures vary widely.

7.4.2.2 Adjustment of Type 2 Gages Using a Two-Point Procedure—A two-point adjustment fixes the instrument's calibration curve at two known thicknesses. Coated reference samples or shims placed over the uncoated substrate or over an uncoated reference sample may be used. The two thicknesses selected must be on either side of the expected coating thickness. The user should carefully follow the gage manufacturer's instructions for performing a two-point adjustment, as the actual step-by-step procedures vary widely.

NOTE 5—ISO 19840 describes the use of a profile correction value when access to the uncoated substrate is not available.

8. Frequency for Measurement of Coating Thickness

8.1 Thickness is determined by placing the probe of the instrument onto the surface of the coated metal material and obtaining the thickness measurement in accordance with the manufacturer's instructions.

8.2 The thickness of a coating or a coating system can vary from area to area on a structure or part. Accordingly, it is recommended that a number of measurements be obtained and the arithmetic mean calculated to determine the high, low, and average coating thickness in a given area. SSPC-PA 2 prescribes a frequency of coating thickness measurement based on the size of the area coated.

8.3 For small parts or components, the number of coating thickness measurements is typically based on the criticality of the application, and should be as agreed upon between the purchaser and seller.

8.4 For mass quantities of manufactured products, the frequency of coating thickness measurement is dictated by the volume produced and should be based on statistical process control (SPC) calculations for sample size selection.

9. Report

9.1 The following items should be reported:

9.1.1 Type of instrument used including manufacturer, model number, serial number, and date of calibration,

9.1.2 Type of coating thickness standard or reference standard, or both, together with the method used for accuracy verification or any adjustment, or both,

9.1.3 Size and description of test specimen,

9.1.4 Base Metal Reading (if appropriate),

9.1.5 The value of each measurement (if appropriate),

9.1.6 Operator identification, and

9.1.7 Date of the inspection.

10. Keywords

10.1 coatings; coating thickness; dry film thickness; eddy current thickness gages; magnetic gages; magnetic method; nondestructive thickness; paint thickness; thickness testing

APPENDIXES

(Nonmandatory Information)

X1. PRECAUTIONS REGARDING VERIFICATION OF GAGE ACCURACY

X1.1 When selecting shims to verify the accuracy of Type 2 coating thickness gages, it is necessary to be aware of additional characteristics that can affect the measured values. These factors include, but are not limited to:

X1.1.1 Permanent creases in the shim due to folding,

X1.1.2 Air entrapment between the shim and substrate,

X1.1.3 Distortion due to environmental conditions, such as temperature, and

X1.1.4 Shim thickness inconsistency (due to the pressure of the probe tip) that may be a permanent “dimple” in the shim.

X1.2 Even with these factors, in many applications, verification of gage accuracy using shims directly on the sample to be measured can be more appropriate than using plated or coated standards. Some gage manufacturers produce certified shims.

X1.3 Independent of what standard is employed, they should be periodically verified to ensure the assigned value is correct. Even coated metal plates can wear or be damaged to an extent that gage readings are affected.

X1.4 When verifying the accuracy of magnetic gages on coated steel standards it is important to be aware of the effect of the coating on some types of magnetic gages. For best accuracy when measuring with magnetic induction principle gages, consider the following:

X1.4.1 Verify gage accuracy on metal plated (conductive coating) standards when measuring conductive coatings (for example, chrome and zinc); verify gage accuracy on epoxy coated (non-conductive) standards when measuring non-conductive coatings (for example, paint).

X1.4.2 Gages that use the Hall-effect principle are not affected by the conductive nature of the coating.

X2. USE OF INSTRUMENTATION WITH SCANNING CAPABILITY

X2.1 Some Type 2 gages are capable of scanning. These gages continuously take measurements while the probe is in contact with the coating until the probe is lifted clear. Often, gages using this methodology will display statistics such as the average, minimum, and maximum coating thickness measurement in the scanned area.

X2.2 Consideration of the scan rate and scan length needs to

be made when determining an inspection method using instruments capable of scanning. For example; if a probe can take 120 readings per minute while it is in contact with the coating/substrate, then a scan length of 1 m (3 ft) at a rate of 0.3 m/s (1 ft/s), a scan of 3 s duration, will result in six readings, from which the average is calculated.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; http://www.copyright.com/