

Standard Recommended Practice for Evaluation of Coating Systems with Zinc Rich Primers

AASHTO Designation: PP30-01¹

1. Scope

1.1 This specification covers the testing criteria for evaluation of zinc rich coating systems for use on iron and steel surfaces.

1.2 The inorganic and organic zinc rich primers with top coats are intended for use on bridges, similar structural steel, and other ferrous metal surfaces, both new and existing, cleaned to a minimum of SSPC-SP 10, which are subject to corrosive atmospheric environments, such as marine, industrial, deicing chemicals, and high humidity.

1.3 The value stated in SI units are to be regarded as standard.

1.4 *This standard may involve hazardous materials, operations, and equipment. It does not purport to address all safety concerns associated with its use. It is the responsibility of the user of this standard to establish the appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

Note 1 - The testing format and suggested acceptance criteria for this standard have been developed around a three-coat system consisting of a zinc primer, epoxy or urethane intermediate, and an aliphatic urethane finish coat.

2. Referenced Documents

2.1 Reference to standard specifications, testing procedures and other standard procedures contained in this document shall be the latest edition of the published document at the date of this "Evaluation Criteria".

2.1.1 AASHTO Standards:

M 300 Inorganic Zinc Rich Primer

2.1.2 ASTM Standards:

A 36 Carbon Structural Steel
B 117 Salt Spray (Fog) Testing
D 476 Titanium Dioxide Pigments

D 512 Chloride Ion in Water
D 520 Zinc Dust Pigment
D 521 Chemical Analysis of Zinc Dust (Metallic Zinc Powder)
D 523 Specular Gloss
D 562 Consistency of Paints Using the Stormer Viscometer
D 610 Evaluating Degree of Rusting on Painted Steel Surfaces
D 714 Evaluating Degree of Blistering of Paints
D 1186 Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base
D 1475 Density of Paint, Varnish, Lacquer, and Related Products
D 1640 Drying, Curing, or Film Formation of Organic Coatings at Room Temperature
D 1654 Evaluation of Painted or Coated Specimens Subjected to Corrosive Environment
D 2196 Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield) Viscometers
D 2240 Rubber Property - Durometer Hardness
D 2244 Calculation of Color Differences from Instrumentally Measured Color Coordinates
D 2369 Volatile Content of Coatings
D 2371 Pigment Content of Solvent-Reducible Paints
D 2697 Volume Nonvolatile Matter in Clear or Pigmented Coatings
D 2698 Determination of Pigment Content of Solvent-Reducible Paints by High Speed Centrifuging
D 3335 Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
D 3718 Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy
D 3960 Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
D 4060 Abrasion Resistance of Organic Coatings by the Taber Abraser

¹ Approved in November 1995, this provisional standard was first published in June 1996.

- D 4400 Sag Resistance of Paints Using a Multinotch Applicator
- D 4417 Field Measurement of Surface Profile of Blast Cleaned Steel
- D 4541 Pull-Off Strength of Coatings Using Portable Adhesion Testers
- D 4940 Conductimetric Analysis of Water-Soluble Ionic Contamination of Blasting Abrasives
- D 5894 Cyclic Salt Fog/UV Exposure of Painted Metal
- E11 Wire-Cloth Sieves for Testing Purposes
- G 92 Characterization of Atmospheric Test Sites
- G 140 Determining Atmospheric Chloride Deposition Rate By Wet Candle Method

2.1.3 SSPC: The Society for Protective Coatings¹

- AB-3 Abrasive Specification Number 3, Newly Manufactured or Re-manufactured Steel Abrasive
- Guide 9 Guide for Atmospheric Testing of Coatings in the field
- PA2 Measurement of Dry Paint Thickness with Magnetic Gages
- Paint 20 Zinc-Rich Primers
- SP 5 White Blast Cleaning
- SP6 Commercial Blast Cleaning
- SP10 Near-White Blast Cleaning

2.1.4 Federal Standard²:

- FED-STD 40 CFR 51.100(s) Volatile Organic Compound (VOC) Definition
- FED-STD 40 CFR 59.406(a) Volatile Organic Compound Compliance Provision
- FED-STD 40 CFR Part 59, Subpart D, Sections 59.400 through 59.413 National Volatile Organic Compound Emission Standards for Architectural Coatings
- FED-STD 595 Colors Used in Government Procurement
- EPA-SW846 Method 1311, Toxicity Characteristic Leaching Procedure (TCLP)
- American National Standards Institute (ANSI) B94.50, Style E.

2.1.5 Other Documents:

AASHTO Standard Specifications for Highway Bridges

Commercial Item Description (CID) A-A-1689B; Tape, Pressure Sensitive Adhesive, Plastic Film²

Commission Internationale de l'Eclairage (CIE) 1976 L*a*b*

Kentucky Transportation Cabinet Test Method 64-250, Analysis for Isocyanate Content (see Appendix X5)

Kentucky Transportation Cabinet Test Method 64-257, Analysis for Hindered Amine Light Stabilizers (HALS) (see Appendix X6)

Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints as approved by the Research Council on Structural Connections³

¹Available from The Society for Protective Coatings, Bldg. 40, 24th Street, Pittsburgh, PA, 15222-4645.

²Available from GSA Specification Department, Federal Supply Services, Specifications Section, 470 East L'Enfant Plaza, SW, Suite 8100, Washington, DC 20407.

³Available from American Institute of Steel Construction, Inc., One East Wacker Drive, Suite 3100, Chicago, IL, 60601-2001.

3. Terminology

3.1 Definitions:

3.1.1 Volatile organic compound or VOC means any organic compound that participates in atmospheric photochemical reactions, that is, any organic compound other than those which the US EPA Administrator designates as having negligible photochemical reactivity. For a list of compounds that the US EPA Administrator has designated as having negligible photochemical reactivity, also referred to as exempt compounds, refer to 40 CFR 51.100(s).

3.1.2 VOC content means the weight of VOC per volume of coating, calculated according to the procedures in 40 CFR 59.406(a).

3.1.3 Dry Film Paint Thickness - the depth of coating to the top of the surface profile peaks, measured in accordance with SSPC PA2.

4. Classification

4.1 Primer.

4.1.1 Inorganic zinc primers shall conform to the material requirements of M 300, except as required by 5.1.1. Organic zinc primers shall conform to the material requirements of SSPC Paint 20, Type II.

4.2 Touch-up primer.

4.2.1 The touch-up primer shall be as recommended by the manufacturer at the time of application.

4.2.2 Touch-up procedures for the intermediate and top coats shall be detailed in the product data sheets or by written submission.

5. Materials

5.1 The materials used in the manufacture of the system shall conform to the requirements of the following specifications:

5.1.1 Zinc Dust - ASTM D 520 Zinc Dust (Metallic Zinc Powder), Type II.

5.1.1.1 Manufacturers shall submit a certificate of analysis from the zinc suppliers showing conformance with the requirements.

5.1.1.2 Prior to submittal for examination, each coating (primer, intermediate and top coat) shall be tested by an NLLAP (National Lead Laboratory Accreditation Program) accredited laboratory to determine its total lead content. The total lead content shall be determined using a dry film sample in accordance with ASTM D 3335. The percentage of total lead in each coating shall not exceed 0.01% (100 ppm).

6. Requirements

6.1 Color - For production, the color of the coatings shall be as mutually agreed, except that the intermediate coat shall contrast in color. For testing requirements, see 7.2.5.

6.2 Pigment.

6.2.1 Prime pigments shall be used except for shades. The pigment for the primer shall be primarily zinc dust and the pigments for any intermediate and/or top coats shall be formulated without using any heavy metal materials listed in the RCRA regulations for toxic characteristic. Titanium dioxide shall meet the requirements of ASTM D 476, Type IV, when used in the top coat.

6.3 Volatile Organic Compounds (VOC).

6.3.1 VOC requirements and classifications should be in accordance with EPA National Volatile Organic Compound Emission Standards for Consumer and

Commercial Products, 40 CFR, Part 59, Subpart D, Sections 59.400 through 59.413.

6.4 Coating Quantitative Requirements.

6.4.1 Slip Coefficient for Primer - Primer coatings for use on new and rehabilitated structures with painted connections designed for Class B allowable stress shall meet the Class B slip coefficient requirements specified in the AASHTO Standard Specifications for Highway Bridges. The coating supplier shall supply test data to indicate compliance, and the data shall also state the cure time, and maximum coating thickness for that coating as indicated by the tests.

6.4.2 A manufacturer shall provide certified test results verifying that the coating seeking approval (in an as-manufactured mixed composition) has been tested for total lead and meets requirements.

6.4.3 Properties (determined in a mixed condition) shall be stated on the certified Product Data Sheet and/or the MSDS as follows:

6.4.3.1 Total solids, percent by mass in accordance with ASTM D 2369.

6.4.3.2 Pigment, percent by mass in accordance with ASTM D 2371.

6.4.3.3 Metallic zinc content, percent by mass in the primer shall be determined by the Standard Test Method for the Determination of Metallic Zinc Content in Both Zinc Dust Pigment and in Cured Films or Zinc-Rich Coatings Utilizing the Differential Scanning Calorimeter, as described in Appendix X3. An optional method to this is the Standard Test Method for the Non-Instrumental Determination of Metallic Zinc, as described in Appendix X4.

6.4.3.4 Total solids, percent by volume in accordance with ASTM D 2697.

6.4.3.5 Mass per volume (grams per liter) in accordance with ASTM D 1475.

6.4.3.6 Viscosity (Stormer at 25° C) KU in accordance with ASTM D 562 (Not suitable for viscosities above 143 KU).

6.4.3.7 Viscosity (Brookfield at 25°C) cP in accordance with ASTM D 2196. The spindle size and revolutions per minute shall be reported.

6.4.3.8 Pot life in hours, at specified temperature and specified humidity.

6.4.3.9 Sag resistance (Leneta) in micrometers wet film thickness in accordance with ASTM D 4400.

6.4.3.10 Recommended minimum and maximum dry film thickness in micrometers.

6.4.3.10.1 Maximum allowable dry film thickness for the primer on faying surfaces.

6.4.3.11 Theoretical coverage: (e.g. m²/liter for 25 micrometers dry film thickness or micrometers/m²/liter, whichever is appropriate for the particular coating).

6.4.3.12 Minimum drying time to touch, to handle and to recoat (and maximum when applicable) in accordance with ASTM D 1640 at 25°C and 50 percent relative humidity.

6.4.3.13 Mixing ratio for multi-component coatings by volume, mass, or a combination of mass and volume. This is not required for a pre-mixed (all-in-one) zinc primer.

6.4.3.14 Mixing ratio for multi-component coatings, by mass.

6.4.3.15 Shelf life of each component stored at 25° C.

6.4.3.16 Infrared analysis by using FT/IR spectroscopy.

6.4.3.17 Heavy metals testing for mixed coatings ASTM D 3335 and D 3718. Heavy metals to be tested will include lead, chromium and cadmium.

6.4.3.18 Dry film analysis for leachable heavy metals shall include Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium and Silver for each coating. The dried film shall be removed from a test panel and pulverized to pass through a 250 µm (No. 60) sieve. The pulverized film passing the 250 µm (No. 60) sieve shall be extracted in accordance with the TCLP, method 1311 of EPA SW-846. The extract shall then be analyzed for heavy metals using the appropriate EPA SW-846 test method for each metal.

6.4.3.19 The manufacturer shall supply, with the submitted coating system, certified chemical test results that will define the character and nature of the coating system being submitted. Actual results shall be verified by the qualifying laboratory, and shall be part of the qualifying laboratory's written report. The type of information provided by the coating manufacturer should include, but not necessarily be limited to, the following: epoxide values (for the epoxy component of two component epoxy

coatings), amine values (for that component of epoxy coatings which contains amine or amidoamine cross-linkers), isocyanate group content (for that component of a polyurethane coating which contains the isocyanate component), and identification of hindered amine light stabilizers (for any topcoat which contains such additives). Note that for epoxy coatings cross-linked with polyamide resin, there is currently no standardized test method for determining amide content.

6.4.3.19.1 Epoxide values can be determined in accordance with ASTM D 1652, Method A. This method measures a quantity called the weight per epoxy equivalent (WPE), which is defined as the grams of resin containing one gram equivalent of epoxy groups. However, since this method was intended for raw materials, the WPE of the epoxy component of a two component coating will actually be the grams of that component (not the grams of actual resin) which contains one gram equivalent of epoxy groups.

For clear components, the method can be used as is. For pigmented components, the sample must first be weighed into a centrifuge tube, then thinned 50 to 100% with xylene or toluene. If a glass stirring rod is used to aid in dispersing the sample in the thinner, it may be necessary to use an additional small amount of thinner to rinse residues off of the rod and back into the centrifuge tube.

The sample is then centrifuged to remove the pigment, and the supernatant should then be transferred to the container in which the D-1652 procedure will be done. The pigment in the bottom of the centrifuge tube should then be redispersed in 2 or 3 ml of solvent, recentrifuged, and the supernatant combined with the original supernatant for analysis.

6.4.3.19.2 Amine values can be determined on the amine or amidoamine contained in the appropriate component of two component epoxy coatings, in accordance with ASTM D 2073. This method is only applicable to clear, unpigmented component. If the component is pigmented, the following modification to D 2073 will be necessary:

Weigh 1.0 grams of the pigmented component to the nearest 0.1 milligram into a glass centrifuge tube and thin with approximately 1 milliliter of methylene chloride. If a glass stirring rod is required to disperse the pigmented component with the methylene chloride, it may be necessary to use a small additional amount of methylene chloride to rinse any material off of the glass stirring rod prior to removing it from the centrifuge tube.

Separate the pigment by high-speed centrifugation, and transfer the supernatant into a 25 milliliter low form beaker. The pigment in the bottom of the centrifuge tube should be redispersed in an additional 2 to 3 milliliters of methylene chloride, recentrifuged, and the supernatant combined with the original supernatant for analysis. At this point, follow the titration procedure described in ASTM D-2073. (Note: Even though the titration is followed potentiometrically and the end points will not be obscured by the color of the pigment, the pigment must still be removed to prevent the possibility of any basic pigments reacting with the hydrochloric acid used in the titration procedure.)

6.4.3.19.3 Isocyanate group content can be determined in accordance with Kentucky Transportation Cabinet Test Method 64-250-96 (See Appendix X5), except that if appropriate, the initial centrifugation can be done on less than 25 grams of sample.

6.4.3.19.4 The presence of hindered amine light stabilizers (HALS) in the polyvol portion of a 2-component urethane coating can be performed in accordance with Kentucky Transportation Cabinet Test Method 64-257 (See Appendix X6). Modifications to the method include the following:

1. 60 milliliter glass centrifuge tubes are not required. Any centrifuge tube capable of holding at least 10 to 15 milliliters of hexane/polyol mixture can be used.
2. A DB-5 or equivalent capillary column can be used.
3. Any appropriate gas chromatograph with a sensitive enough detector can be employed: it is not necessary to use a Hewlett Packard 5890 Series II. Note that this procedure is qualitative only, and will require that the coating manufacturer provide the laboratory with the identity of the specific HALS being used. A control sample of this HALS will have to be obtained in order to verify the retention time.

Note 2 - If manufacturer's standard Product Data Sheet does not contain all of the above required information, a supplemental sheet and/or a MSDS with the additional information shall be provided.

6.5 Application Requirements. The following information shall be supplied by the coatings manufacturer:

6.5.1 The minimum and maximum surface profile requirements (height in micrometers).

6.5.2 Application requirements for ambient temperature, surface temperatures, material temperature and humidity.

6.5.3 Requirements for application by spray, brush, or roller.

7. Testing Requirements

7.1 General.

7.1.1 Tests must be administered or performed by an authorized testing facility as approved by the National Transportation Product Evaluation Program (NTPEP). The principal facility evaluating a specific coating system or any laboratory performing testing for the principal facility must obtain prior approval from the NTPEP before initiating any testing.

7.1.2 All testing equipment shall be cleaned prior to performance of each testing cycle, unless specifications require a more frequent cleaning.

7.1.3 Coating Evaluation Initiation Requirements

7.1.3.1 Manufacturer. Prior to any testing, the Manufacturer shall provide the following to the NTPEP Lead State.

7.1.3.1.1 Name of the manufacturer of the coating system.

7.1.3.1.2 Names of the designated Coatings that will be tested.

7.1.3.1.3 Product data sheet and information required by Section 6 for each coating system that will be tested.

7.1.3.1.4 Indicate the dry film thickness, in micrometers, for each coat of the system tested.

7.1.3.1.5 A clearly marked sample of the paint to be used for each coat of the system. The sample kit shall be a minimum of 12 liters.

7.1.3.2 NTPEP Lead State. The NTPEP Lead State will provide the following to the selected testing laboratory.

7.1.3.2.1 Blind samples of the paint for each coat of the system, clearly marked with an identification code.

7.1.3.2.2 Coating information required to perform the requirements of this Standard or for the preparation of the final report.

7.1.3.2.3 Format requirements for the final report and the information to be included.

7.1.3.2.4 Completion date for the final report as mutually agreed between the NTPEP Lead State and the testing laboratory.

7.1.3.2.5 The coating system that shall be used as a control.

7.1.3.3 Testing Laboratory. The following information will be provided to the NTPEP Lead State by the testing laboratory.

7.1.3.3.1 Indicate what tests the Principal Testing firm will perform.

7.1.3.3.2 Identify what tests will be performed by an authorized outside firm, the Name, Address, and Telephone Number of the firm and the contact person for the firm.

7.1.4 The laboratory performing the testing shall be responsible for application of protective coatings to test panels.

7.1.5 The final report shall include testing results for all samples, panels or tests performed. The final report shall be forwarded to the NTPEP Lead State in two parts. Part one will include all of the laboratory testing requirements. Part two will include the atmospheric testing. Manufacturers will be allowed the option of not having the final test results for their system made public information.

7.2 Test Panel Requirements for Test (Applicable to Test Nos. 2 through 8).

7.2.1 All steel test panels, except Test No. 4 panels, shall be ASTM A36, hot rolled steel or equivalent with minimum dimensions (in mm) as shown below. Certified mill test reports shall be provided as prepared by the steel manufacturer or testing laboratory for all Grade 36 steel identifying actual physical and chemical analysis of the material. Test panels for Test No. 4 shall be standard Taber panels, meeting the requirements of ASTM D4060.

<u>Test</u>	<u>width</u>	<u>length</u>	<u>thickness</u>
2,3,5,6	100	150	6
8	102	305	6

7.2.2 Three test panels shall be prepared for each complete system for each test, except test 8, which shall require five. Test 5 requires three additional

test panels to be prepared with the primer only. Each test will include three control panels, except test eight, which shall require five. Control panels shall be coated in bulk lots by a single applicator for use by all selected laboratories. The location and date of application shall be reported. All control panels utilized during the testing evaluation of a system shall be from the same lot. The quantity of control panels to be coated and the control system to be used shall be approved by NTPEP. During transporting and storage, control panels shall be protected such that coating damage will not occur. Beyond 30 days, the storage temperature and relative humidity for these panels shall be $25 \pm 5^{\circ}\text{C}$ and $50 \pm 20\%$.

7.2.2.1 Suggested acceptance criteria. Two of three panels must pass for the complete system to pass.

7.2.3 The panels shall be abrasively blast cleaned to a white condition using a metallic abrasive to obtain an SSPC SP 5 surface preparation with a nominal anchor profile of 40 to 65 micrometers. The profile must be clean, sharp and free of embedded friable material, with adequate roughness to insure effective adhesion of the applied primer.

Note 3 - The SP5 is required rather than SP10 only for the convenience of the laboratory in order to guarantee that all panels are prepared identically and to assure comparative testing results. Steel surfaces prepared to a lesser degree may not yield the same performance.

7.2.3.1 The metallic abrasive used to obtain the required SSPC-SP5 surface cleanliness shall be a recyclable abrasive conforming to the requirements of SSPC AB-3. The metallic abrasive shall have a chloride content of less than 15 ppm, derived using ASTM D512, and a conductivity per ASTM D4940 of less than 150 micromhos per cm. The working mixture shall be approximately sixty percent shot and forty percent grit. The shot shall be SAE shot number S230 and the grit shall be SAE grit number G40. Hardness of the shot and grit shall be Rockwell C45 $\pm$ 3.

7.2.4 Each coating shall be applied within the dry film thickness range recommended by the manufacturer.

7.2.4.1 All products shall be applied using proper airless equipment except when this method is specifically not allowed by the paint manufacturer. All paints shall be applied to panels mounted vertically at a distance 530mm (21 inches) from the tip of the spray gun. The equipment shall be capable of developing sufficient pressure to properly atomize the coating. Orifice size, application pressure, pump

type and ratio, hose size and length and any atypical application requirements shall be recorded. If the pressure used varies by more than 10% from the suggested pressure listed in the manufacturer's application data information, the actual pressure used and a statement explaining the deviation shall be provided in the final report.

7.2.5 For testing purposes the color of the final top coat shall conform to Federal Standard No. 595, Color Chip No. X4062 (green) (X signifies that the gloss is undesignated) and the color of the intermediate coat shall be a contrasting color.

7.2.6 Each sample or panel shall be marked and identified by a NTPEP assigned system code number. The identification code number shall be placed on the back of each panel with permanent yellow paint stick. It will also be typed and placed in front of the corresponding panel when photographs are taken. The number will have a minimum height of 10 mm and will identify the following information, which will be part of the final report.

7.2.6.1 Generic type of system.

7.2.6.2 Test number being performed.

7.2.6.3 Replica test being performed, i.e., salt #3.

7.2.6.4 Date of panel preparation.

7.2.6.5 Date that the test evaluation was performed.

7.2.7 Test panels coated with the primer only and panels coated with the primer plus intermediate shall be topcoated at the minimum recoat time frame stated in the product data sheet. Curing of the coated test panels, including control panels for the complete system, shall be a minimum of 30 days. The curing climate shall be $25 \pm 2^\circ \text{C}$ and $65 \pm 5\%$ relative humidity. The back of all test panels shall be coated with 75 to 100 μm of a high quality epoxy or urethane barrier coat.

7.2.8 After preparation of the test panels with the coating system to be evaluated the edges shall be sealed and protected by applying vinyl tape around the entire outside edge. The vinyl tape shall extend 5 mm onto the coated surface from the edge of the panel and shall be applied after the coating has cured. The vinyl tape shall meet the requirements of CID A-A-1689B and have an approximate vinyl thickness of 110 micrometers with an approximate neoprene adhesive thickness of 25 micrometers.

7.2.9 Test panels shall be scribed in accordance with ASTM D 1654 with a single "X" mark centered on the panel. The rectangular dimensions of the scribes

shall have a top width of 50 mm and a height of 100 mm. The scribing tool shall be a straight-shank tungsten carbide tip, lathe cutting tool (ANSI B94.50, Style E). Cut shall expose the steel substrate as verified with a microscope.

7.3 Photographic Requirements (Applicable to Test No.s 1 through 7).

7.3.1 Color photographs of each sample or panel shall be taken as follows:

7.3.1.1 All photographs shall include the code identification number for each sample or panel and the number of hours.

7.3.1.2 A photograph of the coated surface of each sample or panel shall be taken after application of each coating to be evaluated.

7.3.1.3 Test No. 1: Surface of each sample prior to and after each test.

7.3.1.4 Test No. 2 and 3.

7.3.1.4.1 Each time frame designated.

7.3.1.4.2 Once blistering or rusting is observed, the panel shall be photographed and its condition documented at the end of each 336 hour cycle for the ASTM D 5894 Cyclic Weathering Resistance Test and 1,000 hours for ASTM B117 Salt Fog Resistance Test.

7.3.1.4.3 Rust creepage evaluation; (1) after washing and prior to stripping of the scribe, and (2) after stripping of the scribe.

7.3.1.5 Test No. 4, 5 and 6: At the completion of each test.

7.4 Measurement of Surface Profile and Dry Film Paint Thickness (Applicable to Test Nos. 1 through 7).

7.4.1 Surface Profile - Measure the total surface profile thickness using a Testex kit in accordance with ASTM D 4417, Method C.

7.4.2 Dry Film Paint Thickness shall be taken in accordance with ASTM D-1186, except as follows - Measure the dry film paint thickness on each test panel, utilizing a Type II dry film thickness gage as follows: Take two gage readings from the top third, the middle third, and the bottom third of the test panel. Readings shall be taken at least 25 mm from any edge. Discard any unusually high or low gage reading that cannot be repeated consistently. The average of the acceptable gage readings shall be no