Designation: D 1014 – ~~95~~02

Standard Practice for Conducting Exterior Exposure Tests of Paints and Coatings on ~~Steel~~ Metal Substrates[1]

This standard is issued under the fixed designation D 1014; 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 Department of Defense.

[1] This practice is under the jurisdiction of ASTM Committee ~~D-1~~ D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.27 on Accelerated Testing.

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1. Scope

1.1 This practice covers ~~the determination~~ procedures to be followed for direct exposure of ~~the relative service of~~ exterior paints and ~~other materials of similar purpose~~ coatings to the environment when applied to metal surfaces. When originators of a weathering test have the actual exposure conducted by a separate agency, the specific conditions for the exposure of test and control specimens should be clearly defined and mutually agreed upon between all parties.

1.2 Experience indicates that the ~~steel~~ metal used as a test ~~surface~~ substrate has a ~~marked bearing~~ significant effect upon ~~the~~ weathering results. ~~It is the~~ The purpose of this ~~test method~~ practice is to ~~minimize the influence of variation in~~ define specific steel and other metal surfaces ~~on any series of tests by providing~~ to be used for ~~uniformity~~ testing in ~~the selection~~ order to minimize this source of ~~the steel surface, particularly in cooperative work. This practice also outlines uniform procedures for conducting the exposure tests and for evaluating and recording results.~~ variability.

1.3 The values stated in ~~inch-pound~~ SI units are to be regarded as the ~~standard. The values given in parentheses are for information only.~~ standard.

1.4 *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:*

A 36 Specification for Carbon Structural Steel[2]

A 283/A 283M Specification for Low and Intermediate Tensile Strength Carbon Steel Plates[2]

~~D 609 Practice~~

B 209 Specification for ~~Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings,~~ Aluminum and ~~Related Coating Products~~ Aluminum-Alloy Sheet and Plate[3]

~~D 610 Test Method~~

B 449 Specification for ~~Evaluating Degree of Rusting~~ Chromates on ~~Painted Steel Surfaces~~ Aluminum[4]

D ~~659 Methods of Evaluating Degree of Chalking of Exterior Paints~~ 523 Test Method for Specular Gloss[5]

D ~~660 Test Method~~ 609 Practice for ~~Evaluating Degree~~ Preparation of ~~Checking of Exterior Paints~~[3] Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products[5]

D 6610 Test Method for Evaluating Degree of ~~Cracking of Exterior Paints~~[3] Rusting on Painted Steel Surfaces[6]

D ~~714 Test~~ 660 Test Method for Evaluating Degree of ~~Blistering~~ Checking of Exterior Paints[5]

D ~~823 Practices~~ 661 Test Method for ~~Producing Films~~ Evaluating Degree of ~~Uniform Thickness~~ Cracking of ~~Paint, Varnish, and Related Products on Test Panels~~[3] Exterior Paints[5]

[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol ~~06.01.~~ 02.02.

[4] *Annual Book of ASTM Standards*, Vol ~~06.02.~~ 02.05.

[5] ~~Discontinued; see *1989 Annual*~~ *Annual Book of ASTM Standards*, Vol 06.01.

[6] *Annual Book of ASTM Standards*, Vol ~~14.02.~~ 06.02.

D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints[5]
D 714 Test Method for Evaluating Degree of Blistering of Paints[5]
D 772 Test Method for Evaluating Degree of Flaking Scaling of Exterior Paints[5]
D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[5]
D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[3]
D 1212 Test Methods for Measurement of Wet Film Thickness of Organic Coatings[5]
D ~~2200 Pictorial Surface Preparation Standards~~ 1400 Test Method for ~~Painting Steel Surfaces~~[4] Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[5]
D ~~4141~~729 Practice for ~~Conducting Accelerated Outdoor Exposure Tests~~ Visual Appraisal of Colors and Color Differences of Diffusely Illuminated Opaque Materials[5]
D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting[4]
D 2200 Pictorial Surface Preparation Standards for Painting Steel Surfaces[6]
D 2201 Practice for Preparation of Zinc-Coated and Zinc-Alloy Coated Steel Panels for Testing Paint and Related Coating Products[5]
D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates[5]
D 2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale[5]
D 2803 Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal[5]
D 3359 Test Methods for Measuring Adhesion by Tape Test[5]
D 4214 Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films[5]
E 41 Terminology Relating to Conditioning[7]
E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[5]
G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials[7]
G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[7]
G 141 Guide for Addressing Variability in Exposure Testing on Nonmetallic Materials[7]
G 147 Practice for Conditioning and Handling of Nonmetallic Materials for natural and Artificial Weathering Tests[7]
2.2 *Other Standard:*
SSPC Method 1 Test Panel Preparation Method No 1, Uncontaminated Rusted Steel SSPC[8]

3. ~~Significance and Use~~

~~3.1 The procedures described~~Terminology

3.1 *Definitions*—The definitions given in ~~this test method~~ Terminologies E 41 and G 113 are ~~intended~~ applicable to ~~aid in evaluating performance of coatings on either new or previously rusted steel.~~

~~3.2 Since the natural environment varies with respect to season and geographic location, test results may not correlate with in-service performance.~~ this practice.

4. ~~B~~Significance and Use ~~M~~

4.1 The procedures described in this practice are intended to aid in evaluating the performance of coatings on various metal panels including either new or previously rusted steel.

4.2 The relative durability of paints in outdoor exposures can be very different depending on the location of the exposure because of differences in solar radiation, time of wetness, temperature, pollutants, and other factors. Therefore, it cannot be assumed that results from one exposure in a single location will be useful for determining relative durability in a different location. Exposures in several locations with different climates which represent a broad range of anticipated service conditions are recommended.

4.2.1 Because of year-to-year climatological variations, results from a single exposure test cannot be used to predict the absolute rate at which a material degrades. Several years of repeat exposures are needed to get an "average" test result for a given location.

4.2.2 Solar radiation varies considerably as function of time of year. This can cause large differences in the apparent rate of degradation in many polymers. Comparing results for materials exposed for short periods (less than one year) is not recommended unless materials are exposed at the same time in the same location.

4.3 The Significance and Use in Practice G 7 addresses many variables to be considered in exterior exposure tests. Guide G 141 provides more information on variability in weathering testing.

5. Materials Used for Test Specimens

~~4~~5.1 A minimum of two and preferably four test specimens shall be used to evaluate the performance of any paint system.

~~4~~5.2 The surface preparation ~~for the test panels should be that expected to be done in the field or in-service. The surface preparation~~ shall be the same for all test panels in the test program unless surface preparation is one of the variables to be evaluated.

[7] *Annual Book of ASTM Standards*, Vol 14.04.
[8] Available from the Society for Protective Coatings, 40 24th Street, Pittsburgh, PA 15222.

Surface preparation must shall be essentially identical for all test panels, as the thoroughness of preparation may directly determine the performance life of the applied coating system.

45.3 TSteel Panels—Unless otherwise specified, fabricate steel test panels should be fabricated from the same material over which the coating is expected to perform in-service, when the exact composition of the substrate is known. Any of the following surfaces may be used:.

45.3.1 *Abrasive Blasted Steel Plate*—The steel plate shall conform to Specification A 36 or Specification A 283/A 283M. The minimum thickness shall be 1/16 in. (1.6 mm). The minimum size shall be 4 3 by 6 in. (100 (75 by 150 mm). Burrs and sharp projections shall be removed from the edges by filing. The test panels shall be freed of oil by suitable grease-removing solvents in accordance with Procedures B, C, or D of Practice D 609. The Unless otherwise specified and agreed upon, the surface shall be blasted to meet the requirements of Standard D 2200, *Sa* 2½, if another degree of surface preparation has not been agreed upon.

4.3.2 Sa 2½.

5.3.2 *Rusted Surfaces*—Hot rolled steel angle or plate, or both, are useful for determining the performance of paints applied to structures that cannot be thoroughly cleaned of rust and corrosion products. The steel angle and plate shall conform to Specification A 283/A 283M. The steel angles shall be at least 4 by 4 by 1/8 in. (100 by 100 by 3.2 mm) in cross section and 12 in. (300 mm) in length. The minimum size of the steel plate shall be 4 by 6 in. (100 by 150 mm) with a minimum thickness of 1/16 in. (1.6 mm). Burrs and sharp projections shall be removed from the edges by filing. The test pieces shall be freed from oil by the use of suitable grease-removing solvents in accordance with Procedures B, C, or D of Practice D 609. Those persons desiring to test coatings over rusty or slightly rusted surfaces (Note 1) should refer to Standard D 2200, select the degree of rusting desired from the rust grades given, and utilize the degree of surface preparation that can be accomplished in the field or on the job.

5.3.2.1 When evaluating performance over rusty surfaces, it is recommended that test specimens be pre-corroded (weathered) in the same environment in which they will be ultimately be exposed. SSPC Method 1 describes this pre-aging procedure. Artificial rusting is permitted but conditions used must be stated in the test report.

NOTE 1—When testing over rusty surfaces, the test specimens should preferably be pre-corroded (weathered) in the same 1—The environment in which they ultimately will be exposed. The environment in which the steel is rusted prior to painting has considerable influence on the performance of paint applied to such steel. Artificial rusting, however, is permitted but conditions must be stated in the test report.

4.3.3 steel.

5.3.3 *Cold-Rolled Steel Strip*—Cold-rolled steel strip has a slightly roughened surface free from mill scale and rust, and is useful for checking the relative performance of paints on a clean, uniform surface. The steel strip shall conform to one of the types described in Practice D 609. The panels shall be not less than 4 by 6 in. (100 by 150 mm) in size and it is recommended that all edges shall be smooth and uniformly rounded. The metal panels shall be prepared by the agreed upon procedure (A, B, C, or D) in Practice D 609.

5.3.4 *Galvanized Steel*—When galvanized steel panels are used, prepare test specimens according to Practice D 2201.

5.4 After surface preparation, the steel panels shall be prime coated as soon as possible to prevent flash rusting or deposit of any foreign contaminant on the cleaned surface. After surface preparation, if the panels are stored prior to coating, precautions must be taken to preserve the clean surface.

5.5 *Aluminum Panels*—Use aluminum panels that have the same alloy, heat treatment, and surface treatment representative of the aluminum substrate to which the coating may be applied in field use. Aluminum alloys and heat treatments are described in Specification B 209. Typical aluminum alloys used for testing coatings are 6061, 5052, and 3024. The minimum thickness shall be 0.020 in. (0.5 mm). The minimum size shall be 3 by 6 in. (75 by 150 mm).

5.5.1 Aluminum panels are typically prepared with a conversion coating to promote coating adhesion and to prevent corrosion of the aluminum. Chromate conversion coatings are described in Specification B 449. Non-chrome conversion coatings may also be used if agreed upon by all interested parties. Follow Practices D 1730 when preparing aluminum and aluminum alloy test specimens.

6. Painting Test Specimens

56.1 Apply all coatings in strict accordance with the coating manufacturer's written recommendations. The If known, the method of application expected for the production work on the job should also be used for test panel application.

56.2 If the method of application is unknown, select one of the following (Note 2):

Automatic Spray Machine
Automatic Dip Coater
Manual Spray Application
Motor Driven Blade Applicator
Brush Application
Roller Coating
Curtain Coating

NOTE 2—Details for the application of paint are given in Practices D 823.

56.2.1 Powder coating application using techniques such as fluid bed dip or electrostatic fluid bed may also be used where appropriate.

6.3 Measure and record the film thickness of each coat in accordance with the methods recommended in Test Methods D 1186 or D 1400. If the test panel is covered by rust and mill scale, these methods will be less accurate, as they are influenced by the surface characteristics of this base metal. In such cases, approximations can be made by wet film thickness measurements in accordance with Test Methods D 1212, or the amount of paint applied to a known area can be weighed and the average dry film thickness computed. It should be noted that even though dry film thickness measurements in accordance with Test Methods D 1186 are less accurate on surfaces with rust and mill scale than on smooth steel surfaces, they are still more accurate than those obtained by Test Methods D 1212 or weighing.

5.4 Allow computed.

6.4 Allow the proper drying time between coats for multiple paint systems and before exposure as required by the coating's manufacturer and include in the test record.

56.5 Paint the back and edges of all test specimens with the same systems as that being tested on the front of each panel. This painting provides considerable information on the behavior of the paint systems on the reverse side. Back and edge painting may also provide "insulating" properties that allow metal panels to be mounted on metal racks.

6.5.1 The edges of steel panels may be coated or wrapped to prevent rusting.

6.6 The test specimens may be scribed to base metal prior to exposure. Rate any corrosion from this point of damage Unless otherwise specified, scribe panels according to Test Method D 1654.

6.7 Unless otherwise specified, follow the procedures described in accordance with Methods D 610.

6. Exposure

6.1 The type Practice G 147 for labeling, shipping, and conditioning / handling of exposure test specimens.

7. Location of Test Sites and Exposure Requirements

7.1 *Test Sites*—The climatic conditions of the position test sites should be representative of those of the painted specimens may area in which the paints are to be used. The type and rate of failure of a paint film will vary when exposed to different combinations of climatic and atmospheric conditions. For reliable results, exposure sites should be selected f that are representative geographically, climatically, and in atmospheric contaminations with those of the following:

- 5°, facing south
- 45°, facing south
- 45°, facing north
- Vertical, facing south
- Vertical, facing north
- Insulated (backed or black box)

locality in which the paint will be used. To obtain conclusions that are valid for paincets with Practice G 7 national distribution requires exposure at several sites, selected to cover a wide range in climatic conditions. Suggested sites include south Florida, Great Lakes region, hot desert southwest, the northeast, and extreme southern Louisiana.

7.2 Conduct all exposures according to Practice D 4141.

6.2 Mount the G 7.

7.3 *Exposure Orientation*—Unless otherwise specified, expose specimens so they do not cast shadows at an angle of 45° facing the Equator.

7.3.1 Other exposure orientations may also be conducted to provide faster results. See Practice G 7 for more information on each other, or contact each other or any metallic material, or any material capable exposure options.

7.4 If required to prevent galvanic corrosion of acting as a wick. Also, steel panels, mount the test specimens so that the products of weathering they are electrically insulated from each other and rain water drippings do not flow from one to another.

6.3 The test period shall be sufficient to evaluate the characteristics test rack. The use of insulators or painting all sides of the system under consideration. specimens to protect against galvanic corrosion are suitable methods for achieving this.

NOTE 3—A suitable material for the construction of racks and supports is painted wood. Metal,s such as conversion coated or anodized aluminum, is also suitable if the suitable.

7.5 Mount test specimens are properly insulated as by the use of porcelain such that rain water, condensation, or suitably selected plastic.

7. Inspections and Records

7.1 After panels have been exposed to the weather, inspections should be made after degradation products do not more than 1 month, at 3 months, and at intervals of 3 months during contaminate the first 2 years, and every 6 months thereafter. Midwinter inspections, however, may be omitted in northern latitudes. Inspections may be made more frequently if desired. Usually the exposures should be continued for a considerable length test surface of time after deterioration has reached the point which best practice calls for repainting.

7.2 Evaluate (resistance to or) degree of rusting, chalking, checking, cracking, and blistering using the following ASTM photographic reference standards: Test Methods D 610, D 659, D 660, D 661, and D 714.

7.3 Records should be kept on report forms agreed upon between the purchaser and seller. other panels.

8. Report Section

8.1 CompleteUse of Control or Reference Materials

8.1 When several paints are being compared, select one paint as a "control." Apply the inspection report covering control paint to the various failure modes agreed upon between same substrate as the test paints. For best results theree shaould be two controls, one known to perform well and one known to perform poorly.

9. Procedure

9.1 After the seller. The report shall clearly show panels have been prepared, identify each specimen with a unique mark that will not be destroyed or become illegible during the exposure. Practice G 147 provides guidance for this procedure.

9.2 Measure the desired properties on all test and reference control specimens prior to exposure. Unless otherwise specified, use non-destructive tests on specimens that will be re-exposed after evaluation. In some cases, destructive tests can be used if the test area will not affect the durability of other areas that will be tested after additional exposure.

9.3 Mount the specimens on the correctly oriented exposure rack that accommodates the dimensions of the specimens being exposed.

9.4 Perform the exposure test in accordance with the guidelines in Practices G 7 and identification G 147.

9.5 Select one of the methods for defining the duration of the exposure according to Practice G 7.

10. Inspections and Records

10.1 Unless otherwise specified, inspect panels after not more than one month of exposure, at 3 months, and at intervals of 3 months during the first two years, and every 6 months thereafter. Midwinter inspections, however, may be omitted in northern latitudes. Inspections may be made more frequently if desired. Usually the exposures should be continued for a considerable length of time after deterioration has reached the point at which best practice calls for repainting.

10.2 After each exposure increment, determine the changes in exposed specimens. The following Test Methods D 523, D 610, D 660, D 661, D 662, D 714, D 772, D 2616, D 3359, D 4214, E 1347, or Practices D 1729 or D 2244 may be used. Consider product use requirements when selecting appropriate methods.

10.2.1 When evaluating degree of rusting, checking, cracking, chalking, erosion, blistering, or flaking use Test Methods D 610, D 660, D 661, D 662, D 714, or D 772, respectively.

10.2.2 When evaluating for filiform corrosion use Guide D 2803.

10.3 *Washing Panels after Exposure*— If panels are washed prior to conducting property measurements, use the following procedure unless otherwise specified. Gently wash the panels using a soft cloth or sponge and clean water or a dilute solution (1 % by weight in water, maximum concentration) of a mild detergent. After washing, rinse thoroughly with clean water, and blot dry with a soft clean cloth. After washing and drying, condition the v panels at room temperature for at least one hour prior to conducting any property measurements.

10.4 Keep records on report forms agreed upon between by all interested parties.

11. Report

11.1 The report section shall contain the following information when applicable and available. In most cases, commercial testing agencies used to perform exposures may not have specific information about the materials used or preparation of the test specimens and therefore cannot be reported.

11.1.1 Complete description of the test specimens and any control and weathering reference standard(s) materials used, a including:

11.1.1.1 Compositthion, including description of the metal substrate to whinch the paint is applied including surfoace trmeatiomen.ts and

811.1.1.2 ThMethod of preparation (reference applicable standards here),

NOTE 4—When exposures are conducted by a contracting agency, specific information covering outdoor weathering tests shall include about the following:

8.2.1 Date composition and preparation procedures may not be known by the contracting agency. It is not the intent of inspection,

8.2.2 Date this standard to require reporting of exposure start,

8.2.3 Reporting testing facility's order number,

8.2.4 Client's (purchaser's) name, address,

8.2.5 Name proprietary information about composition or material processing.

11.1.2 Location of principal contact,

8.2.6 Duration expressed exposure (including whether specimens were exposed at ground level, on a rooftop, and so forth),

11.1.3 Ground cover in area of test racks,

11.1.4 Angle at whimch exposure conducted,

811.21.75 RType of exposure (unbackedi, backed). If backed exposure is used, include thickness and type of backing and, if painted, the color of paint used,

11.1.6 Date exposure started and date exposure completed,

11.1.7 If required, solar radiant energy for all exposures oriented towards the equator including the wavelength bandpass in which radiant energy measured. All solar radiant energy reported shall be measured in accordance with Practice G 7. If required, include a certificate of ~~MJ/m~~ calibration for the radiometer used, with this information,

11.1.8 If used, details of any specimen treatment such as washing conducted during the exposure. This shall include description of the treatment used and the frequency of treatment.

11.1.9 If required, the following climate information:

11.1.9.1 Ambient temperature (daily maximum and minimum),

11.1.9.2 Relative humidity (daily maximum and minimum),

11.1.9.3 Total hours of wetness and method used to measure,

11.1.9.4 Total rainfall amount,

11.1.9.5 Concentration of pollutants such as NO_2 ~~of UV, radiation (295nm~~, SO_2, O_3, and method used to ~~385nm), total solar radiation expressed in MJ/m~~ [2]

~~8.2.8 Type~~ measure the concentration, and

11.1.10 Results of ~~exposure,~~

~~8.2.9 Notation as to ASTM Test Method used,~~

~~8.2.10 Orientation~~ property measurements if required or conducted before and after exposure. This shall include a description of the ~~samples,~~

~~8.2.11 Site location comments section~~ method used to ~~more completely describe~~ measure the ~~f~~ property.

12. Precision and Bias

12.1 *Precision*:

12.1.1 Repeatability and reproducibility of res~~n~~ults obtained by this practice will vary depending on ~~panels,~~

~~8.2.12 Remarks about unusual weather,~~

~~8.2.13 Other information agreed upon betweeen~~ the ~~purchaser and~~ materials being tested, the ~~seller, and~~

~~8.2.14 Name~~ material property being measured, the climate in which the exposures are conducted, and year-to-year differences in climate at a single location. Therefore, no specific statement about the absolute precision of the ~~person and signature~~ results obtained by this practice can be made.

12.1.2 Comparison of test materials to control materials exposed at the ~~person making~~ same time has been shown to reduce the effects of variability in exposure tests.[9]

12.2 *Bias*—Bias in results obtained according to this practice will vary with the materials being tested, the material property being measured, the climate in which the exposures are conducted, and year-to-year differences in climate at a single location. In addition, no acceptable standard reference materials are available for the myriad of material weathering property responses.

913. Keywords

~~9.1 durability; paints; exposure tests; exterior; organic coatings; panels; steel~~

13.1 coating; durability; exposure; metal; paint; powder coating; weathering

[9] Fischer, R., "Results of Round Robin Studies of Light and Water Exposure Standard Practices," *Accelerated and Outdoor Durability Testing of Organic Materials, ASTM STP 1202*, Warren D. Ketola and Doug Grossman, Eds, American Society for Testing and Materials, Philadelphia, 1993.