Designation: D 4141 – 01

Standard Practice for Conducting Black Box and Solar Concentrating Exposures of Coatings[1]

This standard is issued under the fixed designation D 4141; 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.

1. Scope

1.1 This practice covers two accelerated outdoor exposure procedures for evaluating the exterior durability of coatings applied to substrates.

1.2 The two procedures are as follows:

1.2.1 *Procedure A*—Black Box Exposure.

1.2.2 *Procedure B* has been deleted from this practice.

1.2.3 *Procedure C*—Fresnel Reflector Rack Exposure.

NOTE 1—Procedure B described a Heated Black Box procedure that is no longer in common use.

1.3 This standard does not cover all the procedures that are available to the user for accelerating the outdoor exposure of coatings. Other procedures have been used in order to provide a particular effect; however, the two procedures described here are widely used.

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:*

D 523 Test Method for Specular Gloss[2]

D 660 Test Method for Evaluating Degree of Checking of Exterior Paints[2]

D 661 Test Method for Evaluating Degree of Cracking of Exterior Paints[2]

D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints[2]

D 714 Test Method for Evaluating Degree of Blistering of Paints[2]

D 772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints[2]

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[2]

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[2]

D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[2]

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[2]

D 4214 Test Methods for Evaluating Degree of Chalking of Exterior Paint Films[2]

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials[3]

G 90 Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight[3]

G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[3]

G 141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials[3]

G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests[3]

3. Terminology

3.1 The definitions given in Terminology G 113 are applicable to this practice.

4. Summary of Practice

4.1 Several procedures are described that provide acceleration of the degradation that coatings evidence during natural weathering when exposed on an open rack at a fixed angle. The procedures appear in the following order:

4.1.1 *Procedure A*—Exposure on a black box rack facing the equator at 5° from the horizontal.

4.1.2 *Procedure C*—Exposure on a Fresnel reflector rack that provides a high irradiance by following the sun and reflecting sunlight on the test specimens by means of mirrors. The specimens are wet periodically by high purity water spray.

4.2 Each of these procedures requires that coated test panels be placed on devices of specified design and be exposed under specified conditions of weathering.

[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 D01.27 on Accelerated Tests for Protective Coatings.

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[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] *Annual Book of ASTM Standards*, Vol 14.04.

4.3 The selection of Procedure A or C is dependent on several factors.

4.3.1 Procedure A is designed to simulate the weathering that occurs on horizontal automotive surfaces, and is specified in standards used by the automotive industry. Specimens are typically flat-coated metal panels measuring 10 by 30 cm (4 by 12 in.) or 15 by 30 cm (6 by 12 in.).

4.3.2 Procedure C is designed to simulate weathering on both automotive and nonautomotive products. Procedure C typically provides faster results than Procedure A on a calendar basis.[4]

5. Significance and Use

5.1 As with any accelerated test, the difference in rate of weathering is material dependent and no single exposure factor can be used to compare two different weathering exposures. The durability rankings of coatings provided by these two procedures may not agree when coatings differing widely in composition are compared. These two procedures should not be used interchangeably or used for absolute comparison to each other.

5.2 The procedures described in this practice are designed to provide greater degradation rates of coatings than those provided by fixed angle open-rack outdoor exposure racks. For many products, fixed angle exposures will produce higher degradation rates than the normal end use of the material.

5.2.1 The use of Procedure A (Black Box) instead of an open-rack direct exposure is a more realistic test for materials with higher temperature end use service conditions.

NOTE 2—*Procedure A (Black Box)*—For many coatings, this procedure provides greater rates of degradation than those provided by 5°, equator-facing, open-rack exposures because the black box produces higher specimen temperatures during irradiation by daylight and longer time of wetness. The black box specimen temperatures are comparable to those encountered on the hoods, roofs, and deck lids of automobiles parked in unfiltered daylight. The relative rates of gloss loss and color change produced in some automotive coatings by exposures in accordance with Procedure A are given in ASTM STP 781.[5]

NOTE 3—*Procedure C (Fresnel Reflector Rack)*—The acceleration of Procedure C is produced by reflecting sunlight from ten mirrors onto an air-cooled specimen area. In the ultraviolet portion of the solar spectrum, approximately 1400 MJ/m^2 of ultraviolet radiant exposure (295 to 385 nm) is received over a typical one-year period when these devices are operated in a central Arizona climate. This compares with approximately 333 MJ/m^2 of ultraviolet radiant exposure from a central Arizona at-latitude exposure and 280 MJ/m^2 of ultraviolet radiant exposure from a southern Florida at-latitude exposure over the same time period. However, the test described by Procedure C reflects only direct beam radiation onto test specimens. The reflected direct beam sunlight contains a lower percentage of short wavelength ultraviolet radiation than global daylight because short wavelength ultraviolet is more easily scattered by the atmosphere, and because mirrors are typically less efficient at shorter ultraviolet wavelengths. Ultraviolet radiant exposure levels should not be used to compute acceleration factors since acceleration is material dependent.

5.3 The relative durability of coatings in outdoor use can be very different depending on the location of the exposure because of differences in ultraviolet (UV) 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 that represent a broad range of anticipated service conditions are recommended.

5.4 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.

5.4.1 The degradation profile for many polymers is not a linear function of exposure time or radiant exposure. When short exposures are used to predict the service life or as indications of relative durability, the results obtained may not be representative of those from longer exposures.

NOTE 4—Guide G 141 provides information for addressing variability in exposure testing of nonmetallic materials. ASTM G03 Committee is developing a standard guide for application of statistics to exposure test results.

5.5 It is recommended that at least one control material be part of any exposure evaluation. Control materials are used for comparing the performance of the test materials relative to the controls when materials are not being ranked against one another. The control material used should be of similar composition and construction to the test materials and be of known durability. It is preferable to use two control materials, one with relatively good durability and one with poor durability.

6. Test Specimens

6.1 Each test specimen and control specimen shall consist of a uniform coating applied to the surface of a rigid panel. Suitable application procedures are given in Practice D 823.

6.2 Use flat specimens, because warpage, waviness, or curvature may seriously affect the measurements of gloss and color and may produce a poor air seal on the black box rack.

6.3 For Procedure C, specimen sizes are typically limited to a maximum of 13 cm (5 in.) in one dimension, and a maximum of 140 cm (55 in.) in the other dimension. However, specimens are typically 7.5 by 13 cm (3 by 5 in.) or 5 by 13 cm (2 by 5 in.). Because air cooling is used to prevent high specimen temperatures, specimens must be flat. A thickness of less than 0.6 cm (0.25 in.) is preferred. This practice may not apply to specimens thicker than 1.3 cm (0.5 in.) because cooling may be questionable.

6.4 Prepare controls for inclusion in each exposure series to act as comparison standards and to provide a means for determining the severity of the exposure conditions encountered by the series. For best results, there should be at least two controls differing in their durability performance.

6.5 Optionally, using Test Methods D 1186 or Test Method D 1400, measure the dry film thickness of the coatings at several different positions on the test specimens.

[4] Zerlaut, G.A., Rupp, M.W., and Anderson, T.E., "Ultraviolet Radiation as a Timing Technique for Outdoor Weathering of Materials," Paper 850378, *Proceedings*, SAE International Congress, Detroit, February 25, 1985.

[5] Symposium on Permanence of Organic Coatings, *ASTM STP 781*, ASTM, 1982.