



Standard Practice for Conducting Accelerated Outdoor Exposure Tests of Coatings¹

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1. Scope

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

1.2 The three procedures are as follows:

1.2.1 *Procedure A*—Black Box Exposure,

1.2.2 *Procedure B*—Heated Black Box Exposure, and

1.2.3 *Procedure C*—Fresnel Reflector Rack Exposure.

1.3 The durability rankings of coatings provided by these three procedures may not agree when coatings differing widely in composition are compared.

1.4 The acceleration of degradation rates of coatings produced by the three procedures of exposure are discussed.

NOTE 1—Other exposure procedures may provide accelerated results for some types of products.

1.5 The values stated in either inch-pound or SI units are to be regarded separately as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* A specific precautionary statement is given in Note 5.

2. Referenced Documents

2.1 *ASTM Standards:*

D 523 Test Method for Specular Gloss²

D 660 Test Method for Evaluating Degree of Checking of Exterior Paints²

D 714 Test Method for Evaluating Degree of Blistering of Paints²

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels²

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base²

¹ This practice is under the jurisdiction of ASTM Committee D-1 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.

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates²

D 4214 Test Methods for Evaluating Degree of Chalking of Exterior Paint Films²

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials³

G 90 Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight³

3. Summary of Practice

3.1 Several procedures are described that provide acceleration of the degradation that coatings experience during natural weathering. The procedures appear in the following order:

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

3.1.2 *Procedure B*—Exposure on a heated black box panel rack facing the equator at 5° from horizontal.

3.1.3 *Procedure C*—Exposure on a Fresnel reflector panel rack that provides a high intensity of sunlight irradiation by following the sun and focusing the sunlight on the test panels by means of mirrors. The panels are wet periodically by deionized water spray.⁴

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

3.3 The selection of a procedure for producing accelerated degradation is dependent on the intended end use of the coatings, limitations on the time available for the exposure tests, and the degree of reliability required for predictions of durability performance.

4. Significance and Use

4.1 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.

4.2 Following are comments regarding the relative rates of degradation that can be expected for coatings exposed by the

³ *Annual Book of ASTM Standards*, Vol 14.02.

⁴ Fresnel reflector panel racks are located at Heraeus DSET Laboratories, Inc., 45601 N. 47th Avenue, Phoenix, AZ 85027-7042 and South Florida Test Service, Desert Site, 31818 N. 203rd Ave., Wittmann, AZ 85361.

procedures described in this practice.

4.2.1 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 panel temperatures during irradiation by the sun and longer time of wetness. The black box panel temperatures are comparable to those encountered on the hoods, roofs, and deck lids of automobiles parked in direct sunlight.

4.2.2 Procedure B (Heated Black Box)—This procedure is most useful for exposures conducted in the late fall, winter, and early spring when it produces significantly higher panel temperatures than those produced by the 5°, equator-facing, black box. Therefore, this procedure produces greater rates of degradation than those produced by Procedure A, particularly in the case of coatings with rates of degradation that are very temperature dependent.

NOTE 2—The relative rates of gloss loss and color change produced in some automotive and coil coatings by exposures in accordance with Procedures A and B are given in ASTM STP 781.⁵

4.2.3 Procedure C (Fresnel Reflector Rack)—This method provides greater rates of degradation of coatings than those provided by Procedure A or Procedure B. This high acceleration is produced by very high sunlight intensity and high panel temperature.

4.2.4 The degradation rates produced by any of the three procedures depend on the seasons of exposure, geographical location, and type of coating. The rates are higher in late spring, summer, and early fall when the intensity of sunlight irradiation is the greatest and when panel temperatures are higher.

4.2.5 Because outdoor weather conditions vary from season to season and year to year, these procedures are not reliable for establishing absolute performance ratings for coatings. The procedures should be used only for comparing the relative performance of coatings exposed at the same time at the same location.

PROCEDURE A—BLACK BOX EXPOSURE

5. Apparatus

5.1 Black Box, constructed of materials in accordance with Practice G 7, or its equivalent, and positioned so that the surfaces of the test specimens are 5° from the horizontal, facing the equator.

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 Practices D 823.

6.2 Use surfaces of good planarity 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 Prepare reference specimens 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 reference materials differing significantly in their durability performance.

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

7. Procedure

7.1 If change in gloss is to be measured, determine the specular gloss value for each unexposed specimen using a properly calibrated glossmeter in accordance with Test Method D 523.

7.2 If change in color is to be measured, determine the color coordinates for each unexposed specimen using Test Method D 2244. Unless otherwise agreed upon, use the CIE Lab Color Scale. The color-measuring instrument shall be stable and properly calibrated.

NOTE 3—As an alternative procedure, reserve unexposed duplicate specimen panels of each coating as file specimens to determine the color change of the exposed specimens. To minimize color drift, store these panels in a dark, room temperature environment.

7.3 Mount and fasten the specimens on the exposure box. Cover all empty spaces on the black box using black panels so that the entire surface is covered.

NOTE 4—The predominant color of the specimen panels on the black box as well as the temperature of a standard panel should be noted. A black panel on the box will attain a lower temperature if all the other panels are white than if all the other panels are black.

7.4 Expose the test and reference specimens for a specified period of time on the basis of one of the following:

7.4.1 Expose for a specified number of days, months, or years with respect to an agreed upon starting date.

7.4.2 Expose for a specified quantity of radiant exposure either total, typically measured from 300 to 3000 nm, or ultraviolet, typically measured from 300 to 385 nm.

7.4.2.1 For Procedures A and B, when solar ultraviolet radiation is measured, use a total ultraviolet radiometer that measures ultraviolet radiation in the wavelength region from 295 to 385 nm.⁶ Calibrate the radiometer and readout system in suitable radiometric units, and maintain in at least annual calibration against a standard source of spectral irradiance.⁷

7.4.2.2 For Procedure C, use the measurement technique specified in Practice G 90.

7.4.3 Exposure until a specified physical change has occurred in the test specimens, or

7.4.4 Exposure until a specified change has occurred in a reference specimen exposed with the test specimens.

7.5 Unless otherwise agreed upon, remove the test specimens from the black box and gently wash a portion of the

⁶ Model TUVR Total Ultraviolet Radiometer manufactured by the Eppley Laboratory, 12 Sheffield Ave., Newport, RI 02804, has been found to be suitable for this purpose. Instruments manufactured with quartz diffusers (typically prior to 1988) should be returned to the manufacturer for installation of a TFE-fluorocarbon diffuser and a recalibration.

⁷ Suitable calibrations may be obtained from some manufacturers, and from the Eppley Laboratory, 12 Sheffield Ave., Newport, RI 02804. Any large decrease in sensitivity from one calibration to another (5 to 10 %) requires that the diffuser be removed and the internal filter visually checked for water damage.

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

specimen surfaces to remove loose dirt. A suitable procedure consists of gentle rubbing with a sponge wet with water or a 0.05 % solution of a nonionic detergent.⁸ Gently remove water droplets from the specimen surfaces to prevent water spotting.

7.6 Unless otherwise agreed upon, perform the following on the washed portion of each washed specimen:

7.6.1 Measure the specular gloss by Test Method D 523,

7.6.2 Calculate the color difference in accordance with Test Method D 2244 based on instrumental measurements of color before and after exposure.

7.6.3 Checking and cracking rating by Test Method D 660, and

7.6.4 Blistering rating by Test Method D 714.

7.7 Unless otherwise agreed upon, perform a chalk rating by Test Method D 4214 on an unwashed area of the specimen.

PROCEDURE B—HEATED BLACK BOX EXPOSURE

8. Apparatus

8.1 *Black Box*, constructed of materials in accordance with Practice G 7, or its equivalent, equipped with a device to heat the air in the interior of the box to the specified temperature and positioned so that the surfaces of the test specimens are 5° from the horizontal, facing the equator.

NOTE 5—**Precaution:** The heated black box must be properly grounded to prevent possible electrical shock. The heating elements in the heated black box must be installed so that, in normal use, a person cannot come in contact with a hot surface.

9. Procedure

9.1 If change in gloss and color are to be measured, follow 7.1 and 7.2, respectively.

9.2 Mount and fasten the specimens on the exposure box as described in 7.3.

9.3 Set the temperature controller to maintain the air temperature inside the heated black box at approximately 140°F (60°C), or other agreed upon temperature, and to turn the heater on at approximately 9 a.m. and turn off at approximately 3 p.m. each day.

9.4 Expose the specimens for a specified period on the basis of one of the procedures outlined in 7.4.

9.5 Unless otherwise agreed upon, remove the specimens from the black box and gently wash a portion of the specimen surfaces as recommended in 7.5.

9.6 Unless otherwise agreed upon, perform on the washed portion of each specimen the tests outlined in 7.6.

9.7 Unless otherwise agreed upon, perform a chalk rating by Test Method D 4214 on an unwashed portion of the specimen.

PROCEDURE C—FRESNEL REFLECTOR RACK EXPOSURE

10. Apparatus

10.1 *Fresnel Reflector Exposure Rack*, that follows the sun, concentrates sunlight irradiation on the test specimens by means of mirrors, and sprays deionized water on the surfaces

of the test specimens at specified intervals. The rack shall have provisions for cooling the test specimens while they are irradiated. Refer to Practice G 90 for detailed descriptions of the apparatus.

11. Procedure

11.1 If change in gloss and color are to be measured, follow 7.1 and 7.2, respectively.

11.2 Mount and fasten the specimens on the exposure rack in accordance with Practice G 90.

11.3 Set the water spray control to provide a deionized water spray on the specimens during the night at a frequency of 4 per hour, each spray period to be of 3-min duration. Refer to Cycle C of Practice G 90 for detailed operating procedures.

11.4 Expose the specimens for a specified period on the basis of either ultraviolet or total radiant exposure. Both ultraviolet and total radiant exposure must be measured and reported using the procedures described in Practice G 90.

11.5 Unless otherwise agreed upon, remove the specimens from the exposure rack and gently wash a portion of the specimen surfaces as recommended in 7.5.

11.6 Unless otherwise agreed upon, perform on the washed portion of each specimen the tests outlined in 7.6.

11.7 Unless otherwise agreed upon, perform a chalk rating by Test Method D 4214 on an unwashed portion of the specimen.

12. Interpretation of Results

12.1 Express the change in gloss of each specimen either in terms of units of gloss loss or in percent gloss loss relative to the initial gloss value.

12.2 Express the change in color of each specimen in terms of total color difference, ΔE , using one of the calculations given in Test Method D 2244.

12.3 Express the amounts of chalking, checking, and cracking as outlined in Test Methods D 4214 and D 660 (or on the 0 to 10 scale described in Section 7 of the D-1 Handbook).⁹

13. Report

13.1 Report the following information:

13.1.1 The method of exposure used and its geographical location,

13.1.2 The duration of the exposure and the date of the beginning of the test,

13.1.3 The measured amount of ultraviolet and total radiant exposure, expressed in MJ/m². (Required for Procedure C, optional for Procedures A and B.),

13.1.4 The heated black box air temperature used (for Procedure B),

13.1.5 The type of reference specimens used and the severity of their degradation, and

13.1.6 The evaluation measurements performed on each of the exposed specimens:

13.1.6.1 Units of gloss loss or percent gloss loss,

13.1.6.2 Units of ΔE color change, noting the color space and color scales used, and

⁸ Alconox manufactured by Alconox Inc., New York, NY 10003, or equivalent, has been found suitable for this purpose.

⁹ *Paint Testing Manual*, ASTM STP 500, ASTM, 1972, Section 7.

13.1.6.3 Ratings for chalking, checking, cracking, and blistering.

13.1.7 If requested, report the traceability of calibrations for all environmental measurements reported.

14. Keywords

14.1 durability; exterior exposure tests; outdoor exposure; ultraviolet/light/radiation; weathering

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