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Standard Practice for Unfiltered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings[1]

This standard is issued under the fixed designation D3361/D3361M; 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 the selection of test conditions for accelerated exposure testing of coatings and related products in unfiltered open-flame carbon-arc devices conducted according to Practice G151 and G152. This practice also covers the preparation of test specimens, the test conditions suited for coatings, and the evaluation of test results.

1.2 This practice covers unfiltered open-flame carbon-arc exposures of paints and related coatings, and covers the exposure cycle that has been commonly referred to as the "dew cycle." Practice D822/D822M describes filtered open-flame carbon-arc devices, and Practice D5031/D5031M describes enclosed carbon-arc exposures. The radiation from an unfiltered open-flame carbon arc produces shorter wavelengths and higher levels of short wavelength radiation than either filtered open-flame or enclosed carbon arcs.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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]

D358 Specification for Wood to Be Used as Panels in Weathering Tests of Coatings (Withdrawn 2014)[3]

D523 Test Method for Specular Gloss

D609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products

D610 Practice for Evaluating Degree of Rusting on Painted Steel Surfaces

[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 Testing.

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[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] The last approved version of this historical standard is referenced on www.astm.org.

D659 Method for Evaluating Degree of Chalking of Exterior Paints (Withdrawn 1990)[3]
D660 Test Method for Evaluating Degree of Checking of Exterior Paints
D662 Test Method for Evaluating Degree of Erosion of Exterior Paints
D714 Test Method for Evaluating Degree of Blistering of Paints
D772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints
D822/D822M Practice for Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
D823 Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panels
D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
D1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base (Withdrawn 2006)[3]
D1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base (Withdrawn 2006)[3]
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale
D3980 Practice for Interlaboratory Testing of Paint and Related Materials (Withdrawn 1998)[3]
D4214 Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
D5031/D5031M Practice for Enclosed Carbon-Arc Exposure Tests of Paint and Related Coatings
D5796 Test Method for Measurement of Dry Film Thickness of Thin-Film Coil-Coated Systems by Destructive Means Using a Boring Device
D5870 Practice for Calculating Property Retention Index of Plastics
D8331 Test Method for Measurement of Film Thickness of Thin-Film Coatings by Non-Destructive Means Using Ruggedized Optical Interference
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry
G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials
G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials
G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests
G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
G152 Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
G169 Guide for Application of Basic Statistical Methods to Weathering Tests

3. Terminology

3.1 The definitions given in Terminology G113 are applicable to this practice.

4. Significance and Use

4.1 The ability of a paint or coating to resist deterioration of its physical and optical properties caused by exposure to light, heat, and water can be very significant for many applications. This practice is intended to induce property changes associated with end-use conditions, including the effects of sunlight, moisture, and heat. The exposure used in this practice is not intended to simulate the deterioration caused by localized weather phenomena such as atmospheric pollution, biological attack, and saltwater exposure.

4.2 *Cautions*—Variation in results may be expected when different operating conditions are used. Therefore, no reference to the use of this practice shall be made unless accompanied by a report prepared according to Section 10 that describes the specific operating conditions used. Refer to Practice G151 for detailed information on the caveats applicable to use of results obtained according to this practice.

NOTE 1—Additional information on sources of variability and on strategies for addressing variability in the design, execution, and data analysis of laboratory accelerated exposure tests is found in Guide G141.

4.2.1 The spectral power distribution of light from an unfiltered open-flame carbon arc is significantly different from that produced in light and water exposure devices using other carbon-arc configurations or other light sources. The type and rate of degradation and the performance rankings produced by exposures to unfiltered open-flame carbon-arcs can be much different from that

produced by exposures to other types of laboratory light sources. Typically, exposures conducted according to this practice will produce degradation faster than similar exposures conducted in accordance with Practice D822/D822M or D5031/D5031M and may cause different types of degradation.

4.2.2 Interlaboratory comparisons are valid only when all laboratories use the same type of carbon-arc and exposure conditions.

4.3 Reproducibility of test results between laboratories has been shown to be good when the stability of materials is evaluated in terms of performance ranking compared to other materials or to a control.[4,5] Therefore, exposure of a similar material of known performance (a control) at the same time as the test materials is strongly recommended. It is recommended that at least three replicates of each material be exposed to allow for statistical evaluation of results.

4.4 Test results will depend upon the care that is taken to operate the equipment in accordance with Practice G152. Significant factors include regulation of line voltage, freedom from salt or other deposits from water, temperature and humidity control, and conditions of the electrodes.

4.5 *All references to exposures in accordance with this practice must include a complete description of the test cycle used.*

5. Apparatus

5.1 Use filtered open-flame carbon-arc apparatus with automatic humidity control that conforms to the requirements defined in Practices G151 and G152.

5.2 Do not place any filters between the open flame carbon arc and the test specimens.

6. Hazards

6.1 **Warning—**In addition to other precautions, never look directly at the carbon arc because UV radiation can damage the eye. Most carbon-arc machines are equipped with door safety switches, but users of old equipment must be certain to turn off the power to the carbon arc before opening the test-chamber door.

6.2 This light source generates ozone and nitrous oxides. Vent exhaust from the exposure device to the atmosphere.

6.3 The burning carbon rods used in these devices become very hot during use. Make sure to allow at least 15 min for the arcs to cool after the device is turned off before attempting to change the carbon rods.

6.4 Carbon residue and ash are known respiratory irritants. Wear an appropriate high-efficiency dust respirator, gloves, and safety glasses when handling or changing carbon rods. Make sure to wash any carbon residue from hands or arms prior to eating or drinking.

7. Test Specimens

7.1 Apply the coating to flat (plane) panels with the substrate, method of preparation, method of application, coating system, film thickness, and method of drying consistent with the anticipated end use, or as mutually agreed upon between the producer and user.

7.2 Panel specifications and methods of preparation include but are not limited to Practices D609 or D1730, or Specification D358. Select panel sizes suitable for use with the exposure apparatus.

7.3 Coat test panels in accordance with Test Methods D823, then measure the film thickness in accordance with an appropriate procedure selected from Test Methods D1005, D1186, D1400~~or~~, ~~D1400~~D5796, and D8331. Nondestructive methods are preferred because panels so measured need not be repaired.

[4] 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*, ASTM, 1993.

[5] Ketola, W., and Fischer, R., "Characterization and Use of Reference Materials in Accelerated Durability Tests," *VAMAS Technical Report No. 30*, NIST, June 1997.

7.4 Prior to exposing coated panels in the apparatus, condition them at 23 ± ~~2°C~~2 °C [73 ± ~~3°F~~]3 °F] and 50 ± 5 % relative humidity for one of the following periods in accordance with the type of coating:

Baked coatings	24 h
Radiation-cured coatings	24 h
All other coatings	7 days min

7.4.1 Other procedures for preparation of test specimens may be used if agreed upon by all interested parties.

7.5 Mount specimens in holders so that only the minimum specimen area required for support by the holder is covered. Do not use this covered area of the specimen as part of the test area.

7.6 Unless otherwise specified, expose at least three replicate specimens of each test and control material.

7.7 Follow the procedures described in Practice G147 for identification and conditioning and handling of specimens of test, control, and reference materials prior to, during, and after exposure.

7.8 Do not mask the face of a specimen for the purpose of showing on one panel the effects of various exposure times. Misleading results may be obtained by this method, since the masked portion of the specimen is still exposed to temperature and humidity cycles that in many cases will affect results.

7.9 Retain a supply of unexposed file specimens of all materials evaluated.

7.9.1 When destructive tests are run, it is recommended that a sufficient number of file specimens be retained so that the property of interest can be determined on unexposed file specimens each time exposed materials are evaluated.

NOTE 2—Since the stability of the file specimen may also be time-dependent, users are cautioned that over prolonged exposure periods, or where small differences in the order of acceptable limits are anticipated, comparison of exposed specimens with the file specimen may not be valid. Nondestructive instrumental measurements are recommended whenever possible.

7.10 Specimens should not ordinarily be removed from the exposure apparatus for more than 24 h, then returned for additional tests, since this does not produce the same results on all materials as tests run without this type of interruption. When specimens are removed from the exposure apparatus for 24 h or more, then returned for additional exposure, report the elapsed time as noted under Section 10.

8. Procedure

8.1 Unless otherwise specified, operate the device using the following exposure cycle so that the allowable deviations about the set points given with each set point below are within the specified limits specified in the corresponding entry. If the actual operating conditions do not agree with the machine settings after the equipment has stabilized, discontinue the test and correct the cause of the disagreement before continuing.

NOTE 3—Each set point and the corresponding operational fluctuations given in this section represent an operational control point for equilibrium conditions at a single location in the cabinet, which may not necessarily represent the uniformity of those conditions throughout the cabinet. ASTM Committee G03 is working to refine these operational fluctuations and address the uniformity issue.

NOTE 4—Set points and operational fluctuations are listed as set point ± operational fluctuation in this standard. They are sometimes listed in separate columns. The set point is the target condition for the sensor used at the operational control point as programmed by the user. Operational fluctuations are deviations from the indicated set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation and do not include measurement uncertainty. At the operational control point, the operational fluctuation can exceed no more than the listed value at equilibrium. Therefore, when a standard calls for a particular set point, the user programs that exact number. The operational fluctuations specified with the set point do not imply that the user is allowed to program a set point higher or lower than the exact set point specified.

8.1.1 Sixty min light only with black panel temperature controlled at 63 ± ~~5°C~~5 °C [145 ± ~~9°F~~]9 °F] and relative humidity controlled at 50 ± 10 %.

NOTE 5—The black panel temperature is for equilibrium conditions. There will be a period immediately after the dark cycle where the black panel temperature will be less than the control limits given.

8.1.2 Sixty min dark with water spray on the back of test specimens. During this dark cycle the chamber air temperature shall be controlled at 32 ± ~~3°C~~3 °C [90 ± ~~5°F~~]5 °F] and the relative humidity shall be controlled at 95 ± 10 %.

8.1.3 Adjust the water spray so that the only water on the face of the test specimens is from the dew formation caused by the chilled water sprayed on the back of the specimens. The temperature of the water sprayed on the back of the specimens shall be controlled at 7.2 ± ~~2°C~~2 °C [45 ± ~~4°F~~].4 °F].

8.2 Practice D822/D822M lists other exposure cycles that may be used.

8.3 Place test specimens in the device according to the manufacturer's recommendations. It is recommended that all unused spaces in the specimen exposure area be filled with blank metal panels.

8.4 If the irradiance uniformity within the exposure area does not meet the requirements of Practice G151 for exposure without repositioning, use one of the procedures described in Practice G152 to ensure that specimens receive as uniform a radiant exposure as possible.

8.4.1 If specimen repositioning is used, and no repositioning schedule is specified, use the following procedure for specimen repositioning:

8.4.1.1 Once per week, move all holders in the top half of the specimen exposure area to the bottom half and move all holders in the bottom half of the exposure area to the top half. Do not reposition the specimens within the holder.

NOTE 6—Incident energy at the top and bottom of the specimen rack is often only 70 % of that at the center. This condition requires that the procedures described in 8.4 be followed to ensure uniformity of radiant exposure.

8.5 *Water Purity:*

8.5.1 The purity of water used is very important. Without proper treatment to remove cations, anions, organics, and particularly silica, exposed panels will develop spots or stains that may not occur in exterior exposures.

8.5.2 Follow the requirements for water purity described in Practice G151.

8.5.3 If specimens are found to have deposits or stains after exposure in the apparatus, the water purity must be checked to determine if it meets the requirements of 8.5.2. On some occasions, exposed specimens can be contaminated by deposits from bacteria that can grow in the purified water used for specimen spray. If bacterial contamination is detected, the entire system used for specimen water spray must be flushed with chlorine and thoroughly rinsed prior to resuming exposures.

8.5.4 When the water purity requirements are met and there is disagreement between parties on the extent of problems caused by stain or deposit, run referee tests in at least one other laboratory that can meet the water quality requirements described in 8.5.

8.5.5 For devices with humidity control, it is recommended that deionized water be used when generating water vapor to control humidity.

8.6 Some tests for lightfastness are run without any specimen wetting. When this type of test is required, omit the period where water is sprayed on specimens.

8.7 Identification of any control specimen used shall accompany the report.

9. Periods of Exposure and Evaluation of Test Results

9.1 In most cases, periodic evaluation of test and control materials is necessary to determine the variation in magnitude and direction of property change as a function of exposure time or radiant exposure.