Designation: D5031 – 23

Standard Practice for Enclosed Carbon-Arc Exposure Tests of Paint and Related Coatings[1]

This standard is issued under the fixed designation D5031; 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 enclosed carbon arc devices operated according to Practices G151 and G153. 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 does not cover filtered open-flame carbon-arc exposures of paints and related coatings, which is described in Practice D822. Another procedure for exposing these products is covered by Practice D3361/D3361M, in which the specimens are subjected to radiation from an unfiltered open-flame carbon arc that produces shorter wavelengths and higher levels of short wavelength radiation than filtered open flame or enclosed carbon arcs.

NOTE 1—Practice D3361/D3361M requires use of open-flame carbon-arc apparatus with automatic humidity control.

1.3 The values in SI units are to be regarded as standard. The values given in parentheses are for information only and are not considered 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, 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D358 Specification for Wood to Be Used as Panels in Weathering Tests of Coatings (Withdrawn 2014)[3]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

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 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

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

[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.

D2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale
D3361/D3361M Practice for Unfiltered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
D4214 Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
D5870 Practice for Calculating Property Retention Index of Plastics
D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
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
G153 Practice for Operating Enclosed 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 2—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 enclosed 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 enclosed carbon arcs can be much different from those produced by exposures to other types of laboratory light sources.

4.2.2 Interlaboratory comparisons are valid only when all laboratories use the same type of carbon arc, filters, 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 according to Practice G153. 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 enclosed carbon-arc apparatus that conforms to the requirements defined in Practices G151 and G153.

5.2 Unless otherwise specified, the spectral power distribution of the enclosed carbon arc shall conform to the requirements in Practice G153 for the enclosed carbon arc.

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 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.

6.3 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.

[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. 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 Practices D823, then measure the film thickness in accordance with an appropriate procedure selected from Test Method D1005 or Practice D7091. Nondestructive methods are preferred because panels so measured need not be repaired.

7.4 Prior to exposing coated panels in the apparatus, condition them at 23 °C ± 2 °C (73 °F ± 3 °F) and 50 ± 10 % 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

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. This unexposed surface must not be used as part of the test area. In cases where it is necessary to support flexible specimens during exposure, attach the flexible specimens to a thin supporting panel.

NOTE 3—For supporting flexible specimens, aluminum panels that are 0.025 in. (0.64 mm) thick have been found to be acceptable for many applications. Alternatively, stainless steel panels that are at least 0.025 in. (0.64 mm) thick can also be used, to avoid potential corrosion from aluminum panels.

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

7.6.1 If performance comparisons are not being made between the test materials themselves, it is recommended that a control material be exposed simultaneously with experimental materials for determination of relative performance. All concerned parties must agree on the control material, if any is used.

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 4—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 Table 1 lists several exposure cycles that are used for enclosed carbon arc exposures of nonmetallic materials. Obtain mutual agreement between all concerned parties for the specific exposure cycle used. Additional intervals and methods of wetting, by spray, condensation, or both, may be substituted upon agreement among the concerned parties.

NOTE 5—Each set point and the corresponding operational fluctuations found in Table 1 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 Subcommittee G03.03 is working to refine these operational fluctuations and address the uniformity issue.

8.1.1 Unless otherwise specified, maintain relative humidity at 50 % ± 10 % equilibrium during the light-only interval.

8.2 Unless otherwise specified, operate the device so that he allowable deviations about the set points given in Table 1 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.

8.3 If no other cycle is specified, use Cycle No. 1.

8.4 Mount test specimens in the device following the placement and specimen repositioning procedures described in Practice G152. It is recommended that all unused spaces in the specimen exposure area be filled with blank metal panels.

8.5 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 G153 to ensure that specimens receive as uniform a radiant exposure as possible.

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

8.5.2 Once per week, move all specimens 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 of the exposure area. If there are an odd number of specimens, move the two at the bottom of the exposure area to the top of the exposure area (keeping the relative position of these two