Designation: ~~D4459 – 12~~ D4459 – 21

Standard Practice for Xenon-Arc Exposure of Plastics Intended for Indoor Applications[1]

This standard is issued under the fixed designation D4459; 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 specific procedures and test conditions that are applicable for exposure of plastics in window glass-filtered xenon-arc devices in accordance with Practices G151 and G155 for evaluating the stability of plastics intended for use in indoor applications.

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

~~NOTE 1—There is no known ISO equivalent to this practice.~~

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1.3 *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]

D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D3980 Practice for Interlaboratory Testing of Paint and Related Materials (Withdrawn 1998)[3]
D4674 Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments
D5870 Practice for Calculating Property Retention Index of Plastics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
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
G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
G169 Guide for Application of Basic Statistical Methods to Weathering Tests

[1] This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.50 on Durability of Plastics.
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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.

***A Summary of Changes section appears at the end of this standard**

3. Terminology

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

4. Significance and Use

4.1 This practice is intended to simulate the effects produced by exposure to solar radiation through glass. This practice uses exposure in a xenon-arc device equipped with window glass filters and operated in accordance with Practices G151 and G155.

NOTE 2—Practice D4674 describes exposures in a device that uses a combination of fluorescent "cool white" and ultraviolet (UV) lamps to simulate the effects of exposures to indoor fluorescent light and window glass filtered daylight.

4.2 **Warning—**Variation in results may be expected when operating conditions are varied within the accepted limits of this practice. Therefore, all references to the use of this practice must be accompanied by a report prepared in accordance with Section 9 that describes the specific operating conditions used. Refer to Practice G151 for detailed information on the caveats applicable to use of results obtained in accordance with this practice.

NOTE 3—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.

4.3 Test results will depend upon the care that is taken to operate the equipment in accordance with Practice G155. Significant factors include regulation of line voltage, temperature and humidity control, and condition and age of the lamps and filters.

4.4 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. The number of specimens of the control material should be the same as that used for test materials. It is recommended that at least three replicates of each material be exposed to allow for statistical evaluation of results.

5. Apparatus

5.1 Use xenon-arc apparatus that conforms to the requirements defined in Practices G151 and G155.

5.2 The spectral power distribution of the xenon-arc lamp shall conform to the requirements described in Practice G155 for a xenon-arc lamp with window glass filters.

5.3 Unless otherwise specified, use a xenon-arc device equipped with a radiometer capable of monitoring either narrow-band or broad-band irradiance incident on test specimens.

6. Test Specimen

6.1 The size and shape of specimens to be exposed will be determined by the specifications of the particular test method used to evaluate the effects of the exposure on the specimens; the test method shall be determined by the parties concerned. Where practical, it is recommended that specimens be sized to fit specimen holders and racks supplied with the exposure apparatus. Unless supplied with a specific backing as an integral part of the test, specimens shall be mounted so that only the minimum specimen area required for support by the holder shall be 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 or placed in a picture frame type specimen holder.

NOTE 4—For supporting flexible specimens, aluminum panels that are 0.025 in. (0.64 mm) thick have been found to be acceptable for many applications. The use of a backing material, and the type of backing material, may affect specimen temperature.

[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*, Warren D. Ketola and Douglas Grossman, eds., American Society for Testing and Materials, Philadelphia, 1993.

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

6.2 Unless otherwise specified, expose at least three replicate specimens of each test material and of the control material, if used.

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

6.3.1 For destructive tests, it is preferred to retain unexposed file specimens. When this practice is followed, ensure that sufficient file specimens are retained so that the property of interest can be measured on the file specimens for all planned evaluations of the exposed materials.

NOTE 5—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. The stored initial measurements of the file specimens are recommended wherever possible.

6.4 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.

6.5 Do not mask the face of 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.

6.6 Since the thickness of a specimen may affect markedly the results, thickness of test and control specimens shall be within ±10 % of the nominal dimensions.

NOTE 6—~~This~~ The thickness of a specimen is especially important if changes in mechanical properties are being investigated.

~~6.6 Incident energy at the extremes of the specimen exposure area in older equipment may be only 70 % of that at the center. If the irradiance at any position within the exposure area is less than 90 % of the peak irradiance, follow one of the procedures outlined in Practice G155 to ensure either equal radiant exposure or compensation for differences in radiant exposure.~~

~~6.7 Retain a supply of unexposed file specimens of all materials evaluated.~~

~~6.7.1 When destructive tests are run, ensure than sufficient file specimens are retained so that the property of interest can be determined on unexposed file specimens each time exposed materials are evaluated.~~

~~6.8 Specimens should not be removed from the exposure apparatus for more than 24 h and 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 in accordance with Section 9.~~

~~NOTE 5—Since the stability of the file specimens is also 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. Instrumental measurements are recommended whenever possible.~~

7. Procedure

7.1 Operate the xenon-arc device in continuous light mode without any water spray.

7.2 Unless otherwise specified, control the irradiance at one of the following levels:

7.2.1 0.30 ± 0.02 W/(m^2 · nm) at 340 nm.

7.2.2 0.80 ± 0.05 W/(m^2 · nm) at 420 nm.

7.2.3 36.5 ± 2.5 W/m^2 between 300 and 400 nm.

7.2.4 If the exposure device is not equipped with irradiance control, follow the manufacturer's recommendations to produce the specified irradiance levels.

NOTE 7—Instruments without irradiance control have not been manufactured for over 25 years. It is preferable to use instruments with irradiance control to minimize test results variability.

7.3 Unless otherwise specified, control the temperature of an uninsulated black panel at 55 ± 2°C (131 ± 4°F).

7.4 Unless otherwise specified, control relative humidity at 50 ± ~~10 %.~~10 %.

~~NOTE 6—The ± are the operational fluctuations and are the allowable deviations from the specified set points for irradiance, temperature and relative humidity during equilibrium operation. They do not imply that the user is allowed to program a set point higher or lower than that specified. If the operational fluctuations are greater than the maximum allowable after the equipment has stabilized, discontinue the test and correct the cause of the problem before continuing.~~

7.5 It is preferable to use instruments with chamber air temperature control. Unless otherwise specified, if the exposure device is equipped with chamber air control, control the chamber air temperature at 42 ± 2°C (108 ± 4°F). If the exposure device is not equipped with chamber air temperature control, report that chamber air temperature control was not used as a deviation to the practice.

NOTE 8—Previous version of this practice had provisions for instruments without chamber air temperature control. However, these instruments have not been manufactured for over 25 years. It is preferable to use instruments with chamber air temperature control, as variability in specimen temperature will be reduced.

NOTE 9—The ± are the operational fluctuations and are the allowable deviations from the specified set points for irradiance, temperature and relative humidity during equilibrium operation. They do not imply that the user is allowed to program a set point higher or lower than that specified. If the operational fluctuations are greater than the maximum allowable after the equipment has stabilized, discontinue the test and correct the cause of the problem before continuing.

7.6 ~~It is recommended that a control material be exposed at the same time as the test specimens for comparison purposes, if performance comparisons are not being made between the test materials themselves.~~ 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 used.

7.7 Unless otherwise specified, expose at least three replicates of each test and control material evaluated to allow for statistical evaluation of results. Mount test specimens in the device following the placement and specimen repositioning procedures described in Practice G155. It is recommended that all unused spaces in the specimen exposure area be filled with blank metal panels that are not highly reflective.

~~7.6.1 It is recommended that all unused spaces in the specimen exposure area be filled with non-ultraviolet reflecting blanks, for example, grey card stock.~~

7.8 ~~Expose the test and control materials (if used) for~~ If the irradiance uniformity does not meet the requirements of Practice G155 (Procedure), reposition specimens in devices preferably using the procedure described in Practice G151~~a time or radiant exposure agreed upon between all interested~~ (Appendix: SUGGESTED PROCEDURES FOR REDUCING VARIABILITY BY PERIODIC RANDOM POSITIONING OR SYSTEMATIC REPOSITIONING OF SPECIMENS) or, at a minimum, one of the procedures described in Practice G155 ~~parties.~~(Procedure).

7.8.1 ~~Determine the color difference between the exposed and file specimens in accordance with Test Method~~If specimen repositioning is used, and no other repositioning schedule is specified, follow ~~D2244 or~~ the 'Suggested Frequency for Specimen Repositioning' specified in Practice ~~D1729~~G151~~. If materials are not evaluated within 4 h after removal from exposure, store specimens at a temperature of -15 to -20°C. Test all specimens within one week after removal from exposure.~~ (Appendix: SUGGESTED PROCEDURES FOR REDUCING VARIABILITY BY PERIODIC RANDOM POSITIONING OR SYSTEMATIC REPOSITIONING OF SPECIMENS).

~~7.7.2 Where desired, measurement of other properties can also be made on exposed specimens.~~