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

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

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D3980 Practice for Interlaboratory Testing of Paint and Related Materials (Withdrawn 1998)[3]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

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.

[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**

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.

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

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 %.

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

[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.

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 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.

7.8 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 (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 (Procedure).

7.8.1 If specimen repositioning is used, and no other repositioning schedule is specified, follow the 'Suggested Frequency for Specimen Repositioning' specified in Practice G151 (Appendix: SUGGESTED PROCEDURES FOR REDUCING VARIABILITY BY PERIODIC RANDOM POSITIONING OR SYSTEMATIC REPOSITIONING OF SPECIMENS).

8. Periods of Exposure and Evaluation of Test Results

8.1 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.

8.2 The time or radiant exposure necessary to produce a defined change in a material property can be used to evaluate or rank the stability of materials. This method is preferred over evaluating materials after an arbitrary exposure time or radiant exposure.

8.2.1 Exposure to an arbitrary time or radiant exposure may be used for the purpose of a specific test if agreed upon between the parties concerned or if required for conformance to a particular specification. When a single exposure period is used, select a time or radiant exposure that will produce the largest performance differences between the test materials or between the test material and the control material.

8.2.2 The minimum exposure time used shall be that necessary to produce a substantial change in the property of interest for the least stable material being evaluated. An exposure time than produces a significant change in one type of material cannot be assumed to be applicable to other types of materials.

8.2.3 The relation between time in failure in an exposure conducted in accordance with this practice and service life in an outdoor environment requires determination of a valid acceleration factor. Do not use arbitrary acceleration factors relating time in an exposure conducted in accordance with this practice and time in an outdoor environment because they can give erroneous information. The acceleration factor is material-dependent and is only valid if it is based on data from a sufficient number of separate exterior and laboratory-accelerated exposures so that results used to relate times to failure in each exposure can be analyzed using statistical methods.

NOTE 10—An example of a statistical analysis using multiple-laboratory and exterior exposures to calculate an acceleration factor is described by Simms.[6] See Practice G151 for more information and additional cautions about the use of acceleration factors.

8.3 Expose the test and control materials (if used) for a time or radiant exposure agreed upon between all interested parties. After each exposure increment, evaluate or rate changes in exposed test specimens in accordance with applicable ASTM test methods.

8.3.1 Determine the color difference between the exposed and file specimens in accordance with Test Method D2244 or Practice D1729. If materials are not evaluated within 4 h after removal from exposure, store specimens at a temperature of -15 to -20°C, allowing all specimens adequate time to return to room temperature upon removal from cold storage. Test all specimens within one week after removal from exposure.

NOTE 11—For some materials, changes may continue after the specimen has been removed from the exposure apparatus. Measurements (visual or instrumental) should be made within a standardized time period or as agreed upon between interested parties. The standardized time period needs to consider conditioning prior to testing.

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

8.4 Use of results from exposures conducted in accordance with this practice in specifications:

8.4.1 If a standard or specification for general use requires a definite property level after a specific time or radiant exposure in an exposure test conducted in accordance with this practice, base the specified property level on results from round-robin experiments run to determine the test reproducibility from the exposure and property measurement procedures. Conduct these round robins in accordance with Practice E691 or Practice D3980 and include a statistically representative sample of all laboratories or organizations who would normally conduct the exposure and property measurement.

8.4.2 If a standard or specification for use between two or three parties requires a definite property level after a specific time or radiant exposure in an exposure test conducted in accordance with this practice, base the specified property level on two independent experiments run in each laboratory to determine the reproducibility for the exposure and property measurement process. The reproducibility of the exposure/property measurement process is then used to determine the minimum level of property after the exposure that is mutually agreeable to all parties.

8.4.3 When reproducibility in results from an exposure test conducted in accordance with this practice has not been

[6] Simms, J.A., *Journal of Coatings Technology*, Vol 50, 1987, pp. 45-53.