Designation: D 4459 – 06

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

This standard is issued under the fixed designation D 4459; 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 G 151 and G 155 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials

D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

D 3980 Practice for Interlaboratoy Testing of Paint and Related Materials

D 4674 Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

D 5870 Practice for Calculating Property Retention Index of Plastics

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G 141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

G 169 Guide for Application of Basic Statistical Methods to Weathering Tests

3. Terminology

3.1 The definitions in Terminology G 113 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 G 151 and G 155.

NOTE 2—Practice D 4674 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 G 151 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 G 141.

4.3 Test results will depend upon the care that is taken to operate the equipment in accordance with Practice G 155. Significant factors include regulation of line voltage, temperature and humidity control, and condition and age of the burner and filters.

[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.

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

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.[3,4] 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.

5. Apparatus

5.1 Use xenon-arc apparatus that conforms to the requirements defined in Practices G 151 and G 155.

5.2 The spectral power distribution of the xenon-arc lamp shall conform to the requirements described in Practice G 155 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.

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

6.3 Follow the procedures described in Practice G 147 for identification and conditioning and handling of specimens of test, control, and reference materials prior to, during, and after exposure.

6.4 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.

6.5 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 4—This 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 G 155 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 0.3 ± 0.02 W/(m^2 · nm) at 340 nm.

7.2.2 0.8 ± 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.

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 55 ± 5 %.

7.5 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. All concerned parties must agree on the control material used.

7.6 Unless otherwise specified, expose at least three replicates of each test and control material evaluated to allow for statistical evaluation of results.

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.

7.7 Expose the test and control materials (if used) for a time or radiant exposure agreed upon between all interested parties.

7.7.1 Determine the color difference between the exposed and file specimens in accordance with Test Method D 2244 or Practice D 1729. 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.

[3] 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.

[4] 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.

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

7.8 When a control material is used, a complete description of the control material shall be included when reporting results obtained in accordance with this practice.

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 6—An example of a statistical analysis using multiple-laboratory and exterior exposures to calculate an acceleration factor is described by Simms.[5] See Practice G 151 for more information and additional cautions about the use of acceleration factors.

8.3 After each exposure increment, evaluate or rate changes in exposed test specimens in accordance with applicable ASTM test methods.

NOTE 7—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.

8.4 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 E 691 or Practice D 3980 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 established through round-robin testing, specify performance requirements for materials in terms of comparison (ranked) to a control material. All specimens shall be exposed simultaneously in the same device. All concerned parties must agree on the specific control material used.

8.4.3.1 Conduct analysis of variance to determine whether any differences between test materials and control materials is statistically significant. Expose replicates of the test specimens and the control specimen so that statistically significant performance differences can be determined.

NOTE 8—Fischer illustrates use of rank comparisons between test and control materials in specifications.[6]

NOTE 9—Guide G 169 includes examples showing the use of analysis of variance to compare materials.

9. Report

9.1 Report the following information:

9.1.1 Type and model of exposure device.

9.1.2 Age of filters at the beginning of the exposure and whether any filters were changed during the course of the exposure.

9.1.3 Irradiance in W/(m^2· nm) at 340 nm or 420 nm, or radiant exposure in J/(m^2· nm) at 340 nm or 420 nm at the same plane.

9.1.4 Elapsed exposure time.

9.1.5 Type of blank panel used and operating black panel temperature.

9.1.6 Operating relative humidity.

9.1.7 Color difference between exposed and file specimens of all test and control materials determined in accordance with Test Method D 2244 or Practice D 1729.

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

[6] Fischer, R., Ketola, W., "Impact of Research on Development of ASTM Durability Testing Standards," *Durability Testing of Non-Metallic Materials, ASTM STP 1294*, Robert Herling, ed., American Society for Testing and Materials, Philadelphia, 1995.

9.1.7.1 Results from analysis of variance comparing test and control materials.

9.1.8 Results of any other property tests conducted.

9.1.8.1 When retention of characteristic property is determined, calculate and report results in accordance with Practice D 5870.

10. Precision and Bias

10.1 *Precision*—The repeatability and reproducibility of results obtained in exposures conducted in accordance with this practice will vary with the materials being tested, the material property being measured, and the specific test conditions and cycles that are used. It is essential to determine reproducibility of the exposure/property measurement process when using the result from exposures conducted in accordance with this practice in product specifications.

10.2 *Bias*—Bias cannot be determined because no acceptable standard weathering reference materials are available.

11. Keywords

11.1 colorfastness; indoor exposure; lightfastness; light exposure; xenon-arc

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D 4459 - 99) that may impact the use of this standard. (September 1, 2006)

(*1*) Revised ISO equivalency statement as specified in Guide D 4968.
(*2*) Deleted references to obsolete standard G 26.
(*3*) Updated references to new standard G 169.
(*4*) Corrected irradiance and radiant dosage units in text and Report section.
(*5*) Corrected typographical error made in the specification of an “uninsulated” black panel made during the previous revision of this practice.
(*6*) Updated Report section to remove report format requirement, remove wattage reporting requirement, and include irradiance measurement option.