Designation: D5208 – 14 (Reapproved 2022)

Standard Practice for Fluorescent Ultraviolet (UV) Exposure of Photodegradable Plastics[1]

This standard is issued under the fixed designation D5208; 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 specific procedures applicable for fluorescent Ultraviolet (UV) exposure of photodegradable plastics conducted in accordance with Practices G151 and G154. This practice also covers the preparation of test specimens and the evaluation of test results.

1.2 Practice D4329 covers fluorescent UV exposures of plastics intended for long term use in outdoor applications.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

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.*

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

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]

D3826 Practice for Determining Degradation End Point in Degradable Polyethylene and Polypropylene Using a Tensile Test

D4329 Practice for Fluorescent Ultraviolet (UV) Lamp Apparatus Exposure of Plastics

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

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp 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 Materials made from photodegradable plastics are intended to show relatively rapid deterioration of chemical, physical, and mechanical properties when exposed to light, heat, and water after fulfilling their intended purpose. This practice is intended to induce property changes associated with conditions that might be experienced when the material is discarded as litter, 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 salt water exposure.

4.2 *Cautions*—Variation in results can be expected when operating conditions are varied within the accepted limits of this practice. Therefore, no reference to the use of this practice shall be made unless 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 2—Additional information on sources of variability and on

[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.

Current edition approved July 1, 2022. Published July 2022. Originally approved in 1991. Last previous edition approved in 2014 as D5208 - 14. DOI: 10.1520/D5208-14R22.

[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**

strategies for addressing variability in the design, execution and data analysis of laboratory accelerated exposure tests is found in Guide G141.

4.3 Exposure of a similar material of known performance (a control) at the same time as the test specimens provides a standard for comparative purposes. Use of a control to rank the stability of test materials greatly improves agreement between different laboratories.[3,4] It is recommended that at least three replicates of each material evaluated 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 G154. Significant factors include regulation of line voltage, temperature of the room in which the device operates, temperature control, and condition and age of the lamps, if exposure is conducted in a device without irradiance control.

5. Apparatus

5.1 Use of fluorescent UV apparatus that conform to the requirements defined in Practices G151 and G154 is required to conform to this practice.

5.2 The spectral power distribution of the fluorescent UV lamp shall conform to the requirements in Practice G154 for a UVA 340 lamp.

5.3 *Test Chamber Location:*

5.3.1 Locate the apparatus in an area maintained between 18 and 27°C (65 and 80°F). Control of ambient temperature is particularly critical when one apparatus is stacked above another, because the heat generated from the lower unit can interfere with the operation of the units above.

5.3.2 Place the apparatus at least 300 mm from walls or other apparatus. Do not place the apparatus near a heat source such as an oven.

5.3.3 Ventilate the room in which the apparatus is located to remove heat and moisture.

6. Test Specimens

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 For specimens of insulating materials, such as foams, maximum specimen thickness is 20 mm in order to allow for adequate heat transfer for condensation.

6.3 To provide rigidity, attach flexible specimens to a backing panel made of aluminum, 0.635 mm (0.025 mm) thick. Suggested aluminum alloys are 5052, 6061, or 3003.

6.4 Seal any holes in specimens larger than two mm and any openings larger than one mm around irregularly shaped specimens to prevent loss of water vapor. Attach porous specimens to a solid backing such as aluminum that can act as a vapor barrier.

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

6.6 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.

6.7 Do not mask the face of a specimen for the purpose of showing on one panel the effects of various exposure times. Misleading results can 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.

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

NOTE 3—This is especially important when mechanical properties are being investigated.

6.9 Retain a supply of unexposed file specimens of all materials tested.

6.10 Specimens shall not be removed from the exposure apparatus for more than 24 h and then returned for additional tests, since this will not produce the same results on all materials as tests run without this type of interruption. Report any elapsed time as noted under Section 9.

NOTE 4—Since the stability of the file specimen can 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 are not necessarily valid. Instrumental measurements are recommended whenever possible.

7. Procedure

7.1 When the test and control specimens do not completely fill the specimen racks, fill all empty spaces with blank panels to maintain the test conditions within the chamber.

7.2 Unless otherwise specified, control irradiance at 0.89 W/(m^2 · nm) at 340 nm.

NOTE 5—In devices without irradiance control operated at 50 ± 3°C uninsulated black panel temperature the typical irradiance at 340 nm is 0.89 W/(m^2 · nm). (See Note 1 of Table X2.1 in Practice G154 for a full explanation of the current default irradiance.)

7.2.1 During equilibrium operation, the allowed deviation from the 340 nm set point is ±0.02 W/(m^2 • nm). If the indicated irradiance is outside the tolerance, stop the test and correct the problem before continuing.

7.3 Unless otherwise specified, program the device to one of the following test cycles.

7.3.1 *Cycle A*—20 h UV (light only) with uninsulated black panel temperature controlled at 50°C.

[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.

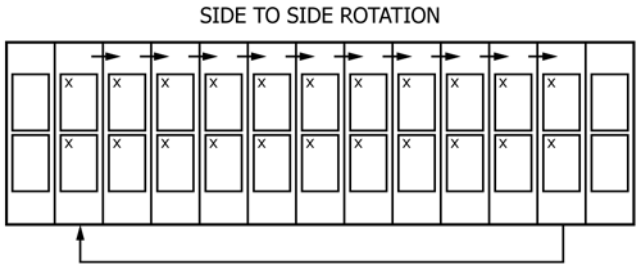

FIG. 1 Sample Rotation

4 h Dark/condensation with uninsulated black panel temperature controlled at 40°C.

Repeat this 24-hour cycle continuously until the desired total exposure is reached.

7.3.2 *Cycle B*—4 h UV (light only) with uninsulated black panel temperature controlled at 50°C.

4 h Dark/condensation with uninsulated black panel temperature controlled at 40°C.

Repeat this 8-hour cycle continuously until the desired total exposure is reached.

7.3.3 *Cycle C*—continuous UV with uninsulated black panel temperature controlled at 50°C. Operate continuously until the desired total exposure is reached.

7.3.4 During equilibrium operation, the maximum allowable deviation from the uninsulated black panel temperature set point is ±3°C. If the indicated temperature of the uninsulated black panel is outside these limits, stop the test and correct the problem before continuing.

NOTE 6—The set points and tolerances for 7.2 and Cycles A, B, and C represent an operational control point for equilibrium conditions at a single location in the cabinet, which does not necessarily represent the uniformity of those conditions throughout the cabinet. ASTM Committee G03 is working to refine these tolerances and address the uniformity issue.

7.3.5 Use Cycle C for materials that will be used for toxicity testing after exposure. This is essential because cycles that use condensation can wash away by-products of photochemical degradation.

7.4 Unless otherwise specified, reposition specimens as follows in order to minimize any effects from temperature or UV light variation. Figure 1 shows a diagram of the specimen repositioning.

7.4.1 Reposition the specimens horizontally at least every third day by (1) moving the two extreme right hand holders to the far left of the exposure area, and (2) sliding the remaining holders to the right.

7.4.2 Reposition the specimens vertically so that each specimen spends the same amount of exposure time in each vertical position within the specimen holder. For instance, if two specimens are stacked vertically in each holder, then the top and bottom specimens shall switch places halfway through the test. If four specimens are stacked vertically, then reposition the specimens vertically three times during the test.

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

8. Periods of Exposure and Evaluation of Test Results

8.1 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 and include a statistically representative sample of all laboratories or organizations who would normally conduct the exposure and property measurement. The precision and bias section contains results from such a round-robin.

8.1.1 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.

8.2 When reproducibility in results from an exposure test conducted in accordance with this practice have not been established through round-robin testing, specify performance requirements for materials in terms of comparison (ranked) to a control material. The control specimens shall be exposed simultaneously with the test specimen(s) in the same device. All concerned parties must agree on the specific control material used.

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

NOTE 7—Fischer illustrates use of rank comparison between test and control materials in specifications.[5]

NOTE 8—Guide G169 includes examples showing use of analysis of variance to compare materials.

8.3 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.

8.4 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.

8.4.1 Exposure to an arbitrary time or radiant exposure can be used for the purpose of a specific test if agreed upon by the parties concerned. When a single exposure period is used, select a time or radiant exposure that will produce the largest

[5] 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, Editor, American Society for Testing and Materials, Philadelphia, 1995.