Designation: D 6695 – 03

Standard Practice for Xenon-Arc Exposures of Paint and Related Coatings[1]

This standard is issued under the fixed designation D 6695; 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 xenon arc devices conducted according to Practices G 151 and G 155. This practice also covers the preparation of test specimens, the test conditions suited for coatings, and the evaluation of test results. Table 1 describes commonly used test conditions.

NOTE 1—ISO 11341:1994 also describes xenon-arc exposures of paints and coatings. However, the exposure conditions described in ISO 11341 are different than those listed in Table 1.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 358 Specification for Wood to Be Used as Panels in Weathering Tests of Coatings[2]
D 523 Test Method for Specular Gloss[3]
D 609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products[3]
D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces[2]
D 659 Method of Evaluating Degree of Chalking of Exterior Paints[4]
D 660 Test Method for Evaluating Degree of Checking of Exterior Paints[3]
D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints[3]
D 714 Test Method for Evaluating Degree of Blistering of Paints[3]
D 772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints[3]
D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[3]
D 1005 Test Methods for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[3]
D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[3]
D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[3]
D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely Illuminated Opaque Materials[3]
D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting[5]
D 2244 Practice for Calculation of Color Tolerances and Color Differences From Instrumentally Measured Color Coordinates[3]
D 2616 Test Method for Evaluation of Visual Color Difference with a Gray Scale[3]
D 3359 Test Methods for Measuring Adhesion by Tape Test[3]
D 3980 Practice for Interlaboratory Testing of Paint and Related Materials[3]
D 4214 Test Methods for Evaluating Degree of Chalking of Exterior Paint Films[3]
D 5870 Practice for Calculating Property Retention Index of Plastics[6]
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[7]
E 1347 Test Method for Color and Color Difference Measured by Tristimulus (Filter) Colorimetry[3]
G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[8]
G 141 Guide for Addressing Variability in Exposure Testing on Nonmetallic Materials[8]
G 147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests[8]

[1] This practice is under the jurisdiction of ASTM Committee D01 on on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.27 on Accelerated Testing.

Current edition approved Jan. 10, 2003. Published March 2003. Originally approved in 2001. Last previous edition approved in 2001 as D 6695 - 01.

[2] *Annual Book of ASTM Standards*, Vol 06.02.
[3] *Annual Book of ASTM Standards*, Vol 06.01.
[4] Discontinued; see *1990 Annual Book of ASTM Standards*, Vol 06.01.
[5] *Annual Book of ASTM Standards*, Vol 02.05.
[6] *Annual Book of ASTM Standards*, Vol 08.03.
[7] *Annual Book of ASTM Standards*, Vol 14.02.
[8] *Annual Book of ASTM Standards*, Vol 14.04.

TABLE 1 Test Cycles Commonly Used for Xenon-Arc Exposure Testing of Paints and Related Coatings[A]

Cycle Number	Cycle Description[B]	Uninsulated Black Panel, Temperature[C]	Typical Irradiance[D]	Typical Uses[E]
1	Continuous light 102 min light only at 50 % ± 5 % RH 18 min light and water spray[F] Repeat continuously	63 ± 2°C 145 ± 4°F	0.35 ± 0.02 W/(m^2·nm) at 340 nm 41.5 ± 2.5 W/m^2 from 300-400 nm	General coatings and historical convention[G]
2	18 h continuous light using: 102 min light only at 50 % ± 5 % RH 18 min light and water spray 6 h dark using: 95 % relative humidity (no water spray) Repeat continuously	63 ± 2°C 145 ± 4°F 24 ± 1.5°C 43 ± 3°F	0.35 ± 0.02 W/(m^2·nm) at 340 nm 41.5 ± 2.5 W/m^2 from 300-400 nm	General coatings
3	4 h light at 50 % ± 5 % RH 4 h dark with water spray Repeat continuously	63 ± 2°C 145 ± 4°F	0.35 ± 0.02 W/(m^2·nm) at 340 nm 41.5 ± 2.5 W/m^2 from 300-400 nm	Exterior pigmented stains
4	12 h light at 50 % ± 5 % RH 12 h dark with water spray Repeat continuously	63 ± 2°C 145 ± 4°F	0.35 ± 0.02 W/(m^2·nm) at 340 nm 41.5 ± 2.5 W/m^2 from 300-400 nm	Exterior wood stains and clears
5	8 h light at 50 % ± 5 % RH 10 h light and water spray 6 h dark with water spray Repeat continuously	63 ± 2°C 145 ± 4°F	0.35 ± 0.02 W/(m^2·nm) at 340 nm 41.5 ± 2.5 W/m^2 from 300-400 nm	Marine enamels
6	40 min light at 50 % ± 5 % RH 20 min light and water spray 60 min light at 50 % ± 5 % RH 60 min dark at 95 % ± 5 % RH (water spray on front and back of specimens) Repeat continuously	70 ± 2 °C (158 ± 4 °F) 70 ± 2 °C (158 ± 4 °F) 38 ± 2 °C (100 ± 4 °F)	0.55 ± 0.02 W/(m^2·nm) at 340 nm 65.5 ± 2.5 W/m^2 from 300-400 nm	Automotive exterior[H]
7	3.8 h light at 50 % ± 5 % RH 1.0 h dark at 95 % ± 5 % RH Repeat continuously	89 ± 3 °C (192 ± 5 °F) 38 ± 2 °C (100 ± 4 °F)	0.55 ± 0.02 W/(m^2·nm) at 340 nm 65.5 ± 2.5 W/m^2 from 300-400 nm	Automotive interior[H]

[A] The cycles described are not listed in any order indicating importance, and are not necessarily recommended for the applications shown.
[B] As stated in 5.2, the spectral power distribution (SPD) of the xenon lamp shall conform to the requirements of Practice G 155 for a xenon lamp with daylight filters.
[C] Unless otherwise indicated, black panel temperatures apply during light-only portion of the cycle. The equilibrium black panel temperature is obtained without a spray period. For light intervals shorter than 30 min, the black panel temperature might not reach equilibrium. Unless otherwise specified, add 6°C (11°F) to the temperature given for the uninsulated black panel when an insulated black panel is used. Practice G 151 provides more information on the temperatures indicated by insulated and uninsulated black panels, which can depend on irradiance level, and the type of xenon-arc filter used.
[D] The irradiance values given are those that have historically been used. In devices capable of producing higher irradiance, the actual irradiance used may be higher than the stated values. For example, Japanese auto industry specifications allow use of exposures according to Cycle 1 with 300 to 400 nm irradiance of up to 180 W/m^2.
[E] Typical uses does not imply that results from exposures of these materials according to the cycle described will correlate to those from actual use conditions.
[F] Unless otherwise specified, water spray refers to water sprayed on the exposed surface of the test specimens.
[G] This cycle has been used for coatings by historical convention and may not adequately simulate the effects of outdoor exposure.
[H] The SPD of the xenon lamp with the filters required in SAE standards J1960 and J1885 does not meet the requirements of Practice G 155 for a xenon lamp with daylight filters.

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources[8]
G 155 Practice for Operating Xenon-Arc Light Apparatus for Exposure of Nonmetallic Materials[8]
G 169 Guide for Application of Basic Statistical Methods to Weathering Tests[8]

2.2 *ISO Standards:*

ISO 11341:1994 Paints and Varnishes—Artificial Weathering and Exposure to Artificial Radiation—Exposure to Filtered Xenon-Arc Radiation[9]

2.3 *Society of Automotive Engineers' Standards:*

SAE J1885, Accelerated Exposure of Automotive Interior Trim Components Using a Controlled Irradiance Water Cooled Xenon Arc Apparatus[10]
SAE J1960, Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Water Cooled Xenon Arc Apparatus[10]

3. Terminology

3.1 The definitions given in Terminology G 113 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,

[9] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.
[10] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

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 *Caution*—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 G 151 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 G 141.

4.2.1 The spectral power distribution of light from a xenon-arc is significantly different from that produced in light and water exposure devices using carbon-arc or other light sources. The type and rate of degradation and the performance rankings produced by exposures to xenon-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 light source, filter type, 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.[11,12] 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 G 155. Significant factors include regulation of line voltage, freedom from salts or other deposits from water, temperature and humidity control, and condition and age of the burner and filters.

4.5 *All references to exposures in accordance with this practice must include a complete description of the test cycle used.*

5. Safety Hazards

5.1 **Warning:** Never look directly at the xenon-arc because UV radiation can damage the eye. Most xenon-arc machines are equipped with door safety switches, but users of old equipment must be certain to turn the power to the lamp off before opening the test-chamber door.

5.2 Xenon-arc lamps should be at or near room temperature before handling.

6. Apparatus

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

6.2 Unless otherwise specified, the spectral power distribution of the xenon-arc shall conform to the requirements in Practice G 155 for xenon-arc with daylight filters.

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 D 609, D 1730, or Specification D 358. Select panel sizes suitable for use with the exposure apparatus.

7.3 Coat test panels in accordance with Practices D 823 and then measure the film thickness in accordance with an appropriate procedure selected from Test Methods D 1005, D 1186, or D 1400. 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 ± 2°C (73 ± 3°F) and 50 ± 5 % 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 min

7.4.1 Other procedures for preparation of test specimens may be used if agreed upon between all interested parties.

7.5 Mount specimens in holders so that only the minimum specimen area required for support by the holder is covered. Do not use this covered area of the specimen as part of the test area.

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

7.7 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.

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 3—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.

[11] 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, ASTM, 1993.

[12] Ketola, W., and Fischer, R. "Characterization and Use of Reference Materials in Accelerated Durability Tests," *VAMAS Technical Report No. 30*, available from NIST, June 1997.