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Standard Practice for Xenon-Arc Exposures of Paint and Related Coatings¹

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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 **G151** and **G155**. This practice also covers the preparation of test specimens, the test conditions suited for coatings, and the evaluation of test results.

NOTE 1—This practice and ISO 16474-2 address the same subject matter but differ in technical content.

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

1.3 *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:²

- D358 Specification for Wood to Be Used as Panels in Weathering Tests of Coatings (Withdrawn 2014)³
- D523 Test Method for Specular Gloss
- D609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products
- D610 Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
- D659 Method for Evaluating Degree of Chalking of Exterior Paints (Withdrawn 1990)³
- D660 Test Method for Evaluating Degree of Checking of Exterior Paints

- D662 Test Method for Evaluating Degree of Erosion of Exterior Paints
- D714 Test Method for Evaluating Degree of Blistering of Paints
- D772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints
- D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels
- D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
- D1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base (Withdrawn 2006)³
- D1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base (Withdrawn 2006)³
- D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
- D1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting
- D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
- D2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale
- D3359 Test Methods for Measuring Adhesion by Tape Test
- D3980 Practice for Interlaboratory Testing of Paint and Related Materials (Withdrawn 1998)³
- D4214 Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
- D5870 Practice for Calculating Property Retention Index of Plastics
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
- E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry
- 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

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

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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.

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

2.2 *ISO Standards:*

ISO 16474-2 Paints and Varnishes—Methods of exposure to laboratory light sources—Part 2: Xenon-arc lamps⁴

2.3 *Society of Automotive Engineers Standards:*

SAE J2412 Accelerated Exposure of Automotive Interior Trim Components using a Controlled Irradiance Xenon-Arc Apparatus⁵

SAE J2527 Performance Based Standard for Accelerated Exposure of Automotive Exterior Materials using a Controlled Irradiance Xenon-Arc Apparatus⁵

3. Terminology

3.1 The definitions given in Terminology **G113** 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 daylight, 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 9 that describes the specific operating conditions used. Refer to Practice **G151** 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 **G141**.

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.^{6,7} 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 **G155**. 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 lamp and filters.

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

5. Apparatus

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

5.2 Unless otherwise specified, the spectral power distribution of the xenon-arc shall conform to the requirements in Practice **G155** for xenon-arc with daylight filters.

6. Test Specimens

6.1 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.

6.2 Panel specifications and methods of preparation include but are not limited to Practices **D609**, **D1730**, or Specification **D358**. Select panel sizes suitable for use with the exposure apparatus.

6.3 Coat test panels in accordance with Practices **D823** and then measure the film thickness in accordance with an appropriate procedure selected from Test Methods **D1005**, **D1186**, or **D1400**. Nondestructive methods are preferred because panels so measured need not be repaired.

6.4 Prior to exposing coated panels in the apparatus, condition them at $23 \pm 2^\circ\text{C}$ ($73 \pm 3^\circ\text{F}$) and $50 \pm 10\%$ 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

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

6.5 Mount specimens in holders so that only the minimum specimen area required for support by the holder is covered. This unexposed surface must not be used as part of the test

⁶ 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.

⁷ 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.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

area. In cases where it is necessary to support flexible specimens during exposure, attach the flexible specimens to a thin supporting panel.

NOTE 3—For supporting flexible specimens, aluminum panels that are 0.025 in. (0.64 mm) which have been found to be acceptable for many applications.

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

6.6.1 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, if any is used.

6.7 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.

6.8 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.

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

6.9.1 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 4—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.

6.10 Specimens should not be removed from the exposure apparatus for more than 24 h then returned for additional tests, since this may 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 under Section 9.

7. Procedure

7.1 Table 1 lists several exposure cycles that are used for xenon-arc exposures of paints and coatings. Obtain agreement between all concerned parties for the specific exposure cycle used. Additional intervals and methods of wetting, by spray, condensation, immersion, or combination of these, may be substituted upon agreement among the concerned parties.

NOTE 5—Each setpoint and its tolerances found in Table 1 represent an operational control point for equilibrium conditions at a single location in the cabinet that may not necessarily represent the uniformity of those conditions throughout the cabinet.

NOTE 6—Spray, condensation, and immersion are different kinds of moisture exposures and frequently produce different results.

7.1.1 Unless otherwise specified, maintain relative humidity at $50 \pm 10\%$ equilibrium during the light-only interval.

7.2 If no other cycle is specified, use Cycle No. 1.

7.3 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. The blanks used shall be resistant to corrosion and shall not contaminate the specimens being exposed.

7.4 If the irradiance uniformity does not meet the requirements of Practice G151, reposition specimens in devices preferably using the procedure described or, at a minimum, one of the procedures described in Practice G155.

Repositioning of specimens throughout the exposure period can minimize variations in test results for materials that are especially sensitive to small variations in temperature, humidity, or irradiance. As such, repositioning is always a good idea and is recommended even if a device meets the irradiance uniformity requirements in Practice G151.

It is also recommended to randomly position multiple specimens of each material throughout the specimen rack or tray. By randomly positioning multiple replicate specimens of one material, the effects of uniformity variations can be reduced.

7.4.1 If specimen repositioning is used, and no other repositioning schedule is specified, the following procedure for specimen repositioning is recommended:

7.4.1.1 Once per week move all holders in the top half of the specimen exposure area to the bottom half, and move all holders in the bottom half of the exposure area to the top half. Do not reposition the specimens within the holder.

NOTE 7—In older devices, incident energy at the top and bottom of the specimen rack is often only 70 % of that at the center. This condition requires that the procedures described in 7.4 be followed to ensure uniformity of radiant exposure.

7.4.1.2 For devices with a planar exposure area, reposition specimens by moving specimens or holders in the half of the exposure area farthest from the door, one position to the right. The rightmost specimen or holder in this area is moved to the rightmost position in the half of the area closest to the door. Other specimens in this area are moved one position left with the leftmost specimen or holder moved to the leftmost position in the half farthest from the door. This repositioning schedule is illustrated in Fig. 1.

7.5 Water Purity:

7.5.1 The purity of water used for specimen spray is very important. Without proper treatment to remove cations, anions, organics, and particularly silica, exposed panels will develop spots or stains that may not occur in exterior exposures.

7.5.2 Follow the requirements for water purity described in Practice G151.

7.5.3 If specimens are found to have deposits or stains after exposure in the apparatus, the water purity must be checked to determine if it meets the requirements of 7.5.2. On some occasions, exposed specimens can be contaminated by deposits from bacteria that can grow in the purified water used for specimen spray. If bacterial contamination is detected, the