Designation: D7869 – 17

Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings[1]

This standard is issued under the fixed designation D7869; 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 specifies the operating procedures for a controlled irradiance xenon arc light and water apparatus. The procedure uses one or more lamp(s) and optical filter(s) to produce irradiance similar to sunlight in the UV and visible range. It also simulates the water absorption and stress cycles experienced by automotive exterior coatings under natural weathering conditions. This practice has also been found applicable to coatings on other transportation vehicles, such as aircraft, trucks and rail cars.

1.2 This practice uses a xenon arc light source with specified optical filter(s). The spectral power distribution (SPD) for the lamp and special daylight filter(s) is as specified in Annex A1. The irradiance level used in this practice varies between 0.40 and 0.80 W/(m^2·nm) at 340 nm. Water is sprayed on the specimens during portions of several dark steps. The application of water is such that the coatings will absorb and desorb substantial amounts of water during testing. In addition, the cycling between wet/dry and warm/cool will induce mechanical stresses into the materials. These test conditions are designed to simulate the physical and chemical stresses from environments in a subtropical climate, such as southern Florida.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4517 Test Method for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy

G113 Terminology Relating to Natural and Artificial Weathering Tests 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

3. Terminology

3.1 Definitions applicable to this standard can be found in Terminology G113.

3.2 *transportation coatings, n*—exterior coatings used for vehicles subjected to natural weathering conditions such as automobiles, aircraft, trucks, rail cars, etc.

4. Summary of Practice

4.1 Test specimens are exposed to specific test conditions designed to simulate the physical and chemical stresses from environments in a subtropical climate, such as southern Florida. The test conditions consist of a primary test cycle and a sub-cycle. The primary test cycle includes two long water exposures and a single, long light exposure with precise spectral match to daylight as described in Annex A1. It is designed to reproduce water penetration failures, such as adhesion, blistering and diffusion of small molecules (**1**).[3] The sub-cycle consisting of shorter alternating water and light

[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 boldface numbers in parentheses refer to the list of references at the end of this standard.

exposures is designed to simulate cyclic stresses such as cracking and surface erosion. These two cycles are designed to replicate the common types of failures driven by the interaction of photo-oxidation during daylight and hydrolysis during water exposure that are seen in a subtropical climate such as gloss loss, color change, adhesion, blistering and cracking (**2**).

5. Significance and Use

5.1 This test procedure is used to simulate the physical and environmental stresses that a coating for exterior transportation applications (for example, automotive) is exposed to in a subtropical climate, such as southern Florida. It has been found that such a subtropical climate causes particularly severe deterioration of such coatings. The long water exposures and wet/dry cycling found in southern Florida are particularly important for this deterioration, in addition to the high dosage of solar radiation (**3**). This practice was developed to address the deficiencies of historical tests used for transportation coatings, especially automotive coatings (**4**).

NOTE 1—This test procedure was developed through eight years of cooperative testing between automotive and aerospace OEM's, material suppliers, and test equipment manufacturers. See References for published papers on this research.

6. Apparatus

6.1 The *xenon arc light and water apparatus* shall comply with Practice G155.

6.1.1 The *xenon arc light and water apparatus* shall have an uninsulated black panel thermometer as described in Practice G151 unless otherwise agreed upon by contractual parties

6.1.2 The *xenon arc light and water apparatus* must be able to control irradiance at 340 nm, relative humidity, uninsulated black panel temperature and chamber temperature, and provide water spray on the front of the specimens.

6.2 *Mass balance*—with a resolution of at least 0.1 g.

7. Reagents and Materials

7.1 *Sponge*. See Annex A2 for more detailed specifications.

7.2 *Purified Water,* as specified in Practice G155 and 8.2.

8. Apparatus Setup

8.1 Maintain and calibrate the apparatus according to manufacturer's instructions.

8.2 *Water Spray*—The water for spray and humidification shall be of the same quality listed in Practice G155 and shall leave no objectionable deposits or stains on the exposed specimens. The water shall have less than 1 mg per litre (1 ppm) total dissolved solids and it shall have less than 0.1 mg per litre (0.1 ppm) silica.

NOTE 2—Silica levels should be determined using Test Method D4517 or equivalent. A combination of deionization and reverse osmosis treatment can effectively produce water with the desired purity. In certain cases some samples could exude materials into the chamber that can promote deleterious effects on other samples.

8.3 Qualify the sponges used for the water uptake per the procedure in Annex A2. For each xenon arc light and water apparatus, verify the water uptake capability in accordance with the procedure in Annex A3 before placing it into service and at least once per year thereafter. Follow the recommendations of the manufacturer of the xenon arc light and water apparatus for additional checks, if any.

8.4 Fit the xenon arc light and water apparatus with a special daylight filter(s) in accordance with the requirements of Annex A1.

NOTE 3—Contact the xenon arc light and water apparatus manufacturer for the proper optical filter(s) required. Follow the manufacturer's recommendations for optical filter maintenance.

8.5 Other optical filters may be used by mutual agreement between the contractual parties.

NOTE 4—Minor differences in the resultant spectral power distribution (especially in the short wavelength UV region) can have an impact on the test results. Follow the manufacturer's recommendations for xenon arc lamp and optical filter maintenance (**5**).

9. Test Procedure

9.1 Refer to Practice G147 for specimen preparation, conditioning and handling. All test specimens must be clean and free from fingerprints or other surface contaminants before testing. Prepare a specimen for exposure to fit the specimen mounting fixture being used, if any. Follow the manufacturers' guidelines for specimen size and mounting.

9.1.1 Seal any cut edges on the test specimens if required, as agreed between contractual parties. For example, (*a*) rust and corrosion products from the cut edges of metal panels may stain the test specimens, (*b*) by-products from the cut edges of plastic substrates may leach out and contaminate test specimens, and (*c*) other panels may not require any edge sealing at all.

NOTE 5—Air-dry primers, plastic barrier tapes and silicone sealants have often been found suitable for edge sealing.

9.2 Fill all unused specimen positions in the xenon arc light and water apparatus' exposure area with inert specimens (for example, anodized aluminum panels) to maintain desired airflow.

NOTE 6—Refer to the manufacturer's instructions for proper operation of the apparatus.

9.3 Program the xenon arc light and water apparatus to run the exposure cycle shown in Table 1 and in accordance with manufacturer's instructions. The duration of the test in terms of number of cycles, hours, or radiant dosage shall be agreed upon by contractual parties.

9.4 Specimens shall be repositioned at a minimum of every two weeks of operation to improve uniformity of exposure. See Practice G151, Appendix X2 for more specific guidance and figures on repositioning of specimens in both rotating rack and flat array xenon arc light and water apparatus.

9.4.1 Specimens in a rotating rack apparatus shall be repositioned to the position immediately above it; specimens in the top position shall be repositioned to the bottom position.

9.4.2 Specimens in a flat array apparatus shall be repositioned to the position immediately to the left; specimens in the left-most position shall be repositioned to the right-most position, with front-back and back-front repositioning if applicable.

TABLE 1 Exposure Cycle

Step Number	Step Minutes	Function	Irradiance Set Point[A] at 340 nm W/(m²·nm)	Black Panel Temperature Set Point[A]	Chamber Air Temperature Set Point[A]	Relative Humidity Set Point[A]
1	240	dark + spray	—	—	40°C	95 %
2	30	light	0.40	50°C	42°C	50 %
3	270	light	0.80	70°C	50°C	50 %
4	30	light	0.40	50°C	42°C	50 %
5	150	dark + spray	—	—	40°C	95 %
6	30	dark + spray	—	—	40°C	95 %
7	20	light	0.40	50°C	42°C	50 %
8	120	light	0.80	70°C	50°C	50 %
9	10	dark	—	—	40°C	50 %
10	Repeat subcycle steps 6 to 9 (shown in bold) an additional 3 times (for a total or 24 h = 1 cycle).					

[A] The set point is the target condition for the sensor used at the operational control point and is programmed by the user. When the exposure cycle calls for a particular set point, the user programs the apparatus to use that exact number. Operational fluctuations are deviations from the indicated set point during equilibrium operation. The maximum allowable operational fluctuation during equilibrium conditions for the exposure cycle above is ±0.02 W/(m²·nm) for irradiance, ±2.5°C for black panel temperature, ±2°C for chamber air temperature, and ±10 % for relative humidity.

NOTE 7—Specimen repositioning in 9.4.1 and 9.4.2 is required to compensate for variations in light, water, relative humidity and temperature within the test chamber.

9.5 The test shall be interrupted for repositioning and specimen evaluations only during a step without water spray.

10. Report

10.1 The test report shall conform to Practice G151. The report shall also include the average of three water collection measurements for each position in the xenon arc light and water apparatus, in accordance with Annex A3.

11. Keywords

11.1 accelerated; automotive; coatings; durability; exposure test; irradiance; lightfastness; weathering; xenon arc

ANNEXES

(Mandatory Information for Equipment Manufacturers)

A1. DAYLIGHT FILTER IRRADIANCE LIMITS BY WAVELENGTH

A1.1 Conformance to the spectral power distribution in Table A1.1 is a design parameter for a xenon-arc source with the different optical filters provided. Manufacturers of equipment claiming conformance to this standard shall be responsible for determining conformance to the spectral power distribution table for all lamp/filter combinations provided, and provide information on maintenance procedures to minimize any spectral changes that may occur during normal use.

Wavelength Band (nm)	Total Irradiance Over Indicated Wavelength Band (W/m²)	
	Minimum	Maximum
$\lambda < 290$	0.00	0.005
$290 \leq \lambda < 295$	0.00	0.01
$295 \leq \lambda < 300$	0.01	0.04
$300 \leq \lambda < 305$	0.10	0.20
$305 \leq \lambda < 310$	0.38	0.56
$310 \leq \lambda < 320$	2.29	3.10
$320 \leq \lambda < 330$	4.76	5.82
$330 \leq \lambda < 340$	6.84	7.56
$340 \leq \lambda < 350$	7.69	9.40
$350 \leq \lambda < 360$	8.13	11.00
$360 \leq \lambda < 370$	8.32	12.47
$370 \leq \lambda < 380$	8.30	13.83
$380 \leq \lambda < 390$	8.64	14.40
$390 \leq \lambda < 400$	9.23	17.15

Note: Irradiance in W/m² normalized to 0.80 W/(m²·nm) at 340 nm.