Designation: D4587 – 23

Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings[1]

This standard is issued under the fixed designation D4587; 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 describes artificial accelerated weathering methods for testing the durability of coatings and related products using fluorescent UV lamps and water apparatus operated in accordance with Practices G151 and G154.

1.2 This practice also makes recommendations for preparation of test specimens, exposure duration, and the evaluation of test results.

NOTE 1—ISO 16474-3 also describes fluorescent UV lamp and water apparatus for artificial accelerated weathering of paints and coatings.

1.3 The values stated in SI units are to be regarded as the 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.*

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]

D16 Terminology for Paint, Related Coatings, Materials, and Applications

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D659 Method for Evaluating Degree of Chalking of Exterior Paints (Withdrawn 1990)[3]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, Coatings and Related Products on Test Panels

D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers

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 Rating Adhesion by Tape Test

D4214 Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films

D5870 Practice for Calculating Property Retention Index of Plastics

D6631 Guide for Committee D01 for Conducting an Interlaboratory Study for the Purpose of Determining the Precision of a Test Method

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

D7787 Practice for Selecting Wood Substrates for Weathering Evaluations of Architectural Coatings

[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.

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

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
E1348 Test Method for Transmittance and Color by Spectrophotometry Using Hemispherical Geometry
E1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry
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 Materials
G169 Guide for Application of Basic Statistical Methods to Weathering Tests

2.2 *ISO Standard:*[4]

ISO 16474-3 Paints and Varnishes—Methods of exposure to laboratory light sources – Part 3: Fluorescent UV Lamps

2.3 *SAE Standard:*[5]

SAE J2020 Accelerated Exposure of Automotive Exterior Materials Using a Fluorescent UV Condensation Apparatus

3. Terminology

3.1 The definitions given in Terminology D16 are applicable to this practice.

3.2 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 degradation of its physical and optical properties caused by exposure to light, heat, and water can be important for many applications. This practice describes artificial accelerated weathering methods designed to reproduce property changes associated with exposure to sunlight, moisture, and heat in end-use conditions. The weathering methods referenced in this practice do not simulate the deterioration caused by localized weather phenomena such as atmospheric pollution, biological attack, and saltwater exposure.

4.2 Cautions—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 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 irradiance of light from fluorescent UV lamps is significantly different from that produced in light and water exposure devices using other light sources. The type and rate of degradation and the performance rankings produced in exposures to fluorescent UV lamps 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 design of apparatus, lamp, 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 material.[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 Repeatability and reproducibility of test results will depend upon the care that is taken to operate the equipment according to 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.

4.5 All references to artificial accelerated weathering in accordance with this practice shall include a complete description of the test cycle and equipment used.

5. Apparatus

5.1 The fluorescent UV lamp and water apparatus shall conform to the requirements defined in Practices G151 and G154.

5.2 Unless otherwise specified, the spectral irradiance of the fluorescent UV lamp shall conform to the requirements in Practice G154 for a UVA 340 lamp.

NOTE 3—Fluorescent UV exposures described in SAE J2020 for automotive applications call for use of fluorescent UVA or UVB lamps.

5.3 *Laboratory Conditions:*

5.3.1 Locate the apparatus in an area maintained between 18 °C and 27 °C (65 °F and 80 °F). Measure ambient temperature at a maximum distance of 150 mm (6 in.) from the plane door of the apparatus. Control of ambient temperature is particularly critical when one apparatus is stacked above another, because the heat generated from the lower unit can affect the ambient conditions of the units above.

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[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*, ASTM, 1993.

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

5.3.2 Place the apparatus at least 300 mm (12 in.) 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. Hazards

6.1 **Warning—**In addition to other precautions, never look directly at the fluorescent UV lamp because UV radiation can damage the eye. Turn the device off before removing panels for inspection.

7. Test Specimens

7.1 Apply the test coating to flat (planar) 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 commonly used include but are not limited to Practices D609, D1730, or Specification D7787. Select panel sizes suitable for use with the apparatus.

7.2.1 For specimens coated on insulating materials, such as plastics, polymeric foams, or composites, check the specimens during the condensation period to verify that visible condensation is occurring on the surface of the specimens. Perform this visual check once per week at least one hour after the start of condensation.

NOTE 4—If condensation is not occurring, the most likely cause involves inadequate convective and/or conductive heat transfer between the specimen and the laboratory room-air cooling; Common causes include: (*1*) the laboratory temperature room-air is too high; (*2*) condensation temperature is set too low, or too close to room temperature; (*3*) thick specimens of insulating material may be preventing the room-air cooling necessary for condensation; or (*4*) improper specimen mounting is allowing vapor to escape from the chamber.

7.3 Coat test panels in accordance with Practices D823, then measure the film thickness in accordance with an appropriate procedure such as Test Method D1005 or D7091. Nondestructive methods are preferred because panels so measured need not be repaired.

7.4 Prior to exposing coated panels in the weathering apparatus, condition them at 23 °C ± 2 °C (73 °F ± 3 °F) and 50 % ± 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

7.4.1 Other procedures for conditioning of test specimens may be used if agreed upon by 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 Identify, condition, and handle all test specimens, controls, and reference materials in accordance with procedures described in Practice G147 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 property 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 5—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 of property changes are anticipated, comparison of exposed specimens with the file specimen may not be valid. Nondestructive instrumental measurements are recommended whenever possible.

7.10 Specimens should not ordinarily be removed from the weathering 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 10.

8. Procedure

8.1 Table 1 lists several artificial weathering cycles have been developed for fluorescent UV lamp and water apparatus exposure of paints and coatings. Obtain agreement between all concerned parties for the specific exposure cycle used. Additional intervals and periods of condensation may be substituted upon agreement among the concerned parties.

NOTE 6—Each setpoint and its tolerances found in Table 1 represent an operational control point for equilibrium conditions at a single location in the cabinet, which may not necessarily represent the uniformity of those conditions throughout the cabinet.

8.2 If no other cycle is specified, use Cycle 2.

8.3 Mount test specimens in the apparatus following the placement and specimen repositioning procedures described in Practice G154.

8.3.1 Fill any empty spaces in the exposure area with blank nonrusting panels. Seal any holes in specimens larger than 2 mm (0.08 in.) and any openings larger than 1 mm (0.04 in.) 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.

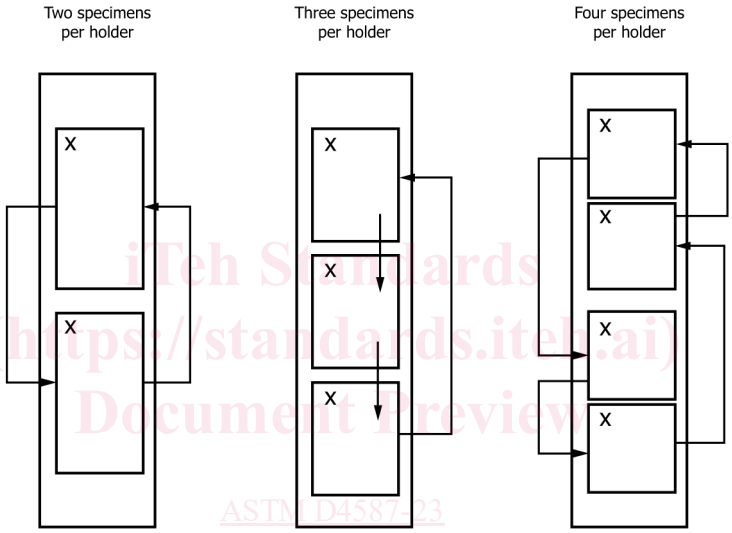
NOTE 7—Specimens in the extreme left and right side of the tester experience a lower irradiance than other specimens. While these positions do meet the irradiance requirements in Practice G151 when repositioning is used, it is recommended that these positions are excluded when test and control specimens do not completely fill the specimen racks.

8.3.2 Reposition specimens in apparatus with a planar exposure area using the following procedure unless it can be

TABLE 1 Test Cycles Commonly Used for Fluorescent UV–Condensation Exposure Testing of Paints and Related Coatings[A]

Cycle Number	Cycle Description	340 nm Irradiance[B]	Black Panel Temperature[C]	Typical Uses[D]
1	8 h UV	0.83 W/(m²·nm)	70 ºC ± 2.5 ºC (158 ºF ± 5 ºF)	Automotive coatings[E]
	4 h condensation	dark period	50 ºC ± 2. ºC (122 ºF ± 5 ºF)	
2	4 h UV	0.89 W/(m²·nm)	60 ºC ± 2.5 ºC (140 ºF ± 5 ºF)	Industrial maintenance coatings[F]
	4 h condensation	dark period	50 ºC ± 2.5 ºC (122 ºF ± 5 ºF)	
3	4 h UV	0.89 W/(m²·nm)	60 ºC ± 2.5 ºC (140 ºF ± 5 ºF)	Exterior wood coatings
	20 h condensation	dark period	50 ºC ± 2.5 ºC (122 ºF ± 5 ºF)	
4	8 h UV	0.89 W/(m²·nm)	60 ºC ± 2.5 ºC (140 ºF ± 5 ºF)	General metal coatings
	4 h condensation	dark period	50 ºC ± 2.5 ºC (122 ºF ± 5 ºF)	

[A] The cycles described are not listed in any order indicating importance, and are not necessarily recommended for the applications listed. Additional exposure cycles are described in Practice G154.
[B] The irradiance set point given is typical for devices operated without irradiance control. Other irradiance levels may be used, but must be described in the report.
[C] Temperature is at equilibrium for either an uninsulated or insulated black panel, although an insulated black panel will often result in lower specimen temperatures when compared to an uninsulated black panel with the same temperature control point. Refer to Practice G151 for more information about the construction and differences between uninsulated and insulated black panels.
[D] Typical uses do not imply that results from exposures of these materials according to the cycle described will correlate to those from actual use conditions.
[E] SAE J2020 describes the test used in many automotive specifications.
[F] Historical convention has established this as a very commonly used test cycle.



NOTE 1—"X" denotes orientation of each specimen.

FIG. 1 Specimen Repositioning Within Holders

shown that the irradiance uniformity meets the requirements of Practice G151 without repositioning. In apparatus that do not have a planar exposure area, reposition specimens using a procedure agreed upon by all interested parties. Repositioning is a best practice and is recommended in all cases, as it can also reduce variability due to temperature or moisture non-uniformity.

8.3.2.1 Unless otherwise specified, move the two extreme right-hand holders to the far left of the exposure area, and slide the remaining holders to the right. More information on repositioning can be found in Practice G151 and G154.

8.3.2.2 Unless otherwise specified, reposition specimens vertically within each specimen holder so that each spends the same amount of exposure time in each vertical position within the specimen holder. Fig. 1 shows the vertical rotation sequence for cases where there are two, three, or four specimens in a holder.

8.3.3 *Repositioning Frequency*—If repositioning is performed, the interval should be 10 % of the exposure time between evaluations, unless otherwise specified.

8.4 *Water Purity:*

8.4.1 Deionized water should be used to produce condensation.

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

9. Periods of Exposure and Evaluation of Results

9.1 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.

9.2 The time or radiant exposure necessary to produce a defined change in a material property can be used to evaluate the stability of materials. This method is preferred over evaluating materials after an arbitrary exposure time or radiant exposure.

9.2.1 Exposure to an arbitrary time or radiant exposure may be used when agreed upon by the parties concerned or if required for conformance to a specification. When a single