



Designation: D5894 – 21

Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)¹

This standard is issued under the fixed designation D5894; 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 basic principles and operating practice for cyclic corrosion/UV exposure of paints on metal, using alternating periods of exposure in two different cabinets: a cycling salt fog/dry cabinet, and a fluorescent UV/condensation cabinet.

1.2 This practice is limited to the methods of obtaining, measuring, and controlling exposure conditions, and procedures. It does not specify specimen preparation nor evaluation of results.

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, 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

D610 Practice for Evaluating Degree of Rusting on Painted Steel Surfaces

D714 Test Method for Evaluating Degree of Blistering of Paints

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.

D1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

D4587 Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings

G85 Practice for Modified Salt Spray (Fog) Testing

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

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

3. Terminology

3.1 *Definitions*—The definitions given in Terminology **G113** are applicable to this practice.

4. Summary of Practice

4.1 The test specimens are exposed to alternating periods of one week in a fluorescent UV/condensation chamber followed by one week in a cyclic salt fog/dry chamber. The fluorescent UV/condensation cycle is 4 h UV at 0.89 W/(m² · nm) at 340 nm at 60°C followed by 4 h condensation at 50°C, using UVA-340 lamps. The fog/dry chamber runs a cycle of 1 h fog at ambient temperature and 1 h dry-off at 35°C. The fog electrolyte is a relatively dilute solution, with 0.05 % sodium chloride and 0.35 % ammonium sulfate.

5. Significance and Use

5.1 The outdoor corrosion of painted metals is influenced by many factors, including: corrosive atmospheres, rain, condensed dew, UV light, wet/dry cycling, and temperature cycling. These factors frequently have a synergistic effect on one another. This practice is intended to provide a more realistic simulation of the interaction of these factors than is found in traditional tests with continuous exposure to a static set of corrosive conditions.

5.2 Results obtained from this practice can be used to compare the relative durability of materials subjected to the specific test cycle used.

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

5.3 No single exposure test can be specified as a complete simulation of actual use conditions in outdoor environments. Results obtained from exposures conducted according to this practice can be considered as representative of actual outdoor exposures only when the degree of rank correlation has been established for the specific materials being tested. The relative durability of materials in actual outdoor service can be very different in different locations because of differences in UV radiation, time of wetness, temperature, pollutants, and other factors. Therefore, even if results from a specific artificial test condition are found to be useful for comparing the relative durability of materials exposed in a particular exterior environment, it cannot be assumed that they will be useful for determining relative durability for a different environment.

5.4 Even though it is very tempting, it is not recommended to calculate an “acceleration factor” relating x hours of laboratory exposure to y months of exterior exposure. Different materials and different formulations of the same material can have significantly different acceleration factors. The acceleration factor also varies depending on the variability in rate of degradation in the laboratory test and in actual outdoor exposure.

5.5 This practice is best used to compare the relative performance of materials tested at the same time in the same exposure device. Because of possible variability between the same type of exposure devices, it is not recommended to compare the amount of degradation in materials exposed for the same duration at separate times, or in separate devices running the same test condition. This practice should not be used to establish a “pass/fail” approval of materials after a specific period of exposure unless performance comparisons are made relative to a control material exposed simultaneously, or the variability in the test is rigorously quantified so that statistically significant pass/fail judgments can be made.

5.6 This practice has been found useful for air-dry industrial maintenance paints on steel^{3,4,5,6,7} and zinc-rich primers but its applicability has not yet been assessed for highly UV-stabilized coating systems, such as for automotive applications.

6. Apparatus

6.1 *Fluorescent UV-Condensation Exposure Chamber*, complying with Practices **G151** and **G154**.

6.2 *UVA-340 Fluorescent Lamps*.

³ Skerry, B. S. and Simpson, C. H., “Combined Corrosion/Weathering Accelerated Testing of Coatings for Corrosion Control,” Presented at Corrosion 91, The National Association of Corrosion Engineers (NACE) Annual Conference 1991, and available from NACE, P.O. Box 218340, Houston, TX 77218.

⁴ Simpson, C. H., Ray, C. J., and Skerry, B. S., “Accelerated Corrosion Testing of Industrial Maintenance Paints Using a Cyclic Corrosion Weathering Method,” *Journal of Protective Coatings and Linings*, Vol 8, No. 5, May 1991, pp. 28–36.

⁵ Cleveland Society for Coatings Technology, “Correlation of Accelerated Exposure Testing and Exterior Exposure Sites,” *Journal of Coatings Technology*, Vol 66, No. 837, October 1994, pp. 49–61.

⁶ Boocock, S. K., “A Report on SSPC Programs to Research Performance Evaluation Methods,” *Journal of Protective Coatings and Linings*, October 1994, pp. 51–58.

⁷ Cleveland Society for Coatings Technology, “Correlation of Accelerated Exposure Testing and Exterior Exposure Sites Part II: One-Year Results,” *Journal of Coatings Technology*, Vol 68, No 858, July 1996, pp. 47–61.

6.3 *Salt Fog/Dry Cabinet*, complying with Practice **G85** Annex 5, Dilute Electrolyte Cyclic Fog/Dry Test.

7. Test Specimens

7.1 The composition and preparation of the substrate, specimen preparation, and the number of specimens shall be agreed upon prior to testing.

7.2 Follow the guidelines of Practice **G85** and Practice **D4587** on the preparation of specimens for the needs of those particular exposures.

7.2.1 Follow the guidelines of Practice **G147** on conditioning and handling of specimens.

7.3 Unless otherwise agreed, flat specimens shall be 75 by 150 mm.

7.4 Expose at least one control specimen with every test. The control specimen should have known durability and be of similar composition to the test specimens. It is preferable to have two control materials: one of higher durability and one of lower durability.

7.5 It is recommended that at least three replicates of each specimen be tested, to compensate for variation within the chambers and variation between specimens.

8. Procedure

8.1 *Fluorescent UV-Condensation Exposure:*

8.1.1 Start the exposure in the fluorescent UV-condensation chamber.

NOTE 1—It has been found that in certain cases the exposure must start in the fluorescent UV/condensation device in order to get realistic rusting and staining as well as faster corrosion. It is thought that the initial UV damage to the coating allows the subsequent salt fog to produce a more realistic corrosion attack on the substrate.

8.1.2 Perform the fluorescent UV-condensation exposure in compliance with Practice **G151** and **G154**, and Cycle 2 of Practice **D4587**.

8.1.3 For irradiance-controlled devices and unless otherwise specified, set the irradiance level to 0.89 W/(m² · nm) at 340 nm; the maximum allowable deviation from the set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation is ±0.02 W/(m² · nm) for irradiance. If mutually agreed upon by all parties, use of non-irradiance controlled devices is permitted, but use of these devices must be included in the test report.

8.1.4 Program a UV/condensation cycle of 4 h UV at 60°C followed by 4 h condensation at 50°C. The temperatures specified refer to the uninsulated black panel control sensor in the chamber, as described in Practice **G154**. The maximum allowable deviation (operational fluctuation) from the set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation is ±2.5°C for temperature.

8.1.5 Use UVA-340 fluorescent lamps.

8.1.6 Expose the specimens for 21 cycles in the fluorescent UV-condensation chamber before transferring them to the fog/dry chamber. These 21 cycles equal a total of 168 h (1 week).

8.1.7 Other cycles and lamps are acceptable if agreed upon prior to the test, and reported in compliance with Section 10.

8.2 Cyclic Salt Fog/Dry Exposure:

8.2.1 Perform the cyclic salt fog/dry exposure according to Practice G85 Annex 5, Dilute Electrolyte Cyclic Fog/Dry Test.

8.2.2 Program a fog/dry cycle of 1 h fog at ambient temperature followed by 1 h dry-off at 35°C at the chamber's reference temperature sensor.

8.2.2.1 If the lab ambient temperature is above 30°C, program a dry-off temperature at least 5°C above the lab ambient to provide positive dry-off. For instance if the lab ambient is 37°C, program a dry-off temperature of at least 42°C.

8.2.2.2 The dry-off temperatures specified in 8.2.2.1 refer to the chamber air control sensor in the fog/dry chamber. The allowable operational fluctuation at equilibrium is $\pm 3^\circ\text{C}$.

8.2.3 Prepare the salt solution with 0.05 % sodium chloride and 0.35 % ammonium sulfate by weight.

8.2.4 Expose the specimens for 84 cycles in the fog/dry chamber before transferring them back to the fluorescent UV-condensation chamber. These 84 cycles equal a total of 168 h (1 week).

8.2.5 Other cycles, temperatures, and electrolytes are acceptable if agreed upon prior to the test, and reported in compliance with Section 10.

NOTE 2—Data from Electrochemical Noise Analysis tests indicate that the temperature of the fog/dry cabinet is not critical to the rate of corrosion, nor is the rate of drying off critical to the rate of corrosion. What is critical is (a) the frequency of drying and (b) that the surface of the specimen does in fact dry off during the 1 h period. Longer fog/dry cycles (for example, 2 h fog, 2 h dry) have been found to produce slower degradation.

8.3 *Specimen Repositioning*—When moving the specimens from one chamber to another, reposition the specimens so that over the course of the test each specimen spends equal amounts of time in each area of the chamber: edges, center, top, bottom. This will help minimize variation in degradation due to variations in conditions within the chamber.

8.4 Do not wash or clean specimens between tests or prior to completion of entire test, or as agreed upon between purchaser and seller prior to testing.

8.5 *Evaluation of Corrosion*—Methods that may be useful for evaluating the corrosion of the specimens are Test Methods

D610, D714, and D1654. Practice D4587 also references a number of other standards that may be used for evaluating the appearance change of the specimens.

8.5.1 Evaluate every 336 h or multiples thereof and after completion of testing. Perform evaluation after complete 2-step (UV exposure and Salt Fog/Dry Exposure) cycles only.

9. Duration of Exposure

9.1 Use one of the following methods to determine the duration of the exposure under this practice:

9.1.1 A mutually agreed-upon specified number of total hours,

9.1.2 The exposure required to produce a mutually agreed upon amount of change in either the test specimens or an agreed upon standard reference specimen, and

9.1.3 If no information is available as to an appropriate exposure duration, expose the specimens for a total of 1008 h, or until significant differences in performance between specimens become apparent.

10. Report

10.1 Report the following information:

10.1.1 Test cycle:

10.1.1.1 UV/condensation cabinet cycle (for example, 4 h UV at 60°C and 4 h condensation at 50°C),

10.1.1.2 Fog/dry cabinet cycle (for example, 1 h fog at ambient temperature and 1 h dry-off at 35°C),

10.1.1.3 Hours spent in each cabinet before transfer from one cabinet to the other (for example, 168 h in the fog/dry cabinet and 168 h in the UV/condensation cabinet), and

10.1.1.4 The total hours of exposure.

10.1.2 Manufacturer's designation and wavelength of peak emission for fluorescent lamps, if different than 8.1.5;

10.1.3 Electrolyte solution (for example, 0.05 % sodium chloride and 0.35 % ammonium sulfate by mass);

10.1.4 Specimen cleaning standards used or cleaning materials and procedures; and

10.1.5 Other information required in Report section of Practice G85 and Periods of Exposure and Evaluation of Results section of Practice D4587.

11. Keywords

11.1 accelerated aging/testing—paints; corrosion; cyclic corrosion; rust; salt spray; ultraviolet