Designation: D 4585 – 99

Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation[1]

This standard is issued under the fixed designation D 4585; 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 procedures for testing water resistance of coatings using controlled condensation. Condensation is produced by exposing one surface of a coated specimen to a heated, saturated mixture of air and water vapor, while the reverse side of the specimen is exposed to the cooling effect of room temperature air. This practice is derived from research of the Cleveland Society for Coatings Technology.[2]

1.2 This practice is limited to the methods of obtaining, measuring, and controlling conditions and procedures of controlled condensation tests. It does not specify specimen preparation, specific test conditions, or evaluation of results.

NOTE 1—Alternative practices for testing water resistance of coatings include Practices D 870, D 1735, and D 2247.

1.3 The values stated in inch-pound 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

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[4]

D 714 Test Method for Evaluating Degree of Blistering Paints[3]

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[3]

D 870 Practice for Testing Water Resistance of Coatings Using Water Immersion[3]

D 1654 Test Method for Evaluation of Painted or Coated Specimens Subject to Corrosive Environment[3]

D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting[5]

D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus[3]

D 2247 Practice for Testing Water Resistance of Coatings In 100 % Relative Humidity[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 3363 Test Method for Film Hardness by Pencil Test[3]

D 4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion-Testers[4]

G 53 Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials[6]

3. Summary of Practice

3.1 Water vapor is generated by heating a pan of water at the bottom of the test chamber. The specimens form the roof or walls of the test chamber so that the back sides of the specimens are exposed to the cooling effects of room temperature air. The resulting heat transfer causes vapor to condense on the test specimens as liquid water saturated with air.

3.2 The temperature and amount of condensate forming on the specimens is controlled by the test temperature and the room temperature. The test specimens are inclined so that condensate runs off the test surface by gravity and is replaced by fresh condensate in a continuous process during the condensate cycle.

3.3 Exposure conditions are varied by selecting: (*a*) the temperature of the test, (*b*) the duration of the test, and (*c*) periodic drying of the specimens. Testing may be conducted at temperatures from 100 to 180°F (38 to 82°C). Any effects such as color change, blistering, loss of adhesion, softening, or

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[1] This practice is under the jurisdiction of ASTM Committee D-1 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] Foecking, N. J., "Cleveland Condensing Type Humidity Cabinet," *Official Digest*, December 1963, Vol 35, No. 467, pp. 1318–1327; and Higgins, W. A., "Cleveland Condensing Type Humidity Cabinet: II," *Official Digest*, November 1965, Vol 37, No. 490, pp. 1392–1404.

[3] *Annual Book of ASTM Standards*, Vol 06.01.

[4] *Annual Book of ASTM Standards*, Vol 06.02.

[5] *Annual Book of ASTM Standards*, Vol 02.05.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

embrittlement are observed and reported.

4. Significance and Use

4.1 Water can cause degradation of coatings, so knowledge of how a coating resists water is helpful in predicting its service life. Failure in a condensation test may be caused by a number of factors including a deficiency in the coating itself, contamination of the substrate, or inadequate surface preparation. The test is therefore useful for evaluating coatings alone or complete coating systems.

4.2 Condensation tests of coatings are used for specification acceptance, quality control, and research and development of coatings and substrate treatments. These tests usually result in a pass or fail determination but the degree of failure also may be measured. A coating system is considered to pass if there is no evidence of water-related failure after a specified period of time.

4.3 Results obtained from the use of condensation tests in accordance with this practice should not be represented as being equivalent to a period of exposure to water in the natural environment, until the degree of quantitative correlation has been established for the coating or coating system.

4.4 The test is usually conducted on metal, plastics, or wood specimens with the coating facing the inside of the chamber. However, it is possible to test the blister resistance of house paints on wood specimens by mounting the uncoated wood surface facing the inside of the chamber.

4.5 This practice can be used for corrosion tests particularly if the specimens are periodically dried. While corrosion products will drain into the water bath, they are not carried into the vapor that condenses on the test specimens.

5. Apparatus

5.1 *Test Chamber* (see Fig. 1 and Fig. 2), consisting of insulated side walls mounted on a base, test specimen racks attached to the side walls, a heated water pan, and provisions for controlling and indicating the vapor temperature within the chamber. Vents, approximately 0.10 to 0.20 in. (3 to 5 mm) wide, shall be provided to admit room air at the bottom of the test chamber.

NOTE 2—The apparatus described in Practice G 53 may be used if the ultraviolet lamps specified in Practice G 53 are turned off.

5.2 Specimens shall form the roof of the test chamber. If the specimens cannot completely fill all the openings, blank panels shall be used. Certain substrates may deform from the heat and moisture. The specimens should be mounted to avoid gaps between specimens that allow heat and moisture to escape. Various types of tape can be used to seal the gaps that develop when the specimen deforms. Specimens shall be inclined from 15 to 75° from the horizontal and arranged so that condensate is returned to the water pan without dripping on other specimens.

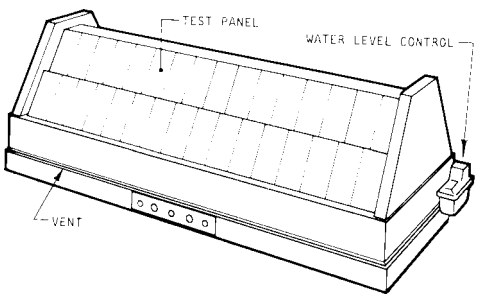

FIG. 1 Controlled Condensation Apparatus

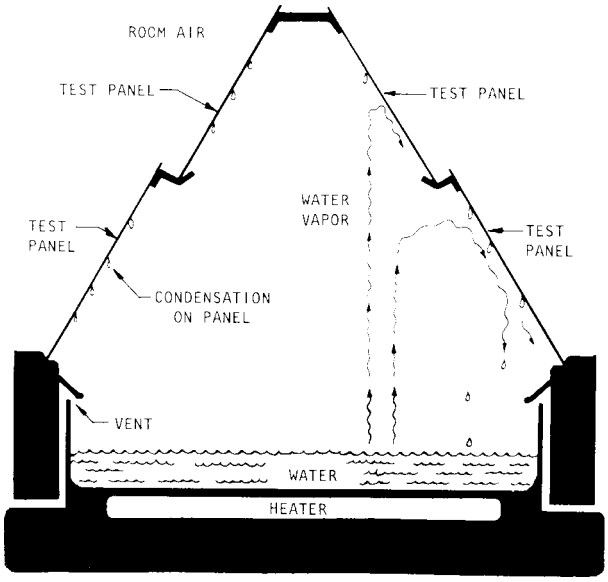

FIG. 2 Apparatus Cross Section

5.3 *Water Supply*, with water level control. The water quality should be agreed upon between the customer and the supplier for running this test.

5.4 *Water Heater*, preferably located under the water pan, controlled by a thermostat with the sensing element located in the water.

5.5 *Thermometer*, with the stem extending into the air-water vapor mixture in the test chamber.

5.6 *Program Timer, Blower, and Air Heater*, (optional) fitted to the chamber to provide periods of drying on a fixed schedule.

6. Test Specimens

6.1 This practice does not cover the preparation of test specimens. The substrate composition and surface preparation, specimen preparation, and the number of specimens should be agreed upon prior to testing.

NOTE 3—Applicable methods for the preparation of test panels and substrates are given in Methods D 609 and Practices D 1730. Practices D 823 cover application techniques for the production of uniform films.

6.2 It's recommended that a control specimen of a paint with known durability be included with each test. Such control specimens can provide warning of changes in test severity in a given apparatus, and can indicate variations in test severity between different apparatuses.

6.3 It's recommended that at least two replicate specimens of each different coating be used, so as to compensate for variations between specimens and variations in test conditions within the apparatus.

6.4 Test specimens should be flat rigid material. Minimum size is 3-in. (76-mm) wide and 6-in. (152-mm) tall. Maximum

thickness is 3/4 in. (8 mm). Materials thicker than 3/4 in. (8 mm) insulate and the condensate does not form on the tested side of the panel. If the test panels overshadow the upper shelf, do not put test panels on the upper shelf.

7. Procedure

7.1 Fill the water pan to a depth of approximately 1 in. (25 mm) with water. The quality of the water in the pan does not affect the test since the evaporation and condensation process yields distilled water, but the use of tap water can result in the accumulation of residues in the water pan.

7.2 Fill all spaces in the specimen holder rack with specimens or corrosion-resistant blank panels. Mount coated metal panels with the coating to be tested facing the inside of the chamber. Coated wood specimens may be mounted in the same way.

7.2.1 Blister tests to simulate the effects of water vapor migration from inside a frame house are mounted with the *uncoated* side of the wood specimen facing the inside of the test chamber.

7.2.2 Close all cracks between specimens and all holes in specimens, to prevent water vapor loss and local temperature variation. Condensate usually seals cracks or holes smaller than 0.04 in. (1 mm), but larger openings must be closed with tape or metal strips.

7.3 Adjust the thermostat to maintain the desired temperature of the saturated air and water vapor mixture. Vapor temperatures of 100, 120, or 140°F (38, 49, or 60°C) are suggested. Other temperatures may be used provided that the temperature is reported in conformance with Section 8. To ensure adequate condensation, maintain at least a 20°F (11°C) temperature differential between the room and the vapor.

7.4 Operate the chamber continuously unless otherwise specified or agreed. The removal of specimens for inspections during operation is permitted. When removing a specimen for inspection, replace it with a blank so that the test conditions are not altered.

7.5 Cyclic operation with alternating periods of condensation and drying may be used. Automatic drying requires the apparatus described in 5.6. For manual drying of specimens, remove them from the apparatus. Drying periods should be at least 4 h long.

7.6 To control for variability within the apparatus, reposition the specimens on a regular basis so that all specimens spend equivalent amounts of time in the various areas of the apparatus (top, bottom, left, right, and center).

7.7 Conclude the test after a specified period of time or after effects from exposure to water are noted.

7.8 Remove specimens at the conclusion of the test. Do not leave the specimens in the apparatus at the conclusion of the test as the specimens can remain wet for hours, or even days, when the apparatus is turned off.

7.9 Wipe the test specimens dry. Rate specimens for changes in color, blistering, etc. Evaluate specimens no less than 5 min and no more than 10 min after removal from test, as the effects from water exposure can change within a short time. Remove only as many specimens as can be rated within the specified time.

NOTE 4— Relevant procedures for evaluating water effects are described in Methods D 610 and D 2616, and Test Methods D 714, D 1654, D 3359, D 3363, and D 4541.

7.9.1 If possible, rate the specimens again after they have been removed from the test for a recovery period long enough that moisture absorbed within the specimen dries out and the specimens reach moisture equilibrium with room air. A recovery period from 12 to 24 h is generally sufficient. The post-recovery rating allows evaluation of the permanent effects of the exposure as distinct from the transient effects, and is especially important for evaluation of color and gloss.

8. Report

8.1 Report the following information:

8.1.1 Sample identification.

8.1.2 Results of the evaluation(s).

8.1.3 Reference to Practice D 4585.

8.1.4 Hours of test duration.

8.1.5 Description of any cyclic operations.

8.1.6 Condensation temperature.

8.1.7 Special conditions of test or any deviations in test procedure.

9. Keywords

9.1 adhesion; blistering; condensation; humidity; resistance-water; rust