



# Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity<sup>1</sup>

This standard is issued under the fixed designation D 2247; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 This practice covers the basic principles and operating procedures for testing water resistance of coatings by exposing coated specimens in an atmosphere maintained at 100 % relative humidity so that condensation forms on the test specimens.

1.2 This practice is limited to the methods of obtaining, measuring, and controlling the conditions and procedures of tests conducted in 100 % relative humidity. It does not specify specimen preparation, specific test conditions, or evaluation of results.

NOTE 1—Alternative practices for testing the water resistance of coatings include Practices D 870, D 1735, and D 4585.

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 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<sup>2</sup>

D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces<sup>3</sup>

D 714 Test Method for Evaluating Degree of Blistering of Paints<sup>2</sup>

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels<sup>2</sup>

D 870 Practice for Testing Water Resistance of Coatings

Using Water Immersion<sup>2</sup>

D 1193 Specification for Reagent Water<sup>4</sup>

D 1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environment<sup>2</sup>

D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting<sup>5</sup>

D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus<sup>2</sup>

D 2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale<sup>2</sup>

D 3359 Test Methods for Measuring Adhesion by Tape Test<sup>2</sup>

D 3363 Test Method for Film Hardness by Pencil Test<sup>2</sup>

D 4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers<sup>3</sup>

D 4585 Practice for Testing Water Resistance of Coatings Using Controlled Condensation<sup>2</sup>

## 3. Summary of Practice

3.1 Coated specimens are placed in an enclosed chamber containing a heated, saturated mixture of air and water vapor. The temperature of the chamber is usually maintained at 38°C (100°F). At 100 % relative humidity (RH), a very small temperature difference between the specimen and the surrounding vapor causes the formation of condensation on the specimens. The exposure condition is varied by selecting the duration of the test. Water permeates the coating at rates that are dependent upon the characteristics of the coating. Any effects such as color change, blistering, loss of adhesion, softening, or embrittlement are observed and reported.

## 4. Significance and Use

4.1 Water can cause the degradation of coatings, so knowledge of how a coating resists water is helpful in predicting its service life. Failure in tests at 100 % relative humidity may be caused by a number of factors including a deficiency in the coating itself, contamination of the substrate, or inadequate surface preparation. This practice is therefore useful for evaluating coatings alone or complete coating systems.

<sup>1</sup> 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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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 06.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 06.02.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 11.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 02.05.

4.2 Tests at 100 % relative humidity 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 may also be measured. A coating system is considered to pass if there is no evidence of water-related failure after a period of time.

4.3 Results obtained from the use of 100 % humidity 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 chamber can be a small laboratory cabinet or a room large enough to hold an automobile or a truck. Some automobile manufacturers test completed vehicles in rooms maintained at 100 % relative humidity. Corrosion tests can be conducted, as the condensate dripping off the test articles is not recirculated.

## 5. Apparatus

5.1 *Test Chamber*, constructed of corrosion-resistant materials with supports for the test specimens.

5.2 *Heated Water Tank*, within the test chamber, a water supply, and a water level control.

5.3 *Thermostatic Control*, for the water heater with the sensor located adjacent to the specimen holders.

5.4 *Thermometer*, with sensor located adjacent to the specimen holders.

5.5 Diagrams and details of the apparatus are shown in the Annex.

## 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 2—Applicable methods for the preparation of test panels and substrates are given in Practices D 609 and 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 with the apparatus.

## 7. Procedure

7.1 Fill the water tank with reagent water conforming to Type IV of Specification D 1193. Tap water should not be used.

7.2 Adjust the temperature of the saturated air and water vapor mixture to  $38 \pm 2^\circ\text{C}$  ( $100 \pm 4^\circ\text{F}$ ).

NOTE 3—Due to heat loss to the specimens and the walls of the chamber, the temperature of the water in the tank will be above the temperature of the air and water vapor mixture.

7.3 Support the specimens approximately  $15^\circ$  from the vertical. Slotted wood supports are suitable for flat specimens. Provide for formation of condensation on the specimens by spacing them at least 30 mm apart. Space the specimens so they do not touch each other, any metallic material, or any material capable of acting as a wick. Arrange specimens so that condensate from one specimen cannot drip on other specimens.

7.4 Droplets of condensation should appear evenly on the specimen at all times if the chamber is operating properly. The chamber should be mapped throughout the exposure zone to avoid areas where condensation does not occur on the panels and reduce variability in the test. Operate the test continuously with the test chamber closed unless otherwise specified. Short interruptions to inspect or remove specimens are permitted, but such interruptions should occur no more than once each day.

7.5 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 (front, back, left, right, and center).

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

7.7 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 Test Methods D 610, D 714, D 1654, D 2616, D 3359, D 3363, and D 4541.

7.7.1 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 specimens 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 2247.

8.1.4 Hours of test duration.

8.1.5 Test temperature.

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

## 9. Keywords

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

**(Mandatory Information)****A1. Apparatus**

A1.1 The apparatus must be constructed so that heated water vapor is generated at the bottom of the chamber. This saturates the air immediately above the water tank with water vapor. The saturated mixture of water vapor and air temperature rises and then cools below the dew point, causing condensation on the specimens. Two types of apparatus have been found to meet the requirements of this practice. One type uses a water tank with an electric immersion heater, and the other uses a submerged air distribution pipe.

A1.2 In chambers using a water tank with electric immersion heater to supply heat and humidity, the area of the heated water tank should be limited to no more than 25 % of the floor area of the chamber. The use of a large heated water tank would tend to make the temperature within the chamber uniform, and thus inhibit or prevent the formation of condensate on the specimens. The water temperature will be approximately from 5 to 10°C (10 to 20°F) above the vapor temperature when the water tank and chamber are properly proportioned.

A1.3 In chambers using a water jacket to supply heat and humidifying tower (optional) and submerged air distribution pipe to supply humidity, the water level in the chamber should be approximately 15 cm (6 in.) above the bottom of the chamber. The level of water in the heating jacket should be approximately 30 cm (12 in.) above the bottom of the chamber. Samples must be placed at a level above the water in the heating jacket to insure proper condensation. Air pressure to

the humidifying tower should be approximately 7 to 14 kPa (1 to 2 psi).

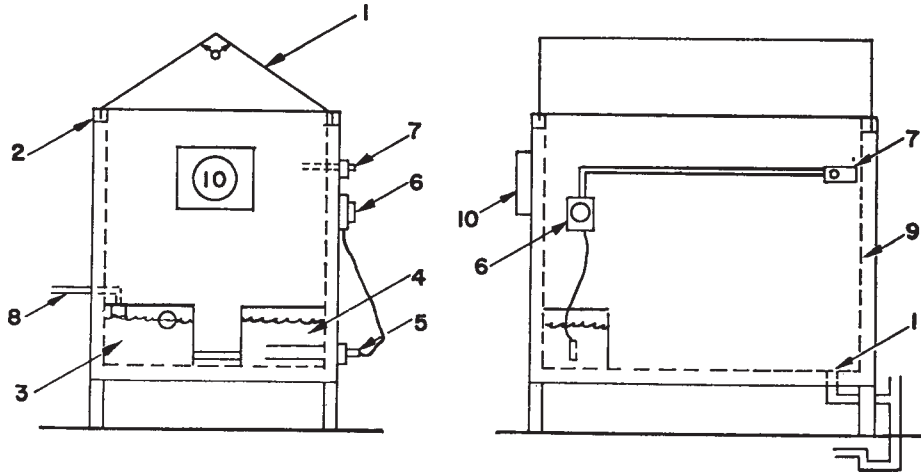
A1.4 Insulation of the enclosure is not required and can possibly interfere with the formation of condensate by reducing the temperature differential within the chamber. It is difficult to produce condensation with small chambers because the temperature differential is slight.

A1.5 Large walk-in chambers may require more than one heated water tank to generate the convective currents needed to cause condensation at all points within the chamber. Circulating fans should be used with caution as their use may reduce the temperature differential and limit condensation.

A1.6 In a properly operating chamber, condensation is observed on the specimens or parts when the chamber is opened for inspections. It may be necessary to avoid placing specimens in the lower portion of the chamber as the temperature differentials at the lower levels may be too small to induce condensation.

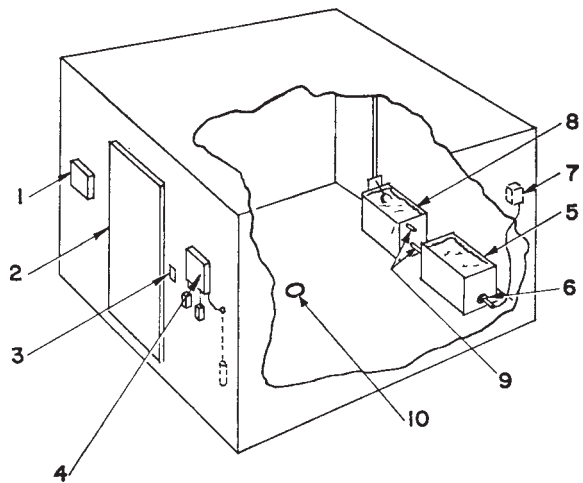
A1.7 In the event that enough condensation does not occur, or condensation does not form at all the desired points, it is possible to increase condensation by turning off the water heater periodically to cause temperature fluctuations.

A1.8 Many variations in the design of the apparatus are possible in the use of this practice. Two typical designs are shown in Fig. A1.1 and Fig. A1.2, and Fig. A1.3.



- 0—Angle of lid, 90 to 125°
- 1—Hinged top, hydraulically operated, or counterbalanced
- 2—Water seal
- 3—Constant-level water tank unheated with overflow outlet and equalizer connection
- 4—Heater water tank for supplying heat and humidity to cabinet
- 5—Immersion heater
- 6—Water temperature limit control
- 7—Thermostatic controller for room temperature. Primary limit control for immersion heater (5)
- 8—Water line
- 9—Insulation if necessary (see A1.3)
- 10—Temperature recorder (optional)
- 11—Drain

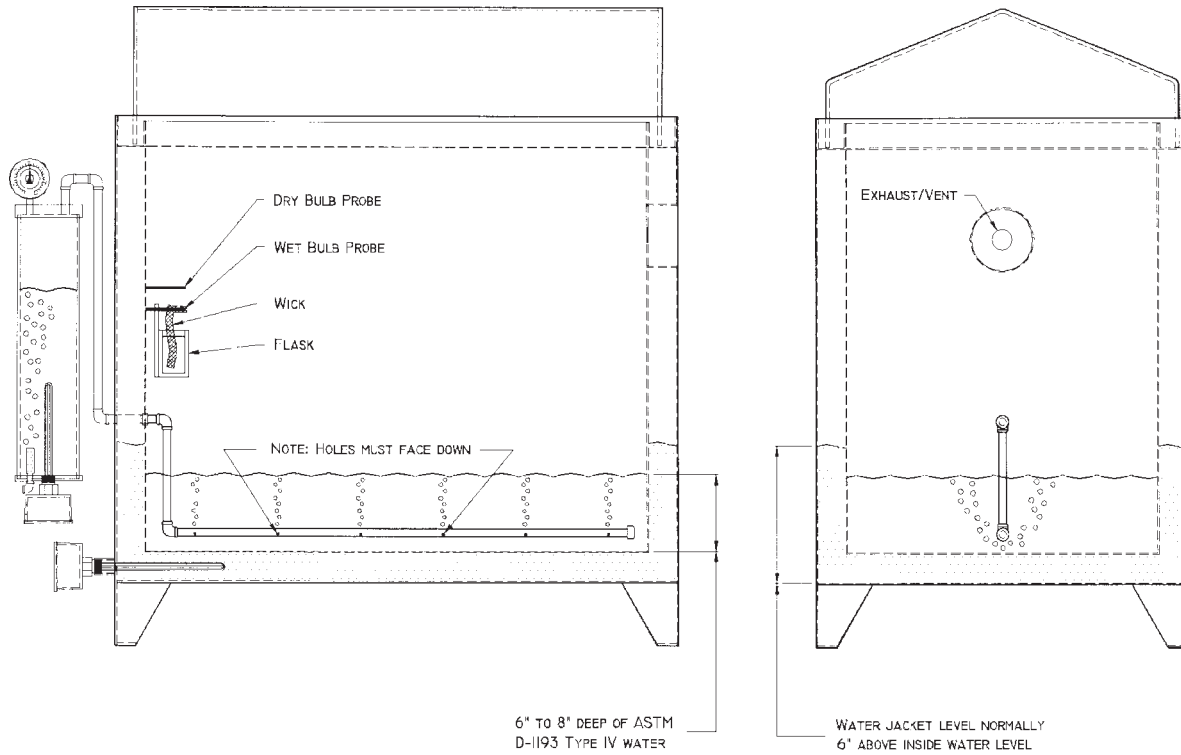
FIG. A1.1 Humidity Cabinet



- 1—Temperature recorder
- 2—Fiberglass door with magnetic closers and rubber seal; inward sloping sill
- 3—Light switch
- 4—Thermostatic controller for room temperature. Primary limit control for immersion heater (6)
- 5—Heated water tank for supplying heat and humidity to room
- 6—Immersion heater
- 7—Water temperature limit control
- 8—Constant level water tank unheated with overflow outlet
- 9—Equalizer connection
- 10—Floor drain

NOTE 1—The chamber shall feature waterproof construction with insulation and vaporproof fixtures on the interior, lighting may be accomplished with a fluorescent fixture above insulating glass sealed in the ceiling. Polyvinyl chloride pipe and flanges shall be used for sleeves through walls.

FIG. A1.2 Walk-in Humidity Chamber



**FIG. A1.3 Humidity Cabinet**

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