



Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference¹

This standard is issued under the fixed designation E 547; 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 test method covers the determination of the resistance of exterior windows, curtain walls, skylights, and doors to water penetration when water is applied to the outdoor face and exposed edges simultaneously with a cyclic static air pressure at the outdoor face higher than the pressure at the indoor face.

1.2 This test method is applicable to any curtain-wall area or to windows, skylights, or doors alone.

1.3 This test method addresses water penetration through a manufactured assembly. Water that penetrates the assembly, but does not result in a failure as defined herein, may have adverse effects on the performance of contained materials such as sealants and insulating or laminated glass. This test method does not address these issues.

1.4 The proper use of this test method requires a knowledge of the principles of pressure measurement.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.6 *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.* For specific hazard statements, see 7.1.

2. Referenced Documents

2.1 *ASTM Standards:*²

E 631 Terminology of Building Constructions

¹ This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on Performance of Windows, Doors, Skylights, and Curtain Walls.

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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. Terminology

3.1 *Definitions*—For definitions of general terms relating to building construction used in this test method, see Terminology E 631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *specimen, n*—the entire assembled unit submitted for test as described in Section 8.

3.2.2 *test pressure difference, n*—the specified difference in static air pressure across the closed and locked or fixed specimen expressed as pascals (lbf/ft²).

3.2.3 *water penetration, n*—penetration of water beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen, not including interior trim and hardware, under the specified conditions of air pressure difference across the specimen. For products with non-planar glazing surfaces (domes, vaults, pyramids, etc.), the plane defining water penetration is the plane defined by the innermost edges of the unit frame.

4. Summary of Test Method

4.1 This test method consists of sealing the test specimen into or against one face of a test chamber, and supplying air to or exhausting air from the chamber at the rate required to maintain the test pressure difference across the specimen for the time cycle specified, while spraying water onto the outdoor face of the specimen at the required rate and observing any water penetration.

5. Significance and Use

5.1 This test method is a standard procedure for determining the resistance to water penetration under cyclic static air pressure differences. The air-pressure differences acting across a building envelope vary greatly. These factors should be fully considered prior to specifying the test pressure difference to be used.

NOTE 1—In applying the results of tests by this test method, note that the performance of a wall or its components, or both, may be a function of proper installation and adjustment. In service, the performance will also depend on the rigidity of supporting construction and on the resistance of

components to deterioration by various causes, vibration, thermal expansion and contraction, etc. It is difficult to simulate the identical complex wetting conditions that can be encountered in service, with large wind-blown water drops, increasing water drop impact pressures with increasing wind velocity, and lateral or upward moving air and water. Some designs are more sensitive than others to this upward moving water.

NOTE 2—This test method does not identify unobservable liquid water which may penetrate into the test specimen.

6. Apparatus

6.1 The description of apparatus in this section is general in nature, and any arrangement of equipment capable of performing the test procedure within the allowable tolerances is permitted.

6.2 Major Components (Fig. 1):

6.2.1 *Test Chamber* or box with an opening, a removable mounting panel, or one open side in which or against which the specimen is installed and sealed. At least one static pressure tap shall be provided to measure the chamber pressure, and shall be so located that the reading is unaffected by the velocity of the air supply to or from the chamber. The air supply opening into the chamber shall be arranged so that the air does not

impinge directly on the test specimen with any significant velocity. A means of access into the chamber may be provided to facilitate adjustments and observations after the specimen has been installed.

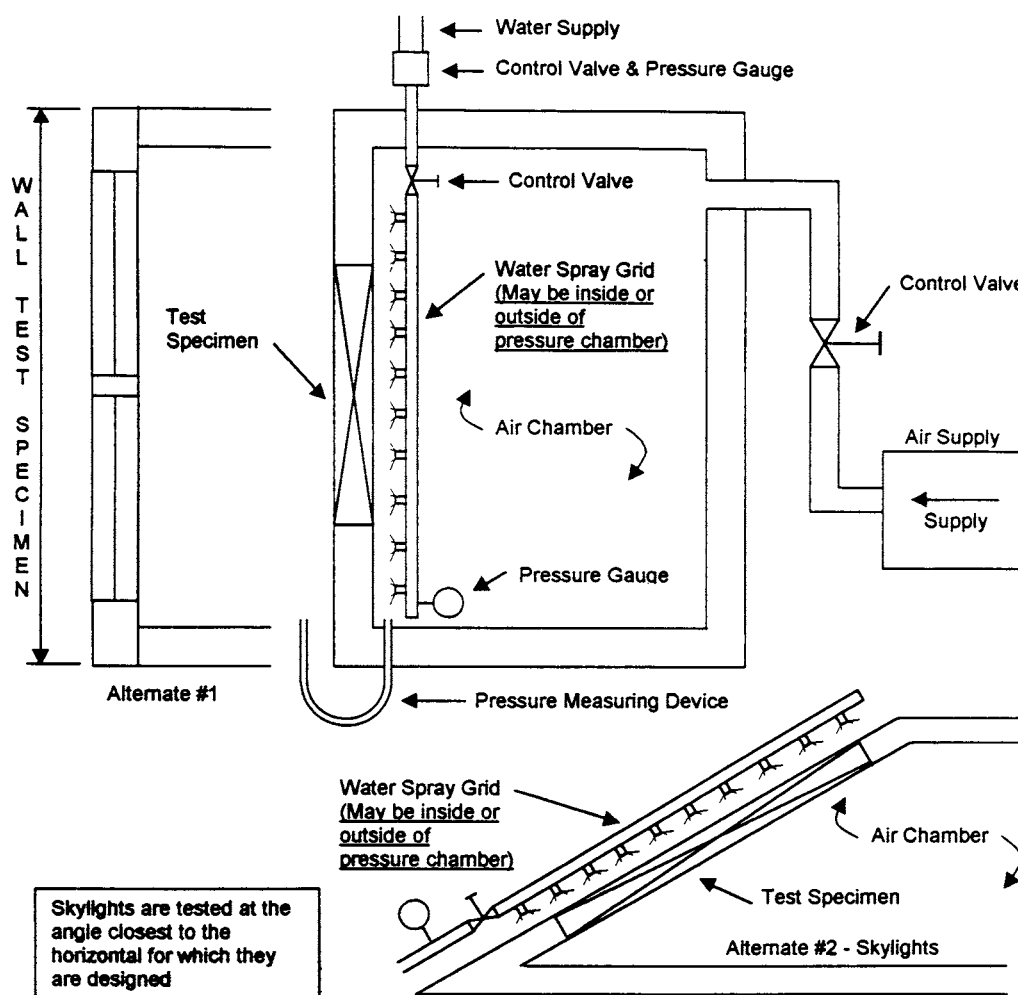
6.2.2 *Air System*—A controllable blower, compressed air supply, exhaust system, or reversible blower designed to provide the required maximum air-pressure difference across the specimen. The system must provide essentially constant air flow at a fixed pressure for the required test period.

6.2.3 *Pressure-Measuring Apparatus*—A device to measure the test pressure difference within a tolerance of $\pm 2\%$ or ± 2.5 Pa (± 0.01 in. of water column), whichever is greater.

6.2.4 Water-Spray System:

6.2.4.1 The water-spray system shall deliver water uniformly against the exterior surface of the test specimen at a minimum rate of $3.4 \text{ L/m}^2 \cdot \text{min}$ ($5.0 \text{ U.S. gal/ft}^2 \cdot \text{h}$).

6.2.4.2 The water-spray system shall have nozzles spaced on a uniform grid, located at a uniform distance from the test specimen, and shall be adjustable to provide the specified quantity of water in such a manner as to wet all of the test



NOTE 1—For a negative pressure system, the water-spray grid would be located outside the chamber and the air supply would be replaced by an air-exhaust system.

FIG. 1 General Arrangement of the Water Leakage Apparatus Positive Chamber System

specimen uniformly and to wet those areas vulnerable to water penetration. If additional nozzles are required to provide uniformity of water spray at the edge of the test specimen, they shall be equally spaced around the entire spray grid.

7. Hazards

7.1 **Warning**—Glass breakage will not normally occur at the small pressure differences applied in this test. Excessive pressure differences may occur, however, due to error in operation or when the apparatus is used for other purposes such as structural testing; therefore, exercise adequate precautions to protect personnel.

8. Test Specimens

8.1 Test specimens shall be of sufficient size to determine the performance of all typical parts of the fenestration system. For curtain walls or walls constructed with prefabricated units, the specimen width shall be not less than two typical units plus the connections and supporting elements at both sides, and sufficient to provide full loading on at least one typical vertical joint or framing member, or both. The height shall be not less than the full building-story height or the height of the unit, whichever is greater, and shall include at least one full horizontal joint accommodating vertical expansion such joint being at or near the bottom of the specimen, and all connections at the top and bottom of the units.

8.1.1 All parts of the test specimen shall be full size, using the same materials, details, and methods of construction and anchorage as used on the actual building.

8.1.2 Conditions of structural support shall be simulated as accurately as possible.

8.2 Window, skylight, door, or other component test specimens shall consist of the entire assembled unit, including frame and anchorage as supplied by the manufacturer for installation in the building.

8.2.1 If only one specimen is to be tested, the selection shall be determined by the specifying authority.

NOTE 3—It should be recognized, especially with windows, that performance is likely to be a function of size and geometry. Therefore, select

specimens covering the range of sizes to be used in a building. In general, the largest size of a particular design, type, construction, and configuration to be used should be tested.

9. Calibration

9.1 The ability of the test apparatus to meet the requirements of 6.2.4 shall be checked by using a catch box, the open face of which shall be located at the position of the face of the test specimen. The calibration device is illustrated in Fig. 2. The catch box shall be designed to receive only water impinging on the plane of the test specimen face and to exclude all run-off water from above. The box shall be 610 mm (24 in.) square, divided into four areas each 305 mm (12 in.) square. Use a cover approximately 760 mm (30 in.) square to prevent water from entering the calibration box before and after the timed observation interval. The water impinging on each area shall be captured separately. A spray that provides at least 1.26 L/min (20 gal/h) total for the four areas and not less than 0.25 L/min (4 gal/h) nor more than 0.63 L/min (10 gal/h) in any one square shall be acceptable.

9.1.1 The water-spray system shall be calibrated at both upper corners and at the quarter point of the horizontal center line (of the spray system). If a number of identical, contiguous, modular spray systems are used, only one module need be calibrated. The system shall be calibrated with the catch boxes at a distance within ± 51 mm (2 in.) of the test specimen location from the nozzle. The reference point for location of the spray system from the specimen shall be measured from the exterior glazing surface of the specimen farthest from the spray system nozzles. The water spray rack shall be installed parallel to the plane of the specimen. Recalibrate at intervals of, not more than, 6 months.

10. Information Required

10.1 The test-pressure difference or differences at which water penetration is to be determined, unless otherwise specified, shall be 137 Pa (2.86 lbf/ft²).

10.2 Unless otherwise specified, failure criteria of this test method shall be defined as water penetration in accordance with 3.2.3. Failure also occurs whenever water penetrates

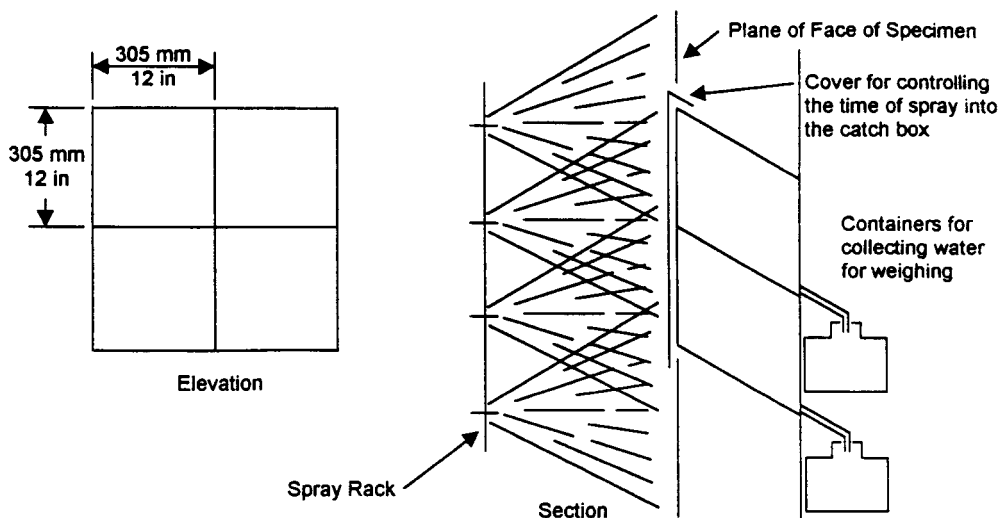


FIG. 2 Catch Box for Calibrating Water-Spray System

through the perimeter frame of the test specimen. Water contained within drained flashing, gutters, and sills is not considered failure.

10.3 The periods of time during which the specimen is to be subjected to pressure difference(s) shall be specified.

10.3.1 In no case shall there be less than two test cycles, and no cycle shall be less than 5 min in duration.

10.3.2 In no case shall the total time of pressure application be less than 15 min.

10.4 If this test method is to be used at other than ambient temperatures, such temperature conditions shall be specified.

11. Procedure

11.1 Remove any sealing material or construction that is not normally a part of the assembly as installed in or on a building. Fit the specimen into or against the chamber opening with the outdoor side of the specimen facing both the high pressure side of the chamber and the water spray, and in such a manner that no joints or openings are obstructed. Skylight specimens shall be tested at the minimum angle from the horizontal for which they are designed to be installed. Seal the outer perimeter of the specimen to the chamber wall and seal at no other points.

NOTE 4—Nonhardening mastic compounds or pressure-sensitive tape can be used effectively to seal the test specimen to the chamber opening, to seal the access door to the chamber, and to achieve airtightness in the construction of the chamber. These materials can be used to seal a separate mounting panel to the chamber. Rubber gaskets with clamping devices may also be used for this purpose provided that the gasket is highly flexible and has a thin contact edge.

11.2 Without disturbing the seal between the specimen and the test chamber, adjust all operable units included in the test specimen so that their operation conforms to the specification requirements. Adjust all hardware for maximum tightness without interfering with their operation.

11.3 Submit each operable unit to five cycles of opening, closing, and locking prior to testing.

11.4 Adjust the water spray to the specified rate.

11.5 Apply the air pressure difference within 15 s and maintain this pressure, along with the specified rate of water spray, for the period of time stipulated by the specification or specifier.

11.6 While maintaining the water spray, reduce the air pressure difference to zero for a period of not less than 1 min.

11.7 Repeat procedure in 11.5 and 11.6 for the specified number of cycles.

11.8 At the conclusion of the required number of cycles (see 10.3.1) remove the air-pressure difference and stop the water spray.

11.9 Observe and record the points of water penetration, if any.

12. Report

12.1 Report the following information:

12.1.1 Dates of test and of report.

12.1.2 Identification of the specimen (manufacturer, source of supply, dimensions, model, type, materials, and other pertinent information).

12.1.3 Detailed drawings of the specimen that provide a description of the physical characteristics, including dimensioned section profiles, sash or door dimensions and arrangement, framing location, panel arrangement, installation and spacing of anchorage, weatherstripping, locking arrangement, hardware, sealants, glazing details, angle from the horizontal for skylights, and any other pertinent construction details. Any modifications made on the specimen to obtain the reported values shall be noted on the drawings.

12.1.4 For window, skylight, and door components, a description of the locking and operating mechanism.

12.1.5 Identification of glass thickness and type and method of glazing.

12.1.6 Type or types of weatherstrip.

12.1.7 A statement or tabulation of pressure difference or differences exerted across the specimen and temperature during the test, number and duration of pressure difference applications, and water application rates during the test.

12.1.8 A record of all points of water penetration on the indoor face of the specimen, and of water penetration as defined in 3.2.3.

12.1.9 When the tests are made to check the conformity of the specimen to a particular specification, an identification or description of that specification shall be included.

12.1.10 A statement that the test or tests were conducted in accordance with this test method, or a complete description of any deviations from this test method.

12.2 If several identical specimens of a component are tested, the results for all specimens shall be reported, each specimen being properly identified, particularly with respect to distinguishing features or differing adjustments. A separate drawing for each specimen shall not be required if all differences between them are noted on the drawings provided.

13. Precision and Bias

13.1 No statement is made either on the precision or bias of this test method for measuring water penetration since the result merely states whether there is conformance to the criteria specified for success.

14. Keywords

14.1 curtain walls; doors; skylights; water penetration; windows

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