Designation: E1680 – 16 (Reapproved 2022)

Standard Test Method for Rate of Air Leakage through Exterior Metal Roof Panel Systems[1]

This standard is issued under the fixed designation E1680; 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 metal roof panel systems to air infiltration resulting from either positive or negative air pressure differences. The test method described is for tests with constant temperature and humidity across the specimen. This test method is a specialized adaption of Test Method E283.

1.2 This test method is applicable to any roof area. This test method is intended to measure only the air leakage associated with the field of the roof, including the panel side laps and structural connections; it does not include leakage at the openings or perimeter or any other details.

1.3 The proper use of this test method requires knowledge of the principles of air flow and pressure measurements.

1.4 The text of this test method references notes and footnotes excluding tables and figures, which provide explanatory material. These notes and footnotes shall not be considered to be requirements of the test method.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 7.

1.7 *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]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

E631 Terminology of Building Constructions

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1592 Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference

E1646 Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference

2.2 *Other Standard:*[3]

AAMA 501 Methods of Test for Metal Curtain Walls

3. Terminology

3.1 *Definitions*—For definitions of general terms relating to building construction used in this test method, see Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air leakage (Q)*—the volume of air flowing per unit of time through the assembled specimen under a test pressure difference, expressed in cubic feet per minute (cubic metres per second).

3.2.2 *extraneous air leakage (Q_L)*—the difference between the metered air flow (Q_m) and air leakage (Q); the leakage of the remainder of the test chamber.

3.2.3 *metered air flow (Q_m)*—the volume of air flowing per unit of time through the air flow metering system, expressed in cubic feet per minute (cubic metres per second).

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.57 on Performance of Metal Roof Systems.

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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] Available from Fenestration & Glazing Industry Alliance (FGIA), 1900 E Golf Rd, Suite 1250, Schaumburg, IL 60173, https://www.fgiaonline.org/.

3.2.4 *rate of air leakage*—the air leakage per unit of specimen area (*A*), expressed in cubic feet per minute per square foot (cubic metres per second per square metre).

3.2.5 *reference standard conditions*—dry air at a pressure of 29.92 in. Hg (101.3 kPa), temperature of 69.4 °F (20.8 °C), and air density of 0.075 lb/ft^3 (1.2 kg/m^3).

3.2.6 *specimen*—the entire assembled unit submitted for testing as described in Section 8.

3.2.7 *specimen area (A)*—the area determined by the overall dimensions of the test specimen expressed in square feet (square metres). The dimensions used to determine area shall not include exterior framework.

3.2.8 *test pressure difference*—the specified difference in static air pressure across the fixed specimen, expressed in pounds-force per square foot (pascals).

4. Summary of Test Method

4.1 The test procedure consists of sealing and fixing a test specimen into or against one face of an air chamber, supplying air to or exhausting air from the chamber at the rate required to maintain the specified test pressure difference across the specimen, and measuring the resultant air flow through the specimen.

5. Significance and Use

5.1 This test method is a standard procedure for determining air leakage characteristics under specified air pressure differences.

NOTE 1—The air pressure differences acting across a building envelope vary greatly. The slope of the roof and other factors affecting air pressure differences and the implications of the resulting air leakage relative to the environment within buildings are discussed in the literature.[4,5,6] These factors shall be considered fully when specifying the test pressure difference to be used.

NOTE 2—When applying the results of tests by this test method, note that the performance of a roof or its components, or both, may be a function of proper installation and adjustment. The performance in service will also depend on the rigidity of supporting construction, the presence of interior treatments, the roof slope, and the resistance of components to deterioration by various causes: corrosive atmospheres, aging, ice, vibration, thermal expansion, and contraction, etc. It is difficult to simulate the identical complex environmental conditions that can be encountered in service, including rapidly changing pressures due to wind gusting. Some designs are more sensitive than others to these environmental conditions.

5.2 Rates of air leakage are sometimes used for comparison purposes. The comparisons are not always valid unless the components being tested and compared are of essentially the same size, configuration, and design.

NOTE 3—The specimen construction discussed in 1.2 and required in 8.1 isolates a source of leakage. The rate of air leakage measured during the test method has units of cubic feet per minute per square foot (litres per second per square metre). Openings and details such as end laps or roof curbs are excluded since leakage is measured more appropriately in cubic feet per minute per foot (litres per second per metre) at these conditions. The test specimen area is relatively small; the inclusion of details will give unrealistic import to the detail's presence when compared to actual roof constructions. This test method shall not be relied on singularly to form conclusions about overall air leakage through metal roofs. A roof contains many details. Although prescribed modifications are outside the scope of this test method, an experienced testing engineer is able to use the principles presented in the test method and to generate significant data by isolating specific details and measuring leakage.

Additional leakage sources are introduced if details are included. If total leakage is then measured, the results will generally be conservative relative to tests without details. To minimize the number of tests, the specifier may allow details such as end laps when qualitative or general quantitative results are desired and the isolation of sources is not required for performance. Only one panel end lap shall be allowed. The user shall be aware of the bias when comparing alternate systems if end laps are included.

NOTE 4—This is a test procedure. It is the responsibility of the specifying agency to determine the specimen construction, size, and test pressures after considering the test methods' guidelines. Practical considerations suggest that every combination of panel thickness, span, and design load need not be tested in order to substantiate product performance.

6. Apparatus

6.1 This description of the apparatus 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* (see Fig. 1).

6.2.1 *Test Chamber*—A well-sealed chamber or box with either an opening, a removable mounting panel, or one open face in which or against which the specimen is installed and sealed. The specimen shall be installed horizontally. At least one static pressure tap shall be provided to measure the chamber pressure. All pressure taps shall be located so that the reading is unaffected by the air supply either to or from the chamber. The air supply opening into the chamber shall be arranged so that air does not impinge directly on the test specimen with any significant velocity. When required, a means of access shall be provided into the chamber 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 air flow at the specified test pressure difference. the system shall provide constant air flow at a fixed pressure for the period required to obtain readings of air flow and pressure difference, and it shall be capable of maintaining positive and negative pressures.

6.2.3 *Pressure Measuring Apparatus*—A device for measuring the test pressure difference within a tolerance of ±2 %, or ±0.01 in. (±2.5 Pa), of water column, whichever is greater. The device must measure positive and negative pressures.

6.2.4 *Air-Flow Metering System*—A device to measure the air flow within the limitations of error prescribed in 6.3. (The publications listed in Footnotes 5 and 6[5,6] present background information on fluid metering practices.)

6.3 The air flow through the test specimen shall be determined with an error not greater than ± 5 % when this flow equals or exceeds 2 ft^3/min (0.94 L/s) or ± 10 % when the air flow is below 2 ft^3/min but more than ½ ft^3/min (0.24 L/s).

[4] *ASHRAE Handbook of Fundamentals*, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., 1972, Chapter 25.

[5] *Fluid Meters—Their Theory and Application*, 5th edition, 1959.

[6] Chapter 4, "Flow Measurements," *ASME—Power Test Code*, 2nd edition, Part 5, 1956.

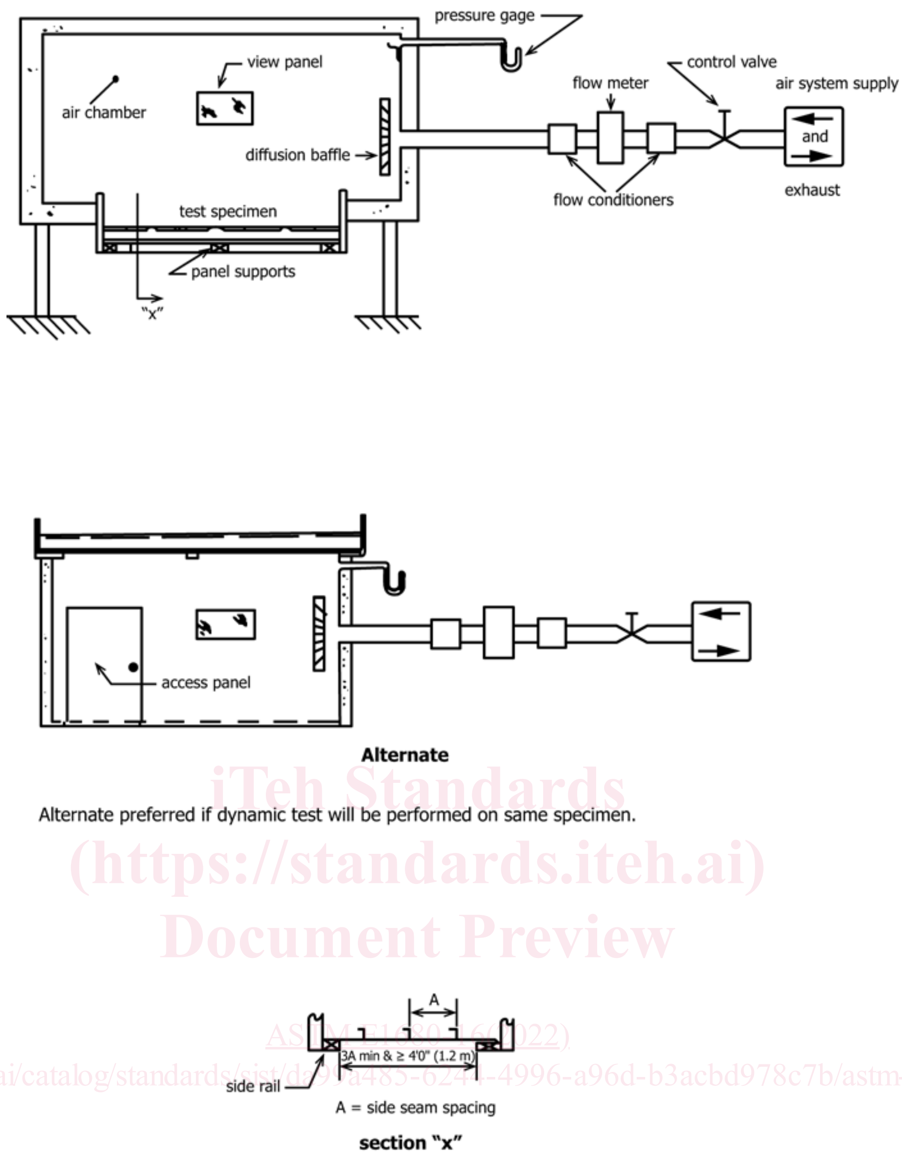

FIG. 1 General Arrangement of Air Leakage Apparatus

NOTE 5—A greater percentage of error will usually be acceptable at lower flows. Special flow-measuring techniques are necessary if higher precision is required. The accuracy of the specimen leakage flow measurement is affected by the accuracy of the flowmeter and amount of extraneous leakage of the apparatus (see Annex A1 of Test Method E283).

7. Safety Precautions

7.1 Glass breakage and specimen failure will not normally occur at the small pressure differences applied in this test procedure. Larger or excessive pressure differences occur during preload, 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 Specimen

8.1 The roof specimen shall be of sufficient size to determine the performance of all typical parts of the roof system. For roofs constructed with prefabricated or preformed units or panels, the specimen width shall be equivalent to or greater than the width of three typical units plus the side rail supporting elements at each edge. The specimen shall contain at least three assembled side lap seams; this allows partial width units. The specimen width shall be sufficient to provide loading on at least one typical unit (see Fig. 1). When partial width units are used at the specimen sides, the maximum portion to be used in calculating the specimen area shall be one half of the unit. The specimen shall be of sufficient length to develop a multispan condition unless the panel is used only in single-span applications. If two spans are used, they shall be unequal, with the shorter being 75 % of the longer. Building perimeter details need not and interior details, other than typical side seams, shall not be inlcuded (see Note 3 for commentary and exceptions). The specimen perimeter shall be well sealed.

NOTE 6—The unbalanced span criterion more closely simulates multi-span panel deflection curvature. This works the panel sidelap while minimizing the specimen length.

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

8.1.2 The condition of structural support shall be simulated as accurately as possible. If the roof accommodates thermal expansion parallel to the panel length, this detail must be included in the test specimen, and the interior support must be able to slide parallel to the panel or its attachment, or both.

8.2 If insulation is an optional component of the roof system, it shall not be included in the test specimen.

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

NOTE 7—Air leakage is likely to be a function of size, geometry, and stiffness. Therefore, select specimens covering the range of sizes to be used in a building. In general, the largest size and least stiff of a particular design, type, construction, and configuration shall be tested (see Note 3 for related commentary).

9. Calibration

9.1 Calibration shall be accomplished by mounting a plywood or similar rigid blank to the test chamber in place of a test specimen, using the same mounting procedures as those used for standard specimens. The blank shall be 7⁄8 in. ± 1⁄8 in. (22 mm ± 3 mm) thick, with a 6 in. (150 mm) diameter hole over which calibrated orifice plates shall be mounted. The blank is not prohibited from accommodating more than one orifice plate.

9.2 Each calibration orifice plate shall be constructed of 1⁄8 in. (3 mm) thick stainless steel having an outside diameter of 8 in. (200 mm) and containing an interior diameter square-edged orifice, which has been calibrated traceable to the National Institute of Standards and Technology (NIST) at 0.57 lbf⁄ft^2, 1.57 lbf⁄ft^2, and 6.24 lbf/ft^2 (27 Pa, 75 Pa, and 298 Pa).

NOTE 8—Calibrated orifice plates traceable to NIST may be obtained by using the method in Annex A2 of Test Method E283.

9.3 Fasten the calibration orifice plate to the blank, center the plate over a 6 in. (150 mm) diameter hole, and seal it with a suitable adhesive tape or mastic compound to prevent perimeter leakage.

NOTE 9—Chambers having a minimal depth dimension may create air flow patterns that affect the calibration results. A minimum chamber depth of four orifice diameters should be available to alleviate this condition, or multiple orifice plates should be used, with the distance between orifice plates being four orifice diameters at minimum.

9.4 Calibration shall consist of determining the flow through the meter system to be calibrated using at least one reference orifice plate within each of the following ranges:

ft^3/min (m^3/h)
0–10 (0–17)
10–20 (17–34)
20–40 (34–68)
40–80 (68–136)

The air-flow measuring system shall be considered within the limits of calibration when the maximum air-flow reading under test does not exceed the highest calibration performed by more then 20 %.

9.5 Performance of the flow measurements shall be made under normal operation conditions for the laboratory being calibrated. Provision must be made to account for extraneous chamber leakage so as not to compromise the integrity of the calibration procedure.

9.6 Flow readings shall be measured at each of the three pressure differentials given in 9.2. Reverse the calibration orifice plate if required, reseal the plate, and measure the flow readings at the negative value of each of the three pressure differentials given in 9.2.

9.7 The measured flow at each listed pressure for each orifice plate must be in accordance with the limits given in 6.3.

9.8 Calibration shall be performed every six months at a minimum.

10. Information Required

10.1 Unless otherwise specified, the test-pressure difference or differences at which air leakage is to be determined shall be −1.57 lbf/ft^2 (−75 Pa). Unless otherwise specified, test-pressure differences shall be both + and −1.57 lbf⁄ft^2 for roof applications steeper then 30° from horizontal.

NOTE 10—This commentary is included to assist the specifier in the selection of test pressures. This test method is consistent with the Test Method E283 default test pressure and the AAMA 501.

Shallow roofs rarely see large positive wind pressures unless the resultant pressure is caused by building openings. The Test Method E283 default magnitude has been adopted for low sloped roofs, but a negative pressure has been chosen. Positive pressures are more probable at steeper slopes. Most model codes recognize this, and 30° from horizontal is generally selected as the slope above which positive external wind pressures must be considered. This test method selects the 30° slope as its break point. The test method adopts Test Method E283 test pressure recommendations over the steeper slope range but requires both positive and negative pressure applications.

If a product will be used only on applications greater than 60° from horizontal, consider testing in accordance with Test Method E283 while recognizing that steep roofs are subjected to positive and negative wind loads and that the preload criteria make this test method meaningful at the steepest slopes.

This test method's default test pressures recognize that service conditions of any duration are associated with lower velocity winds; this does not imply that air leakage associated with hurricanes would be acceptable. The test method provides a valid means of comparing systems. Do not exceed the default conditions unless unusual site conditions exist or "value added" benefits are required and have been considered.

10.2 The preload test pressure differences, positive and negative, are to be specified. The positive preload pressure difference shall be the greater of 75 % of the building live load or 50 % of the building design positive wind pressure difference. The positive test pressure shall be greater than or equal to 15 lb/ft^2 (720 Pa). The negative preload pressure difference shall be 50 % of the design wind uplift pressure difference.

NOTE 11—This is not a structural adequacy test; For example, among others, Test Method E1592 is used for roofs. The preload test pressure requirement of 11.3 and the thermal movement requirement of 11.2 represent significant departures from the Test Method E283 procedure. The requirements are included to work the side seams prior to imposing test pressures. The requirements illustrate a greater concern over roof leaks plus the greater panel lengths and consequent expansion in roofs. The recommended design pressures and number of applications do not overly tax the capacities of most test apparatus nor lengthen the time duration of tests since they simulate service life by repetitively preloading