Designation: E283 – 04 (Reapproved 2012)

Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen[1]

This standard is issued under the fixed designation E283; 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.

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

1. Scope

1.1 This test method covers a standard laboratory procedure for determining the air leakage rates of exterior windows, curtain walls, and doors under specified differential pressure conditions across the specimen. The test method described is for tests with constant temperature and humidity across the specimen.

1.2 This laboratory procedure is applicable to exterior windows, curtain walls, and doors and is intended to measure only such leakage associated with the assembly and not the installation. The test method can be adapted for the latter purpose.

NOTE 1—Performing tests at non-ambient conditions or with a temperature differential across the specimen may affect the air leakage rate. This is not addressed by this test method.

1.3 This test method is intended for laboratory use. Persons interested in performing field air leakage tests on installed units should reference Test Method E783.

1.4 Persons using this procedure should be knowledgeable in the areas of fluid mechanics, instrumentation practices, and shall have a general understanding of fenestration products and components.

1.5 The values stated in SI units are to be regarded as 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 problems, 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 statement see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E783 Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors

3. Terminology

3.1 *Definitions*—Terms used in this standard are defined in Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air leakage rate (q_A or q_l), L/(s·m^2) (ft^3/min·ft^2), or L/(s·m) (ft^3/min·ft)* —the air leakage per unit of specimen area (A) or per unit length of operable crack perimeter (l).

3.2.2 *extraneous air leakage (Q_e), m^3/s (ft^3/min)*—the volume of air flowing per unit of time through the test chamber and test apparatus, exclusive of the air flowing through the test specimen, under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.2.1 *Discussion*—Extraneous leakage is the sum of all leakage other than that intended to be measured by the test.

3.2.3 *specimen*—the entire assembled unit submitted for test as described in Section 7.

3.2.4 *specimen air leakage (Q_s), L/s (ft^3/min)*—the volume of air flowing per unit of time through the specimen under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.5 *specimen area (A), m^2 (ft^2)*—the area determined by the overall dimensions of the frame that fits into the rough opening.

3.2.6 *standard test conditions*—in this test method, dry air at:

Pressure—101.3 kPa (29.92 in. Hg)
Temperature—20.8°C (69.4°F)
Air Density—1.202 kg/m^3 (0.075 lbm/ft^3)

[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.

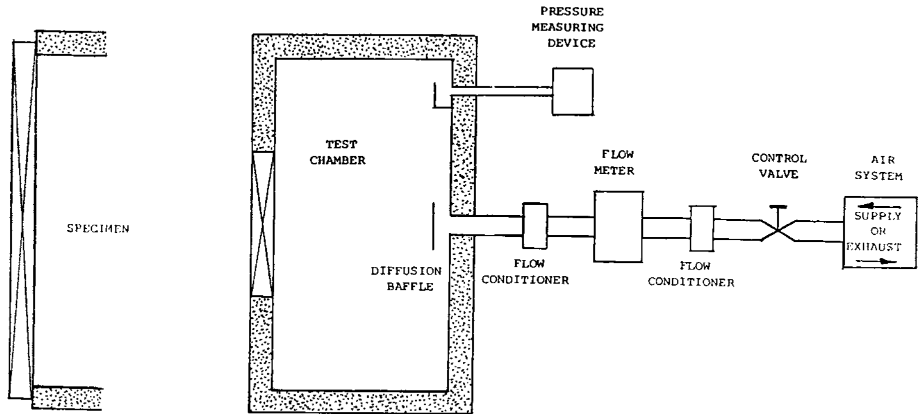

FIG. 1 General Arrangement of the Air Leakage Apparatus

3.2.7 *test pressure differences, Pa (lbf/ft^2)*—the specified differential static air pressure across the specimen.

3.2.8 *total air flow (Q_t), L/s (ft^3/min)*—the volume of air flowing per unit of time through the test chamber and test apparatus, inclusive of the air flowing through the test specimen, under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.9 *unit length of operable crack perimeter (l), m (ft)*—the sum of all perimeters of operable ventilators, sash, or doors contained in the test specimen, based on the overall dimensions of such parts. Where two such operable parts meet the two adjacent lengths of perimeter shall be counted as only one length.

4. Summary of Test Method

4.1 The test consists of sealing 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 the air leakage characteristics under specified air pressure differences at ambient conditions.

NOTE 2—The air pressure differences acting across a building envelope vary greatly. The factors affecting air pressure differences and the implications or the resulting air leakage relative to the environment within buildings are discussed in the literature.[3,4,5] These factors should be fully considered in specifying the test pressure differences to be used.

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

6. Apparatus

6.1 The description of the apparatus in this section is general in nature. Any suitable arrangement of equipment capable of maintaining the required test tolerances is permitted.

6.2 *Test Chamber*—A well sealed box, wall, or other apparatus into or against which the specimen is mounted and secured for testing. An air supply shall be provided to allow a positive or negative pressure differential to be applied across the specimen without significant extraneous losses. The chamber shall be capable of withstanding the differential test pressures that may be encountered in this procedure. At least one static air pressure tap shall be provided on each side of the specimen to measure the test pressure differences. The pressure tap shall be located in an area of the chamber in which pressure readings will not be affected by any supply air. The air supply opening to the chamber shall be located in an area in which it does not directly impinge upon the test specimen.

6.2.1 *Supply Air System*—A controllable blower, exhaust fan, or reversible blower designed to provide the required air flow at the specified test pressure difference. The system should provide essentially constant air flow at the specified test pressure difference for a time period sufficient to obtain readings of air flow.

6.2.2 *Pressure Measuring Apparatus*—A device to measure the differential test pressures to ±2 % of setpoint or ±2.5 Pa (±0.01 in. of water column), whichever is greater.

6.2.3 *Air Flow Metering System*—A device to measure the air flow into the test chamber or through the test specimen.

7. Hazards

7.1 **Precaution—**Glass breakage may occur at the test pressure differences applied in this test. Adequate precautions should be taken to protect personnel.

8. Test Specimen

8.1 The test specimen for a wall shall be of sufficient size to determine the performance of all typical parts of the wall 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

[3] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

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

[5] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

shall be not less than the full building story height or the height of the unit, whichever is greater, and shall include at least on full horizontal joint, accommodating vertical expansion, such joint being at or near the bottom of the specimen, as well as all connections at top and bottom of the units.

8.1.1 All parts of the wall 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 The test specimen for a window, door, or other component shall consist of the entire assembled unit, including frame and anchorage as supplied by the manufacturer for installation in the building. If only one specimen is to be tested the selection shall be determined by the specifying authority.

NOTE 3—The air leakage rate is likely to be a function of size and geometry of the specimen.

9. Calibration

9.1 Calibration shall be performed by mounting a plywood or similar ridge blank to the test chamber in place of a test specimen, using the same mounting procedures as used for standard specimens. The blank shall be 19 ± 3 mm (¾ ± ⅛ in.) thick with a 150-mm (6-in.) diameter hole(s) over which NIST traceable orifice plates shall be mounted. The blank shall be attached to a minimum 140 mm (5 ½ in.) deep (nominal 2 × 6) pine test frame (buck) with dimensions 1220 mm wide by 1830 mm high (4 ft wide by 6 ft high). The test frame and blank shall be sealed at all joints.

9.2 Each NIST traceable orifice plate shall be constructed of 3 mm (⅛ in.) thick stainless steel having an outside diameter of 200 mm (8 in.) and interior square edge diameters of 25.40 mm (1.000 in.), 38.10 mm (1.500 in.), and 50.80 mm (2.000 in.).

9.3 Fasten the orifice plate to the blank, centered over a 150–mm (6–inch) diameter hole. Seal the hole in the orifice plate with a suitable adhesive tape so that an extraneous reading on the air flow system can be obtained. Measure the amount of such leakage with the orifice plate sealed, at the air pressure difference to be applied during calibration. After determining the extraneous leakage, remove the adhesive tape from the hole in the orifice plate and repeat the process to determine the total measured flow.

9.4 Calibration of the air leakage test equipment shall consist of determining the flow through the air flow system to be calibrated using all applicable orifice plate sizes for the design range of the flow metering apparatus. The orifice plate to be used for each of the following air flow ranges is indicated in Table.

Orifice Plate Hole Sizes	Nominal Flow	Differential Pressure Across Orifice Plate
25.4 mm (1.0 in.)	3.47 L/s (7.36 ft^3/min)	75 Pa (1.57 psf)
38.1 mm (1.5 in.)	7.66 L/s (16.24 ft^3/min)	75 Pa (1.57 psf)
50.8 mm (2.0 in.)	13.64 L/s (28.90 ft^3/min)	75 Pa (1.57 psf)

NOTE 4—Three orifice plates are used to allow the air flow measuring equipment to be used for a variety of specimen sizes and chamber/wall setups.

NOTE 5—At test pressure other than 75 Pa (1.57 psf), the laboratory shall calibrate the airflow measuring equipment with the applicable orifice plates and record the measurements at the specified pressure(s). Using pressures greater than 75 Pa (1.57 psf) may not permit reproducibility between laboratories, nor may it warrant meeting calibration tolerance requirements as specified at 75 Pa (1.57 psf).

9.5 The air flow measuring system shall be considered within the limits of calibration when the maximum air flow reading during testing does not exceed the highest calibrated air flow value by 20 %. The air flow measuring system shall be considered to be all piping and test chamber elements from the air flow measuring device to the orifice plate.

9.6 The measured flow at each listed pressure for each orifice plate shall be determined with an error not greater than ± 5 % when the flow is greater than 0.944 L/s (2 ft^3/min) or ± 10 % when the flow is less than 0.944 L/s (2 ft^3/min) but greater than 0.236 L/s (0.5 ft^3/min).

NOTE 6—At lower flows, a greater percentage of error will usually be acceptable. If higher precision is required, special flow measuring techniques are necessary. The accuracy of the specimen leakage flow measurement is affected by the accuracy of the flowmeter and the amount of extraneous leakage of the apparatus (Annex A1).

9.7 Alternate means may be used for calibrating the air flow measuring system as long as they can be proven to provide the same level of accuracy and are traceable to NIST.

9.8 Calibration shall be performed at least once every six months using the method described above. Alternative orifice mounting conditions may be used during interim calibration periods for air flow checking purposes.

10. Test Conditions

10.1 The specifying authority shall supply the following information:

10.1.1 Specimen test size,

10.1.2 Test pressure difference (if no value is designated, 75 Pa (1.57 lb/ft^2)), and

10.1.3 Direction of air flow, exfiltration or infiltration. (If none is specified, the test shall be infiltration.)

10.2 *Air Leakage Rate*—Basis for reporting air leakage rate shall be total air leakage L/s (ft^3/min), per unit length of operable crack perimeter, L/(s·m) (ft^3/min·ft), and per unit area of outside frame dimension, L/(s·m^2) (ft^3/min·ft^2).

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. Installation should be such that no parts or openings of the specimen are obstructed.

NOTE 7—Nonhardening mastic compounds or pressure sensitive tape can be used effectively to seal the test specimen to the chamber, and to achieve air tightness in the construction of the chamber. These materials can also 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 narrow contact edge.

11.2 Without disturbing the seal between the specimen and the test chamber, adjust all hardware, ventilators, balances, sash, doors, and other components included as an integral part of the specimen so that their operation conforms to test method requirements.

11.3 To ensure proper alignment and weather seal compression, fully open, close, and lock each ventilator, sash, or door five times prior to testing.

11.4 Adjust the air flow through the test chamber to provide the specified test pressure difference across the test specimen. When the test conditions are stabilized, record the air flow through the flowmeter and the test pressure difference. This measured air flow is designated the total air flow, Q_t. Measure the barometric pressure, and temperature of the air at the test specimen.

11.5 Eliminate extraneous chamber leakage, or, if this is impractical, measure the amount of such leakage with the specimen sealed at the air pressure differences to be exerted during the air leakage tests. Designate this measured air flow as the extraneous air flow, Q_e.

12. Calculation

12.1 Express the total air flow, Q_t, and the extraneous leakage, Q_e, in terms of flow at standard conditions, Q_{st}, using the Eq 1 and 2.

$$Q_{st} = Q(W/W_s)^{1/2} \quad (1)$$

$$W = 3.485 \times 10^{-3} (B/(T+273)) \quad (2)$$

where:

Q = airflow at non-standard conditions, L/s (ft^3/min)
Q_{st} = airflow corrected to standard conditions, L/s (ft^3/min)
W_s = density of air at reference standard conditions—1.202 kg/m^3 (0.075 lb/ft^3),
W = density of air at the test site, kg/m^3 (lb/ft^3),
B = barometric pressure at test site corrected for temperature, Pa (in. Hg), and
T = temperature of air at flowmeter, °C (°F).

NOTE 8—Use the equation $W = 1.326 (B/(T + 460))$ for calculating in inch-pound units (lb/ft^3).

12.2 Express the air leakage through the test specimen as follows:

$$Q_s = Q_t - Q_e \quad (3)$$

where:

Q_s = air leakage through the test specimen, L/s (ft^3/min), at standard conditions.

12.3 Calculate the rate of air leakage for the test specimen according to 12.3.1 and 12.3.2.

12.3.1 To calculate q_l rate of air leakage per unit of length of operable crack perimeter use Eq 4:

$$q_l = Q_s/l, \text{ L/(s·m) (ft}^3\text{/min·ft)} \quad (4)$$

12.3.2 To calculate q_A rate of air leakage per unit area:

$$q_A = Q_s/A, \text{ L/(s·m}^2\text{) (ft}^3\text{/min·ft}^2\text{)} \quad (5)$$

13. Report

13.1 Report the following information:

13.1.1 *General*—Testing agency, date and time of test, and date of report.

13.1.2 *Sample Description*—Manufacturer, model, operation type, materials, and other pertinent information; description of the locking and operating mechanisms if applicable; glass thickness, type and method of glazing; weather seal dimensions, type, and material; and crack perimeter and specimen area.

13.1.3 *Drawings of Specimen*—Detailed drawings of the specimen showing 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, and any other pertinent construction details. Any modifications made on the specimen to obtain the reported test values shall be noted.

13.1.4 *Location of Air Seal*—Detailed drawing showing the air seal between the test specimen and the test chamber or mounting frame. The drawing shall clearly indicate the location of the air seal relative to the specimen frame.

13.1.5 *Test Parameters*—List or describe the specified test pressure difference(s), whether the tests were conducted for infiltration or exfiltration, and whether a positive or negative test pressure was used.

13.1.6 *Pressure Differences and Leakage*—A statement or tabulation of the pressure differentials exerted across the specimen during the test and the corresponding specimen air leakage (Q_s) and the two air leakage rates (q_l and q_A).

13.1.7 *Compliance Statement*—A statement that the tests were conducted in accordance with this test method, or a complete description of any deviation from this test method. When the tests are conducted to check for conformity of the specimen to a particular performance specification, the specification shall be identified.

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

14. Precision and Bias

14.1 The precision and bias of this test method has not been determined.

15. Keywords

15.1 air leakage; curtain walls; doors; fenestration; laboratory method; static pressure chamber; windows

ANNEX

(Mandatory Information)

A1. ERRORS IN WINDOW AIR LEAKAGE MEASUREMENT

A1.1 Terminology

A1.1.1 *Symbols:*

A1.1.1.1 Q_s = air flow through specimen.

A1.1.1.2 Q_{ts} = total air flow.

A1.1.1.3 Q_{es} = extraneous air flow.

A1.1.1.4 Δ = delta.

NOTE A1.1—Symbols A1.1.1.1-A1.1.1.4 have been converted to standard conditions.

A1.2 In the apparatus using a supply air system, $Q_s = Q_{ts} - Q_{es}$, the extraneous air leakage (Q_{es}) represents all the air leakage leaving the chamber which does not pass through the specimen proper. This includes leakage passing through the chamber walls and around the specimen mounting. When the mounting panel is used, leakage between the chamber and the panel contributes to extraneous leakage. The extraneous leakage flow is a function of the pressure difference between the chamber and the room, which is also the test specimen difference.

A1.3 The total error in the specimen flow determination (neglecting errors in the air density determination) is as follows:

$$\Delta Q_s/Q_s = [\Delta Q_{ts}/(Q_{ts} \cdot Q_{es})] \pm [\Delta Q_{es}/(Q_{ts} \cdot Q_{es})] \quad (A1.1)$$

A1.3.1 According to 6.2.3, the air flow through the test specimen is to be determined with an error no greater than $\Delta Q_s/Q_s = \pm 5$ % if the extraneous leakage is accurate to $\Delta Q_{es}/Q_{es} = \pm 10$ % and Q_{es} is 10 % of Q_s, then the contribution of the extraneous leakage to the overall error in Eq 2 is ± 1 %. (Note that the error attributed to the extraneous leakage determination is a function not only of the accuracy of the flow meter used in the determination, but also of the constancy of the leakage from the time of determination to the time of test.) The error contributed by the flow meter to the total error is then limited to 4 %, but because $Q_{ts} = Q_s + Q_{es} = 1.10\ Q_s$ the accuracy required of the flowmeter is:

$$\Delta\left(\frac{Q_{ts}}{Q_t}\right) = \frac{4}{1.1}\ \% = 3.6\ \% \quad (A1.2)$$

A1.3.2 It is seen that the major factor affecting the accuracy required of the flowmeter is the proportion of Q_{es} to Q_s. If $\Delta Q_{es}/Q_{es}$ remains at ±10 %, but Q_{ts} is 50 % of Q_s, the error contributed by the extraneous leakage becomes 5 % and no error can be tolerated in the flowmeter if the conditions of 6.2.3 are to be met—with Q_{es} in excess of 50 % it is impossible to achieve the required overall limit of error. Likewise, if the extraneous leakage is eliminated, the flowmeter error can be as great as 5 %.