Designation: E783 – 02 (Reapproved 2010)

Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors[1]

This standard is issued under the fixed designation E783; 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 provides a field procedure for determining the air leakage rates of installed exterior windows and doors.

1.2 This test method is applicable to exterior windows and doors and is intended to measure only such leakage associated with the assembly and not the leakage through openings between the assemblies and adjacent construction. The test method can be adapted for the latter purpose, provided the potential paths of air movement and the sources of infiltration and exfiltration can be identified, controlled, or eliminated.

1.3 This test method attempts to create and given set of natural environmental conditions. There is a strong possibility that the test method or the test apparatus may, by virtue of their design and use, induce air leakage that does not occur under natural environmental exposure.

1.4 This test method is intended for the field testing of installed exterior windows or doors. Persons interested in laboratory testing of fenestration products should reference Test Method E283.

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

1.6 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.

1.7 *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 precautionary statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

E631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions*—Terms used in this test method 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)*—the air leakage per unit of specimen area (A) or per unit length of operable crack perimeter (L), expressed as $m^3/s - m^2$ ($ft^3/min - ft^2$), or $m^3/s - m$ ($ft^3/min - ft$).

3.2.2 *extraneous air leakage (Q_e)* —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, expressed in m^3/s (ft^3/min).

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 air leakage (Q_s)*—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, expressed in m^3/s (ft^3/min).

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

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

3.2.6 *test specimen*—the assembled window or door unit as installed in the exterior wall of a building. The test specimen

[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.

consists of the major components of the assembly, including all joints, cracks, or openings between such components and any panning, receptors, extenders, sills, mullions, or other parts or components used for assembly and installation. The test specimen excludes any joints, cracks, or openings between the assembly and any interior or exterior trim that is not an integral part of the system, and excludes any joints, cracks, or openings between the assembly and the adjacent wall construction.

3.2.7 *total air flow* (Q_t)—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, expressed in m^3/s (ft^3/min).

3.2.8 *unit length of operable crack perimeter (L)*—the sum of all perimeters of operable ventilators, sash, or doors contained in the test specimen, based on the overall dimensions of such parts, expressed in m (ft). Where two suchoperable 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 chamber to cover the interior or exterior face of a test specimen, supplying air to or exhausting air from the chamber at a rate required to maintain the specified test pressure difference across the specimen, and measuring the resultant air flow across the specimen.

5. Significance and Use

5.1 This test method is a standard procedure for determining the air leakage characteristics of installed exterior windows and doors under specified static air pressure differences.

NOTE 1—The air pressure differences acting across a building envelope vary greatly. The factors affecting air pressure differences and the implications of 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.

5.3 Rates of air leakage of essentially identical windows or doors, as determined in the laboratory (Test Method E283) and as measured in the field by this test method, have sometimes been used for comparison purposes. The correlation between the laboratory and field test results, and the correlation between actual performance of in-service products and the response to these tests has not been established because of insufficient data.

5.4 Rates of air leakage, as determined by this test method may be affected by: the age or physical condition of the test specimen; the type or quality of installation; the care exercised in the attachment of the test apparatus and the determination of extraneous leakage; and the actual conditions to which the test specimen is exposed beyond those imposed by the test method, that is temperature, relative humidity, wind impingement, etc. Consideration must be given to the proper selection of test specimens, the choice of appropriate test technique (when a choice is given within this test method), and the proper use and interpretation of the results obtained from this test to minimize the effect of these conditions.

5.5 Rates of air leakage, as determined by this test method may include air leakage that does not occur during normal operation and exposure, or that does not contribute to the overall air leakage for the structure. Air may be supplied to or exhausted from wall cavities or adjacent construction, or may bypass interior or exterior trim or components in a manner not experienced during normal operation or exposure. Care must be taken to prevent such leakage from occurring, or consideration must be given that such leakage may have occurred during the test.

5.6 This test method addresses the issue of air leakage through the high pressure face of the test specimen only. Air leakage from the adjacent wall cavity through sill, head, and jambs of the window frame is considered extraneous air leakage and, therefore, not a component of the measured specimen air leakage. Such extraneous air leakage through the perimeter frame of the test specimen can be a significant source of air leakage into, or out of, the building if the frame is not sealed against air infiltration from the adjacent wall cavity.

6. Apparatus

6.1 The description of the apparatus in this section is general in nature (see Fig. 1). Any suitable arrangement of

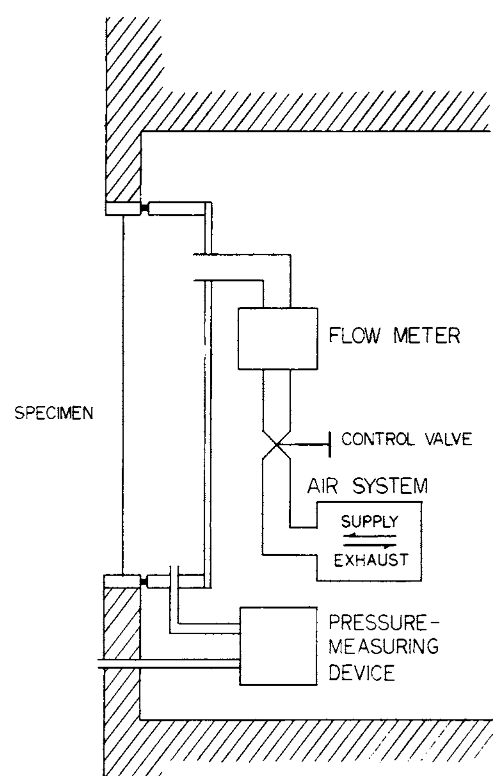

FIG. 1 General Arrangement of Air Leakage Test Apparatus

[3] *ASHRAE Handbook of Fundamentals*, 1989.
[4] *Fluid Meters—Their Theory and Application*, 5th Edition, 1959.
[5] Chapter 4, "Flow Measurements," *Power Test Code*, 2nd Edition, Part 5, 1956 .

equipment capable of maintaining the required test tolerances is permitted.

6.1.1 *test chamber*—a chamber formed by sealing a sheet of plywood, plastic, or other suitable material against the frame of the test specimen. At no time during the test shall the sheet or any other part of the testing assembly, come in contact with or restrict any point where air leakage may occur. At least one static air pressure tap shall be provided on each side of the specimen to measure the chamber pressure versus the ambient (indoor to outdoor) air pressure, and shall be located so that the reading is unaffected by outdoor impinging wind, or by the air supply to or exhaust from the test chamber. The air supply opening to the chamber shall be located in an area in which it does not directly impinge upon the test specimen.

6.1.2 *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.

6.1.3 *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.

6.1.4 *air flow metering system*—a device to measure the air flow into the test chamber or through the test specimen. The air flow measurement error shall not exceed ±5 % when the air flow equals or exceeds 9.44×10^{-4} m^3/s (2 ft^3/min) or ±10 % when the air flow is less than $9.44^{-4} \times 10$ m^3/s (2 ft^3/min). (The reference listed in Annex A1 presents background information on fluid metering practices.)

NOTE 2—At lower flows a greater percentage of errors will be acceptable. If higher precision is required, special flow metering techniques are necessary. The accuracy of the specimen air leakage flow measurement is affected by the accuracy of the flowmeter and the amount of extraneous air leakage. (See Annex A1).

7. Hazards

7.1 Glass breakage may occur at the test pressure differences applied in this test. Adequate precautions should be taken to protect personnel, observers, and bystanders.

NOTE 3—Additional precautions may be necessary to protect passers-by when tests are conducted to measure exfiltration. The choice of whether the test chamber is affixed to the interior or exterior side of the test specimen, and whether the tests are conducted using positive or negative static air pressure can aid in the protection.

8. Test Conditions

8.1 The specifying authority shall supply the following information:

8.1.1 Test specimen sampling, selection, and identification (see Section 9).

8.1.2 Test pressure difference(s) if no value is designated, 75 Pa (1.57 lb/ft^2).

8.1.3 Standard Test Conditions—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)

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

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

8.3 The testing agency shall supply the following information:

8.3.1 Whether the test chamber will be affixed to the interior or exterior side of the test specimen, and

8.3.2 Whether the test(s) will be conducted using positive or negative static air pressure differences.

9. Sampling, Test Specimens, and Test Units

9.1 Determine the number of specimens to be tested and the procedures to be used for the selection and identification of test specimens according to the following:

9.1.1 The intended use of the test results;

9.1.2 The expected or estimated variation in results from test specimen to test specimen;

9.1.3 The level of confidence desired in extrapolating the test results to specimens not tested.

9.2 Establish specific limitations or requirements for the repair, adjustment, or modification of test specimens prior to testing.

NOTE 4—Although the specifying authority is responsible for establishing test specimen sampling, selection, and identification procedures, such procedures should be mutually agreed upon by all parties involved prior to testing.

10. Preparation of Test Specimen

10.1 Select and identify the test specimen in accordance with the procedures established in 8.1.1 and 9.

10.2 Conduct a detailed visual examination of the test specimen and the construction adjacent to the test specimen. Record all pertinent observations.

NOTE 5—The purpose of this examination is to record the physical condition of the test specimen and adjacent construction at the time of testing. Examples of pertinent observations to be recorded include: any damage or deterioration observed; missing or broken components; misalignment or misadjustment of weatherstrip or other components; cleanliness of the test specimen; out-of-square installation; etc.

10.3 Record any repairs, modifications, or adjustments made to the test specimen, particularly those that may affect the measured results.

10.4 Make certain that the test specimen, and specifically that all weatherstrip, is thoroughly dried prior to testing.

NOTE 6—The results of this test may be significantly affected by the presence of water within the test specimen. The test should not be conducted immediately after a rain, window washing, or other condition where water can be retained by the test specimen.

11. Preparation of Test Apparatus

11.1 Fit the test chamber to the perimeter of the test specimen to cover the entire assembly through which air leakage is to be determined. If possible, exclude from the test chamber those joints, cracks, or openings for which air leakage is not to be determined, or tape or otherwise seal such openings to prevent leakage from occurring during the test. Provide suitable support for the test chamber so that it does not contact or restrict any point where air leakage may occur. Seal all joints between the test specimen perimeter and the test chamber; seal any openings between the test chamber and any air supply or exhaust ducts, pressure taps or other measuring devices.

11.2 Measure the extraneous air leakage through and around the test chamber, test apparatus, and test specimen, at the test pressure difference(s) to be exerted during the air leakage tests, using one of the following techniques:

11.2.1 For applications where the higher-pressure side of the test specimen is accessible without disturbing the seals between the test chamber, test apparatus, and test specimen, tape or otherwise seal a" loosely" fit sheet of thin polyethylene film over the higher-pressure side of the test specimen. Tape or seal the full perimeter of the film to the test specimen, making sure to cover only those joints, cracks, or openings intended to be measured for air leakage during the test. Adjust the air flow to provide the test pressure difference(s) to be exerted during the air leakage tests. When the system reaches equilibrium (as evidenced by the film being held tightly against the surface of the test specimen, and a constant static air pressure difference and air flow), measure and record the metered air flow. Designate this measurement Q_e. Remove the polyethylene film and all tape or sealant, without disturbing any other seals, prior to conducting the air leakage tests.

11.2.2 For applications where the lower-pressure side of the test specimen is accessible without disturbing the seals between the test chamber, test apparatus, and test specimen, securely tape or otherwise seal and hold down a tightly fit sheet of polyethylene film over the lower pressure side of the test specimen. The sheet must be sufficiently strong not to tear or rip under the pressures to be exerted, and the tape or other seal must resist breaking away. Tape or seal the full perimeter of the film to the test specimen, making sure to cover only those joints, cracks, or openings intended to be measured for air leakage during the test. Adjust the air flow to provide the test pressure difference(s) to be exerted during the test. When the system reaches equilibrium (as evidenced by a constant deformation of the film, and a constant static air pressure difference and air flow), measure and record the metered air flow. Designate this measurement Q_e. Remove the polyethylene film and all tape or sealant, without disturbing any other seals, prior to conducting the air leakage tests.

11.2.3 For applications where neither of these approaches is acceptable, other methods of measuring extraneous air leakage may be used provided such techniques are agreed upon by all parties involved.

NOTE 7—The accurate measurement and handling of extraneous air leakage is an important factor in conducting these tests. Inaccurate measurement or handling of extraneous air leakage can result in the test reporting higher or lower air leakage measurements than may actually exist. Care must be taken in the location, sealing, and removal of the polyethylene film. Extraneous air leakage measurements must also be conducted at the precise test pressure differences to be used during the air leakage tests.

NOTE 8—The technique described in 11.2.1 is the preferred approach for measuring extraneous air leakage. Testing agencies may wish to consider providing access doorways in positive pressure chambers to allow for the application and removal of the polyethylene film.

12. Calibration

12.1 Specific procedures for calibration of the total air flow measurement system are being developed in a separate ASTM document. When complete, that document will be referenced. However, all test apparatus shall be calibrated at a minimum of every 6 months to the tolerances established in Section 6. The procedures for this calibration are, at this time, the responsibility of the testing agency. Calibration should be conducted at or near the environmental conditions (temperature, relative humidity, etc.) under which the tests are to be conducted and to which the test apparatus is to be exposed.

13. Procedure

13.1 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 metered air flow, Q_t.

NOTE 9—Because this test is conducted in the field, static air pressure differences may not truly stabilize, but may vary plus or minus due to changes in outdoor wind speed or changes in indoor air pressures. Tests should be conducted when outdoor wind and indoor pressure changes are at a minimum, or steps should be taken to minimize their effect. When such conditions cannot be corrected, the range of static air pressure differences observed and the average static air pressure difference shall be recorded.

13.2 Measure the barometric pressure, temperature, and relative humidity of the air near the exposed side of the test specimen, and of the air near the air intake or exhaust of the air system. Measure and record the speed and direction of the air movement (wind) at or near the exposed surface of the test specimen. Such measurements shall be taken immediately prior to or during the test.

NOTE 10—The measured air leakage through the test specimen is affected by the density and viscosity of the air. Tests should be conducted as near to the reference standard conditions as possible.

NOTE 11—If tests are to be conducted at extremes of outdoor temperature and humidity, that is, near or below freezing, consideration must be given to the effect of such extremes on the accuracy and serviceability of the test apparatus as well as the effect on the measured air leakage.

14. Calculation

14.1 Express the total air flow, Q_t, and the extraneous leakage, Q_e, in terms of flow at standard conditions, using Eq 1 and 2.

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

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

where:

Q = airflow at nonstandard conditions,
Q_{st} = airflow corrected to standard conditions,
W_s = density of air at reference standard conditions (1.202 kg/m^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, and
T = temperature of air at flowmeter, C.

NOTE 12—For IP measurements, $W_s = 0.075$ lb/ft^3
$W = 1.326(B/(t + 460))$ where B is measured in inches Hg and t is in °F.

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

$$Q_s = Q_t - Q_e \tag{3}$$

where:

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

14.3 Calculate the rate of air leakage for the test specimen according to both of the following methods:

Rate of air leakage per unit of length of operable crack perimeter:

$$qL = Q_s/L,\ \text{m}^3/\text{h} - \text{m}\ (\text{ft}^3/\text{min} - \text{ft}) \tag{4}$$

and rate of air leakage per unit area:

$$q_A = Q_s/A,\ \text{m}^3/\text{h} - \text{m}^2\ (\text{ft}^3/\text{min} - \text{ft}^2) \tag{5}$$

15. Report

15.1 Report the following information:

15.1.1 *General*—Testing agency, date and time of test, date of report, identification and location of building.

15.1.2 *Sample Description*—Manufacturer, model, operation type, materials, and other pertinent information; identification and location of test specimen within the building; physical condition of the test specimen (from 10.2); description of any modifications made to the test specimen (from 10.3); age of the test specimen, if known; 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.

15.1.3 *Drawings of Specimen*—Detailed drawings of the specimen if available 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.

15.1.4 *Sampling Procedures*—If applicable, describe or list the procedures established from Section 9.

15.1.5 *Test Parameters*—List or describe the specified test pressure difference(s), whether the tests were conducted for infiltration or exfiltration, whether a positive or negative test pressure was used, whether the chamber was affixed to the interior or exterior of the test specimen, etc. If possible list or describe those joints, cracks, or openings that were specifically included or excluded during the test. List or describe the extraneous air leakage measurement procedures used.

15.1.6 *Ambient Test Conditions*—List the indoor and outdoor air temperatures, relative humidities, barometric pressures, wind speed and direction, etc. as measured and recorded during the test.

15.1.7 *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).

15.1.8 *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.

16. Precision and Bias

16.1 At present, insufficient data exists for determining precision and bias. A reasonable estimate of the uncertainty within a given air leakage rate determination is in the order of 15 % or less, depending upon the care exercised in complying with Section 11.

17. Keywords

17.1 air leakage; doors; fenestration; field method; static pressure chamber; test method; windows

ANNEX

(Mandatory Information)

A1. ERRORS IN WINDOW AIR LEAKAGE MEASUREMENT

A1.1 *Definitions*

A1.1.1 Q_s = air flow through specimen.

A1.1.2 Q_{ts} = total air flow.

A1.1.3 Q_{es} = extraneous air flow.

A1.1.4 Δ = delta.

NOTE A1.1—All of the above have been converted to standard conditions.

A1.2 In the apparatus using a supply air system,

$$Q_s = Q_{ts} - Q_{es} \tag{A1.1}$$

A1.2.1 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:

$$\Delta Q_s/Q_s = [\Delta Q_{ts}/(Q_{ts} - Q_{es})] \pm [\Delta Q_{es}/(Q_{ts} - Q_{es})] \quad (A1.2)$$

A1.3.1 In accordance with 6.1.4, the air flow through the test specimen is to be determined with an error no greater than

$$\Delta Q_s/Q_s = \pm 5\,\% \quad (A1.3)$$

If the extraneous leakage is accurate to:

$$\Delta Q_{es}/Q_{es} = \pm 10\,\% \quad (A1.4)$$

and Q_{es} is 10 % of Q_s then the contribution of the extraneous leakage to the overall error in equation A1.2 is ±1 %.

NOTE A1.2—The error attributed to the extraneous leakage determination is a function not only of the accuracy of the flowmeter 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:

$$\Delta Q_{ts}/Q_t = 4\,\%/1.1 = 3.6\,\% \quad (A1.5)$$

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 6.1.4 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 %.