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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Method for FIELD MEASUREMENT OF AIR LEAKAGE THROUGH INSTALLED EXTERIOR WINDOWS AND DOORS[1]

This standard is issued under the fixed designation E 783; 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 method covers the determination of the resistance of installed exterior windows and doors to air leakage resulting from static air pressure differences.

1.2 This method is applicable to window and door assemblies only and is intended for measuring only the air leakage associated with such assemblies, and not the leakage through openings between the window or door assemblies and adjacent construction. However, the method can be adopted 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 method attempts to create a given set of natural environmental conditions. There is a strong possibility that the 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 The proper use of this method requires a working knowledge of the principles of air flow and pressure measurement as utilized in this method.

1.5 The values stated in inch-pound units are to be regarded as the standard. SI units may be approximate equivalents.

1.6 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 7.

2. Applicable Document

2.1 *ASTM Standard:*

E 283 Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors[2]

3. Descriptions of Terms Specific to This Standard

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

3.2 *extraneous air leakage (Q_L)*—the difference between the metered air flow (Q_m) and the air leakage (Q).

NOTE 1—Extraneous air leakage is the sum of all leakage other than that intended to be measured by the test, that is, leakage through the test apparatus, leakage through construction adjacent to the test specimen, etc.

3.3 *length of crack (L)*—the sum of all perimeters of all ventilators, operable sash, or door panels contained in the test specimen, based on the overall dimensions of such parts, expressed in metres (feet). Where two such parts meet, the two adjacent lengths of perimeter shall be counted as only one length.

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

[1] This method is under the jurisdiction of ASTM Committee E-6 on Performance of Building Constructions and is the direct responsibility of Subcommittee E06.51 on Component Performance of Windows, Curtain Walls, and Doors.

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[2] *Annual Book of ASTM Standards*, Vol 04.07.

3.5 *rate of air leakage*—the air leakage per unit of test specimen area (A), expressed in cubic metres per second per square metre (cubic feet per minute per square foot); or the air leakage per unit length of crack (L), expressed in cubic metres per second per metres of cracked length (cubic feet per minute per foot of cracked length).

3.6 *reference standard 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 lb/ft^3)

3.7 *specimen area (A)*—the area determined by the overall dimensions of the test specimen as described in 3.9, expressed in square metres (square feet).

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

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

4. Summary of 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 a specified static air pressure difference across the specimen, and measuring the resultant air flow through the specimen.

5. Significance and Use

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

5.2 Rates of air leakage are sometimes used for product comparison purposes. Such comparisons may not be valid unless the products being 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 E 283) and as measured in the field by this 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 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 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 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.

6. Apparatus

6.1 The following descriptions of major components of apparatus (see Fig. 1) are general in nature, and any arrangement of equipment capable of performing the test procedures within allowable 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 to measure the chamber air pressure versus the ambient (indoor—outdoor) air pressure, and shall be lo-

cated 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 to or exhaust from the test chamber shall be arranged so that air does not impinge directly on the test specimen with any significant velocity.

6.1.2 *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 test pressure difference within a tolerance of ±2 %, 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 through the test specimen and to measure extraneous air leakage. The air flow-metering system shall be accurate to within ±10 %.

7. Safety Precautions

7.1 Glass breakage should not occur at the pressure differences normally applied during this test. However, because excessive air pressure differences may occur due to error in operation or gusting wind, should it occur, adequate precautions should be taken to protect testing personnel, observers, and bystanders from the possibility of broken glass.

NOTE 2—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 this protection.

8. Information Required

8.1 The specifying authority shall supply the following information or provide guidance as to its specification:

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

8.1.2 Test pressure difference(s) to be applied during the test. (If no value is designated, 75 Pa (1.57 lbf/ft^2) shall be used.),

8.1.3 Direction of air flow (infiltration or exfiltration or both), and

8.1.4 Basis of reporting rate(s) of air leakage (per unit length of crack, or per unit area).

8.2 The testing agency shall supply the following information:

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

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

9. Sampling

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 3—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 Section 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 4—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; and 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 5—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 no thicker than 0.05 mm (2 mils, 0.002 in.) 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_1. 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_1. 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 6—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 7—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 calibration procedures for air flow measurements as used in this method are yet to be developed. However, all test apparatus shall be calibrated in the laboratory or in the field to the tolerances established in Section 6 prior to use. 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 static air pressure difference has stabilized, measure and record the air flow through the air

flow-metering system and the actual static air pressure difference under which this measurement was taken. Designate this measured air flow Q_m.

NOTE 8—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 pressure. 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 and record 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 9—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 10—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. Calculations

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

$$Q = Q_m - Q_l$$

where:

Q = air leakage through the test specimen, m^3/s or ft^3/min,
Q_m = metered air flow, m^3/s or ft^3/min, and
Q_l = extraneous air leakage, m^3/s or ft^3/min.

14.2 Convert the measured air leakage through the test specimen (Q) to air leakage at reference standard conditions (Q_s) as follows:

$$Q_s = Q(W/W_s)^{1/2}$$
$$W = 1.326(B - 0.378rp)/(t + 460)$$

where:

B = barometric pressure at test site corrected for temperature, in. Hg,
r = relative humidity at test site (dimensionless),
p = vapor pressure of dry air at dry bulb temperature t, in. Hg, dry bulb temperature, °F,
W = density of air at the test site, lb/ft^3, and
W_s = density of air at reference standard conditions ($W_s = 0.075$ lb/ft^3).

NOTE 11—For metric measurements, the formula for the density of air (W) becomes $W = 3.485 \times 10^{-3}(B - 0.378rp)/(t + 273)$, where B and p are measured in pascals, and t is measured in degrees Celsius. $W_s = 1.202$ kg/m^3.

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

14.3.1 To express the rate of air leakage per unit length of crack, divide the air leakage at reference standard conditions (Q_s) by the total length of crack (Q_s/L).

14.3.2 To express the rate of air leakage per unit area, divide the air leakage at reference standard conditions (Q_s) by the total test specimen area (Q_s/A).

15. Report

15.1 The report shall include 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, dimensions, materials, etc.; 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; etc.

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

15.1.4 *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.

15.1.5 *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.

15.1.6 *Pressure Differences and Leakage*—A statement or tabulation of the static air pressure difference(s) exerted across the test specimen during the test and the corresponding rate of air leakage as calculated from Section 14.

15.1.7 *Compliance Statement*—A statement that the tests were conducted in accordance with this method, or a complete description of any deviation from this method.

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.

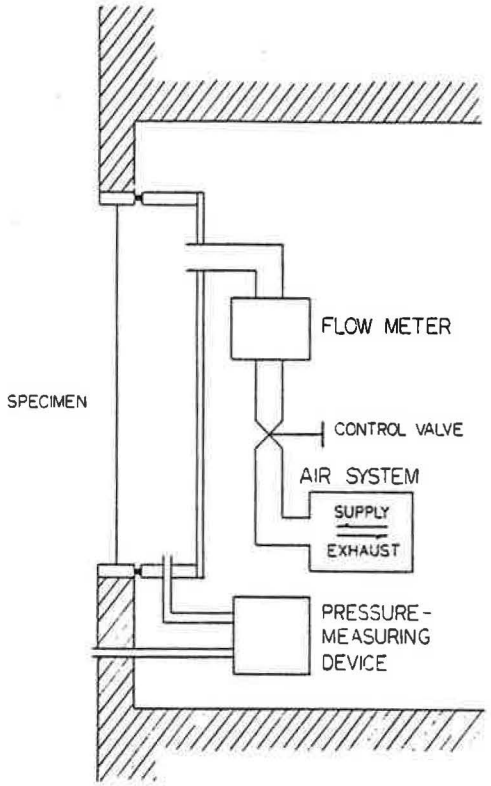

FIG. 1 General Arrangement of Air Leakage Test Apparatus