



Designation: **E2319–04 (Reapproved 2019) E2319 – 22**

## Standard Test Method for Determining Air Flow Through the Face and Sides of Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen<sup>1</sup>

This standard is issued under the fixed designation E2319; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method is a modified version of Test Method ~~E283~~**E283/E283M**, and provides a standard laboratory procedure for determining air leakage separately through the face and sides 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.

NOTE 1—Detailing buildings with continuous air barriers requires that the air barrier plane in a window system be clearly defined. When special circumstances dictate that the air barrier be sealed to the window frame at a location other than that used to seal the specimen to the test chamber in this test method, additional laboratory testing may be required to clarify potential paths of air flow through the sides of the window frame. The adapted testing procedure described herein is intended for this purpose.

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 2—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**. Test Method **E783** will not provide the user with a means of determining air flow through the sides of tested specimens.

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 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 hazard statement 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.*

<sup>1</sup> 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.

Current edition approved Jan. 1, 2019/Aug. 1, 2022. Published January 2019/August 2022. Originally approved in 2004. Last previous edition approved in 2011 as E2319–04 (2011) (2019). DOI: [10.1520/E2319-04R19-10.1520/E2319-22](https://doi.org/10.1520/E2319-04R19-10.1520/E2319-22).

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

[E283/E283M](#) 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

[E783](#) Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors

### 2.2 ISO/IEC Standard:<sup>3</sup>

[ISO/IEC 17025](#) Testing and Calibration Laboratories

## 3. Terminology

3.1 *Definitions*—Terms used in this standard are defined in Terminology [E631](#).

### 3.2 Descriptions of Terms Specific to This Standard:

3.2.1 *air leakage rate through the face of the specimen* ( $q_{A(f)}$  or  $q_{lc(f)}$ ), L/(s·m<sup>2</sup>) (ft<sup>3</sup>/min·ft<sup>2</sup>), or L/(s·m) (ft<sup>3</sup>/min·ft)—the air leakage through the face of the specimen per unit of specimen area ( $A$ ) or per unit length of operable crack perimeter ( $lc$ ).

3.2.2 *air leakage rate through the face and sides of the specimen* ( $q_{A(fs)}$ ), L/(s·m<sup>2</sup>) (ft<sup>3</sup>/min·ft<sup>2</sup>)—the air leakage through the face and sides of the specimen per unit of specimen area ( $A$ ).

3.2.3 *air leakage rate through the sides of the specimen* ( $q_{A(s)}$  or  $q_{lf(s)}$ ), L/(s·m<sup>2</sup>) (ft<sup>3</sup>/min·ft<sup>2</sup>), or L/(s·m) (ft<sup>3</sup>/min·ft)—the air leakage through the sides of the specimen per unit of specimen area ( $A$ ) or per unit length of outside perimeter of specimen frame ( $lf$ ).

3.2.4 *air leakage through the face of the specimen* ( $Q_{s(f)}$ ), L/s (ft<sup>3</sup>/min)—the volume of air flowing per unit of time through the face of the test specimen under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.5 *air leakage through the face and sides of the specimen* ( $Q_{s(fs)}$ ), L/s (ft<sup>3</sup>/min)—the volume of air flowing per unit of time through the face and sides of the test specimen under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.6 *air leakage through the sides of the specimen* ( $Q_{s(s)}$ ), L/s (ft<sup>3</sup>/min)—the volume of air flowing per unit of time through the sides of the test specimen under a test pressure difference and test temperature difference, converted to standard conditions.

#### 3.2.6.1 Discussion—

Air leakage through the sides of the frame ( $Q_{s(s)}$ ) is provided to inform specifiers of the potential leakage through the specimen at the window surrounds. The actual amount of leakage through the sides of the frame depends on the positioning of the sealants, flashings and air barriers relative to the frame.

3.2.7 *extraneous air leakage* ( $Q_e$ ), L/s (ft<sup>3</sup>/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.

#### 3.2.7.1 Discussion—

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

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

3.2.9 *specimen area* ( $A$ ), m<sup>2</sup> (ft<sup>2</sup>)—the area determined by the overall dimensions of the frame that fits into the rough opening.

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

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

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

3.2.11 *test pressure differences*, Pa (lbf/ft<sup>2</sup>)—the specified differential static air pressure across the specimen.

3.2.12 *total air flow through face* ( $Q_{r(f)}$ ), L/s (ft<sup>3</sup>/min)—the volume of air flowing per unit of time through the test chamber and test apparatus, inclusive of the air flowing through the face of the test specimen but exclusive of the air flowing through the sides of the specimen, under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.13 *total air flow through face and sides* ( $Q_{r(fs)}$ ), L/s (ft<sup>3</sup>/min)—the volume of air flowing per unit of time through the test chamber and test apparatus, inclusive of the air flowing through the face and sides of the test specimen, under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.14 *total air flow through sides* ( $Q_{r(s)}$ ), L/s (ft<sup>3</sup>/min)—the volume of air flowing per unit of time through the test chamber and test apparatus, inclusive of the air flowing through the sides of the test specimen but exclusive of the air flowing through the face of the specimen, under a test pressure difference and test temperature difference, converted to standard conditions.

3.2.15 *unit length of operable crack perimeter* ( $lc$ ), 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.

3.2.16 *unit length of outside perimeter of specimen frame* ( $lf$ ), m (ft)—the perimeter of the test specimen, measured at the edge of the outer frame.

#### 4. Summary of Test Method

4.1 The test consists of sealing the interior and exterior of 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 face and sides of the specimen.

#### 5. Significance and Use

5.1 This test method is a standard procedure for determining the air flow characteristics of various components of the window system under specified air pressure differences at ambient conditions.

NOTE 3—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.<sup>4,5,6</sup> 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~~ 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

<sup>4</sup> ASHRAE *Handbook of Fundamentals*, 1989. Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, <http://www.ashrae.org>.

<sup>5</sup> *Fluid Meters—Their Theory and Application*, 5th Edition, 1959.

<sup>6</sup> *Power Test Code*, 2nd Edition, Part 5, Chapter 4, “Flow Measurements,” 1956. Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

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. The inlet into the chamber (sealed box) shall be located or be shielded with a baffle so that the air flow is not directed upon the test specimen.

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

6.2.3 *Air Flow Metering System*—A device to measure the air flow ~~into~~ to  $\pm 5\%$  into/out of the test chamber or through the test specimen. Typically air flow is measured using a mass flow meter or volumetric flow meter. Methods to adjust volumetric flow meter measurements to standard conditions are included in Section 12.

6.2.4 *Air Temperature Measurement Apparatus*—A device to measure the temperature of the air to  $\pm 0.5$  K at the flow meter. This device may be built-in or integral to the flow meter.

6.2.5 *Absolute Pressure Measurement Apparatus*—A device to measure the absolute pressure to  $\pm 2\%$  within the laboratory.

6.2.6 *Relative Humidity Measurement Apparatus*—A device to measure the relative humidity of the air to  $\pm 2\%$  R.H. at the flow meter or at a location where no change in the moisture content can occur between the flow meter and the relative humidity sensor. This device may be built-in or integral to the flow meter.

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

## 9. Calibration Validation

9.1 Calibration Validation shall be performed by mounting a plywood or similar rigid ~~blank~~ panel to the test chamber in place of a test specimen, using the same mounting procedures as used for standard specimens. The blank panel shall be  $1919 \text{ mm} \pm 3 \text{ mm}$  ( $3 \text{ mm}$  ( $3/4 \text{ in.} \pm 1/8 \text{ in.}$ )) thick, with a  $150 \text{ mm}$  (6 in.) diameter hole(s) over which NIST traceable orifice plates shall be mounted. The blank in.) thick. The edge of the aperture supporting the orifice plate shall not be less than  $50 \text{ mm}$  (2 in.) from the nearest edge

of the aperture in the orifice plate. The overall dimension of the orifice plates shall sufficiently overlap the supporting aperture to enable adequate sealing. The panel shall be attached to a minimum ~~140 mm~~ 140 mm (5½ in.) deep (nominal 2 by 6) pine test frame (buck) with dimensions of 1220 mm wide by 1830 mm high (4 ft wide by 6 ft high). The test frame and ~~blank~~ panel shall be sealed at all joints.

9.2 Each ~~NIST traceable~~ NIST traceable orifice plate shall be constructed of ~~33.175 mm (1/8 in.)~~ 33.175 mm (1/8 in.) thick stainless steel having an outside diameter of ~~200 mm (8 in.)~~ 200 mm (8 in.) dimension sufficient to cover the aperture of the panel as specified in 9.1, 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.)~~ 25.40 mm (1.000 in.), 38.10 mm (1.500 in.), 50.80 mm (2.000 in.), and 63.50 mm (2.500 in.) as needed. The dimensions of the orifice plate shall be NIST-traceable or verified by an ISO/IEC 17025-accredited calibration laboratory.

9.3 Fasten the orifice plate to the ~~blank, centered over a 150 mm (6 in.) diameter hole.~~ panel, centered over the panel aperture. 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, sealed~~ sealed at the air pressure difference to be applied as referenced in 10.1.2 ~~during calibration.~~ After determining the extraneous air leakage, remove the adhesive tape from the hole in the orifice plate and repeat the process to determine the total measured flow. The measured air flows shall be corrected to standard conditions (see Section 12).

9.4 Calibration Validation of the air leakage test equipment shall consist of determining the flow through the air flow system to be ~~calibrated~~ validated 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~~ each of the following corresponding air flow ranges is indicated in Table 1 ~~the table.~~ When needed, additional orifice plate sizes may be used to adequately cover the air flow system measuring range outside of Table 1 nominal flow ranges. It is also allowed to use other means of validation for the air leakage equipment given that it can be demonstrated that the alternative method yields accuracy of validation equal or exceeding that of the orifice plate method. For ranges of nominal flow between 3.47 L/s (7.36 ft<sup>3</sup>/min) to 21.33 L/s (45.20 ft<sup>3</sup>/min), the use of the corresponding orifice plates referenced in Table 1 is mandatory.

NOTE 5—~~Three~~ A minimum of 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.

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

NOTE 6—At test pressures other than 75 Pa (1.57 psf), the laboratory shall ~~calibrate~~ validate the ~~air flow~~ air flow 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 validation when the maximum air flow reading during testing does not exceed the highest ~~calibrated~~ validated 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<sup>3</sup>/min) or ±10 % when the flow is less than 0.944 L/s (2 ft<sup>3</sup>/min) but greater than 0.236 L/s (0.5 ft<sup>3</sup>/min).

NOTE 7—At lower flows, a greater percentage of error will usually be acceptable. If higher precision is required, special flow measuring techniques are

TABLE 1 Orifice Plates Data

Orifice Plate Hole Sizes	Nominal Flow	Differential Pressure Across Orifice Plate
6.35 mm (0.25 in.)	0.22 L/s (0.47 ft <sup>3</sup> /min)	75 Pa (1.57 psf)
12.7 mm (0.5 in.)	0.88 L/s (1.86 ft <sup>3</sup> /min)	75 Pa (1.57 psf)
25.4 mm (1.0 in.)	3.47 L/s (7.36 ft <sup>3</sup> /min)	75 Pa (1.57 psf)
38.1 mm (1.5 in.)	7.66 L/s (16.24 ft <sup>3</sup> /min)	75 Pa (1.57 psf)
50.8 mm (2.0 in.)	13.64 L/s (28.90 ft <sup>3</sup> /min)	75 Pa (1.57 psf)
63.5 mm (2.5 in.)	21.33 L/s (45.20 ft <sup>3</sup> /min)	75 Pa (1.57 psf)

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 (see Annex A1).

9.7 Alternate means may be used for calibrating/validating 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/Validation shall be performed at least once every six months using the method described above. Alternative orifice mounting conditions may be used during interim calibration/validation periods for air flow checking purposes; purposes, but these methods shall be documented in the laboratory's Operation Manual.

**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~~ 75 Pa (1.57 lb/ft<sup>2</sup>)), 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<sup>3</sup>/min), per unit length of operable crack perimeter, L/(s·m) (ft<sup>3</sup>/min·ft), per unit length of outside perimeter of frame, L/(s·m) (ft<sup>3</sup>/min·ft), and per unit area of outside frame dimension, L/(s·m<sup>2</sup>) (ft<sup>3</sup>/min·ft<sup>2</sup>).

**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 8—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 Seal the specimen to the test chamber on both the interior and the exterior. Seal the interior with air seal tape and/or sealant and the exterior with air seal tape, as shown in Figs. 2 and 3.

11.3 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.

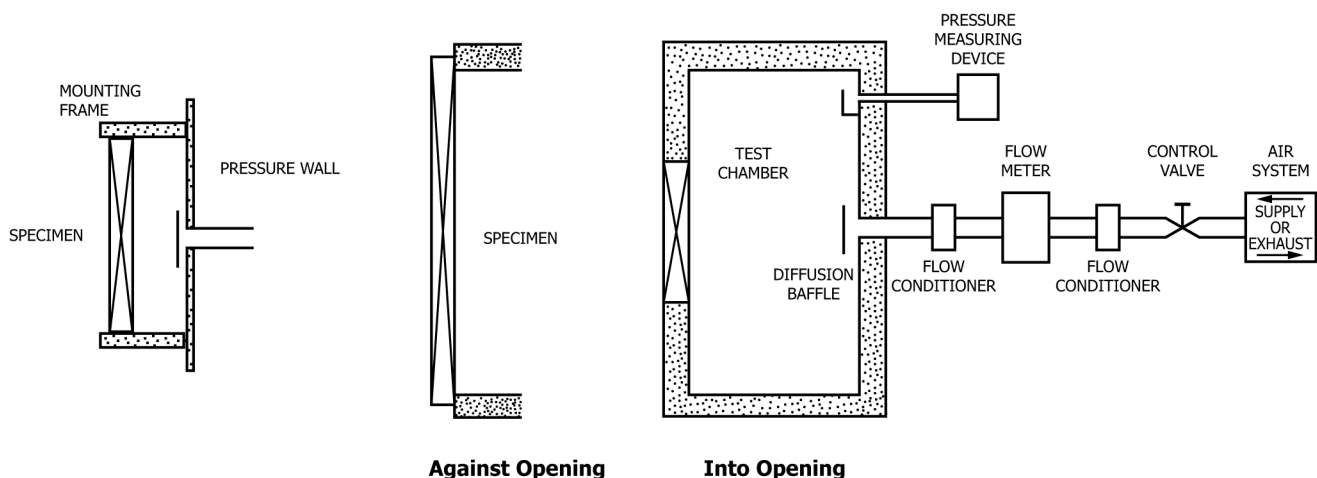
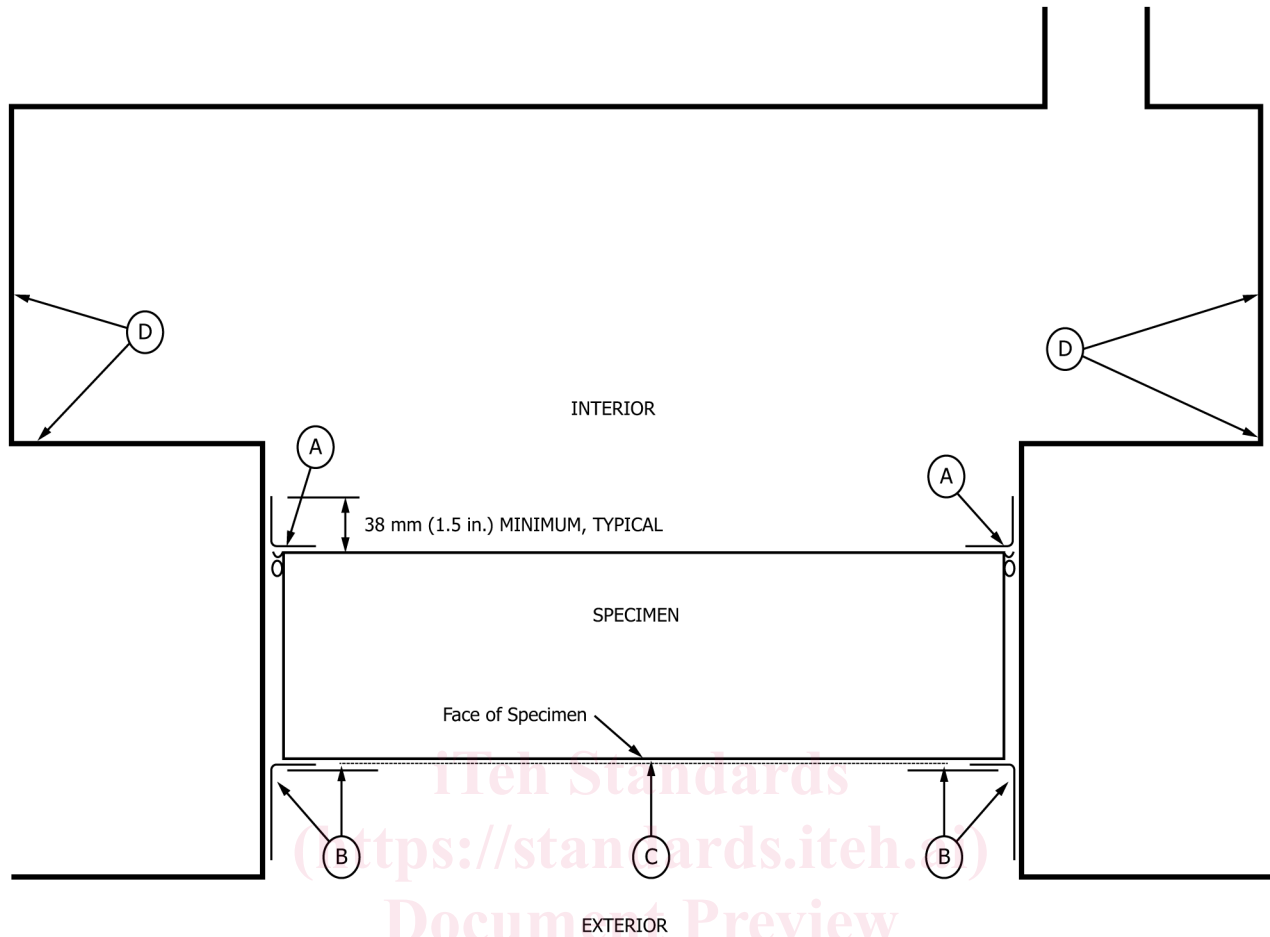


FIG. 1 General Arrangement of the Air Leakage Apparatus





- (A) AIR SEAL TAPE AND/OR SEALANT
- (B) AIR SEAL TAPE
- (C) POLYETHYLENE FILM (DOTTED)
- (D) TEST CHAMBER

FIG. 2 Arrangement of Air Leakage Apparatus with Specimen Fit into Test Chamber

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

11.5 Seal the exterior polyethylene film to the air seal tape. For test specimens fit against the chamber opening, as shown in Fig. 3, ensure that the polyethylene covers the sides of the specimen.

NOTE 9—The interior seal can be applied to the inboard surface of the glazing pocket or other perimeter window surface intended by the manufacturer to be the air barrier plane for the specimen.

11.6 Adjust the air-flow through the test chamber to provide the specified test pressure difference across the test specimen. When the test conditions have stabilized, record the air-flow through the flowmeter and the test pressure difference. The measured air flow is designated as the Extraneous Air Flow,  $Q_e$ . Measure the barometric pressure and the temperature of the air at the test specimen.

11.7 For test specimens fit into chamber opening, see Fig. 2 and proceed according to 11.7.1 and 11.7.2. For test specimens fit against chamber opening, see Fig. 3 and proceed according to 11.7.3 and 11.7.4.