Designation: E2357 – 17

Standard Test Method for Determining Air Leakage of Air Barrier Assemblies[1]

This standard is issued under the fixed designation E2357; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the air leakage rate of air barrier assemblies that are used in building enclosures. This procedure measures the air leakage of a representative air barrier assembly before and after exposure to specific conditioning cycles and then assigns a rating dependent upon the results. Although this is a laboratory procedure, the method may also be applied to site mockups.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

E330/E330M Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

E631 Terminology of Building Constructions

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

E1424 Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure and Temperature Differences Across the Specimen

E1677 Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls

E2178 Test Method for Air Permeance of Building Materials

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general terms related to building construction used in this test method, refer to Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air barrier*—a designated "plane" of reduced air flow between different environments.

3.2.2 *air barrier accessory*—a transitional component of the air barrier that provides continuity.

3.2.3 *air barrier assembly*—the air barrier materials and accessories that provide a continuous designated plane to the movement of air through portions of building enclosure assemblies.

3.2.4 *air barrier material*—a primary element that provides a continuous barrier to the movement of air.

3.2.5 *air barrier system*—a combination of air barrier assemblies installed to provide a continuous barrier to the movement of air through building enclosures.

3.2.6 *air leakage rate*—the quantitative measure of air passage through a set surface area of an assembly within a given time period under a pressure differential between the two sides of the assembly.

3.2.7 *building enclosure*—a system of building components and materials designed and installed in such a manner as to provide a barrier between different environments, including dissimilar interior environments.

3.2.8 *continuity*—an uninterrupted succession of an air barrier materials, accessories and assemblies.

3.2.9 *durability*—the ability of a building component to perform its required functions over a period of time within the environment to which it is exposed.

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation Performance.

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

3.2.10 *negative pressure*—air pressure on one side of a building enclosure lower than on the other side.

3.2.11 *positive pressure*—air pressure on one side of a building enclosure higher than on the other side.

4. Summary of Test Method

4.1 This test method establishes a specimen preparation protocol with which an air barrier assembly may be evaluated. A test specimen is constructed and tested in separate pressures. Up to three specimens are constructed, each additionally representing different field conditions. Specimen 3 is optional and may be combined with Specimen 2. By applying air pressure differentials across the specimens in stages, the air barrier and system components may be evaluated as to their specific air leakage.

5. Significance and Use

5.1 This method is intended to simulate the performance of various air barrier materials/accessories when combined into an assembly. Based upon the results of the measurements, this procedure then assigns an air leakage rating for the air barrier assembly.

5.2 This method does not purport to establish all criteria necessary for consideration in the selection of an air barrier assembly. The results are intended to be used for comparison purposes and may not represent the field installed performance of the air barrier assembly when installed as part of an air barrier system in a building. However, the results of these tests may be useful in determining the appropriate use of a specified air barrier system assembly.

5.3 This method does not purport to establish all criteria necessary for air barrier systems of all construction types. Test Method E2178 provides an air permeance test method for testing of some air barrier materials. Specification E1677 provides a specification for air barrier systems for low-rise framed building walls.

6. Sampling

6.1 For each air barrier assembly, up to three specimens shall be tested as described in Annex A1. The proponent may elect not to prepare and test specimen three or combine the details of Specimen 3 with Specimen 2.

7. Test Apparatus

7.1 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.

7.2 *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.

7.2.1 *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 and cyclic loads at the specified test pressure difference for a time period sufficient to obtain readings of air flow.

7.2.2 *Pressure Measuring Apparatus*—A device to measure the differential test pressures to ±2 % of setpoint or ±2.5 Pa, whichever is greater.

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

7.3 This test method is intended for laboratory use. Persons interested in performing field air leakage tests on air barrier assemblies should reference Test Method E783.

8. Sample Preparation

8.1 *Air Leakage and Structural Performance Tests:*

8.1.1 As the air barrier assembly is site-assembled, the specimens tested shall be representative of the site assembly. Therefore the test specimens shall be fabricated as prescribed by the proponent in providing for the specimen construction required herein.

8.2 *Air Leakage and Structural Performance Test Specimens:*

8.2.1 This test method specifies a minimum of (2) specimens for testing. Annex A2 describes the requirements of the test specimens. To meet these requirements, one specimen shall be an opaque wall (Fig. A1.1) and one specimen shall have penetrations, terminations and connections as outlined in Annex A2, Fig. A1.2. The test specimens are to be conditioned prior to being submitted to the structural performance qualification test program and subsequently, to the air leakage rate procedure. Photographs are to be taken of original test specimens including joining details.

8.3 *Conditioning for Tests:*

8.3.1 Unless otherwise stated, the specimens shall be tested "as received." No modifications to the proponents' assembly instructions are permitted.

8.3.2 If the evaluation of the aged performance of the air barrier assemblies is desired by the proponent, the specimens may be conditioned prior too testing by exposure, ultraviolet radiation or thermal cycling, or both.

9. Test Procedure

9.1 *Air Leakage:*

9.1.1 The air leakage rate shall be measured at each of the air pressure differences across the test specimen in accordance with Test Method E283.

9.1.2 *Air Leakage Test Conditions*—The air leakage rate of the specimens, for both positive and negative cases, shall be determined with a minimum of seven (7) measurements conducted across the sample in accordance with Test Method E283. The seven (7) measurements shall be as follows: 25 Pa, 50 Pa, 75 Pa, 100 Pa, 150 Pa, 250 Pa, and 300 Pa.

TABLE 1 Sustained Loads, Cyclic Loads and Gust Loads

NOTE 1—The wind loads specified in Table 1 are not intended to represent conditions for a specific building; rather they are intended to provide a uniform basis for comparison purposes. The wind loads are based on the assumption that the air barrier will take the full wind load and that the air barrier would see two severe storms in the first 15 years in service, The Q10 design values of 400/600 Pa for sustained wind conditions originates from values in the National Building Code of Canada for window design. Design values for window glass area were used because windows are part of both exterior envelope and the air barrier, and must take the full wind load on the building. The user may consult the map in Fig. 1 (Basic Wind Speeds in Miles per Hour), Specification E1677, and Test Method E330/E330M for guidance on wind speeds for the area where a specific building is or will be located.

For geographical areas where pressure design value is	Specimens as in accordance with Appendix X1 for wood frame, metal or masonry	P_1, P'_1 sustained for 1 h[A] (Pa)	P_2, P'_2 2000 cycles[B] (Pa)	P_3, P'_3 gust wind (Pa)
Q_{10} < 0.20 kPa	Specimen 1, 2, 3	400	530	800
Q_{10} > 0.20 kPa	Specimen 1, 2, 3	600	800	1200

[A] Specimens shall be conditioned for a minimum of 24 h at laboratory conditions prior to loading.
[B] The 2000 cycles can be applied in either four stages of 500 cycles per stage or two stages of 1000 cycles per state, with pressure direction reversal occurring between stages.

See Annex A3 for reference to P_1, P'_1, P_2, P'_2, P_3 and P'_3.

9.1.3 *Results*—The air leakage results for each test series shall be curve fit using a least squares procedure to establish the relationship between pressure difference and leakage. See 11.4 for the data fitting requirements.

9.2 *Wind Pressure Conditioning:*

9.2.1 After the initial leakage testing, the specimen shall be exposed to the pressure loading in Table 1. The loading schedule for application of positive and negative pressure shall be as outlined by the graph presented in Annex A3 at the maximum values contained in Table 1 for sustained loads, cyclic loads and gust loads.

9.2.2 *Observations to be Reported*—After each loading stage (sustained, cyclic or gust loading), the air barrier assembly shall be inspected by the testing agency for signs of fracture, delamination, loosening of fasteners, and so forth. The air barrier assembly shall not demonstrate any change in structure, which would affect the integrity of the assembly. Photographs are to be taken of any failures.

9.3 *Post Conditioning Air Permeance:*

9.3.1 The air leakage test of 9.1 shall be repeated after the conditioning listed in 9.2. The post conditioning permeance values shall be used to establish the system rate. (See Section 10.)

9.4 *Deflection Measurements:*

9.4.1 Maximum deflections of the air barrier material and the test specimen shall be recorded at the wind pressures as outlined in Table 2 for both positive and negative pressures. The measurements shall be taken after the post conditioning leakage tests of 9.3.

TABLE 2 Wind Pressure Loading

NOTE 1—The wind pressure loads specified in Table 2 are not intended to represent conditions for a specific building; rather they are intended to provide a uniform comparison basis. The wind pressure loads are based on the assumption that the air barrier will take the full wind load and include a safety factor. Although in theory and in some applications (such as a pressure equalized rain-screen wall) a single air barrier layer may be exposed to the full pressure load, in many common applications the air barrier layer is subjected to a much smaller load (as low as 30 % of the total load) because of partial wind load being absorbed by other wall layers.

For geographical areas where wind design value is	Record maximum deflection(s) after completion of wind pressure loading at following load[A]
Q_{10} < 0.40 kPa	$D_{0.40}$ at 960 Pa
Q_{10} > 0.40 kPa	$D_{0.60}$ at 1440 Pa

[A] The wind pressure loading shall be maintained for a minimum of 10 s and the maximum deflection, at any point on the specimen, from the supporting member of the air barrier assembly shall be determined for both positive and negative pressures.

10. Calculation

10.1 *Establishing Air Leakage Rate:*

10.1.1 The determination of the air leakage rate for the assembly shall be based on the results of tests of the wall assemblies as shown in Annex A1. The referenced air leakage rate for each wall assembly shall be the higher data point value leakage rate at 75 Pa for the exfiltration and infiltration cases.

10.1.1.1 The reference base air leakage rate at 75 Pa determined for Specimen 1, the Opaque Wall, shall be the system air leakage rating assigned to the assembly provided that the air leakage at 75 Pa obtained for Specimen 2 is no more than 10 % greater than the reference base air leakage for Specimen 1. The air leakage rate of the specimen to be reported, for both positive and negative cases, shall be the air leakage rate of the specimen after it has been subjected to the structural loading schedule in accordance with 9.2. (Regression line must go through point of origin or assembly behavior during test must be explained.)

11. Report

11.1 Report the following information:

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

11.1.2 *Sample Description*—Proponent, product manufacturer, product type, related materials, and other pertinent information; description of the test frame, equipment used, penetrations made, conditioning, manufacturer's installation guidelines, material qualities; specimen area.

11.1.3 *Drawings of Specimen*—Detailed drawings of the specimen showing dimensioned 'window' dimensions and arrangement, framing location, panel arrangement, installation and spacing of anchorage, flashing details, and any other

pertinent construction details. Any modifications made on the specimen to obtain the reported test values shall be noted. Photographs of detail conditions may be submitted in lieu of drawings of details.

11.1.4 *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.

11.1.5 *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.

11.1.6 *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 ($Q_{s(f)}$ and $Q_{s(s)}$) and the two air leakage rates (q_1 and q_A) for both the face and sides of the specimen.

11.1.7 *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.

11.2 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.

11.3 *Structural Performance Test:*

11.3.1 For sustained, cyclic, and gust loads, the test pressure and duration shall be reported. If the specimen fails, the pressure difference at which structural failure was observed along with a description of the failure shall be reported.

11.4 *Air Leakage Rate Tests:*

11.4.1 Measured air flow versus pressure difference data must be presented in graphic form for both positive and negative cases. The flow rate equation shall be established through linear fitting of data by method of least squares for positive and negative pressure readings. The 95 % confidence interval must be calculated and reported. An acceptable method is presented in X1.5.

11.4.2 All air leakage rates must be expressed in $L/s{\cdot}m^2$. Flow per unit area shall include area of penetrations. Air leakage data for Specimens 2 and 3, but shall not include area changes for fasteners.

11.4.3 The air leakage rate at the reference pressure of 75 Pa must be identified on the graph for each test specimen.

11.5 *Observations and Comments:*

11.5.1 Observations after each loading applied and comments on the performance of the specimen and mode of failure, if any, shall be provided. Any remedial measures applied to the specimen shall be reported and justifications provided, as well as the implications to assembly design.

12. Precision and Bias

12.1 The precision and bias of this practice has not been determined. The precision and bias of the individual test procedures required are given in those methods.

13. Keywords

13.1 air barrier; air barrier accessories; air barrier assemblies; air barrier materials; air barrier systems; air leakage; air leakage rate

ANNEXES

(Mandatory Information)

A1. TEST SPECIMENS

A1.1 See Fig. A1.1, Fig. A1.2, and Fig. A1.3.

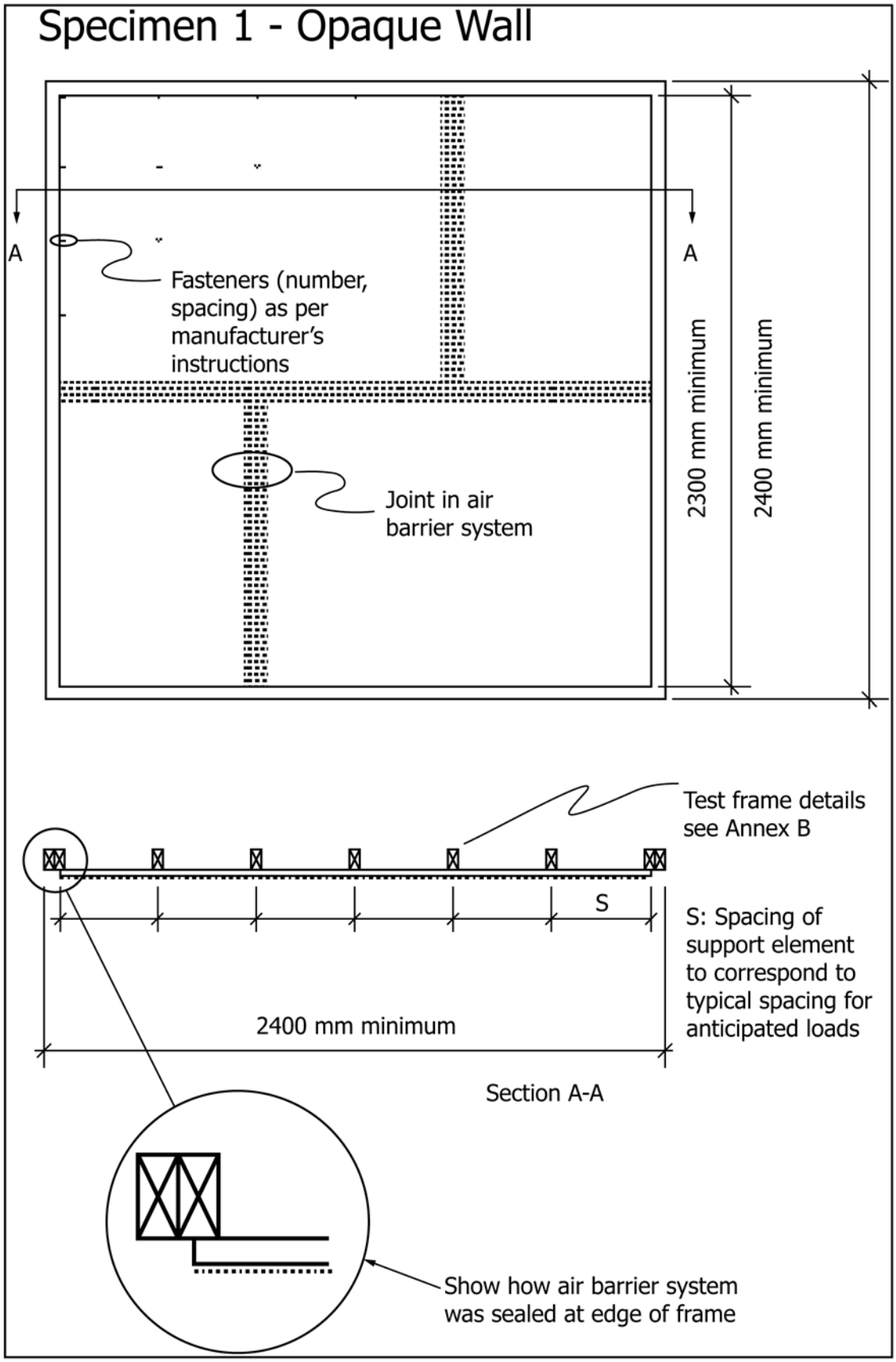

FIG. A1.1 Specimen 1—Opaque Wall

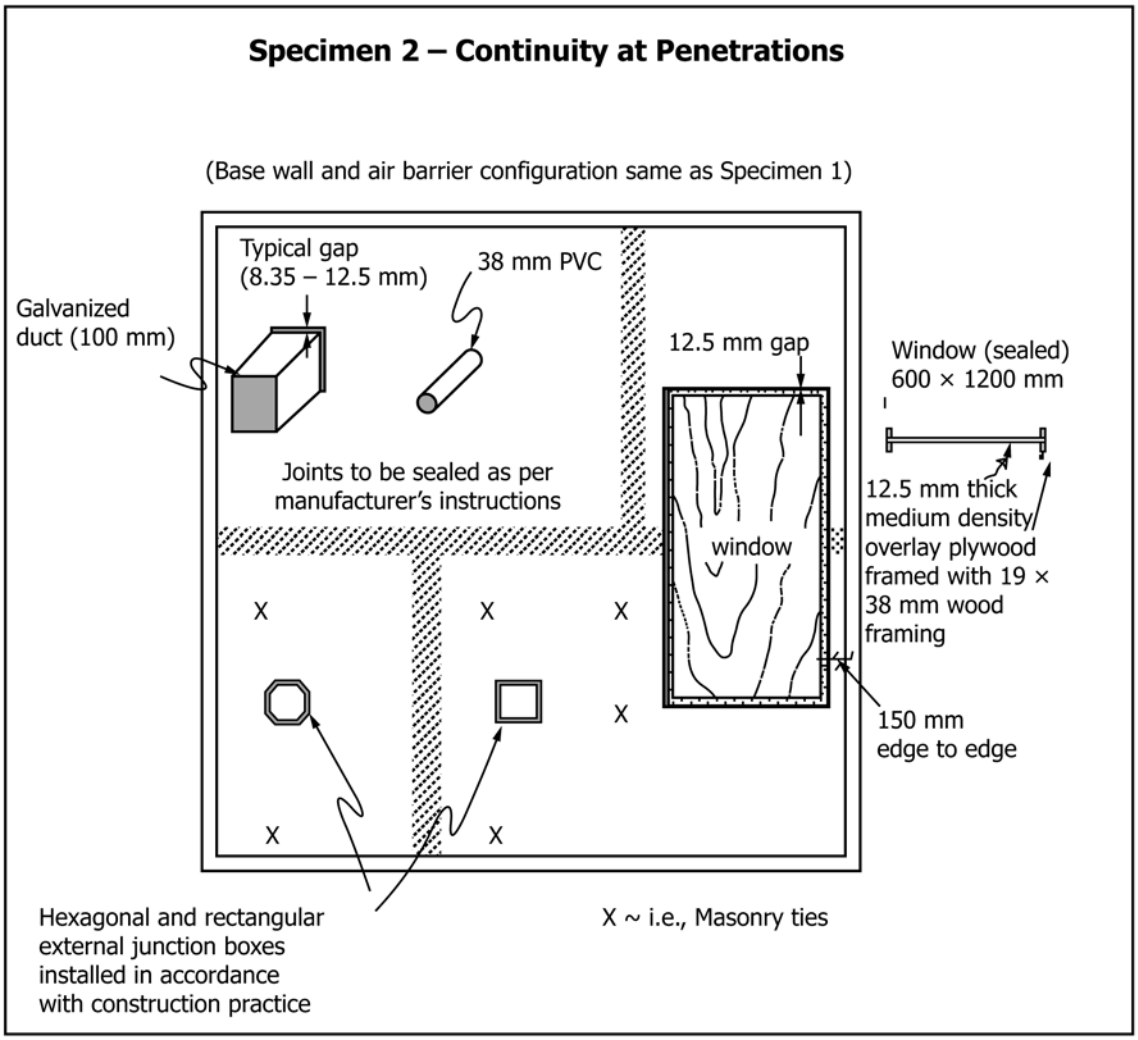

FIG. A1.2 Specimen 2—Continuity at Penetrations

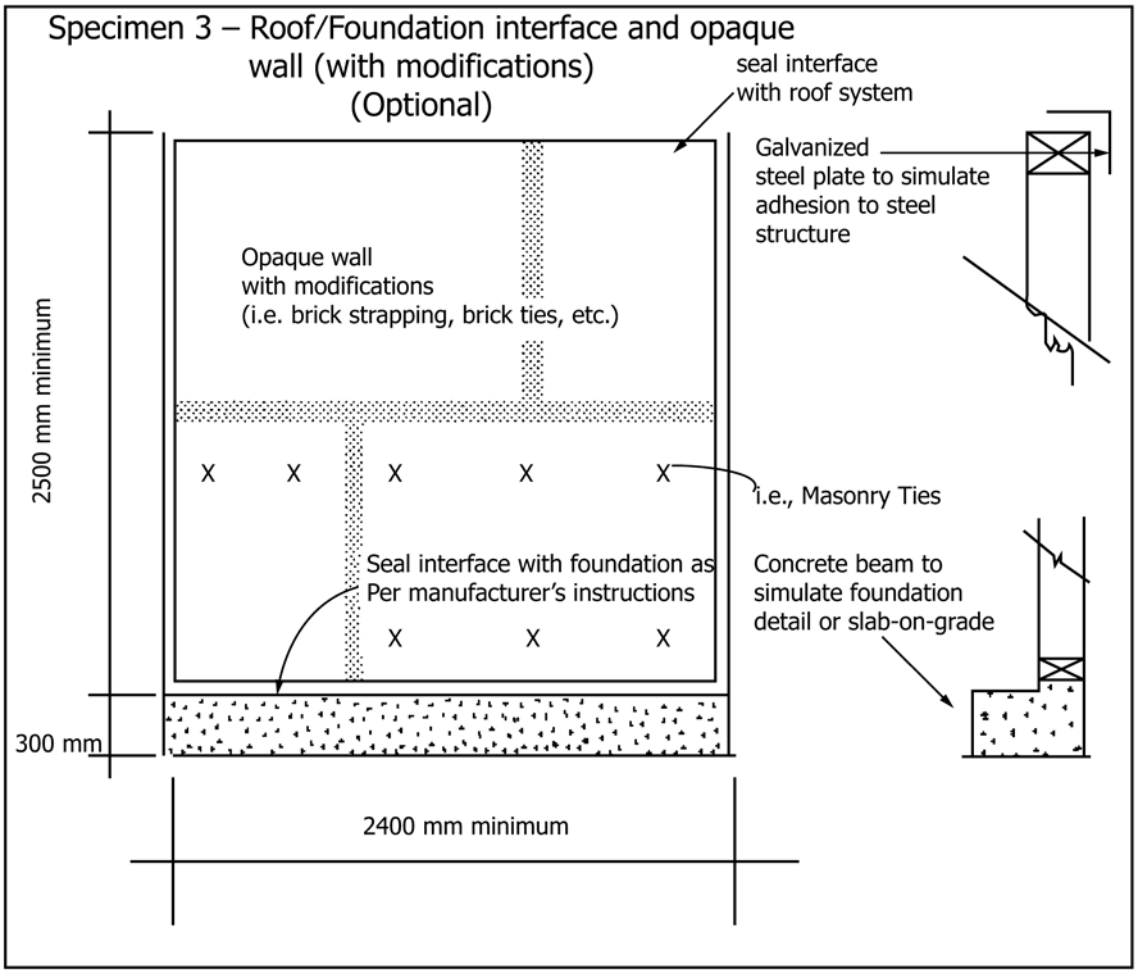

FIG. A1.3 Specimen 3—Roof/Foundation Interface and Opaque Wall (with Modifications) (Optional)

A2. SPECIMEN CONSTRUCTION DETAILS

A2.1 General

A2.1.1 In order to establish an airtight test frame, the proponent must identify a singular plane of continuity for the proprietary air barrier system. The test specimens shall be representative of an air barrier assembly, installed on either side of a conditioned environment, constructed as a single plane for the control of air leakage. Other ancillary components of the wall assembly shall not be included (for example, interior gypsum board, sheathing, cladding) in the test specimen unless the element is an integral part of the air barrier assembly (for example, Exterior Insulation Finish Systems (EIFS)). If the omitted elements will penetrate the air barrier system in final installation, the penetrating fasteners must be incorporated in test Specimen 2 as stated below.

A2.1.2 The opaque wood frame, steel stud, or masonry wall shall be constructed in accordance with the practice of the trade and shall be designed to resist the anticipated loading.

A2.2 Fabrication of Specimen

A2.2.1 *Frame Construction:*

A2.2.1.1 *Specimen 1:*

(1) Air barrier system material where the main material is a large panel-type (for example, exterior gypsum board, plywood) shall be installed with a horizontal joint and staggered vertical joint as shown in Specimen 1.

(2) Air barrier system material where the main material is the long infinite roll-type (for example, polyolefin membranes) must be installed with a minimum of one vertical and one horizontal joint.

A2.2.1.2 *Specimen 2:*

(1) Specimen 2 shall have the same joint configuration as Specimen 1 and the penetrations shall be incorporated into the test frame as shown. The air barrier assembly details for sealing around and across the penetrations shall be carried out in accordance with the proponent's instructions.

(2) The default material shall be a bare medium density overlay plywood window sealed and secured into a rabbeted wood buck.

(3) The junction boxes incorporated into the specimen shall be external or internal boxes, depending on whether the air barrier assembly is installed internally or externally. The boxes may be proprietary and form part of the continuity of the proprietary air barrier assembly or may be conventional boxes which are air sealed with air barrier materials. However, the methodology used to air seal junction boxes shall be stated in the published test report on the assembly performance.

A2.2.1.3 *Specimen 3:*

(1) Specimen 3 shall have the same joint configuration as Specimen 1.

(2) A concrete beam shall be introduced to represent the air barrier assembly/foundation wall interface and additionally a metal plate to simulate tie into metal roof system assembly materials; and brick ties shall be introduced into the opaque wall assembly. The air barrier assembly details for sealing around brick ties and across the foundation interface shall be carried out in accordance with the proponent's instructions. If the proprietary air barrier assembly is not destined to be utilized in conjunction with masonry veneer, other cladding fasteners shall be incorporated or another element shall be introduced representative of the wall assembly construction dedicated to this air barrier assembly, such as an expansion joint in a panel-type air barrier assembly.

A2.2.2 *Masonry Construction:*

A2.2.2.1 *Specimen 1:*

(1) The masonry base wall shall have a vertical expansion control joint to be bridged by the air barrier assembly.

(2) Air barrier assembly materials where the main airtightness material is the long roll-type (for example, modified bituminous membranes) shall be installed with staggered end-of-roll lap joints (for example, one vertical and one horizontal joint).

(3) Masonry ties shall be introduced in Specimen 1 only if the air barrier assembly is dedicated to concrete block assemblies with brick ties. Otherwise masonry ties shall be incorporated in Specimen 3.

A2.2.2.2 *Specimen 2:*

(1) Specimen 2 shall have the same joint configuration as Specimen 1 and the penetrations shall be incorporated into the test frame as shown. The air barrier assembly details for sealing around and across the penetrations shall be carried out in accordance with the proponent's instructions.

(2) The default material shall be a bare medium density overlay plywood window sealed and secured into a rabbeted wood buck.

A2.2.2.3 *Specimen 3:*

(1) Specimen 3 shall have the same joint configuration as Specimen 1.

(2) A concrete beam shall be introduced to represent the air barrier assembly/foundation wall interface and additionally a metal plate to simulate tie into metal roof system assembly materials; brick ties and control or expansion joints should be incorporated in this specimen. The air barrier system details for sealing around brick ties and across the foundation interface shall be constructed in accordance with the proponent's instructions. If the proprietary air barrier system is not destined to be utilized in conjunction with masonry veneer, the specimen shall incorporate exterior finish fasteners that penetrate the air barrier system.

A3. STRUCTURAL LOADING SCHEDULE

A3.1 See Fig. A3.1.

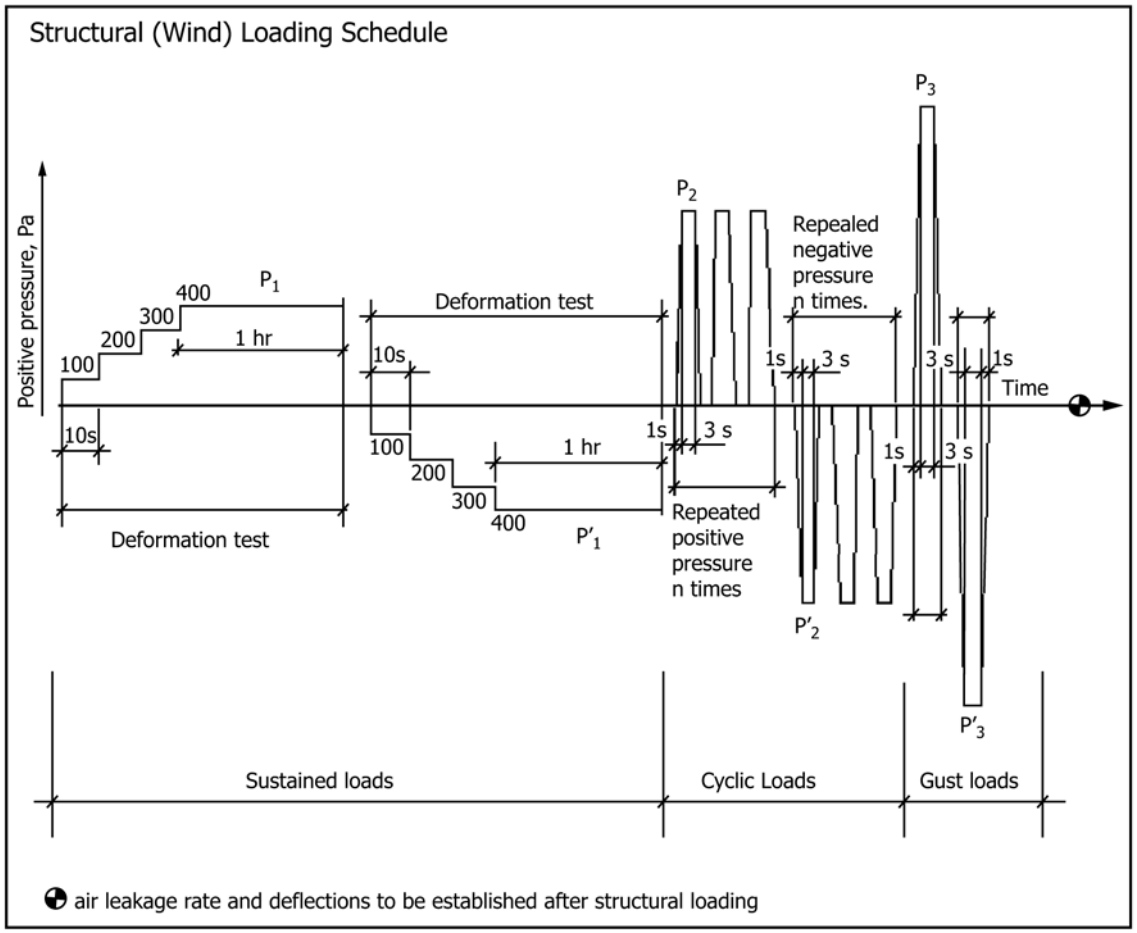

FIG. A3.1 Structural (Wind) Loading Schedule

APPENDIX

(Nonmandatory Information)

X1. OTHER INFORMATION AND CONSIDERATIONS

X1.1 Commentary

X1.1.1 The purpose of an air barrier system is to reduce the leakage of air into and through the building enclosure. To achieve this goal, air barrier assembly must provide a continuous barrier. Air barrier assembly shall cover joints provided by design as well as openings in the building enclosure created during the field construction process. Reduction of air leakage by the air barrier system provides:

X1.1.1.1 *Energy Conservation:*

(1) Air leakage into and out of the conditioned space would have to be heated or cooled to the desired indoor air temperature (**1**, **2**).[3]

(2) Air leakage through the building enclosure decreases the effectiveness of the wall insulation system (**1**, **2**, **3**).

(3) Leakage of moist air from a heated interior or humid exterior can increase the moisture content of the wall, which increases energy consumption and decreases the thermal performance of insulation (**1**, **2**, **3**).

X1.1.1.2 *Moisture Control:*

(1) Air barrier assemblies reduce leakage of moisture-laden air through the opaque wall that can create condensation/frost within the wall assembly. This can have a damaging effect on wall materials such as framing members and impact the thermal performance of other wall materials.

X1.1.2 The test methods contained herein do not purport to address all concerns associated with the air barrier system, such as durability, suitability for intended use, and so forth.

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

X1.2 Use Considerations

X1.2.1 For the air barrier system to be effective it must reduce air flow. This resistance to air flow can only be achieved by maintaining continuity (no breaks or tears). Continuity of joints must be maintained by overlapping, sealing with weatherable adhesive tapes or caulkings/gaskets. Caulked joints must accommodate dimensional changes in framing members without loss of seal integrity. Such dimensional changes can be induced by lumber drying and settling thermal movement and structural movement. Special care (for example, gasketing, sealing) must be used to reduce air leakage around unavoidable penetrations such as plumbing, air ducts, electrical conduits and window/door edges.

NOTE X1.1—Test Method E1424 may be utilized to determine the effect of temperature on air barrier assembly.

X1.2.2 An air barrier system must be capable of resisting wind loads when the wall is finished. The air barrier system must resist both pressure and suction without rupturing or breaking away or detaching from its support.

X1.2.3 Air barrier system's may have a range of permeance. All materials in a wall assembly must be considered in evaluating condensation, not just one material. It is the relationship of the total permeance of all the wall materials, the position of those materials in the building enclosure, and the temperature at those positions that influences condensation potential.

X1.2.4 To account for variant geographical conditions, differing pressure values for testing are provided.

X1.3 Application Considerations

X1.3.1 Air barrier assembly's can be designed or specified and installed in various locations in the building enclosure. The various considerations, based on the rationale for air barrier system is discussed below.

X1.3.1.1 *Interior Application:*

(1) Considerations for installing an air barrier system on the interior side of the insulation material are as follows:

(a) To reduce outside air leakage into the conditioned space.

(b) An interior vapor retarder, which reduces vapor diffusion into the opaque wall, can perform as an interior air barrier assembly.

(c) Interior side application protects the air barrier assembly's from large changes in temperature that can be encountered in the exterior application.

(d) Reduces interior air leakage into the opaque wall that can affect the R-value of the insulation.

(e) Reduces moist air leakage from the interior into the opaque wall, which may result in damage to structural properties, for example, framing, metal fasteners, masonry ties.

(f) Interior side application does not provide protection from exterior air and water leakage into the opaque wall. Exterior driven air and water intrusions reduce the effectiveness (R-value) of the insulation, and increase the potential for moisture damage.

NOTE X1.2—When an air barrier system is installed on the interior, designers should provide information for exterior air and water leakage protection of the opaque wall.

X1.3.1.2 *Exterior Application:*

(1) Considerations for installing an air barrier system on the exterior side of the insulation material are as follows:

(a) Reduces outside air leakage into the conditioned space.

(b) Reduces outside air leakage within and around thermal insulation. Air movement, including convective currents within the opaque wall, can cause a loss of effective R-value (**2, 3**).

(c) Reduces the potential that cold or hot air leakage will flow into the opaque wall.

(d) Can provide water-resistant protection for interior wall components, lumber, insulation, and other envelope materials.

(e) Exterior side application does not protect the wall cavity from interior side air and moisture vapor leakage into the insulated opaque wall.

(f) In moderate to cold climates, water vapor must be able to escape from the opaque wall, or be kept warm enough to reduce the likelihood of condensation.

(g) In hot and humid climates, an air barrier system can also serve as a vapor retarder. See X1.2 for further information.

X1.4 Standards

X1.4.1 *Related Standards:*

E96/E96M Test Methods for Water Vapor Transmission of Materials

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D638 Test Method for Tensile Properties of Plastics

D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between 30C and 30C with a Vitreous Silica Dilatometer

D726 Test Method for Resistance of Nonporous Paper to Passage of Air (Withdrawn 2009)[4]

E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D4216 Specification for Rigid Poly(Vinyl Chloride) (PVC) and Related PVC and Chlorinated Poly(Vinyl Chloride) (CPVC) Building Products Compounds

D4495 Test Method for Impact Resistance of Poly(Vinyl Chloride) (PVC) Rigid Profiles by Means of Falling Weight

E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

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

E1424 Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure and Temperature Differences Across the Specimen

E1677 Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls

[4] The last approved version of this standard is referenced on www.astm.org.

CCMC Technical Guide for Air Barrier Systems for Exterior Walls of Low-Rise Buildings[5]

X1.5 Reporting Errors

X1.5.1 *Recommended Procedure for Estimating Errors in Derived Quantities:*

X1.5.1.1 This test method contains several derived quantities which are often used to summarize the air tightness of the building or component tested. It is important to report an estimate of the error in such quantities. The following method is recommended: all derived quantities depend on the estimation of the air leakage coefficient C and air pressure exponent n of Eq X1.1. To determine C and n, make a log transformation of the variables Q and dP for each reading.

$$X_1 = In(dP_1)$$

For I = 1.n

$$Y_1 = In(Q_1)$$

where n is the total number of test readings. Eq X1.1 then transforms into:

$$y = \mathrm{In}(C) + n \cdot x \tag{X1.1}$$

[5] Available from National Research Council of Canada (NRC), 1200 Montreal Road, Ottawa, Ontario K1A 0R6, Canada, http://www.nrc-cnrc.gc.ca/eng.

TABLE X1.1 Two-sided Confidence Limits T (95 %, N-2) for a Student Distribution

N-2	3	4	5	6	7	8	9	10
T (95 %,N-2)	3.182	2.776	2.571	2.447	2.365	2.306	2.262	2.228

Compute the following quantities:

$$\bar{x} = \frac{1}{n} \sum_{I(=)1}^{n} X_1 \tag{X1.2}$$

$$\bar{y} = \frac{1}{n} \sum_{I(=)1}^{n} Y_1 \tag{X1.3}$$

$$S_x^2 = \frac{1}{n-1} \sum_{I(=)1}^{n} \left(X_1 - \bar{X}\right)^2 \tag{X1.4}$$

$$S_y^2 = \frac{1}{n-1} \sum_{I(=)1}^{n} \left(Y_1 - \bar{Y}\right)^2 \tag{X1.5}$$

$$S_{xy} = \frac{1}{n-1} \sum_{I(=)1}^{n} \left(X_1 - \bar{X}\right)\left(Y_1 - \bar{Y}\right) \tag{X1.6}$$

Then the best estimate of n and $\ln(C)$ is given by:

$$n = \frac{S_{xy}}{S_x^2} \tag{X1.7}$$

$$\ln(C) = \bar{y} - n \cdot \bar{x} \tag{X1.8}$$

and the confidence interval in the estimate of y using Eq X1.1 at any x is:

$$\mathrm{I}y\,(x) = Sy(x)T(95\%, N-2) \tag{X1.9}$$

Therefore the airflow rate Q predicted by Eq X1.1 at any pressure difference dP lies in the interval:

$$\left(Q \cdot \exp^{-\mathrm{I}y(\mathrm{I}n(dP))},\ Q \cdot \exp^{\mathrm{I}y(\mathrm{I}n(dP))}\right) \tag{X1.10}$$

with a probability of 95 %.

X1.5.1.2 It is this interval that shall be used to estimate the error in the leakage area or the airflow rate across the building material at a reference pressure (for example, 75 Pa).

X1.5.1.3 In practice, the above error analysis can be carried out using standard statistical computer programs.

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