Designation: D8052/D8052M – 17

Standard Test Method for Quantification of Air Leakage in Low-Sloped Membrane Roof Assemblies[1]

This standard is issued under the fixed designation D8052/D8052M; 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 laboratory technique for determining air leakage in low-sloped membrane roof assemblies under specified negative air pressures differences.

1.2 This test method is intended to measure air leakage of a roof assembly with rooftop penetrations.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1079 Terminology Relating to Roofing and Waterproofing

D7586/D7586M Test Method for Quantification of Air Intrusion in Low-Sloped Mechanically Attached Membrane Roof Assemblies

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

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

E2357 Test Method for Determining Air Leakage of Air Barrier Assemblies

2.2 *CAN/CSA Standard:*[3]

CAN/CSA-A123.21-14 Standard Test Method for the Dynamic Wind Uplift Resistance of Membrane-roofing Systems

3. Terminology

3.1 *Definitions*—Terms used in this test method are defined in Terminology D1079, Terminology E631, Test Method E283, and Test Method D7586/D7586M.

4. Summary of Test Method

4.1 The air leakage test consists of installing a roof assembly with five typical rooftop penetrations between two chambers, a bottom chamber where the roof assembly is installed in a horizontal plane and a top chamber through which air is exhausted at a rate required to maintain the specified pressure difference across the roof assembly, and measuring the resultant air flow through the specimen. Although the roof assembly is tested in horizontal plane, the results are applicable to low slope roofs as defined in Terminology D1079.

5. Significance and Use

5.1 This test method can be useful in understanding the response of low-sloped membrane roof assemblies to air pressure differences induced across the assembly.

5.2 This test method can be useful in understanding the role of different roofing components in providing resistance to air leakage through the roof assembly.

5.3 When applying the results of tests by this test method, note that the performance of a roof or its components, or both, depends on proper installation.

5.4 This test method does not purport to establish all criteria necessary for the consideration of air movement in the design of a roof assembly. Air intrusion in roofing systems is separate and distinct from air leakage in roofing systems. Test Method D7586/D7586M provides an air intrusion test method for mechanically attached roof assemblies. The results are intended to be used for comparison purposes and likely do not represent the field installed performance of the roof assembly.

[1] This test method is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.20 on Roofing Membrane Systems.

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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] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.

6. Test Apparatus

6.1 This description of the apparatus is general in nature, and any arrangement of the equipment capable of performing the test method within the allowable tolerances is permitted.

6.2 The major components of the test apparatus are shown in Fig. 1 and described below:

6.2.1 *Pressure Box*—The pressure box shall consist of two test chambers designated as the top chamber and the bottom chamber.

6.2.1.1 *Top Chamber*—The interior length and width dimension of top chamber shall be minimum 6.1 m [20 ft] long and 2.44 m [8 ft] wide, respectively. It shall have a minimum height of 0.9 m [3 ft] and shall be movable. To measure the chamber pressure, it shall be fitted with at least one pressure tap. Provision shall be made for an opening on the top chamber through which the pipe network will be installed and connected to the blower. The top chamber shall be provided with window openings to view the test specimen response and a gust simulator. The gust simulator shall consist of flap valve connected to a stepping motor through a timing belt arrangement. To facilitate the control of test pressures that is applied over the test specimen, the top chamber shall be well sealed by appropriate sealing products. The top chamber shall be structurally resilient to resist deformation from wind loads induced during the wind conditioning.

NOTE 1—Sealing products such as non-hardening mastic compounds or pressure-sensitive tape can be used to achieve the air tightness in the construction of the pressure chamber, to seal the perimeter edges of the test specimen to the bottom chamber and to seal the access door to the chamber.

6.2.1.2 *Bottom Chamber*—A supporting frame for the top chamber, which shall have a minimum interior length and width dimension of 6.1 m [20 ft] long and 2.44 m [8 ft] wide, respectively, and a minimum height of 0.9 m [3 ft]. The bottom chamber shall comprise a structural support on which the test specimen shall be installed horizontally as shown in Fig. 1. The structural support shall be installed on a height adjustable platform that can accommodate membrane roof assemblies with different thickness. The bottom chamber and the structural support must be capable of supporting the loads transferred from the test assembly during the conditioned specified in 9.8.

6.2.2 *Air System*—A controllable blower designed to provide the required airflow at the specified negative pressures. The blower shall be capable of creating suction pressures of up to 5 kPa [100 psf].

6.2.3 *Pressure Measuring Apparatus*—A device for measuring the test pressure difference within a tolerance of ±2 % of the reading or ±2.5 Pa [0.05 psf], whichever is greater.

6.2.4 *Airflow Measurement System*—A device to measure the air flow into the test chamber or through the test specimen.

NOTE 2—The accuracy of the specimen leakage flow measurement is affected by the accuracy of the flowmeter and amount of extraneous leakage of the apparatus (see Annex A1 of Test Method E283).

6.2.5 *Data Acquisition System*—A computer based system capable of reading and recording the pressure and airflow measurements.

7. Test Specimen

7.1 The specimens tested shall be representative of the field built roofing assemblies. Therefore, the test specimens shall be fabricated as prescribed by the proponent in providing for the specimen construction required herein.

7.2 The test specimen shall include the following five penetrations: wooden curb, metal curb, cast iron plumbing vent with pre-manufactured boot, ABS (Acrylonitrile butadiene styrene), or PVC (Polyvinyl Chloride) plumbing vent with field fabricated pipe seal, and a roof drain (see Fig. 2). All

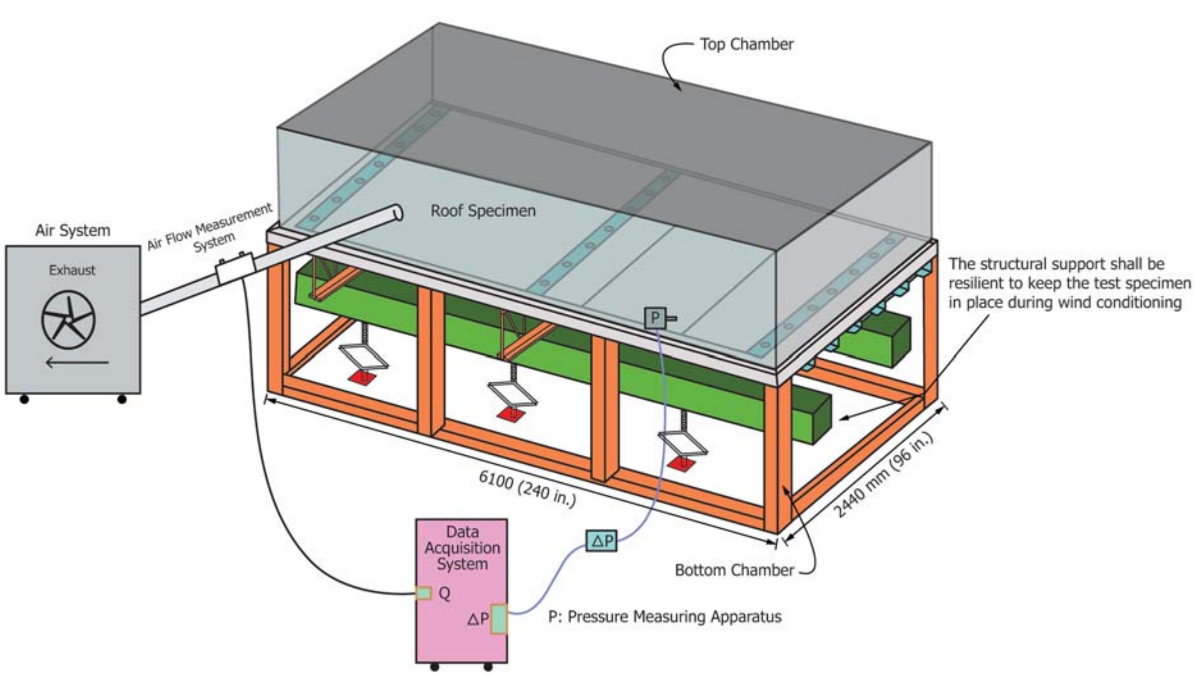

FIG. 1 Air Leakage Test Apparatus

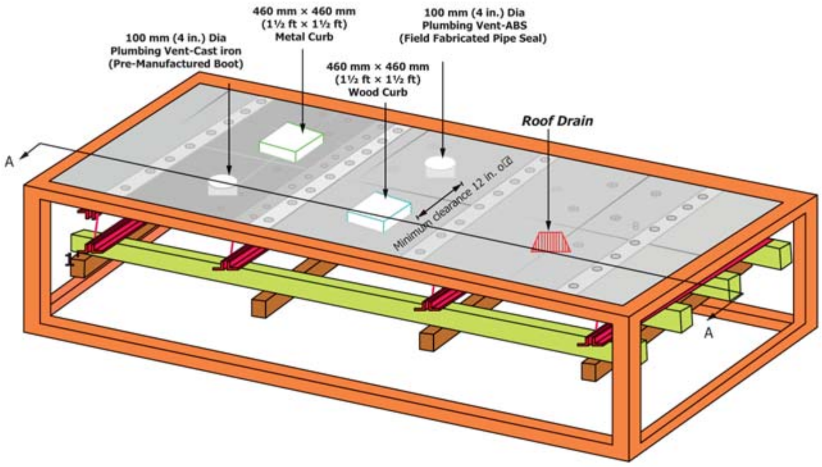

FIG. 2 Typical Layout of Test Specimen

penetrations shall be installed in accordance with the manufacturer's installation instructions. The penetrations shall be covered (see Fig. 3) to ensure that the measured air leakage is through the test specimen and not through the penetrations during the testing.

7.3 The perimeter edges of the structural deck shall be flush to the interior of the bottom chamber and shall be sealed to the bottom chamber using suitable sealing products as shown in the cross-sectional view (Fig. 3). This is crucial to ensure that the deck seams or joints are the flow paths and not the deck edges.

7.4 When insulated test specimens are tested, the top surface of the insulation board shall be flush with the top edges of the bottom chamber.

7.5 To ensure that edges of the roofing membrane are not part of the flow paths during air leakage testing, the roofing membrane shall have a minimum overhang of 600 mm [24 in.] on all the four sides and shall be sealed to the outside of the bottom chamber as shown in Fig. 3 by suitable sealing products (see Note 1).

8. Calibration

8.1 Calibration shall be performed in accordance to the procedure described in Test Method E283.

9. Test Procedure

9.1 With the test specimen constructed in the bottom chamber and covered with the top chamber, the test procedure comprises of measuring the extraneous leakage of the top chamber and air leakage of the test specimen.

9.2 Ensure that the top chamber is tightly fixed to the bottom chamber during the test to make sure that no membrane slippage occurs. (See Note 3.)

NOTE 3—Clamping devices or gaskets may be used for tightening the top chamber to the bottom chamber.

9.3 To measure the extraneous leakage, close the gust simulator, cover the specimen appropriately with a continuous sheet of roofing membrane or a polyethylene sheet, and connect the air system and airflow measurement system as shown in Fig. 3.

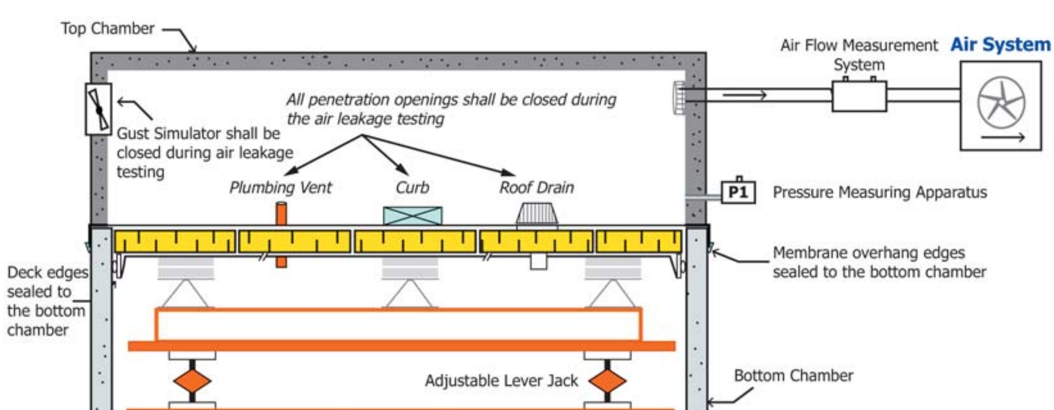

FIG. 3 General Arrangement of the Air Leakage Setup

9.4 Apply suction of 25 Pa [0.5 psf], and maintain the pressure for one minute. Thereafter, raise the suction and hold for one minute as follows: 50 Pa [1.04 psf], 75 Pa [1.57 psf], 100 Pa [2.09 psf], 150 Pa [3.13 psf], 250 Pa [5.22 psf], and 300 Pa [6.27 psf]. During the test, measure the extraneous leakage of the top chamber and record the results.

9.5 During the entire testing process, the barometric pressure, temperature, and relative humidity of the air at the test specimen shall be recorded.

9.6 Express the measured extraneous leakage of the top chamber in terms of flow at standard conditions and plot the relationship between the air flow and pressure difference as per Eq 1.

$$Q_e = c(\Delta P)^n \tag{1}$$

where:

Q_e = air flow or extraneous leakage, L/s [ft^3/min],
c = flow coefficient,
ΔP = pressure difference, and
n = exponent indicating the flow types or openings.

9.7 *Pre-Conditioning Air Leakage:*

9.7.1 After the completion of the extraneous leakage measurement, remove the covering membrane or polyethylene sheet, and repeat the procedure 9.4 to measure the pre-conditioning air leakage of the test specimen. If the measured air leakage is same as the extraneous leakage of specimen from 9.6, proceed to 9.8, otherwise identify the air flow paths that could be the result of workmanship and seal them appropriately, and repeat 9.4. Designate this measured air flow as the extraneous air flow, Q_e.

9.8 *Wind Pressure Conditioning:*

9.8.1 Subject the test specimen to CSA A123.21-14 Level A dynamic load cycle with a test wind pressure of 2.8 kPa [60 psf] (Fig. 4).

9.8.2 After the wind pressure conditioning, the test specimen shall be inspected by the testing agency for any signs of failure such as seam delamination, membrane tear, construction details failure, and so forth. The test specimen shall not demonstrate any change in structure that would affect the integrity of the assembly.

9.9 *Post Conditioning Air Leakage:*

9.9.1 The air leakage test of 9.4 shall be repeated after wind conditioning to quantify the air leakage of the test specimen. This measured air leakage is designated the total air leakage, Q_t.

10. Calculation

10.1 At each pressure level, the flow rate through the test specimen (Q_s) shall be determined by subtracting the extraneous air flow (Q_e) from the total air leakage (Q_t).

$$Q_s = Q_t - Q_e \tag{2}$$

10.2 Calculate the rate of air leakage in accordance with the following method:

$$\text{Rate of air leakage per unit area} = Q_s/A \tag{3}$$

where:

A = area of the test specimen.

11. Report

11.1 The test report shall contain the following information: date of test and report, the name of the author of the report, and the names and addresses of the party commissioning the test.

11.2 Detailed description of the construction method of the test specimen, the name(s) of the manufacturer(s) of all components, and a description of all components.

11.3 Detailed drawings of the specimen showing dimensioned section profiles.

11.4 Where additional specimen(s) are tested, results for all specimens shall be reported, with each specimen being properly identified, particularly with respect to distinguishing features or differing adjustment.

11.5 List the ambient air temperature, relative humidity, and barometric pressure as measured and recorded during the test.

11.6 Tabulation of the applied negative pressures on the test specimen and the corresponding air flow rates.

11.7 Time history plot of the wind pressure loading shall be reported.

11.8 The measured air flow versus pressure difference data in graphic form (log/log graph) for the test specimen. The flow rate equation shall be established through linear fitting of data

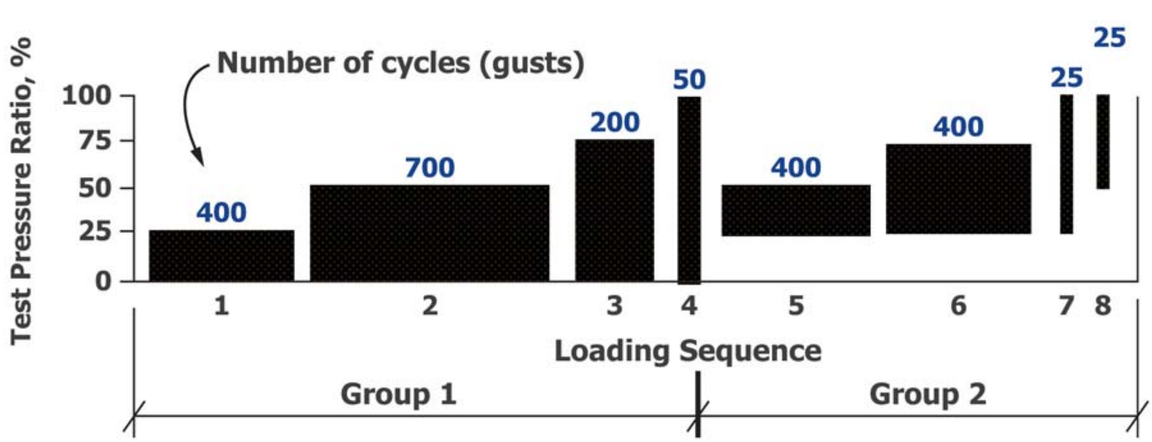

FIG. 4 CSA A123.21-14 – Level A: 2200 Cycles

by method of least squares. The coefficient of determination (r^2) must be calculated and presented.

11.9 All air leakage rates must be expressed in $L/s.m^2$ and the air leakage rate at the reference pressure of 75 Pa must be identified on the graph.

12. Precision and Bias

12.1 The accuracy required for the determination air leakage is affected by the extraneous leakage of the testing chamber and the appropriate sealing measures, such as in 7.2 and 7.4.

12.2 The repeatability relative standard deviation is determined to be between 2 to 5 %. For example, the standard deviation of air flow measurements at each test pressure level from two identical specimens would be expected to range between 2 to 5 % of the mean. The reproducibility of this test method is being determined and will be available on or before December 2019.

13. Keywords

13.1 air; air flow; air leakage; flow; flow meter; laboratory method; membrane; negative pressure; pressure; roof; wind pressure

APPENDIX

(Nonmandatory Information)

X1. GENERAL DISCUSSION

X1.1 Conventional roofs with the waterproofing membrane exposed to the weathering and insulation below are common low-sloped membrane roofing assemblies. In these assemblies the membrane can be mechanically attached, fully adhered, or partially attached to the substrate.

X1.2 In these roofing assemblies most of the attention has been focused on the performance of individual roof components to maintain the integrity of the waterproofing system. Meanwhile, relatively little attention has been given to the overall assembly performance with regards to air movement, which is still misunderstood within the building community.

X1.3 For airflow to occur across a building component, there must exist two prerequisites: one is the pressure difference between two locations; the other is a continuous flow path or openings connecting the locations. In the building envelope, air movement can be described by the following terms (Molleti et al):[4]

X1.3.1 *Air Leakage*—When air enters or leaves from one environmental condition to the other environmental condition through the building envelope assembly such as walls and windows, it is termed as "Air Leakage."

X1.3.2 *Air Intrusion*—When conditioned indoor air enters into a building envelope assembly but cannot escape to the exterior environment, as is the case for mechanically attached roofs, it is termed "Air Intrusion."

X1.4 In a roof assembly, the roofing membrane provides the waterproofing function of the roof. Therefore the roofing membranes are impermeable to water and thus to air movement as well. As a roofing assembly comprises of parapet walls, rooftop structures and penetrations, continuity of the membrane is very critical as any opening in the membrane may lead to water ingress and can lead to air leakage. This holds true irrespective of roof membrane type and its attachment mode. In mechanically attached roof membranes, as a result of inherent membrane fluttering behavior, there is air intrusion into roof assemblies. Controlling air intrusion is critical to ensuring good roofing system performance because it can have effects on wind uplift resistance, moisture accumulation, and thermal resistance. In functioning roof membrane assemblies, air intrusion is separate and distinct from air leakage (Fig. X1.1). Currently there exists an ASTM standard (Test Method D7586/D7586M) to quantify air intrusion in mechanically attached roof assemblies.

X1.5 Building air barriers constructed of materials and assemblies other than the deemed-to-comply materials and assemblies require additional testing to comply with IECC 2012 requirements for air barriers. The existing standards–Test Method E2357, Specification E1677, and Test Method E283–are intended for measuring air leakage rates through wall and window assemblies. They do not adequately address industry-recognized characteristics of construction and performance requirements of roof membrane assemblies.

X1.6 Therefore, to evaluate the air barrier performance of roof membrane assemblies, a new test method was developed by taking Test Method E2357 as the platform. The test method describes a new test setup with test specimen details that incorporates five essential roof top penetrations/details. Test Method E2357's wall assembly-specific wind conditioning protocol simulates (positive) pressures. To account for wind flow conditions over a roof assembly, a test protocol that simulates (negative) suctions is incorporated into the current test method.

X1.7 The current test method can evaluate air leakage performance of any generic low sloped membrane roof assemblies. It will be a qualitative tool for all those new materials and

[4] Molleti, S., Baskaran, B. A., Ko, K. P., and Beaulieu, P., "Air Leakage vs. Air Intrusion in Low-Sloped Roofing Assemblies," Proceeding of the 12th Canadian Conference on Building Science and Technology, Montréal, Quebec, May 2009, pp. 567–578.

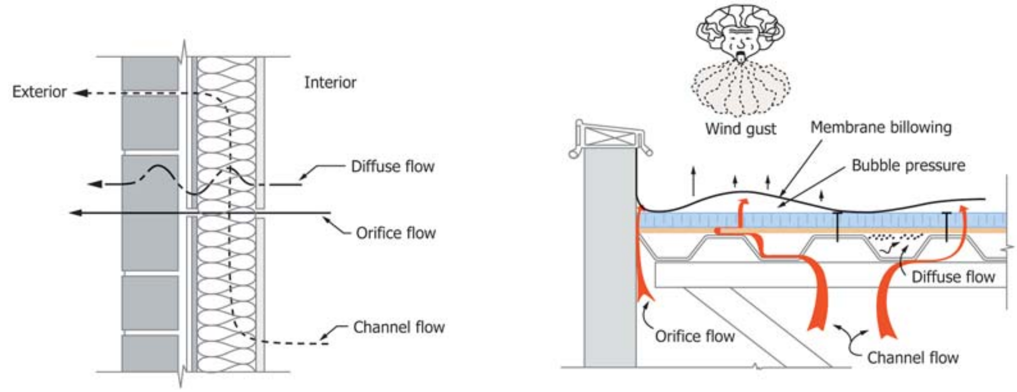

FIG. X1.1 Concept of Air Leakage (Brick Cladding Wall) Versus Air Intrusion (Mechanically Attached Roofing System)

components emerging in the roofing market thereby eliminating non-engineered roofing assemblies.