Designation: D8052/D8052M – 22

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 pressure 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 nonconformance 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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]

D1079 Terminology Relating to Roofing and Waterproofing
D7586/D7586M Test Method for Quantification of Air Intrusion in Low-Sloped Mechanically Attached Membrane Roof Assemblies (Withdrawn 2020)[3]
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
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E1677 Specification for Air Barrier (AB) Material or Assemblies for Low-Rise Framed Building Walls
E1680 Test Method for Rate of Air Leakage through Exterior Metal Roof Panel Systems
E2357 Test Method for Determining Air Leakage Rate of Air Barrier Assemblies

2.2 *CAN/CSA Standard:*[4]

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/E283M, 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, 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-sloped 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.

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

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

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.

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 are 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 thicknesses. The bottom chamber and the structural support must be capable of supporting the loads transferred from the test assembly during the conditions specified in 9.8.

6.2.2 *Air System*—A controllable blower designed to provide the required air flow 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 *Air Flow 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

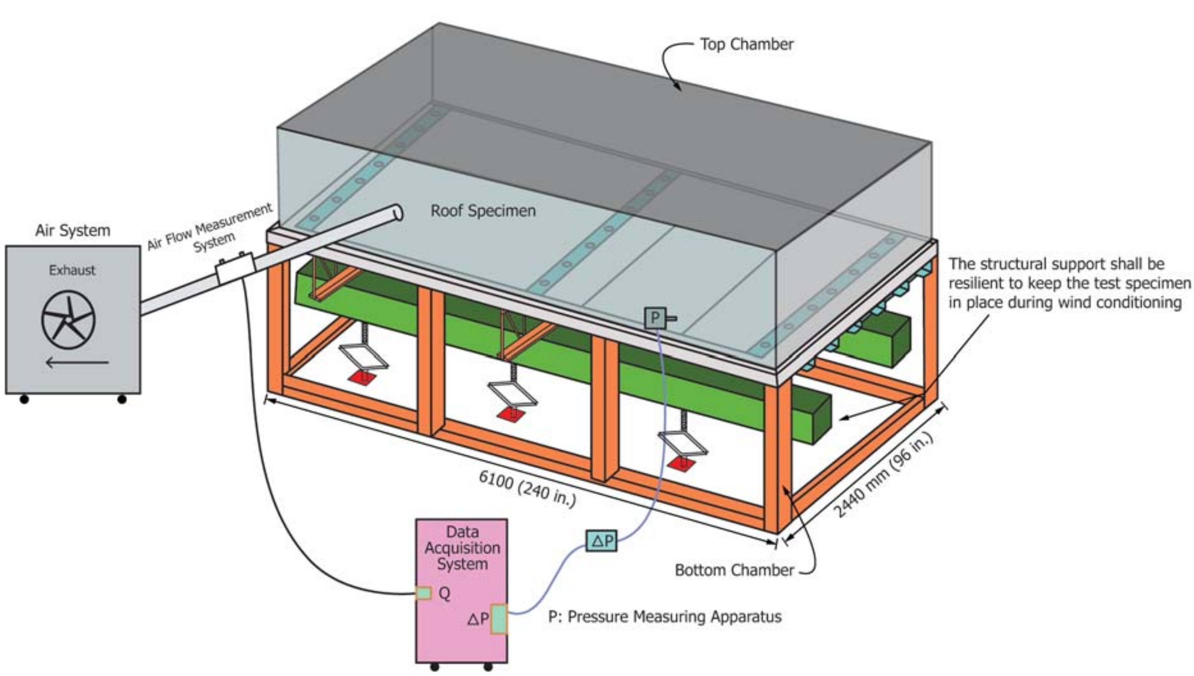

FIG. 1 Air Leakage Test Apparatus

affected by the accuracy of the flow meter and amount of extraneous leakage of the apparatus (see Annex A1 of Test Method E283/E283M).

6.2.5 *Data Acquisition System*—A computer-based system capable of reading and recording the pressure and air flow 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 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/E283M.

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 air flow measurement system as shown in Fig. 3.

9.4 Apply suction of 25 Pa [0.5 psf], and maintain the pressure for 1 min. Thereafter, raise the suction and hold for 1 min 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.

$$Q_e = c(\Delta P)^n \quad (1)$$

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

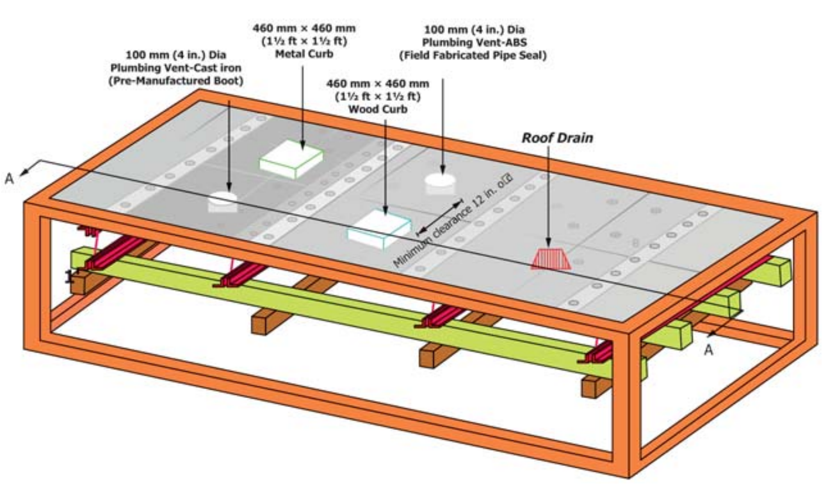

FIG. 2 Typical Layout of Test Specimen

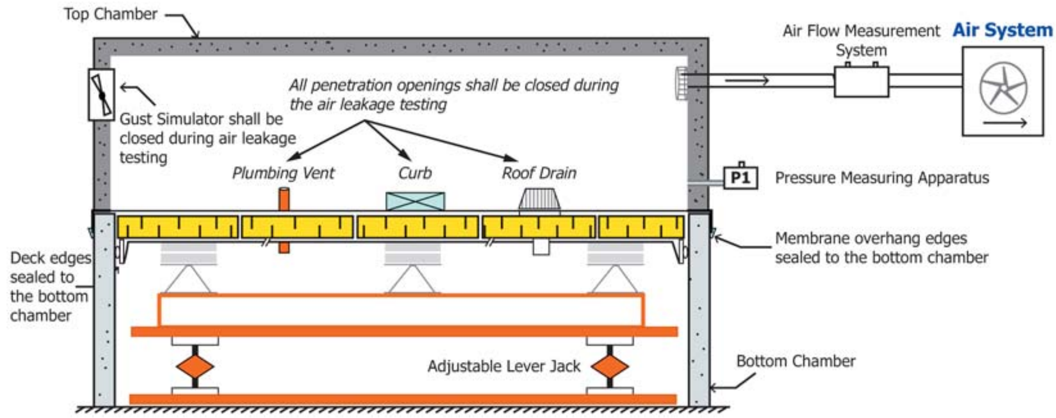

FIG. 3 General Arrangement of the Air Leakage Setup

sheet, and repeat the procedure in 9.4 to measure the preconditioning 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).

$$Q_s = Q_t - Q_e \quad (2)$$

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

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

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.

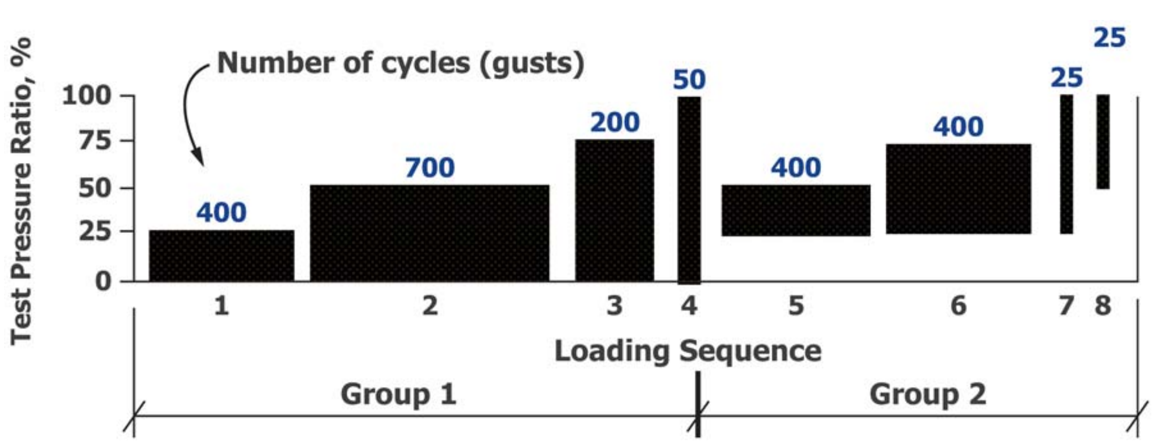

FIG. 4 CSA A123.21-14 – Level A: 2200 Cycles

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 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[5]

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, 7.3, and 7.5.

12.2 The precision of this test method is based on the interlaboratory study (ILS) of ASTM D8052/D8052M Standard Test Method for Quantification of Air Leakage in Low-Sloped Membrane Roof Assemblies. This ILS was completed in April 2021. The ILS established the precision of the test method following the calibration procedure specified in Section 8. These calibration measurements validate the air flow measuring system for the Section 9 test procedure. The Section 9 procedures were not included in the round-robin testing due to the complexities involved in constructing an equivalent roof test specimen by each participating lab. A similar approach was followed to develop the precision and bias section for Test Method E1680, and the current ILS study followed that approach. A total of six laboratories participated in the testing of concentric bored orifice plates with three bore diameters of 12.7 mm [0.5 in.], 25.4 mm [1.0 in.], and 38.1 mm [1.5 in.]. Each participating laboratory was requested to report triplicate test results for each orifice plate size at the air pressure difference of 50 Pa [1.0 psf] (optional), 75 Pa [1.5 psf], 120 Pa [2.5 psf], 240 Pa [5.0 psf], 360 Pa [7.5 psf], 480 Pa [10 psf], and 600 Pa [12.5 psf]. Test results received from the six laboratories were arranged and analyzed in accordance with Practice E691.

12.2.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the stated values in only one case in 20.

12.2.1.1 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, which is accepted as plausible due to random causes under the normal and correct operation of the test method.

12.2.1.2 Tables 1-7 list the repeatability limits of air leakage rate measured at 50 Pa to 600 Pa.

12.2.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the stated values in only one case in 20.

12.2.2.1 Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, which is accepted as plausible due to random causes under the normal and correct operation of the test method.

12.2.2.2 Tables 1-7 list the reproducibility limits of air leakage rate measured at 50 Pa to 600 Pa.

12.3 *Bias*—No accepted reference material or test specimen suitable for determining the bias for this test method was incorporated into this study. Therefore no statement on bias is being made.

12.4 The precision statement was determined through statistical examination of 133 test results, from six different laboratories, on three sample specimens.

13. Keywords

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

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D08-2001. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Rate of Air Leakage at 50 Pa (optional)^A (L/s)

Material	Average $\bar{x}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
12.7 mm orifice	0.716	0.012	0.146	0.034	0.409
25.4 mm orifice	2.771	0.007	0.134	0.019	0.375
38.1 mm orifice	6.361	0.022	0.840	0.061	2.352

^{A} The data was analyzed based on data submitted by five labs.