~~Designation:E1554–03~~ Designation: E 1554 – 07

Standard Test Methods for Determining ~~External~~ Air Leakage of Air Distribution Systems by Fan Pressurization[1]

This standard is issued under the fixed designation E 1554; 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

~~1.1These test methods cover two techniques for measuring the air leakage of the sections of air distribution systems that pass outside the conditioned space in low-rise residential and small low-rise commercial buildings. Both techniques use air flow and pressure measurements to determine the leakage characteristics, and include separate measurements of the supply-side and the return-side distribution system leakage.~~

~~1.2These test methods also specify the auxiliary measurements needed to characterize the magnitude of the distribution system air leakage during normal operation (a measurement of pressure differentials across duct leaks during normal distribution-system operation), and to normalize the distribution system's air leakage by the total recirculating air flow induced by the air handler fan.~~

~~1.3The proper use of these test methods requires a knowledge of the principles of air flow and pressure measurements.~~

~~1.4These test methods are intended to produce a measure of the air leakage between an air distribution system and its surroundings exterior to the conditioned space of a building.~~

~~1.5The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.~~

~~1.6~~

1.1 The test methods included in this standard are applicable to the air distribution systems in low-rise residential and commercial buildings.

1.2 These test methods cover four techniques for measuring the air leakage of air distribution systems. The techniques use air flow and pressure measurements to determine the leakage characteristics.

1.3 The test methods for two of the techniques also specify the auxiliary measurements needed to characterize the magnitude of the distribution system air leakage during normal operation.

1.4 A test method for the total recirculating air flow induced by the system blower is included so that the air distribution system leakage can be normalized as is often required for energy calculations.

1.5 The proper use of these test methods requires knowledge of the principles of air flow and pressure measurements.

1.6 Three of these test methods are intended to produce a measure of the air leakage from the air distribution system to outside. The other test method measures total air leakage including air leaks to inside conditioned space.

1.7 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.8 *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.* For specific hazard statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 631 Terminology of Building Constructions ~~E741Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution~~

E 779 Test Method for Determining Air Leakage Rate by Fan Pressurization

E 1258 Test Method for Airflow Calibration of Fan Pressurization Devices

2.2 *ASME Standard:*[3]

MFC-3M Measurement of Fluid Flow in Pipes Using Orifice Nozzle and Venturi

[1] These test methods are under the jurisdiction of ASTM Committee E06 on Performance of Buildings and are the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation Performance.

Current edition approved ~~Dec.~~Nov. 1, ~~2003.~~2007. Published ~~January 2004.~~December 2007. Originally approved in 1993. Last previous edition approved in ~~1994~~2003 as ~~E1554–94.~~E 1554 – 03.

[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 American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

3. Terminology

3.1 *Definitions*—Refer to Terminology E 631 for definitions of other terms used in these test methods.

3.1.1 ~~*air handler fan*—the air moving fan for the distribution system located in the air-handling unit.~~

3.1.2~~*air-handling unit*—the distribution-system fan and portion of the distribution system that is integral to the furnace, air-conditioner, or heat-pump.~~

3.1.3~~*building envelope*—the boundary or barrier separating the interior volume of a building from the outside environment.~~

3.1.4~~*conditioned space*—the portion of a building whose air temperature or humidity is intentionally controlled for human occupancy.~~ —the boundary or barrier separating the interior volume of a building from the outside environment. Even when a garage is conditioned, for this standard it is considered to be outside the building envelope.

3.1.2 *blower*—the air moving device for a forced air space conditioning and/or ventilation system.

4. ~~Summary of Test Methods~~

~~4.1Two alternative measurement and analysis procedures are specified. The first of these techniques, Test Method A, is based upon changes in flow through distribution system leaks at fixed envelope pressure differences due to air handler operation. The envelope pressure differences are generated by a separate air moving fan, both pressurization and depressurization measurements are performed. The second technique, Test Method B, is based upon pressurizing the distribution system at the same time as the house in order to isolate the leaks that are outside the building envelope. Measured system operating pressures are then used to estimate leakage under operating conditions. Test Method B is shown schematically in~~ Summary of Test Methods

4.1 Four alternative measurement and analysis methods are specified and labeled A through D, Test Methods A and B give separate values for supply and return leakage to outside. Test Methods C and D do not separate supply and return leakage. Test Methods A, B, and C determine leakage to outside, but Test Method D measures total leakage, including leakage to inside. Test Method A is based upon changes in flow through distribution system leaks to outside due to blower operation over a range of envelope pressure differences. The envelope pressure differences are generated by a separate air moving fan and both pressurization and depressurization measurements are performed. Test Methods B and C are based upon pressurizing the distribution system at the same time as the building in order to isolate the leaks that are outside the building envelope. For Test Method B, measured system operating pressures are then used to estimate leakage under operating conditions. Test Method C determines the leakage to outside at a uniform reference pressure of 25 Pa (0.1 in. water) instead of operating pressure, and does not separate supply and return leaks. Test Methods B and C are shown schematically in Fig. 1.

~~4.2These test methods also include specifications for the auxiliary measurements to interpret the air leakage measurements. These include measurement of the pressures that drive distribution-system air leakage during normal system operation and measurement of the air handler fan flow.~~ . Unlike Methods A, B, and C, Method D does not attempt to measure the leakage to outside under normal operating conditions, but measures the total system leakage at a uniform reference pressure of 25 Pa (0.1 in. water). The schematic in Fig. 3 applies to Method D.

4.2 These test methods also include specifications for the auxiliary measurements to interpret the air leakage measurements.

5. Significance and Use

5.1 Air leakage between an air distribution system and unconditioned spaces affects the energy losses from the distribution system, the ventilation rate of the building, and ~~potentially~~ the entry rate of air pollutants.

5.2 The determination of infiltration energy loads and ventilation rates of residences and small commercial buildings are typically based on the assumption that the principal driving forces for infiltration and ventilation are the wind and indoor/outdoor temperature differences. This can be an inappropriate assumption for buildings that have distribution systems that pass through unconditioned spaces, because the existence of relatively modest leakage from that system has a relatively large impact on overall ventilation rates. The air leakage characteristics of these exterior distribution systems are needed to determine their ventilation, energy, and pollutant-entry implications.

5.3 Air leakage through the exterior air distribution envelope may be treated in the same manner as air leakage in the building envelope as long as the system is not operating (see Test Method E 779~~). However, when the air handler fan is turned on, the pressures across the air distribution-system leaks are significantly larger than those driving natural infiltration, thereby inducing much larger flows. Thus, it is important to be able to isolate these leaks from building envelope leaks. Due to the different impacts of supply-side and return-side distribution-system leaks, these two air leakage pathways shall be measured separately. The leakage of air distribution systems must be measured in the field, because it has been shown that workmanship is often more important than design in determining the leakage of these systems. In addition, it is important to distinguish leaks to the conditioned parts of a building from leaks to the outside.~~

~~5.4As an alternative to the test methods in this standard, air infiltration with and without an air distribution system operating may be measured directly using the tracer dilution method (see Test Method E741). The test methods described in this standard provide an indirect way to relate the infiltration rate to the leakage of the building and the air distribution system.~~

~~5.5Combined with the fan pressurization method for measuring envelope leakage (Test Method E779) there are several advantages over the tracer dilution method. The methods described in this standard produce results that characterize the air tightness of the building envelope and the air distribution systems. The methods described in this standard are used to compare the relative air leakage of several similar air distribution systems, to identify the leakage sources and rates of leakage from different~~

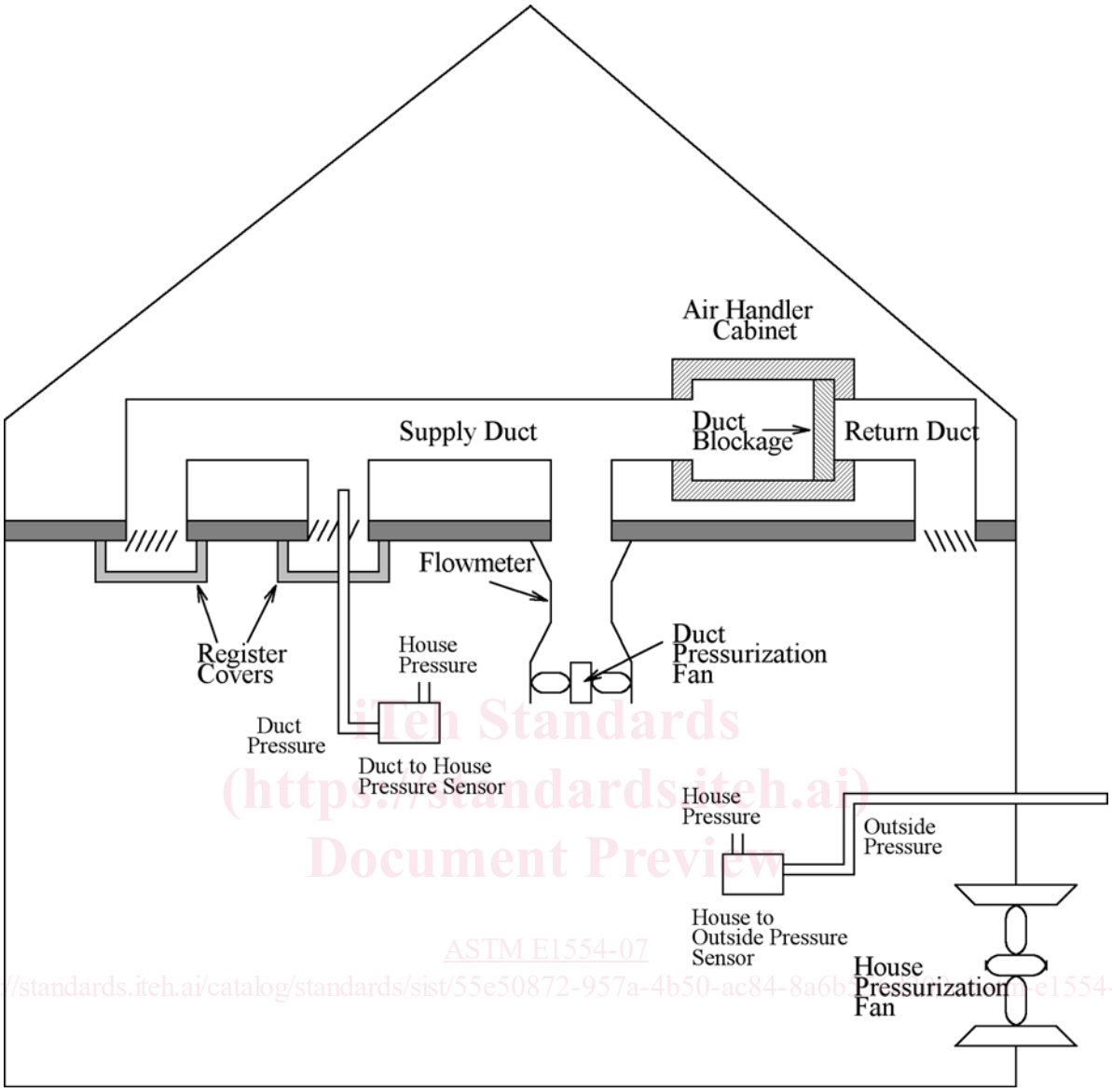

FIG. 1 Schematic of Method B—Distribution System and Building Pressurization Test (for Supply Leakage)

components of an air distribution system, and to determine the air leakage reduction for individual retrofit measures applied incrementally to an existing air distribution system.). However, when the system blower is on, the pressures across the air distribution system leaks are usually significantly larger than those driving natural infiltration. Depending on the size of the leaks, these pressures can induce much larger flows than natural infiltration. Thus, it is important to be able to isolate these leaks from building envelope leaks. The leakage of air distribution systems must be measured in the field, because it has been shown that workmanship and installation details are more important than design in determining the leakage of these systems.

5.4 For codes, standards, and other compliance or quality control applications, the precision and repeatability at meeting a specified target (for example, air flow at reference pressure) is more important than air leakage flows at operating conditions. Some existing codes, standards, and voluntary programs require the use of a simpler test method (Test Method D) that does not separate supply from return leakage, leakage to inside from leakage to outside, or estimate leakage pressures at operating conditions.

5.5 Test Methods A, B, and C can be used for energy use calculations and compliance and quality control applications. Test Method D is intended for use in compliance and quality control only.

6. Apparatus

6.1The following description of apparatus is general in nature. Any arrangement of equipment using the same principles and capable of performing the test procedure within the allowable tolerances is permitted. Those items required for Test Method A are labeled (A only), those for Test Method B are labeled (B only), and those for both test methods are labeled (A and B). Most of the components are illustrated in Fig. 1.

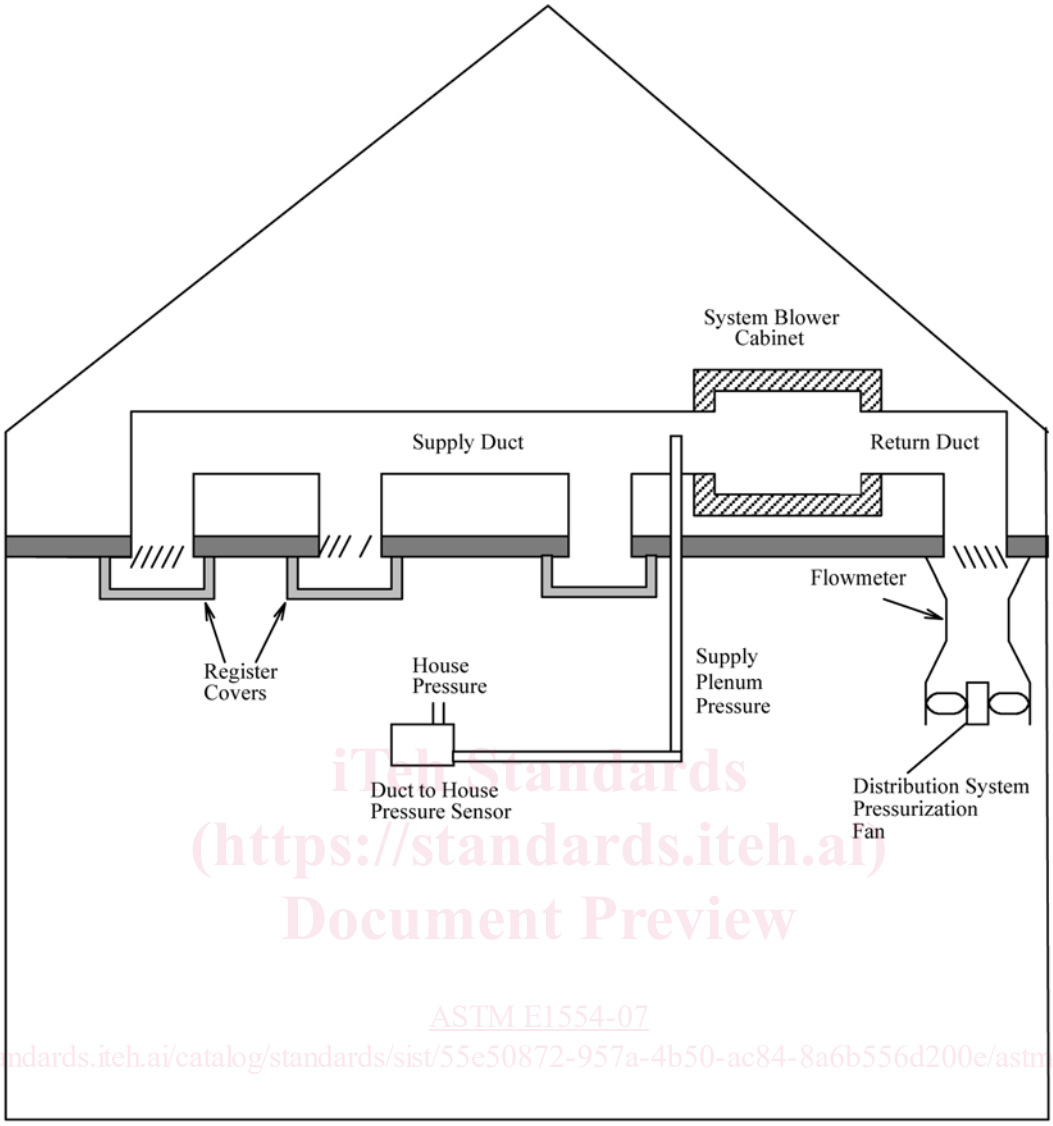

FIG. 2 Schematic of Method C—Distribution System Pressurization Test

6.1 The following description of apparatus is general in nature. Any arrangement of equipment using the same principles and capable of performing the test procedure within the allowable tolerances is permitted. The items are labeled for each test method.

6.2 *Major Components*:

6.2.1 *Air-Moving Equipment ~~(A and B)~~*—~~A fan, blower, or blower door assembly that is capable of moving air into and out of the conditioned space at the flow rates required to create the full range of test pressure differences (up to 25 Pa). The system shall provide constant air flow at each incremental pressure difference at fixed pressure for the period required to obtain readings of air flow rate. The air moving equipment shall be able to accomplish both pressurization and depressurization of the conditioned space and distribution system.~~ (A, B, and C)—A fan, blower, or blower door assembly that is capable of moving air into and out of the building at the flow rates required to create the full range of test pressure differences. The air moving equipment shall be able to accomplish both pressurization and depressurization of the building and distribution system.

6.2.2 *Air Flow-Regulating System (A, B, and ~~B)~~C)*—A ~~device,~~device such as a damper or variable speed motor ~~control, that will~~ control to regulate and maintain air flow through the air moving equipment (see 6.2.1~~) and pressure difference across the leaks within specific limits.~~).

6.2.3 *Air Flow Measuring Device ~~(A only)~~(A)* —A device to measure airflow with an accuracy of ±5 % of the measured flow through air moving equipment in 6.2.1. The air flow measuring system shall be calibrated in accordance with Test Method E 1258 or ASME MFC-3M, whichever is applicable. The temperature dependence and range of the calibration shall be explicitly reported.

6.2.4 ~~*Duct Flow Measurement Device (B only)*~~Distribution System Flow Measurement Device *(B, C, and D)*—A device to measure airflow with an accuracy of ±5 % of the measured flow. The airflow measuring system shall be calibrated in accordance with Test Method E 1258 or ASME MFC-3M, whichever is applicable. The temperature dependence and range of the calibration shall be explicitly reported.

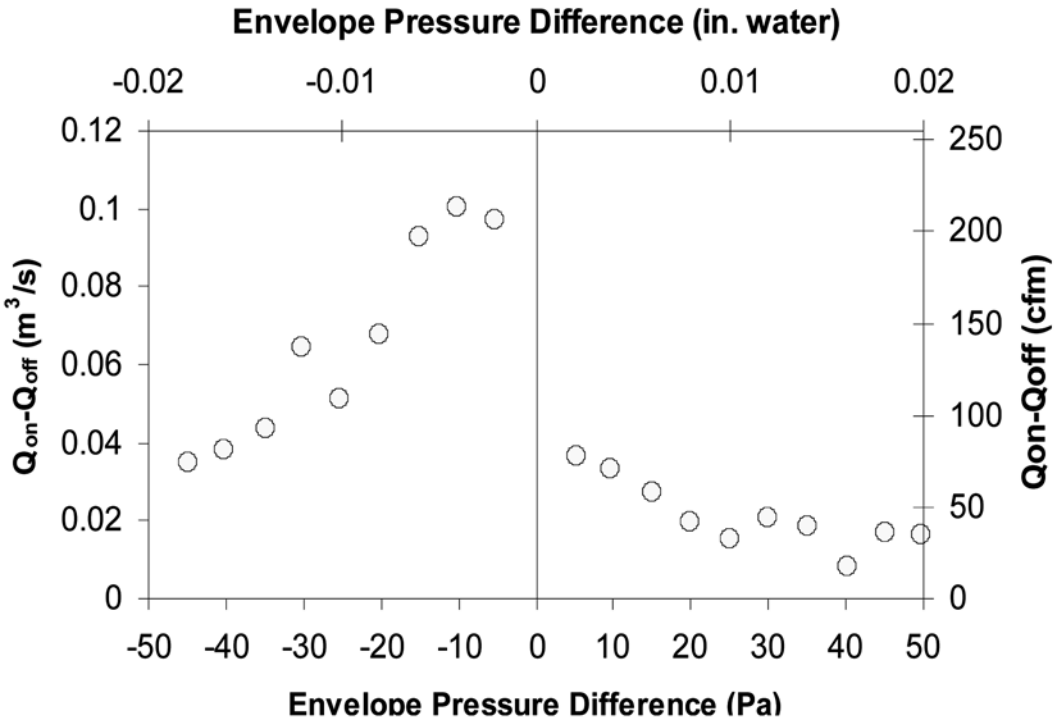

FIG. 3 Example of Air-Flow Difference and Envelope Pressure Plot for Test Method A.1

6.2.5 *Pressure-Measuring Device ~~(A and B)~~*—~~A manometer or pressure indicator to measure pressure differences with an accuracy of ±0.25 Pa (±0.001 in. H~~ (All methods)—A device to measure pressure differences with an accuracy of ±0.25 Pa (±0.001 in. H_2O) or ±1 % of measured pressure, whichever is greater.

6.2.6 ~~*Duct Pressure Measuring Probe (B only)*—A probe to measure the static pressure within a duct under flow conditions.~~ Distribution System Pressure Measuring Probe *(B, C, and D)*—A probe to measure the static pressure within a distribution system under flow conditions.

6.2.7 *Air Temperature Measuring Device ~~(A and B)~~*—~~To give an accuracy of ±0.5°C (1°F).~~

~~6.2.8*Simultaneous Pressure and Flow Measurement System (A and B)*—A system that provides for essentially simultaneous measurement of building envelope and distribution-system pressures, as well as building envelope and distribution-system flows. Three alternative systems are a computerized data acquisition system, a multi-channel sample and hold system, and an interleaved multi-point sampling technique (that is, sequential recording of the pressures and flow signals averaged over at least three sets of signal-series samples).~~ (All methods)—To give an accuracy of ±0.5°C (0.9°F).

7. Hazards

7.1 Glass should not break at the pressure differences normally applied to the building, however, protective eye wear shall be provided to personnel.

7.2 When conducted in the field, safety equipment required for general field work shall be supplied, such as safety shoes, hard hats, and so forth.

7.3 Because air-moving equipment is involved in this test, a proper guard or cage to house the fan or blower and to prevent accidental access to any moving parts of the equipment ~~must~~shall be provided.

7.4 Hearing protection shall be provided for personnel who work close to noises such as those generated by moving air.

7.5 When the blower or fan is operating, a large volume of air is being forced into or out of the building, the air-distribution system, or both. Precautions shall be undertaken such that plants, pets, occupants, or internal furnishings shall not be damaged due to the influx of cold or warm air. Similar precautions shall be exercised with respect to sucking debris or exhaust gases from fireplaces and flues into the interior of the building extinguishing pilot lights, flame rollout for combustion appliances and drawing sewer gas into the building.

8. Procedure

8.1 *General*—~~The basic procedure involves pressurization and depressurization of air distribution systems and buildings with concurrent flow and pressure measurements to determine the air leakage of the distribution system. It also includes measurement of distribution-system pressures and fan flows during normal system operation. The air handler fan speed and heating or cooling function must be the same for all steps of the test procedure.~~ —The basic procedure involves pressurization and depressurization of air distribution systems and buildings with concurrent flow and pressure measurements to determine the air leakage of the distribution system.

8.1.1 *Test Method A (Flow Difference) for Air Leakage Determination*—~~This technique is based upon changing the flow through distribution system leaks by operating the air handler fan and simultaneously pressurizing (and depressurizing) the building envelope and distribution system.~~ This technique is based upon changing the flow through distribution system leaks by operating the blower fan and simultaneously pressurizing (or depressurizing) the building envelope and distribution system. There are two alternatives for gathering the required test data utilizing the same analysis procedure. Test Method A.1 records data at fixed envelope pressure stations. Test Method A.2 records data continuously as the envelope air flows and pressure are gradually changed by the envelope air moving equipment. The blower speed and heating or cooling function shall be the same for all steps of the test procedure.

8.1.2 ~~*Test Method B (Fan Pressurization) for Air Leakage Determination*—This technique is based upon sealing the registers of the distribution system and pressurizing the system to measure the flow out through the leaks at the imposed pressure difference. With the house pressurized to the same pressure, this test isolates the leaks that are to outside only. Measurements of system operating pressures allow the leakage flow at the fixed test pressure to be converted to the leakage flow at operating conditions (pressures).~~ Test Method B: Fan Pressurization of Distribution System and Building for Air Leakage Determination—This technique is based upon sealing the registers of the distribution system and pressurizing the system to measure the flow through the leaks at the imposed pressure difference. With the building pressurized to the same pressure, this test isolates the leaks that are to outside only. Measurements of system operating pressures allow the leakage flow at the fixed test pressure to be converted to the leakage flow at operating pressures. Often air distribution systems are located outside the conditioned space of a building, but are not completely outside. Example locations include attics, crawlspaces, and garages. These locations are defined as buffer zones.

8.1.3 ~~*Choice of Test Method*—In general, Test Method A will have lower operating condition air leakage flow uncertainties for leaky systems than Test Method B, due to uncertainties in Test Method B when converting to operating system pressures. Test Method B will be preferred for houses that have very leaky envelopes, where the changes in envelope pressures and flows used in Test Method A will result in greater uncertainties, or if testing to determine compliance with a specified low leakage value.~~ Test Method C: Fan Pressurization of Distribution System and Building for Air Leakage Determination at a Determination at a Reference Pressure—This technique is based upon sealing the registers of the distribution system and pressurizing the system to measure the flow through the leaks at a reference pressure difference of 25 Pa (0.1 in. water). With the building pressurized to the same pressure, this test isolates the leaks that are to outside only, but does not separate supply and return leaks or convert results to operating pressures.

8.1.4 *Test Method D: Fan Pressurization of Distribution System for Total Air Leakage Determination*—This technique is based upon sealing the registers of the distribution system and pressurizing the system to measure the flow through the leaks at the imposed pressure difference. The result is a total distribution system leakage at a single reference pressure difference of 25 Pa (0.1 in. water). This test does not separate supply and return leaks, convert to operating pressures, or isolate leaks to outside from those to inside.

8.2 ~~*Procedure for Test Method A*~~ Procedure for Test Method A: Air Flow Difference:

Test Method A has four parts to the test:

(1) Building pressurized, blower off.

(2) Building pressurized, blower on.

(3) Building depressurized, blower on.

(4) Building depressurized, blower off.

8.2.1 *Environmental Measurements*—At the beginning and the end of each test, measure the outdoor temperature, indoor temperature, and ~~indoor temperature.~~ barometric pressure.

8.2.2 *Building Preparation*:

8.2.2.1 *Envelope*—~~Open all interconnecting doors in the conditioned space (except for closet doors, which shall be closed) so that a uniform pressure will be maintained within the conditioned space to within 10% of the measured inside/outside pressure difference. Verify this condition by performing differential pressure measurements between several rooms at the highest test pressure. Fireplace and other operable dampers shall be closed. If the air handling unit is located in a closet, the closet door shall be closed during testing.~~ Open all interconnecting doors in the building. Fireplace and other operable dampers shall be closed. If the air handling unit is located in a closet, the closet door shall be closed during testing. The condition of openings to outside for spaces that contain ducts (for example, garage doors or basement windows) shall be recorded.

8.2.2.2 *Distribution System*—HVAC-balancing dampers and registers, in general, shall not be adjusted. However, for multiple zoned systems, the position of zonal dampers should be fixed for the duration of the test. Several tests may be performed with zone dampers fixed at different settings, but at least one of the tests ~~should~~shall have all zone control dampers in the fully open position.

8.2.3 ~~*Test Method A: Flow Difference Measurements*:~~ Air Flow Difference Measurements

8.2.3.1 Connect the air moving/flow-regulating/flow measurement assembly to the building envelope using a window or door opening. Seal or tape openings to avoid leakage at these points.

8.2.3.2 Install the envelope pressure difference sensor. The outside pressure measurement location ~~should~~shall be sheltered from wind and sunshine. The inside pressure measurement location ~~should~~shall be as far away as possible from the localized air flows induced by the air moving apparatus. All the envelope pressures use the outside pressure as the reference.