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# Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Retarder Systems[1]

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## 1. Scope

1.1 These practices cover standardized techniques for locating air leakage sites in building envelopes and air retarder systems.

1.2 These practices offer a choice of means for determining the location of air leakage sites with each offering certain advantages for specific applications.

1.3 Some of the practices require a knowledge of infrared scanning, building and test chamber pressurization and depressurization, smoke generation techniques, sound generation and detection, and tracer gas concentration measurement techniques.

1.4 The practices described are of a qualitative nature in determining the air leakage sites rather than determining quantitative leakage rates.

1.5 *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 6.

## 2. Referenced Documents

2.1 *ASTM Standards:*

E 631 Terminology of Building Constructions[2]

E 741 Test Method for Measuring Air Leakage Rate by Tracer Dilution[2]

E 779 Test Method for Determining Air Leakage Rate by Fan Pressurization[2]

2.2 *Other Standards:*

ANSI-ASHRAE Standard 101 Application of Infrared Sensing Devices to the Assessment of Building Heat Loss Characteristics[3]

ISO Standard 6781 Thermal Insulation—Qualitative Detection of Thermal Irregularities in Building Envelopes—Infrared Method[3]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *air leakage rate*, *n*—the volume of air movement per unit time across the building envelope or air retarder system, including flow through joints, cracks, and porous surfaces, or combinations thereof, in which the driving force for such air leakage in buildings is either mechanical pressurization or evacuation, natural wind pressures, or air temperature differences between the building interior and the outdoors, or combinations thereof.

3.1.2 *air leakage site*, *n*—a location on the building envelope or air retarder system where air can move between the building interior and the outdoors.

3.1.3 *air infiltration*, *n*—air leakage into the building.

3.1.4 *air exfiltration*, *n*—air leakage out of the building.

3.1.5 *building envelope*, *n*—the boundary or barrier separating the interior volume of a building from the outside environment.

3.1.5.1 *Discussion*—For the purpose of these practices, the interior volume is the deliberately conditioned space within a building generally not including the attic space, basement space, and attached structures, unless such spaces are connected to the heating and air conditioning system, such as a crawl space plenum. The actual building envelope may extend beyond these boundaries because of ducting or other construction features.

3.1.6 *air retarder system*, *n*—a system in building construction that is designed and installed to reduce air leakage either into or through the building envelope.

3.1.7 *test specimen*, *n*—the part of the air retarder system on the building to be tested that may consist of the selected areas of materials comprising the principle resistance to airflow, joints between such materials and joints between the materials and structural, mechanical or other penetrations through such materials, and excludes any material which does not form an integral part of the air retarder system.

3.2 For other definitions, see Terminology E 631.

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[1] These practices are under the jurisdiction of ASTM Committee E-6 on Performance of Buildings and are the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation.

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[2] *Annual Book of ASTM Standards*, Vol 04.11.

[3] Available from American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

## 4. Summary of Practice

4.1 This standard presents the following seven practices for detecting air leakage sites in building envelopes:

4.1.1 Combined building depressurization (or pressurization) and infrared scanning,

4.1.2 Building depressurization (or pressurization) and smoke tracers,

4.1.3 Building depressurization (or pressurization) and airflow measuring devices,

4.1.4 Generated sound and sound detection,

4.1.5 Tracer gas detection,

4.1.6 Chamber depressurization (or pressurization) and smoke tracers, and

4.1.7 Chamber depressurization and leak detection liquids.

4.2 These practices are described as follows:

4.2.1 *Building Depressurization (or Pressurization) with Infrared Scanning Techniques*—This practice relies on the existence of an indoor–outdoor temperature difference of at least 5 °C. In most geographic locations, this condition is met during some portion of the day over a large fraction of the year. Outdoor air is moved through the building envelope by depressurizing the building interior with a fan (see Test Method E 779) or using the mechanical system in the building. Because the infiltrating air is at a different temperature than the interior surfaces of the building envelope, local interior surface temperature changes take place which can be detected by infrared scanning equipment. The infrared pattern resulting from air leakage is different from that associated with varied levels of thermal conductance in the envelope, allowing air leakage sites to be identified. This practice can also be performed by pressurizing the building and scanning the exterior of the building envelope.

4.2.2 *Smoke Tracer in Conjunction With Building Pressurization or Depressurization*—This practice consists of pressurizing or depressurizing the building using a fan or the mechanical system in the building and moving a smoke tracer source over the interior or the exterior surface of the building envelope. If the building is pressurized and the smoke tracer source is moved over the interior of the building envelope, air exfiltration through air leakage sites will draw smoke from the tracer source to the site, revealing its location visually. Alternatively, if the building is depressurized and the smoke tracer source is moved over the interior of the building envelope surface, then air jets at each air leakage site will cause the smoke to move rapidly inward. Similarly, the smoke tracer source can be employed on the exterior of the building envelope.

4.2.3 *Building Depressurization (or Pressurization) in Conjunction With Airflow Measurement Devices, or Anemometers*—This practice consists of depressurizing or pressurizing the building using a fan or the building's mechanical systems and moving an anemometer over the interior building envelope surface. If the building is depressurized, air jets will be present within the building at each air leakage site. As the anemometer is moved over the building envelope surface, it will register an air velocity peak at the location of the air leakage site. If the building is pressurized, interior air will flow toward each air leakage site. In this case, the resulting measured air velocity peak will be less distinct.

4.2.4 *Generated Sound in Conjunction With Sound Detection*—This practice consists of locating a sound generator within the building and moving a sound detection device over the exterior of the building envelope. Increased sound intensity is indicative of an air leakage site. Alternatively, the sound generator can be located outside the building and the interior surface of the building envelope can be surveyed using the sound detection device.

4.2.5 *Tracer Gas*—This practice consists of releasing a tracer gas on one side of the building envelope and using a tracer gas detector to measure the concentration of the tracer gas on the other side. A measurable tracer gas concentration indicates the location of an air leakage site. Pressurizing or depressurizing the building envelope using a fan or the building's mechanical system improve the results obtained by this method.

4.2.6 *Chamber Pressurization or Depressurization in Conjunction With Smoke Tracers*—This practice consists of sealing an approximately airtight chamber to a section of the interior or exterior of the air retarder system and using a fan to create a pressure differential across the air retarder specimen. If a smoke tracer source is moved over the surface of the test specimen on the higher pressure side, air leakage will draw smoke toward an air leakage site, visually indicating the location. Conversely, if a smoke tracer is moved over the surface of the test specimen on the low pressure side, air jets at air leakage sites will cause smoke to move away from the air leakage site.



4.2.7 *Chamber Depressurization in Conjunction With Leak Detection Liquid*—The practice consists of applying a leak detection liquid to the test specimen surface, sealing a transparent chamber around the specimen and depressurizing the chamber with a fan. The location of an air leakage site is indicated by bubbling of the detection liquid at the air leakage site.

4.2.8 *Other Practices*—Practices such as the use of a smoke bomb are not described here since they are very specialized and require extreme caution due to additional difficulties such as triggering smoke alarms and causing lingering odors.

## 5. Significance and Use

5.1 Air infiltration into the conditioned space of a building accounts for a significant portion of the thermal space condition load. Air infiltration can affect occupant comfort by producing drafts, cause indoor air quality problems by carrying outdoor pollutants into occupied building space and, in hot humid climates, can deposit moisture in the building envelope resulting in deterioration of building envelope components. In cold climates, exfiltration of conditioned air out of a building can deposit moisture in the building envelope causing deterioration of building envelope components. Differential pressure across the building envelope and the presence of air leakage sites cause air infiltration and exfiltration **(1)**.[4]

[4] The **boldface** numbers in parentheses refer to the list of references at the end of these practices.

5.2 In some buildings, restricting air movement between interior zones of a building may be desired to separate dissimilar interior environments or prevent the movement of pollutants. Although not dealt with specifically in this standard, the detection practices presented can also be useful in detecting air leaks between interior zones of the building.

5.3 Air leakage sites are often difficult to locate because air flows may be small under the prevailing weather conditions. Wind conditions can aid in air leakage detection by forcing air to enter a building; however, where air is exiting, the building envelope construction may make observations difficult. For these reasons, forced pressurization or depressurization is strongly recommended for those practices which require controlled flow direction.

5.4 The techniques for air leakage site detection covered in these practices allow for a wide range of flexibility in the choice of techniques that are best suited for detecting various types of air leakage sites in specific situations.

5.5 The infrared scanning technique for air leakage site detection has the advantage of rapid surveying capability. Entire building exterior surfaces or inside wall surfaces can be covered with a single scan or a simple scanning action, provided there are no obscuring thermal effects from construction features or incident solar radiation. The details of a specific air leakage site may then be probed more closely by focusing on the local area. Local leak detection is well addressed with the smoke tracer, anemometer, sound detection, the bubble detection and the tracer gas techniques, however these techniques are time consuming for large surfaces. The pressurized or depressurized test chamber and smoke tracer or a depressurized test chamber and leak detection liquid practices can be used in situations where depressurizing or pressurizing the entire envelope is impractical, such as is the case during construction. Both of the practices enable the detection of very small leaks. To perform these practices requires that the air retarder system be accessible.

5.6 Complexity of building air leakage sites may diminish the ability for detection. For example, using the sound detection approach, sound may be absorbed in the tortuous path through the insulation. Air moving through such building leakage paths may lose some of its temperature differential and thus make thermographic detection difficult. The absence of jet-like air flow at an air leakage site may make detection using the anemometer practice difficult.

5.7 Stack effect in multistory commercial buildings can cause gravity dampers to stand open. Computer-controlled dampers should be placed in normal and night modes to aid in determining the conditions existing in the building. Sensitive pressure measurement equipment can be used for evaluating pressure levels between floors and the exterior. Monitoring systems in high-tech buildings can supply qualitative data on pressure differences.

## 6. Hazards

6.1 Glass should not break at the pressure differences normally applied to the test structure. However, for added safety, adequate precautions such as the use of eye protection should be taken to protect the personnel. Occupant protection must also be considered.

6.2 Since the test is conducted in the field, safety equipment required for general field work also applies, such as safety shoes, hard hats, etc.

6.3 Because air-moving equipment may be involved in these tests, provide a proper guard or cage to house the fan or blower and to prevent accidental access to any moving parts of the equipment.

6.4 Noise may be generated by the moving air from pressurization systems. Therefore, make hearing protection available to personnel who must be close to the noise source.

6.5 Use of smoke tracers often produces pungent and caustic fumes. Although extremely localized, precautions should be taken so that smoke inhalation is minimized and respiratory protection is provided as required. See Note 1.

NOTE 1—Hands should be washed before eating if large quantities of pungent or caustic fumes have been generated.

6.6 Moving air from the pressurization devices can produce cold drafts affecting plants, birds, wall-mounted pictures, papers on desks, etc. These sensitive items should be moved out of the air path. Prolonged depressurization testing may result in lower temperatures in critical areas of the building and may adversely affect building components, for example frozen pipes.

6.7 Depressurization in buildings with fireplaces can cause movement of ashes into occupied spaces. Close dampers or cover fireplaces, or both, prior to depressurization.

6.8 Caution must be exercised as to the choice of tracer gases used and the level of concentration provided. Health guidelines, fire and explosion limits must not be exceeded. See Test Method E 741.

## 7. Procedure

7.1 Each practice enables the locating of air leakage sites and, if sealing methods are employed, enables the sites to be resurveyed to evaluate qualitatively the degree of success of the sealing procedure. Some air leakage sites involve preferred directional flow, requiring the correct choice of pressurization or depressurization to ensure detection. The following are more detailed descriptions of each of the practices previously presented.

7.2 *Depressurization (or Pressurization)/Infrared Practice*—This practice is based upon the principle that outside air, when drawn through the building envelope by building depressurization, will induce a temperature change in the inside surfaces surrounding the air leakage site. Infrared scanning methods can be used to detect the sites by sensing differences in the adjacent interior surface temperatures **(2,3,4)**. Training in the use of this equipment is essential.

7.2.1 *Background*—It is clear from using pressurization and depressurization techniques, such as described in Test Method E 779, that airflow through leakage sites is markedly increased with higher inside-outside pressure differences. During almost any day of the year, temperature differences of 5 °C or more between the inside and outside environments are present for at least part of the day. Under these conditions, air drawn through an air leakage site will alter the local surface temperatures around the site. Infrared equipment with sufficient sensitivity and resolution (see ISO Standard 6781 and ANSI-ASHRAE