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# Standard Guide for Assessing Depressurization-Induced Backdrafting and Spillage from Vented Combustion Appliances[1]

This standard is issued under the fixed designation E1998; 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 guide describes and compares different methods for assessing the potential for, or existence of, depressurization-induced backdrafting and spillage from vented residential combustion appliances.

1.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions.

1.3 Residential vented combustion appliances addressed in this guide include hot water heaters and furnace. The guide also is applicable to boilers.

1.4 The methods given in this guide are applicable to Category I (draft-hood- and induced-fan-equipped) furnaces. The guide does not apply to Category III (power-vent-equipped) or Category IV (direct-vent) furnaces.

1.5 The methods in this guide are not intended to identify backdrafting or spillage due to vent blockage or heat-exchanger leakage.

1.6 This guide is not intended to provide a basis for determining compliance with code requirements on appliance and venting installation, but does include a visual assessment of the installation. This assessment may indicate the need for a thorough inspection by a qualified technician.

1.7 Users of the methods in this guide should be familiar with combustion appliance operation and with making house-tightness measurements using a blower door. Some methods described in this guide require familiarity with differential-pressure measurements and use of computer-based data-logging equipment.

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

1.9 *This guide does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety, health, and environmental practices and to determine the applicability of regulatory limitations prior to use.* Carbon monoxide (CO) exposure or flame roll-out may occur when performing certain procedures given in this guide. See Section 7, for precautions that must be taken in conducting such procedures.

1.10 *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]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

E631 Terminology of Building Constructions

E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

2.2 *CAN/CGSB Standard:*[3]

CAN/CGSB 51.71 The Spillage Test—Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired; Space Heating Appliances; Water Heaters, and Fireplaces

2.3 *ANSI Standard:*[4]

ANSI Z21.47 Gas-fired Central Furnace

2.4 *NFPA Standard:*[5]

NFPA 54 National Fuel Gas Code

[1] This guide 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] Available from Canadian General Standards Board (CGSB), 11 Laurier St., Phase III, Place du Portage, Gatineau, Quebec K1A 0S5, Canada, http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

## 3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general terms related to building construction used in this specification, refer to Terminology E631, and for general terms related to sampling and analysis of atmospheres, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air leakage, n*—the movement or flow of air through the building envelope which is driven by a pressure differential across the envelope.

3.2.2 *air leakage rate, n*—the volume of air movement per unit time across the building envelope.

3.2.3 *airtightness, n*—the degree to which the building envelope resists flow of air.

3.2.4 *blower door, n*—a fan pressurization device incorporating a controllable fan and instruments for airflow measurement and building pressure difference measurement that mounts securely in a door or other opening.

3.2.5 *Category 1 appliance, n*—an appliance that operates with non-positive static pressure and with a vent gas temperature that avoids excessive condensate production in the vent (see NFPA 54).

3.2.6 *Category III appliance, n*—an appliance that operates with a positive vent pressure and with a vent gas temperature that avoids excessive condensate production in the vent (see NFPA 54).

3.2.7 *Category IV appliance, n*—an appliance that operates with a positive vent pressure and with a vent gas temperature that may cause excessive condensate production in the vent (see NFPA 54).

3.2.8 *combustion system spillage, n*—entry of combustion products into a building from dilution air inlets, vent connector joints, induced draft fan case opening, combustion air inlets, or other locations in the combustion or venting system of a vented combustion appliance (boiler, fireplace, furnace, or water heater), caused by backdrafting, vent blockage, or leaks in the venting system.

3.2.9 *continuous pressure differential, n*—the incremental house depressurization due to fans that can be operated continuously, such as furnace blower or supply/exhaust ventilator.

3.2.10 *downdrafting, n*—the reversal of the ordinary (upward) direction of air flow in a chimney or flue when no vented combustion appliances are operating (as opposed to backdrafting, which occurs when vented combustion appliances are operating).

3.2.11 *house depressurization, n*—the situation, pertaining to a specific location in a house, whereby the static pressure at that location is lower than the static pressure in the immediate vicinity outside the house.

3.2.11.1 *Discussion*—The pressure difference between indoors and outdoors is affected by building tightness (including the distribution of leakage sites across the building envelope), indoor-outdoor temperature difference, local winds, and the operation of indoor appliances such as exhaust fans, forced-air system fans, and vented combustion appliances (boilers, fireplaces, furnaces, or water heaters). Thus, the existence and extent of house depressurization at a specific location varies over time, depending on outdoor conditions and the operation of indoor appliances.

3.2.12 *induced conditions, n*—conditions for house depressurization created with the use of exhaust fans or blower door.

3.2.13 *induced draft (ID) fan, n*—a fan used in a venting system that removes flue gases under non-positive static vent pressure.

3.2.13.1 *Discussion*—An appliance with an ID fan is a Category I appliance, as its venting system is under non-positive static vent pressure.

3.2.14 *intermittent pressure differential, n*—the incremental house depressurization due to fans that are operated intermittently, such as clothes dryer, kitchen exhaust or bathroom fan.

3.2.15 *natural conditions, n*—outdoor temperature and wind conditions that create house depressurization.

3.2.16 *pressure differential, n*—pressure difference across the building envelope, expressed in pascals (inches of water or pound-force per square foot or inches of mercury).

3.2.17 *vented combustion appliance, n*—includes fossil-fuel-fired furnace, boiler or water heater vented to outside.

3.2.17.1 *Discussion*—The term vented combustion appliances in this standard excludes fireplaces and gas logs vented to outside. Also, it does not include appliances such as gas ranges or unvented space heaters.

## 4. Summary of Guide

4.1 This guide summarizes different methods for assessing backdrafting and spillage from vented combustion appliances. For each method the equipment needed, test procedures, data reporting, results and interpretation, and technician and test time required are presented. Advantages and uncertainties of each method are discussed.

4.2 Assessment of depressurization-induced backdrafting and spillage is conducted under either induced depressurization or natural conditions. Depressurization is induced in a residence by deliberately operating exhaust fans or a blower-door fan. Assessments conducted under induced conditions can indicate only the potential for backdrafting and spillage. Assessments under natural conditions can indicate actual backdrafting and spillage events. Assessments under either induced or natural conditions may not be valid for weather, house tightness, or operational conditions beyond those encountered during the period of measurements.

4.3 The guide includes four types of short term tests conducted under induced conditions: (*1*) house depressurization test with preset criteria; (*2*) downdrafting test; (*3*) appliance backdrafting test; and (*4*) cold vent establishment pressure (CVEP) test. A continuous backdraft test to identify backdrafting events under natural conditions, which involves continuous monitoring of vent differential pressures, is also described. For identification of spillage events or consequences thereof under natural conditions, a continuous spillage test that involves

continuous monitoring of spillage-zone temperatures and indoor air quality is described. Because they are conducted under a variety of naturally occurring conditions, the continuous methods can provide more definitive results for conditions under which tests are conducted. However, the continuous methods also can be more time-consuming and resource-intensive to apply.

4.4 A purpose of the guide is to encourage the use of consistent procedures for any selected method.

## 5. Significance and Use

5.1 Although a number of different methods have been used to assess backdrafting and spillage (see NFPA 54, CAN/CGSB-51.71, and **1-4**)[6] a single well-accepted method is not yet available. At this point, different methods can yield different results. In addition, advantages and drawbacks of different methods have not been evaluated or described.

5.2 To provide a consistent basis for selection of methods, this guide summarizes different methods available to assess backdrafting and spillage. Advantages and limitations of each method are addressed.

5.3 One or more of the methods described in this guide should be performed when backdrafting or spillage from vented combustion appliances is suspected to be the cause of a potential problem such as elevated carbon monoxide (CO) levels or excessive moisture.

5.4 The following are examples of specific conditions under which such methods could be performed:

5.4.1 When debris or soot is evident at the draft hood, indicating that backdrafting may have occurred in the past,

5.4.2 When a new or replacement combustion appliance is added to a residence,

5.4.3 When a new or replacement exhaust device or system, such as a downdraft range exhaust fan, a fireplace, or a fan-powered radon mitigation system, is added,

5.4.4 When a residence is being remodeled or otherwise altered to increase energy efficiency, as with various types of weatherization programs, and

5.4.5 When a CO alarm device has alarmed and a combustion appliance is one of the suspected causes of the alarm.

5.5 Depending on the nature of the test(s) conducted and the test results, certain preventive or remedial actions may need to be taken. The following are examples:

5.5.1 If any of the short-term tests indicates a potential for backdrafting, and particularly if more than one test indicates such potential, then the appliance and venting system should be further tested by a qualified technician, or remedial actions could be taken in accordance with 5.5.3.

5.5.2 If continuous monitoring indicates that backdrafting is occurring, and particularly if it indicates that spillage is occurring that impacts indoor air quality (for example, elevated CO concentrations or excessive moisture in the house), then remedial action is indicated.

5.5.3 Possible remedial actions include the following:

5.5.3.1 At a minimum, a CO alarm device could be installed in the house.

5.5.3.2 Limiting the use of devices or systems that increase house depressurization, such as fireplaces and high-volume exhaust fans. Proper sealing of any air leakage sites, especially at the top floor ceiling level, can also reduce house depressurization at the lower levels of the house.

5.5.3.3 Partially opening a window in the furnace or appliance room, if available. Keeping the door nearest the appliance room open at all times or putting louvers in the door.

5.5.3.4 Providing increased makeup air for the appliance (for example, by providing a small duct or opening to the outdoors near the appliance).

5.5.4 If remedial actions are not successful, then consideration can be given to correcting or replacing the venting system or, if necessary, replacing the spilling appliance with one that can better tolerate house depressurization.

5.6 The understanding related to backdrafting and spillage phenomena is evolving. Comprehensive research using a single, reliable method is needed to better understand the frequency, duration, and severity of depressurization-induced spillage in a broad cross section of homes (**5**). In the absence of a single well-accepted method for assessing the potential for or occurrence of backdrafting or spillage, alternative methods are presented in this guide. The guide is intended to foster consistent application of these methods in future field work or research. The resultant data will enable informed decisions on relative strengths and weaknesses of the different methods and provides a basis for any refinements that may be appropriate. Continued efforts along these lines will enable the development of specifications for a single method that is acceptable to all concerned.

## 6. Principles and Methods

6.1 *Background*—Residences can be depressurized due to operation of exhaust equipment and imbalanced air distribution systems, as well as local weather. The extent of house depressurization depends on the capacity of the exhaust equipment, the degree of imbalance in the air distribution system, and the airtightness of the building envelope. Outdoor temperatures also can affect the depressurization of the house. For example, the natural depressurization of a house would be a few to several pascals greater under winter conditions in the northern parts of the country than during summer. The changes in depressurization of the house due to outdoor conditions (temperature and wind) often can be greater than changes caused by exhaust appliances. Downdrafting, which can result from house depressurization, is the reversal of the ordinary (upward) direction of air flow in a chimney or flue when no vented combustion appliances are operating. Backdrafting generally occurs when an appliance starts up against a downdrafting chimney and cannot establish draft. Vented combustion appliances equipped with draft hoods or diverters or induced-draft fans depend on hot flue gases to create a thermal buoyancy that exhausts combustion products through a chimney. When the natural or induced draft or thermal buoyancy

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