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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 *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 and health 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.

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

E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

2.2 *CGSB Standard:*[3]

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]

Z21.47 Gas-fired Central Furnace

2.4 *NFPA Standard:*[5]

54 National Fuel Gas Code

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminologies E631 and 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.

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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 the CGSB Sales Centre, Ottawa, Canada K1A 1G6.

[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.

3.2.5 *Category I 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**) 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 cannot overcome backdrafting, there will be spillage of combustion products including carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x) and water vapor into indoor spaces.

6.2 *Principles of Vent Operation and Backdrafting*—A schematic of one typical installation of a water heater and furnace connected to a common B-vent (chimney) through vent connectors is shown in Fig. 1. There can be a number of variations

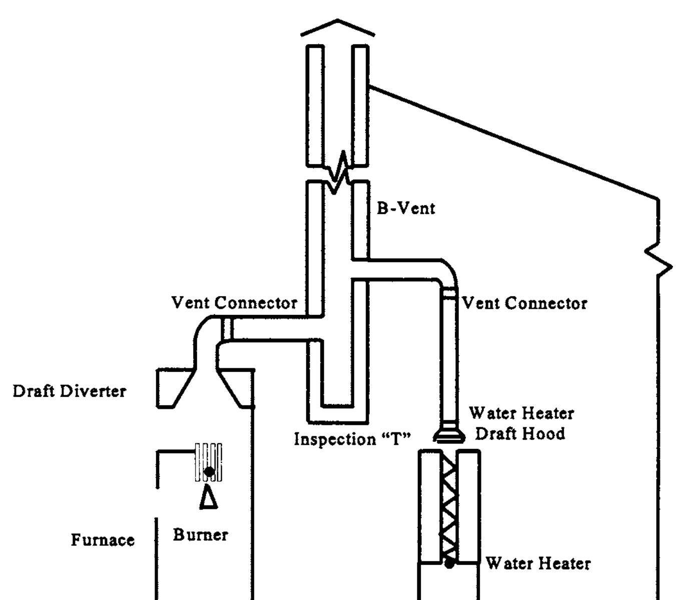

FIG. 1 Schematic of Combined Water Heater and Furnace Venting System

to this example, including vent connectors that are connected to a masonry chimney, or separate venting systems for each appliance. Draft-hood or induced-draft combustion appliances depend on the thermal buoyancy of hot flue gases related near the chimney. In the case of backdrafting, or reversal of the ordinary vent flow, hot flue gases tend to follow the path with the smallest pressure or least resistance. For draft-hood-equipped appliances, the path of least resistance is the draft hood or diverter. For induced-draft furnaces, this path could be either at the draft hood of the other appliance (for example, water heater) that is connected to the common vent, or around leakage points in the vent system, especially at connections.

6.3 *Principles of Assessment*—Since the upward flow in the chimney or venting system depends on pressure differentials created by the buoyancy of hot flue gases, measurement of the static pressure in the vent system (relative to that in the room where the appliance is located) is one basic measurement parameter to indicate backdrafting. Spillage of the flue gases around the draft hood or diverter can be observed visually or inferred from a temperature sensor. (The visual test, which provides a reliable indication of backdrafting, can be accomplished by using a smoke pencil or a small flame created by a cigarette lighter to indicate the flow direction of the flue gases.) Quantitative assessment of the impact of spillage at the draft hood or diverter cannot be accomplished without special equipment, because of the temperature and moisture content of flue gases. However, the consequences of spillage can be assessed by measuring air quality in the area where combustion appliances are located.

6.4 *Methods*—The available methods for assessing backdrafting and spillage can be divided into two major groups: those conducted under induced depressurization and those conducted under natural conditions. Methods used under induced conditions can provide an indication of the potential for backdrafting. The tests conducted under induced conditions require less testing time than those under natural conditions and, thus, are termed short-term tests. Ideally, short-term tests should be repeated under different weather conditions. Methods used under natural conditions detect actual backdrafting and spillage events but require continuous monitoring over a period typically one week or longer. The period of continuous monitoring, ideally, should be long enough to cover a range of weather conditions. Relationships between the results of short-term tests under induced conditions and continuous monitoring under natural conditions have been investigated (**6, 7, 8**) but are not yet qualified or established.

6.5 The methods included in this guide are grouped under two categories: induced conditions and natural conditions.

6.5.1 Induced Conditions include house depressurization test with preset criteria, downdrafting test, appliance backdrafting test, and cold vent establishment pressure (CVEP) test.

6.5.1.1 The following general rules apply in conducting tests under induced conditions: (*1*) when such tests are initiated, the temperature of the common vent should be close to the temperature of the mechanical room, so that the test approximates a cold vent condition; and (*2*) testing of a water heater should precede furnace or boiler testing, as the water heater has a lower heat output and will require a correspondingly shorter time to cool the common vent following its operation.

6.5.2 Natural Conditions include continuous backdrafting test, and Continuous spillage test.

6.6 Observations and tests for assessing hazards, given in Section 7, should be followed prior to conducting the tests. The tests for assessing backdrafting and spillage are summarized, beginning in Section 8, in terms of equipment needed, the condition of the house for testing, test procedures, technician time needed, test duration, and test outputs and their interpretation.

7. Hazards and Assessment

7.1 A major hazard in conducting the tests described in this guide is CO exposure. Flame roll-out and associated fire potential is another potential hazard (**9**). Hazards associated with blower-door testing must also be considered. Hazards associated with blower-door testing are noted in Test Method E779;E779 precautions and tests for other hazards are given below.

7.2 *Carbon Monoxide Exposure*—In some situations, appliances may generate CO due to backdrafting. It is imperative that flue CO levels be measured prior to conducting any tests and that continuous CO monitoring be conducted in the mechanical room or the appliance area (test space) while these tests are occurring. The procedures for flue CO measurements are given below.

7.2.1 *Flue CO Measurements Prior to Conducting Tests*—For flue CO measurements, use a combustion analyzer that is capable of measuring flue CO levels on an air-free basis. All exhaust devices in the house, including fireplaces or wood-burning stoves, should be off during the testing period.

7.2.1.1 Place the sampling probe for the combustion analyzer under the water heater draft hood and down into the throat of the heat exchanger as far as possible. Ensure that the probe's thermocouple (if present) is not in contact with metal. Record flue CO levels at least once per min when the appliance is fired.

7.2.1.2 Turn down the furnace thermostat. Turn on the water heater by turning its thermostat to the highest setting. Open a hot water faucet to ensure that the water heater continues to fire during the test.

7.2.1.3 Wait until 5 min have elapsed since the appliance was started. Using a match or a smoke pencil, check for draft at the water heater draft hood (lack of draft indicates likelihood of a blocked vent).

7.2.1.4 Remove the sampling probe, shut off the faucet and return the water heater thermostat to its original setting.

7.2.1.5 If the furnace has an induced draft (ID) fan, drill a sampling hole just above the furnace collar and insert the sampling probe through this hole. Otherwise, place the sampling probe under the furnace draft hood and into the heat exchanger if possible. Record flue CO levels at least once per min when the appliance is fired.

7.2.1.6 Turn on the furnace and set the thermostat sufficiently high that it will continue to fire for at least 5 min.

7.2.1.7 Wait until 5 min have elapsed, and conduct a match or smoke pencil test as in 7.2.1.3.

7.2.1.8 Remove the sampling probe and return the thermostat to its original setting. If a sampling hole was drilled, insert a plug or screw to close it.

7.2.1.9 If the CO value for the water heater or furnace flue gases exceeds 400 ppm (air-free basis as described in ANSI-Z21.47), or there is evidence of a blocked vent, then further testing should be postponed until a qualified technician has visited the house to resolve any such apparent problems.

7.2.2 *CO Monitoring During the Tests*—Several levels of protection against excessive CO exposure due to induced backdrafting of combustion appliances, based on existing standards or guidelines for CO concentrations in flue gases and in ambient air, should be considered. Occupational Safety and Health Administration (OSHA) guidelines for CO exposure limit concentrations to 200 ppm for short-term (15 min) exposure and 50 ppm for 8-hour-average exposure. The sensor for CO monitoring in the test space should have a visual readout that will alert technicians to unusual concentrations in the breathing zone of their activity. Additionally, a CO alarm device is to be installed in the living area of the house during these tests.

7.2.2.1 If the CO level in the flue gas exceeds 400 ppm (air-free basis as described in ANSI-Z21.47) during the visual inspection or during backdrafting or CVEP tests, then the affected test is to be terminated. The responsible appliance should be inspected or tested or tuned by a qualified technician.

7.2.2.2 As an additional margin of safety, technicians are to observe the CO levels in the mechanical room during these tests and note any time when the ambient concentration exceeds 100 ppm for 15 min. Testing is to be terminated in such instances. It is unlikely that the ambient concentration will exceed 100 ppm when the flue-gas concentration is below 400 ppm.

7.2.2.3 Should the CO alarm activate, any test in progress should be terminated and the house temporarily evacuated and ventilated.

7.3 *Visual Assessment*:

7.3.1 Verify that there is no fuel or other flammable material stored in the mechanical room or area and that no combustible material is stored within 2 ft of the appliances (furnace or water heater) to be tested.

7.3.2 Make a visual assessment for scorch marks on the outside of the water heater near the burner to see if flame-rollout may have happened previously. If there is evidence of scorching (such as at the base of the water heater), then further testing should be postponed until a qualified technician has tested the appliance.

7.3.3 During forced backdrafting conditions flame roll-out may occur, even if there is no evidence of prior occurrences, because relatively high depressurization conditions are induced with a blower door under this method. Should flame roll-out occur, the test should be discontinued.

7.3.4 A qualified technician should visually inspect the venting system to determine that there is no blockage or restriction, leakage, corrosion, or other deficiencies that could cause an unsafe condition, check for proper size and horizontal pitch, and ensure compliance with local codes.

8. House Depressurization Test With Preset Criteria (see NFPA 54, CAN/CGSB-51.71, and Refs. 1-4)

8.1 *Summary of Procedure*—Details of this procedure are given in CAN/CGSB-51.71. In summary, the test is conducted under closed-house conditions (exterior doors, windows, fireplace or woodstove dampers, or both, closed). Interior doors on perimeter rooms that do not contain exhaust devices are closed. The water and furnace remain off throughout the test. Following baseline measurements of the indoor-outdoor pressure difference with all continuous and intermittent house fans off, the incremental house depressurization due to continuous fans (furnace blower, combined supply and exhaust ventilator, continuous air exhaust or supply systems) and intermittent fans (clothes dryer, kitchen exhaust, bathroom fans, fireplace simulator) is measured. The continuous pressure differential and intermittent pressure differential are then compared with preset criteria to determine pass or fail status.

8.2 *Equipment Needed*—A differential pressure measuring device, outdoor pressure tube, outdoor pressure averaging system, and a wood-fire simulator, are needed.

8.3 *House Conditions*—Set the house conditions according to Table 1.

8.4 *Procedures*—

8.4.1 *Set Up Differential Pressure Measurement*—Connect indoor and outdoor ports to a differential-pressure measurement device. The port for indoors should be in, or connected by tubing to, the room containing the appliance(s) to be tested. The port for outdoors should be connected by tubing to one or more outdoor sites. It is preferable to have outdoor sites on each side of the house that are connected to the outdoor port through a common manifold. To minimize the effect of local winds on the outdoor pressure measurement, and to avoid snow or rain accumulation, or both, each outdoor hose should be placed in an open-ended housing that faces downward. The housing should be attached to a vertical stake or stand near a

TABLE 1 Initial House Conditions for House Depressurization Test[A]

House Feature	Configuration
Windows	Close
Exterior doors	Close
Basement door	Close
Doors on an enclosed furnace room	Close
Interior doors on perimeter rooms not containing exhaust devices	Close
Chimney with manual damper	Close
Chimney without manual damper	Leave as is
Make-up air supply with manual damper	Close
Make-up air supply without damper	Leave as is
Woodstove or fireplace	No fire: close doors and air control dampers
Fuel-fired appliances (furnace, boiler, water heater, gas fireplace, pellet stove)	Turn down thermostats
Floor drains	Fill with water
Exhaust and supply fans	Off
Ventilating and air moving devices	Off
Clothes dryer	Off
Attic hatch	Close
Crawl space vents	Close
Broken windows and other short term openings	Tape over
Sub-slab ventilation fans or subfloor ventilation systems for soil gas control	Turn off

[A] See NFPA 54.

corner formed by the exterior wall and the ground (a stagnation region), near the midpoint of the wall.

8.4.2 *Determine Baseline Depressurization*—Determine the value of the indoor-outdoor pressure differential with all continuous and intermittent house fans off, in accordance with the house conditions established in 8.3 (see Table 1). Pressure differences may be quite variable, especially under windy conditions; thus, an average of several values should be used.

8.4.3 *Turn on Furnace Blower*—Operate the blower at maximum speed if it can be switched on independently of other exhausts. The house depressurization level in the appliance room, relative to outdoors, should be assessed with the door to the appliance room (if any) both open and closed. The door position that results in the highest level of house depressurization should be used for the remainder of the test. If the furnace blower does not increase the house depressurization, turn it off.

8.4.4 *Turn on Combined Supply and Exhaust Ventilators*—Operate each of these devices at its highest setting and check if house depressurization increases. If it does, leave the device running; otherwise, turn it off.

8.4.5 *Turn on Continuous Air Exhaust Systems*—Turn on such devices intended for continuous use, such as subslab ventilation systems.

8.4.6 *Turn on Continuous Air Supply Systems*—Operate any of these devices intended to operate throughout the heating season.

8.4.7 *Record Continuous Pressure Differential*—Record the maximum pressure differential created by continuous ventilation systems; this differential, after subtracting the baseline depressurization value obtained in 8.4.2, is termed the continuous pressure differential.

8.4.8 *Turn on Exhaust Fans*—This includes clothes dryer, if it exhausts to the outdoors; kitchen exhaust, if it exhausts to the outdoors or in attics; and other intermittent exhaust fans rated at more than 75 L/s (159 CFM).

8.4.9 *Simulate a Fire in an Open Fireplace*—Open chimney damper. Open air combustion air supply to the fireplace. Place a wood-fire simulator (camping stove, typically 9.5 J/h or 10 000 Btu/h) in the fireplace. Temporarily open a nearby door or window to the outdoors. Light the simulator and adjust to a high rate of burn. Allow at least 5 min for the chimney to warm up. Tightly close the door or window to the outdoors.

8.4.10 *Record Intermittent Pressure Differential*—Read and record the maximum pressure differential due to exhaust fans and fire simulators, in combination with continuous ventilation systems: this differential, after subtracting the baseline value obtained in 8.4.2, is termed the intermittent pressure differential.

8.5 *Data Reporting*:

8.5.1 Record measured depressurization levels in pascals (Pa) caused by any forced-air circulating fans and combined supply and exhaust ventilators.

8.5.2 Record continuous and intermittent pressure differentials.

8.6 *Results and Interpretations*:

8.6.1 House depressurization limits specified in CAN/CGSB-51.71 are 5 Pa continuous and intermittent for open combustion appliances (buoyancy systems with draft hoods or relief-air openings, and 5 Pa continuous and 10 Pa intermittent for closed combustion appliances (systems consisting of a single appliance on a flue that has no draft hood or relief air).

8.6.2 Compare the maximum pressure differentials (continuous and intermittent) with depressurization limits for each vented, fuel-burning appliance in the dwelling.

8.6.3 This method provides results in a pass or fail form. For example, if the intermittent pressure limit is 5 Pa (this limit varies with appliance fuel and venting configuration) and the measured intermittent pressure differential is 6 Pa depressurization, then the house fails the test and is considered to be spillage-prone.

8.6.4 The method provides pass or fail results without operation of any vented combustion appliances: thus, their ability to tolerate, or overcome, the house depressurization induced during the test is not assessed.

8.6.5 The pass or fail criteria may not be appropriate for all types of homes, appliances, venting systems, and climates.

8.6.6 Results of this test for a particular home may vary with weather conditions (temperature and windspeed). The exact nature of relationship between test results and weather conditions is not fully understood at present.

8.7 *Technician and Test Time*—About 30 to 40 min of technician or testing time is required, including the time for setting up equipment.

9. Downdrafting Test (4)

9.1 *Summary of Procedure*—The test is conducted under closed-house conditions (exterior doors, windows, fireplace or woodstove dampers, or both, closed). Ideally, the test should be performed during a period of low wind speeds (less than 2 m/s or 5 mph). Interior doors on perimeter rooms that do not contain exhaust devices are open. The water heater and furnace remain off throughout the test. After all continuous fans and intermittent exhaust devices (including a fireplace simulator or a gas-log fireplace) are turned on, downdrafting is assessed visually with a flame or smoke pencil.

9.2 *Equipment Needed*—Flame lighter or smoke pencil for visual indication of downdrafting, temperature sensor for measuring vent temperature, camping stove to simulate fireplace operation are needed.

9.3 *House Conditions*—Keep the house in its (winter) closed configuration as given in Table 2. Tables 1 and 2 are similar except for the position or status of interior doors, the damper of the make-up air supply, and subslab or subfloor ventilation systems. The conditions in Table 2 are intended to represent a reasonable-worst-case scenario. For a worst-case depressurization level, add the step given in 9.4.3.6. Subslab ventilation systems are left in the condition set by occupants to minimize radon exposure.

9.4 *Procedures*:

9.4.1 Turn down furnace/boiler and water heater thermostats.

9.4.2 Allow time for cooling the common vent if either of these appliances was operating recently.

9.4.3 Set up continuous fans and intermittent exhaust devices.