



# Fuel Gas Appliances Combustion Air and Inspection

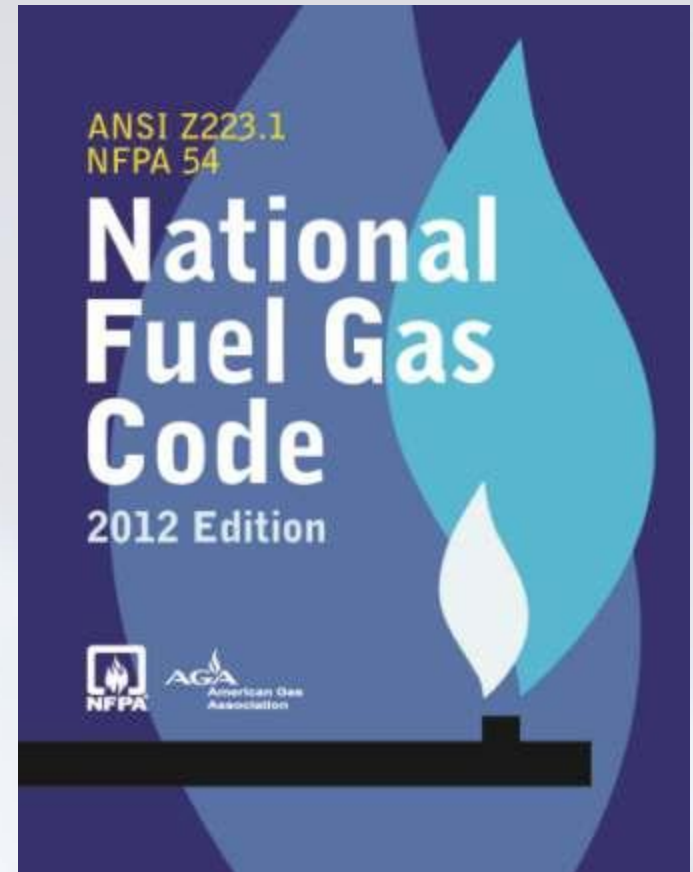
*National Fuel Gas Code ANSI Z223.1/NFPA 54*

*Combustion Safety Expert Meeting  
June 28<sup>th</sup>, 2012  
San Antonio, TX*



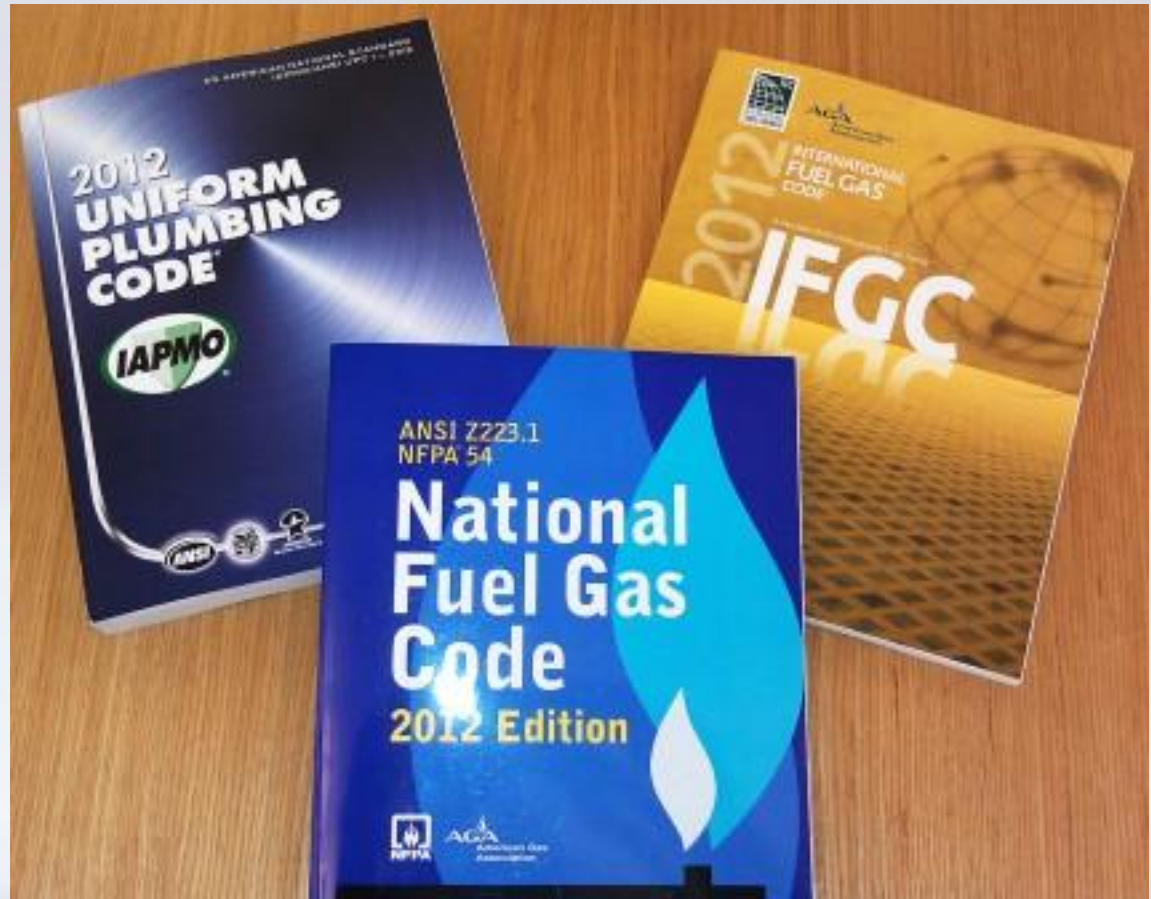
# Combustion Air Code Requirements

- Dual Secretariats
  - AGA: ASC Z223
  - NFPA: NFPA 54
- ANSI Standard since 1974
- Natural Gas and LP systems and appliances
- Listed appliances require the use of NFGC
- Combustion air - basis for most of U.S. requirements




# Combustion Air Code Requirements

Same combustion air requirements is in all model fuel gas installation codes



# Combustion Air - General

Section 9.3 - Allows multiple methods



## 9.3\* Air for Combustion and Ventilation.


### 9.3.1 General.

**9.3.1.1** Air for combustion, ventilation, and dilution of flue gases for appliances installed in buildings shall be obtained by application of one of the methods covered in 9.3.2 through 9.3.6. Where the requirements of 9.3.2 are not met, outdoor air shall be introduced in accordance with methods covered in 9.3.3 through 9.3.6.

*Exception No. 1: This provision shall not apply to direct vent appliances.*

*Exception No. 2: Type 1 clothes dryers that are provided with makeup air in accordance with Section 10.4.3.*

Does not apply to:  
Direct Vent Appliances  
& Clothes Dryers





# Combustion Air - General

Non-draft type appliances  
use manufacturer instructions

9.3.1.2 Appliances of other than natural draft design and other than category I vented appliances shall be provided with combustion, ventilation and dilution air in accordance with the appliance manufacturer's instructions.

9.3.1.3 Appliances shall be located so as not to interfere with proper circulation of combustion, ventilation, and dilution air.

9.3.1.4 Where used, a draft hood or a barometric draft regulator shall be installed in the same room or enclosure as the appliance served so as to prevent any difference in pressure between the hood or regulator and the combustion air supply.

9.3.1.5 Where exhaust fans, clothes dryers, and kitchen ventilation systems interfere with the operation of appliances, makeup air shall be provided.

Located not to interfere  
with combustion air

Draft hood/regulator in  
same enclosure

Exhausting air equipment  
(that interfere) required to  
be provided with make-up  
air

# Combustion Air – Taken from the Indoors

Indoor air supply – Two methods to calculate “required volume”

**9.3.2 Indoor Combustion Air.** The required volume of indoor air shall be determined in accordance with method 9.3.2.1 or 9.3.2.2 except that where the air infiltration rate is known to be less than 0.40 *ACH*, the method 9.3.2.2 shall be used. The total required volume shall be the sum of the required volume calculated for all appliances located within the space. Rooms communicating directly with the space in which the appliances are installed through openings not furnished with doors, and through combustion air openings sized and located in accordance with 9.3.2.3, are considered a part of the required volume.

**9.3.2.1\* Standard Method:** The minimum required volume shall be 50 ft<sup>3</sup> per 1,000 Btu/hr (4.8 m<sup>3</sup>/kW).

1 - Unknown/Not-Specified infiltration rate

Method based on 0.50 ACH

# Combustion Air – Taken from the Indoors

**9.3.2.2\* Known Air Infiltration Rate Method:** Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows:

(1) For appliances other than fan-assisted: calculated using the following equation:

$$\text{Required volume}_{\text{other}} \geq \frac{21 \text{ ft}^3}{\text{ACH}} \left( \frac{I_{\text{other}}}{1,000 \text{ Btu/hr}} \right)$$

(2) For fan-assisted appliance, calculate using the following equation:

$$\text{Required volume}_{\text{fan}} \geq \frac{15 \text{ ft}^3}{\text{ACH}} \left( \frac{I_{\text{fan}}}{1,000 \text{ Btu/hr}} \right)$$

where:

$I_{\text{other}}$  = all appliances other than fan-assisted input in Btu per hour

$I_{\text{fan}}$  = fan-assisted appliance input in Btu per hour

$\text{ACH}$  = air change per hour (percent of volume of space exchanged per hr, expressed as a decimal)

(3) For purposes of this calculation, an infiltration rate greater than 0.60  $\text{ACH}$  shall not be used in equations in 9.3.2.2 (1) and 9.3.2.2 (2).

2. KAIR Method - must use if 0.40 ACH & lower

Calculations based on ACH and whether the appliance is fan-assisted or has a draft hood

Fan-Assisted found to require less air – no dilution air

Upper ACH limit on use of KAIR method

# Combustion Air – Taken from the Indoors

**9.3.2.3 Indoor Opening Size and Location.** Openings used to connect indoor spaces shall be sized and located in accordance with the following:

- (1)\* *Combining spaces on the same story.* Each opening shall have a minimum free area of 1 in.<sup>2</sup>/1,000 Btu/hr (2,200 mm<sup>2</sup>/kW) of the total input rating of all appliances in the space but not less than 100 in.<sup>2</sup> (0.06 m<sup>2</sup>). One opening shall commence within 12 in. (300 mm) of the top of the enclosure and one opening shall commence within 12 in. (300 mm) of the bottom of the enclosure. The minimum dimension of air openings shall be not less than 3 in. (80 mm).
- (2) *Combining spaces in different stories.* The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are connected by one or more openings in doors or floors having a total minimum free area of 2 in.<sup>2</sup>/1,000 Btu/hr (4,400 mm<sup>2</sup>/kW) of total input rating of all appliances.

Combining indoor spaces to meet the required volume is allowed

Spaces on the same floor:

- Two openings required
- One upper & one lower
- Minimum size of 100 in<sup>2</sup>

Spaces on different floor:

- One or two openings
- Total size equals on the same floor



# Combustion Air – Taken from the Outdoors

## Outdoor Air Requirements – Require openings to the outdoors

### Opening Options:

- Two openings
- One opening

### Two openings:

- One upper & one lower
- Different sizing depending on type

**9.3.3 Outdoor Combustion Air.** Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with the methods in 9.3.3.1 or 9.3.3.2. The minimum dimension of air openings shall not be less than 3 in. (80 mm).


**9.3.3.1 Two Permanent Openings Method:** Two permanent openings, one commencing within 12 in. (300 mm) of the top and one commencing within 12 in. (300 mm) of the bottom, of the enclosure, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors or spaces that freely communicate with the outdoors, as follows:

- (1)\* Where directly communicating with the outdoors or where communicating to the outdoors through vertical ducts, each opening shall have a minimum free area of  $1 \text{ in.}^2/4,000 \text{ Btu/hr}$  ( $550 \text{ mm}^2/\text{kW}$ ) of total input rating of all appliances in the enclosure.
- (2)\* Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of  $1 \text{ in.}^2/2,000 \text{ Btu/hr}$  ( $1,100 \text{ mm}^2/\text{kW}$ ) of total input rating of all appliances in the enclosure.

# Combustion Air – Taken from the Outdoors

## Single High Opening

- Larger opening size
- Located high



**9.3.3.2\* One Permanent Opening Method:** One permanent opening, commencing within 12 in. (300 mm) of the top of the enclosure, shall be provided. The appliance shall have clearances of at least 1 in. (25 mm) from the sides and back and 6 in. (150 mm) from the front of the appliance. The opening shall directly communicate with the outdoors or shall communicate through a vertical or horizontal duct to the outdoors or spaces that freely communicate with the outdoors and shall have a minimum free area of the following:

- (1)  $1 \text{ in.}^2/3,000 \text{ Btu/hr}$  ( $700 \text{ mm}^2/\text{kW}$ ) of the total input rating of all appliances located in the enclosure, and
- (2) Not less than the sum of the areas of all vent connectors in the space

# Combustion Air – Taken from the Outdoors

Combining indoor volume and outdoor opening is allowed

Allows smaller outdoor openings based on available indoor volume

**9.3.4 Combination Indoor and Outdoor Combustion Air.** The use of a combination of indoor and outdoor combustion air shall be in accordance with the following:

- (1) **Indoor Openings.** Where used, openings connecting the interior spaces shall comply with Section 9.3.2.3.
- (2) **Outdoor Opening(s) Location.** Outdoor opening(s) shall be located in accordance with Section 9.3.3.
- (3) **Outdoor Opening(s) Size.** The outdoor opening(s) size shall be calculated in accordance with the following:
  - (a) The ratio of interior spaces shall be the available volume of all communicating spaces divided by the required volume.
  - (b) The outdoor size reduction factor shall be 1 minus the ratio of interior spaces.
  - (c) The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with Section 9.3.3, multiplied by the reduction factor. The minimum dimension of air openings shall not be less than 3 in. (80 mm).

# Combustion Air – Openings

Combustion air openings serve three main purposes:

1. Provide combustion/dilution air to help ensure complete combustion and proper venting
2. Provide appliance ventilation to help cool controls and components
3. Provide a safety valve in the event of a blocked vent -
  - Upper opening allows spilled flue gases to exit room
  - Bottom opening (or the larger upper in a one opening system) allows sufficient fresh air to enter the room to help ensure complete combustion.



# Combustion Air – Other Methods

## Other combustion air options allowed:

- Engineered
- Mechanical

**9.3.5 Engineered Installations.** Engineered combustion air installations shall provide adequate supply of combustion, ventilation and dilution air and shall be approved by the authority having jurisdiction.

**9.3.6 Mechanical Combustion Air Supply.** Where all combustion air is provided by a mechanical air supply system, the combustion air shall be supplied from outdoors at the minimum rate of 0.35 ft<sup>3</sup>/min per 1,000Btu/hr (0.034 m<sup>3</sup>/min per kW) for all appliances located within the space.

**9.3.6.1** Where exhaust fans are installed, additional air shall be provided to replace the exhausted air.

**9.3.6.2** Each of the appliances served shall be interlocked to the mechanical air supply system to prevent main burner operation where the mechanical air supply system is not in operation.

**9.3.6.3** Where combustion air is provided by the building's mechanical ventilation system, the system shall provide the specified combustion air rate in addition to the required ventilation air.

# Combustion Air – Other Requirements

## Requirements for louver, grilles and screens

- Size based on free opening
- Minimum mesh size
- Mechanical Interlocking

### 9.3.7 Louvers, Grilles, and Screens.

**9.3.7.1 Size of Openings.** The required size of openings for combustion, ventilation, and dilution air shall be based on the net free area of each opening. Where the free area through a design of louver or grille or screen is known, it shall be used in calculating the size opening required to provide the free area specified. Where the louver or grille design and free area are not known, it shall be assumed that wood louvers will have 25 percent free area and metal louvers and grilles will have 75 percent free area. Nonmotorized louvers and grilles shall be fixed in the open position.

**9.3.7.2 Minimum Screen Mesh Size.** Screens shall have a mesh size not smaller than  $\frac{1}{4}$ -inch.

**9.3.7.3 Motorized Louvers.** Motorized louvers shall be interlocked with the appliance so they are proven in the full open position prior to main burner ignition and during main burner operation. Means shall be provided to prevent the main burner from igniting should the louver fail to open during burner startup and to shut down the main burner if the louvers close during burner operation.

# Combustion Air – Ducts

## Requirements for duct construction

**9.3.8 Combustion Air Ducts.** Combustion air ducts shall comply with 9.3.8.1 through 9.3.8.8.

**9.3.8.1** Ducts shall be constructed of galvanized steel or a material having equivalent corrosion resistance, strength and rigidity.

*Exception: Within dwellings units, unobstructed stud and joist spaces shall not be prohibited from conveying combustion air, provided that not more than one fireblock is removed.*

**9.3.8.2** Ducts shall terminate in an unobstructed space, allowing free movement of combustion air to the appliances.

# Combustion Air – Ducts

## Requirements for duct construction cont.

9.3.8.3 Ducts shall serve a single space.

9.3.8.4 Ducts shall not service both upper and lower combustion air openings where both such openings are used. The separation between ducts serving upper and lower combustion air openings shall be maintained to the source of combustion air.

9.3.8.5 Ducts shall not be screened where terminating in an attic space.

9.3.8.6 Horizontal upper combustion air ducts shall not slope downward toward the source of combustion air.

9.3.8.7 The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry, metal or factory built chimney shall not be used to supply combustion air.

*Exception: Direct vent appliances designed for installation in a solid fuel-burning fireplace where installed in accordance with the manufacturer's installation instructions.*

9.3.8.8 Combustion air intake openings located on the exterior of the building shall have the lowest side of the combustion air intake openings located at least 12 in. (300 mm) vertically from the adjoining finished ground level.



# Chapter 11 – Placing Appliances in Operation

## Chapter 11 – Procedures to place appliances in operation

Includes draft check

- 5 minutes after start

Annex G – suggested method

**11.1.1.1** The input rate can be adjusted by either changing the size of a fixed orifice, changing the adjustment of an adjustable orifice, or readjusting the appliance's gas pressure regulator outlet pressure (where a regulator is provided in the appliance).

**11.1.1.2** Input rate shall be determined by either one of the following:

- (1) Checking burner input by using a gas meter.
- (2) Checking burner input by using orifice pressure drop and orifice size.

**11.1.1.3** Overfiring shall be prohibited.

**11.1.2 High Altitude.** Gas input ratings of appliances shall be used for elevations up to 2,000 ft (600 m). The input ratings of appliances operating at elevations above 2,000 ft (600 m) shall be reduced in accordance with one of the following methods:

- (1) 4 percent for each 1,000 ft (300 m) above sea level before selecting appropriately sized appliance.
- (2) As permitted by the authority having jurisdiction.
- (3) Listed appliances derated in accordance with the manufacturer's installation instructions shall be permitted.

### 11.2\* Primary Air Adjustment.

The primary air for injection (Bunsen)-type burners shall be adjusted for proper flame characteristics in accordance with the appliance's manufacturers' instructions. After setting the primary air, the adjustment means shall be secured in position.

### 11.3 Safety Shutoff Devices.

Where a safety shutoff device is provided, it shall be checked for proper operation and adjustment in accordance with the appliance manufacturer's instructions. Where the device does not function properly to turn off the gas supply in the event of pilot outage or other improper operation, it shall be properly serviced or replaced with a new device.

### 11.4 Automatic Ignition.

Appliances supplied with means for automatic ignition shall be checked for operation within the parameters provided by the manufacturer. Any adjustments made shall be in accordance with the manufacturer's installation instructions.

### 11.5 Protective Devices.

Where required by the manufacturer's installation instructions,

all protective devices furnished with the appliance, such as a limit control, fan control to blower, temperature and pressure relief valve, low-water cutoff device, or manual operating features, shall be checked for operation within the parameters provided by the manufacturer. Any adjustments made shall be in accordance with the manufacturer's installation instructions.

### 11.6\* Checking the Draft.

Draft hood-equipped appliances shall be checked to verify that there is no draft hood spillage after 5 minutes of main burner operation.

### 11.7 Operating Instructions.

Operating instructions shall be furnished and shall be left in a prominent position near the appliance for the use of the consumer.

## Chapter 12 Venting of Appliances

### 12.1 Minimum Safe Performance.

Venting system shall be designed and constructed so as to convey all flue and vent gases to the outdoors.

### 12.2 General.

Listed vents shall be installed in accordance with Chapter 12 and the manufacturer's installation instructions.

### 12.3 Specification for Venting.

**12.3.1 Connection to Venting Systems.** Except as permitted in 12.3.2 through 12.3.6, all appliances shall be connected to venting systems.

**12.3.2 Appliances Not Required to be Vented.** The following appliances shall not be required to be vented.

- (1) Listed ranges
- (2) Built-in domestic cooking units listed and marked for optional venting
- (3) Listed hot plates and listed laundry stoves
- (4) Listed Type 1 clothes dryers exhausted in accordance with Section 10.4.

# Annex G - Safety Inspection

## Annex G – Recommended Procedure

Applies to furnaces and boilers

54-166

NATIONAL FUEL GAS CODE

Z223.1-166

**Figure F2.4.**  
**A range of Winter Design Temperatures Used in Analyzing Exterior Masonry Chimneys in the United States.**



99% Winter Design Temperatures for the Contiguous United States

This map is a necessarily generalized guide to temperatures in the contiguous United States. Temperatures shown for areas such as mountainous regions and large urban centers are not necessarily accurate. The data used to develop this map are from the 1993 *ASHRAE Handbook — Fundamentals* (Chapter 24, Table 1: climate Conditions for the United States).

For 99% winter design temperature in Alaska, consult the *ASHRAE Handbook — Fundamentals*.

99% winter design temperature for Hawaii are greater than 37°F

vent diameter in the FAN+NAT column vent has a Btu/hr rating greater than 135,000 Btu/hr. The 4 in. common vent has a capacity of 138,000 Btu/hr. Reducing the maximum capacity by 20 percent (13.2.20) results in a maximum capacity for a 4 in. corrugated liner of 110,000 Btu/hr, less than the total input of 135,000 Btu/hr. So a larger liner is needed. The 5 in. common vent capacity listed in Table 13.2(a) is 210,000 Btu/hr, and after reducing by 20 percent is 168,000 Btu/hr. Therefore, a 5 in. corrugated metal liner should be used in this example.

**Single Wall Connectors.** Once it has been established that relining the chimney is necessary, Type B double-wall vent connectors are not specifically required. This example could be redone using Table 13.2(b) for single wall vent connectors. For this case, the vent connector and liner diameters would be the same as found above with Type B double wall connectors.

### **Annex G** **Recommended Procedure for** **Safety Inspection of an Existing** **Appliance Installation**

*This annex is not a part of the requirements of this code but is included for informational purposes only.*

#### **G.1 General.**

The following procedure is intended as a guide to aid in determining that an appliance is properly installed and is in a safe condition for continuing use.

This procedure is intended for central furnace and boiler installations, and may not be applicable to all installations. This procedure should be performed prior to any attempt

2012 Edition

# Annex G - Safety Inspection

Includes draft testing procedure

to modify the appliance or the installation. If it is determined a condition that could result in unsafe operation exists, shut off the appliance and advise the owner of the unsafe condition.

The following steps should be followed in making the safety inspection:

- (1) Conduct a test for gas leakage.
- (2) Visually inspect the venting system for proper size and horizontal pitch, and determine that there is no blockage, restriction, leakage, corrosion, or other deficiencies that could cause an unsafe condition.
- (3) Shut off all gas to the appliance, and shut off any other fuel gas burning appliance within the same room. Use the shutoff valve in the supply line to each appliance.
- (4) Inspect burners and crossovers for blockage and corrosion.
- (5) *Furnace Installations.* Inspect the heat exchanger for cracks, openings, or excessive corrosion.
- (6) *Boiler Installations.* Inspect for evidence of water or combustion product leaks.
- (7) Close all building doors and windows and all doors between the space in which the appliance is located and other spaces of the building that can be closed. Turn on any clothes dryers. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers. If, after completing Steps 8 through 13, it is believed sufficient combustion air is not available, refer to Section 9.3 of this code.
- (8) Place the appliance being inspected in operation. Follow the lighting instructions. Adjust the thermostat so the appliance will operate continuously.
- (9) Determine that the pilot(s), where provided, is burning properly and that the main burner ignition is satisfactory, by interrupting and re-establishing the electrical supply to the appliance in any convenient manner. If the appliance is equipped with a continuous pilot(s), test all pilot safety device(s) to determine whether it is operating properly by extinguishing the pilot(s) when the main burner(s) is off and determining, after 3 minutes, that the main burner gas does not flow upon a call for heat. If the appliance is not provided with a pilot(s), test for proper operation of the ignition system in accordance with the appliance manufacturer's lighting and operating instructions.
- (10) Visually determine that the main burner gas is burning properly (i.e., no floating, lifting, or flashback). Adjust the primary air shutters as required. If the appliance is

equipped with high and low flame controlling or flame modulation, check for proper main burner operation at low flame.

- (11) Test for spillage at the draft hood relief opening after 5 minutes of main burner operation. Use the flame of a match or candle or smoke.
- (12) Turn on all other fuel gas burning appliances within the same room so they will operate at their full inputs. Follow lighting instructions for each appliance.
- (13) Repeat Steps 10 and 11 on the appliance being inspected.
- (14) Return doors, windows, exhaust fans, fireplace dampers, and any other fuel gas burning appliance to their previous conditions of use.
- (15) *Furnace Installations.* Check both the limit control and the fan control for proper operation. Limit control operation can be checked by blocking the circulating air inlet or temporarily disconnecting the electrical supply to the blower motor and determining that the limit control acts to shut off the main burner gas.
- (16) *Boiler Installations.* Verify that the water pumps are in operating condition. Test low water cutoffs, automatic feed controls, pressure and temperature limit controls, and relief valves in accordance with the manufacturer's recommendations to determine that they are in operating condition.

## Annex H Indoor Combustion Air Calculation Examples

*This annex is not a part of the requirements of this code but is included for informational purposes only.*

### H.1 New Installation.

Determine if the indoor volume is sufficient to supply combustion air for the following new installation example.

*Example Installation 1:* A 100,000 Btu/hr fan-assisted furnace and a 40,000 Btu/hr draft hood equipped water heater is being installed in a basement of a new single family home. The basement measures 25 ft x 40 ft with an 8 ft ceiling.

#### *Solution*

- (1) Determine the total required volume: Since the air infiltration rate is unknown, the standard method to determine combustion air is used to calculate the required volume.

## Annex G - Basic Draft Test Procedure

### Step 1

- Close all doors and windows
- Close fireplace damper
- Operate all air exhausting equipment

### Step 2

- Turn on first appliance
- Check burner/flame for proper operation/appearance

### Step 3

- Check draft after 5 minutes
  - If OK – Begin Step 4
  - If Not OK – Correct combustion air in accordance with 9.3

### Step 4

- Turn on all other appliances located in the same room
- Recheck draft



# Summary

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## **ANSI Z223.1/NFPA 54 National Fuel Gas Code**

- ANSI Standard since 1974
- All listed gas appliances refer to NFGC
- Requirements for use of indoor volume and outdoor air for combustion
- Requires a safety inspections including draft
- Requires make-up air for exhausting air equipment



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