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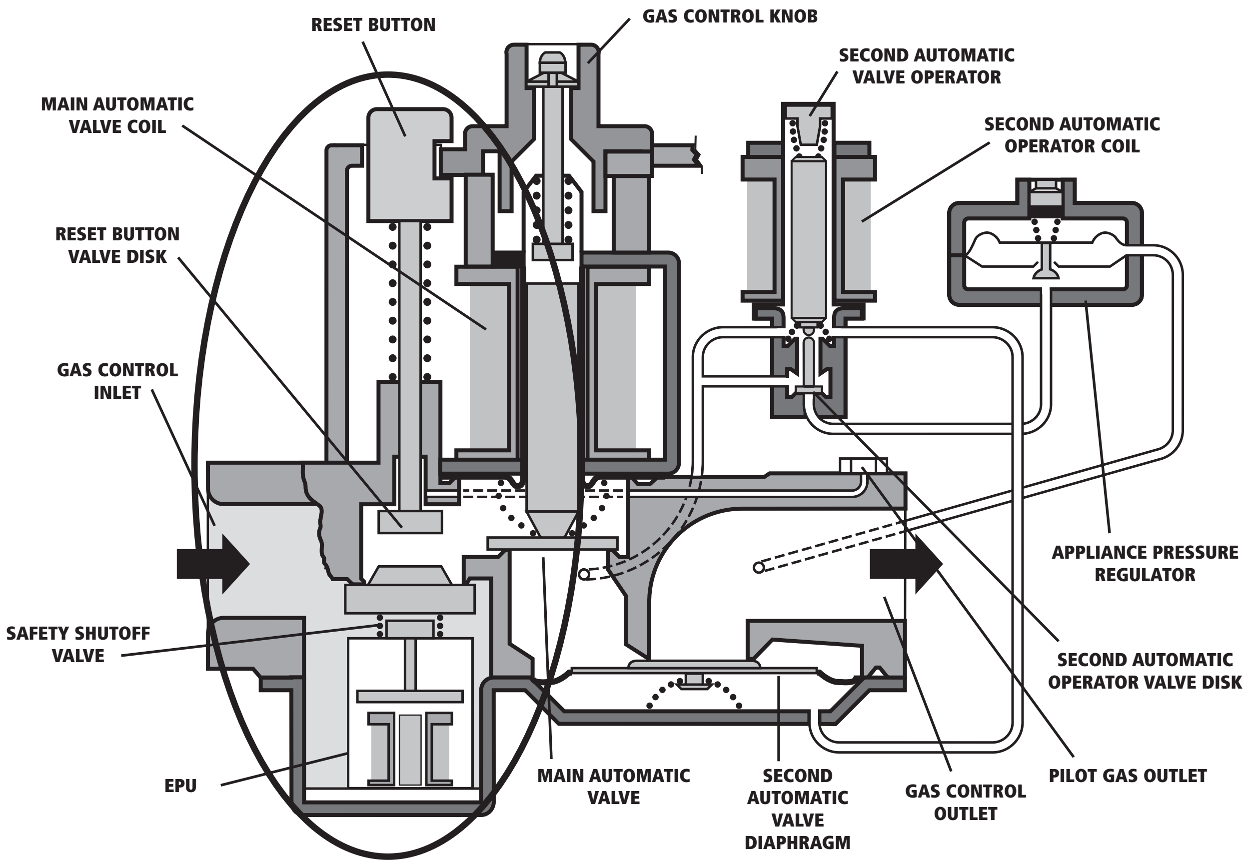
2. OPERATIONAL SEQUENCE: MILLIVOLT POWERED AUTOMATIC GAS CONTROL VALVE

We look now at the sequence of actions and results in the functioning of the millivolt powered automatic gas control valve. The illustrations are representational only; they do not depict the complexity of passageways or the actual position of components. The representations depict one of a number of different valve designs.

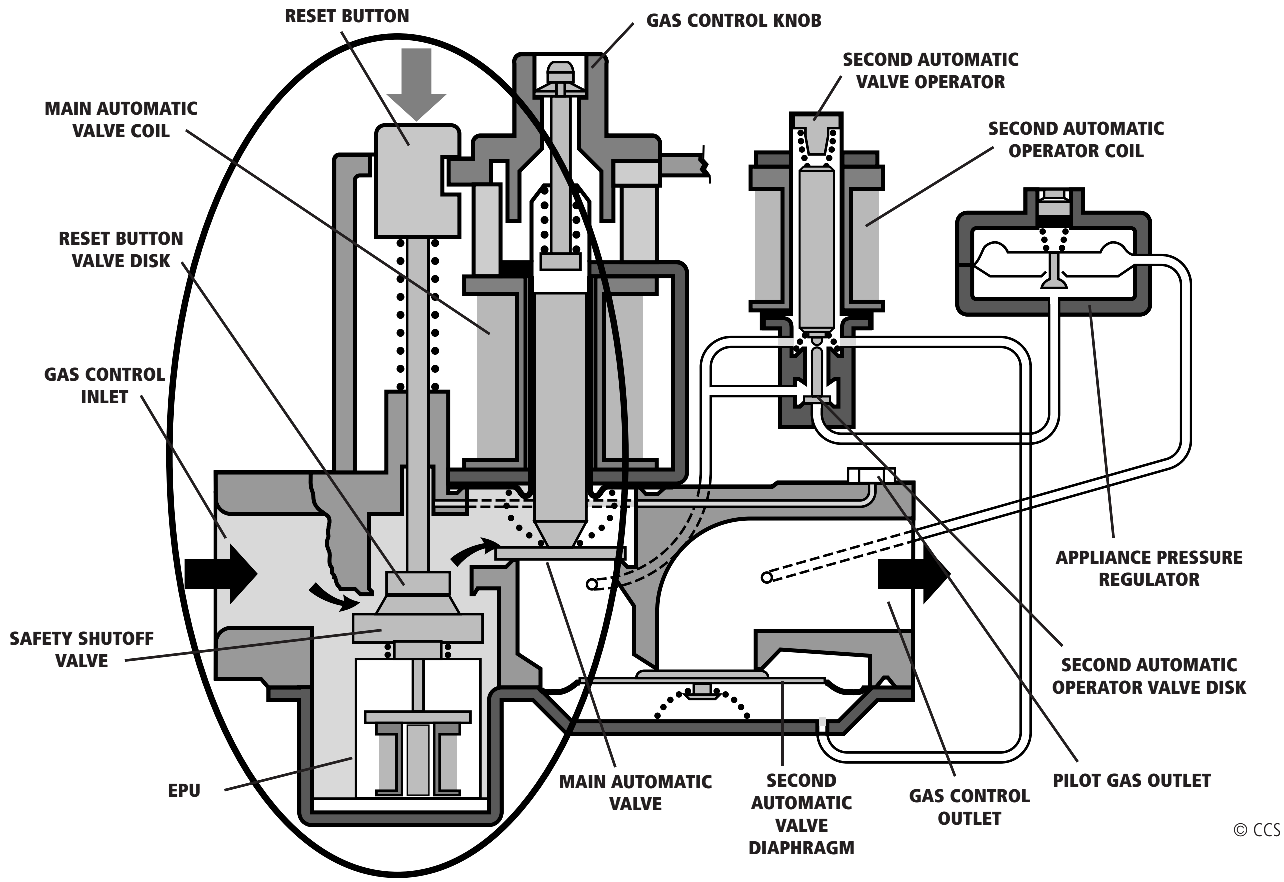


MILLIVOLT POWERED AUTOMATIC GAS CONTROL VALVE

CONTROL KNOB POSITION: OFF

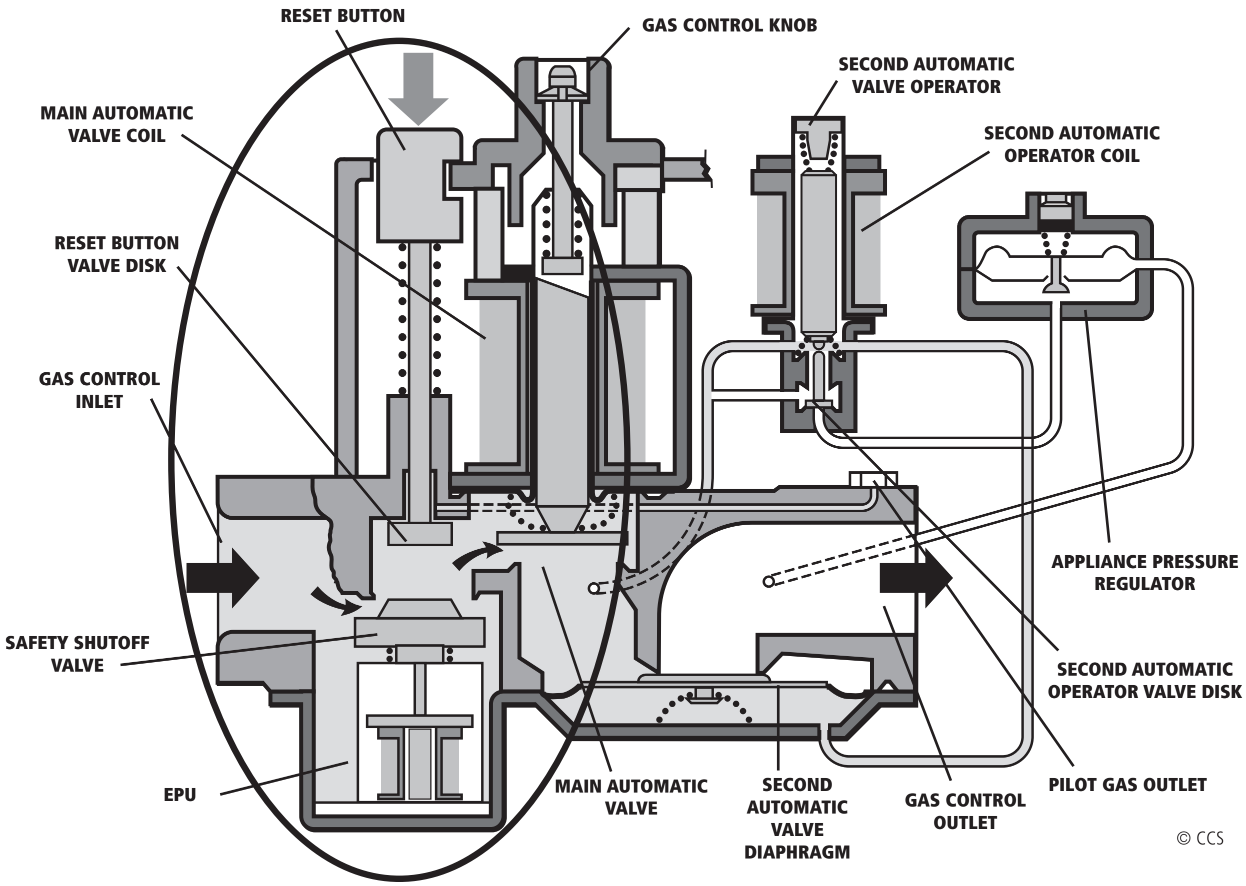
MAIN BURNER SWITCH/CONTROL/THERMOSTAT: NO HEAT DEMAND

1. With the control knob in the OFF position, gas cannot flow to the pilot or main burner.



MILLIVOLT POWERED AUTOMATIC GAS CONTROL VALVE
CONTROL KNOB: PILOT POSITION, DEPRESSED FOR PILOT IGNITION
MAIN BURNER SWITCH/CONTROL/THERMOSTAT: NO HEAT DEMAND

2. When the control knob is turned to the PILOT position and the reset button is depressed, gas flows to the pilot hood and is ignited. Gas cannot flow to the burner side.

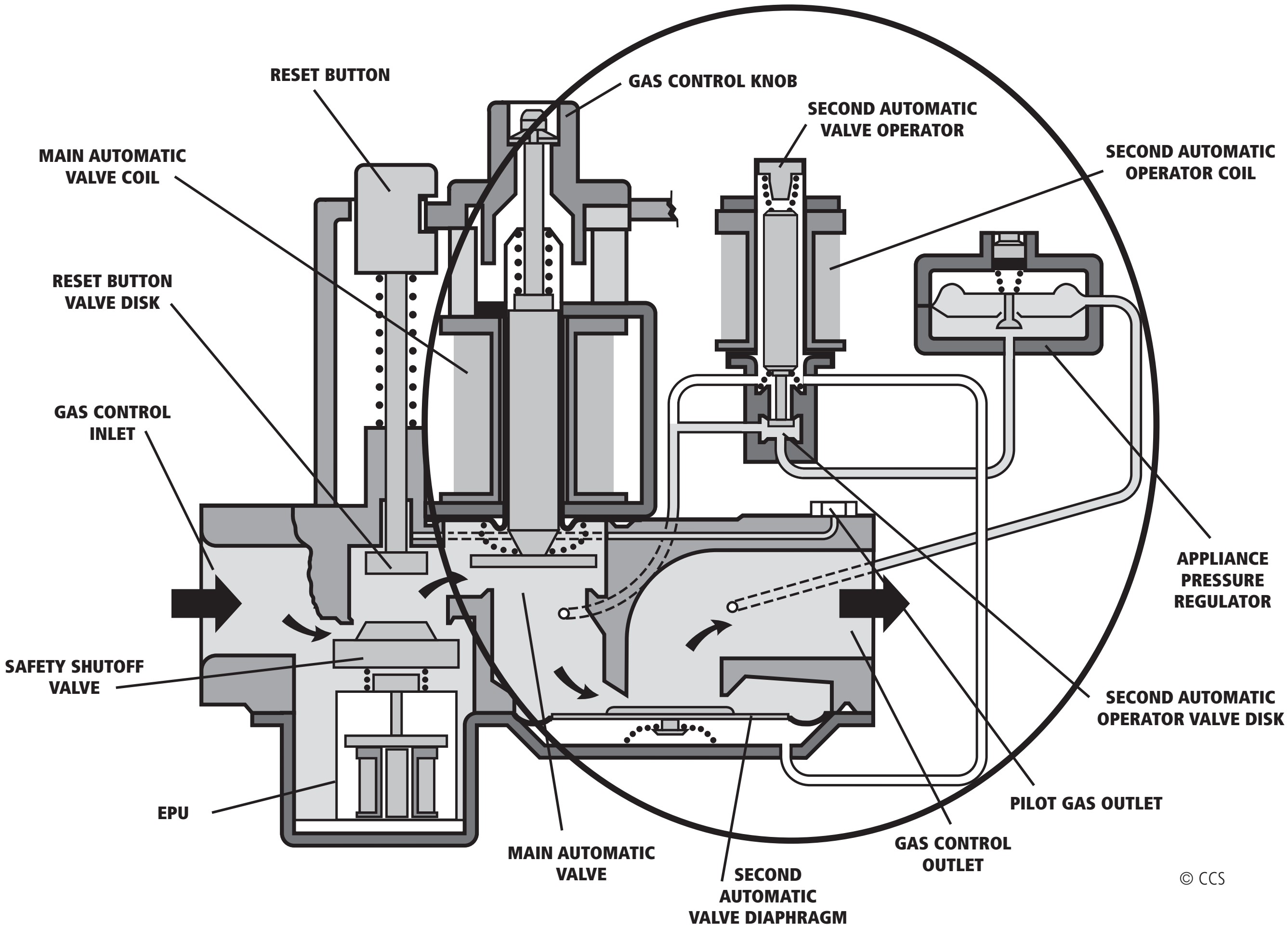


MILLIVOLT POWERED AUTOMATIC GAS CONTROL VALVE

CONTROL KNOB POSITION: ON POSITION

MAIN BURNER SWITCH/CONTROL/THERMOSTAT: NO HEAT DEMAND

3. When the pilot flame heats the thermocouple sufficiently to produce millivoltage to hold the safety shutoff valve open, the control knob is released and turned to the ON position. Gas still cannot flow to the burner side because there is no heat demand.



MILLIVOLT POWERED AUTOMATIC GAS CONTROL VALVE
CONTROL KNOB POSITION: ON POSITION
MAIN BURNER SWITCH/CONTROL/THERMOSTAT: HEAT DEMAND

4. When the remote switch, control, or thermostat signals heat demand, the circuit from the thermopile to the valve operator(s) is completed (closed) to deliver millivoltage to the operator coil.
5. The operator coil becomes magnetized and attracts one end of the activator device.
6. The upward movement of one end of the activator opens a portal that leads to the appliance regulator (and on some valves closes a portal that supplied gas pressure to the back side of a sensing diaphragm).
7. The appliance regulator diaphragm responds to incoming gas pressure and to the output setting and sends gas to the side of the sensing diaphragm that will open the portal that allows gas to flow to the main burner.

8. When the remote switch, control, or thermostat is turned off or heat demand is satisfied, the thermopile millivoltage circuit is interrupted (opened) and the operator coil(s) lose magnetism.
9. The activator is released by the coil and returns to its original position that closes the portal supplying gas to the appliance regulator. Gas cannot flow to the burner side. Gas continues to flow to the pilot hood and the flame stays lit.
10. The process starts again when a switch, control, or thermostat demands heat, unless the pilot flame is lost.

If the pilot flame is lost at any time, the thermocouple drops out (ceases to supply the millivoltage to the EPU to keep the safety shutoff valve open). Gas cannot flow to the pilot or to the main burner side.

1.6 VAC Control Valve Operational Sequence

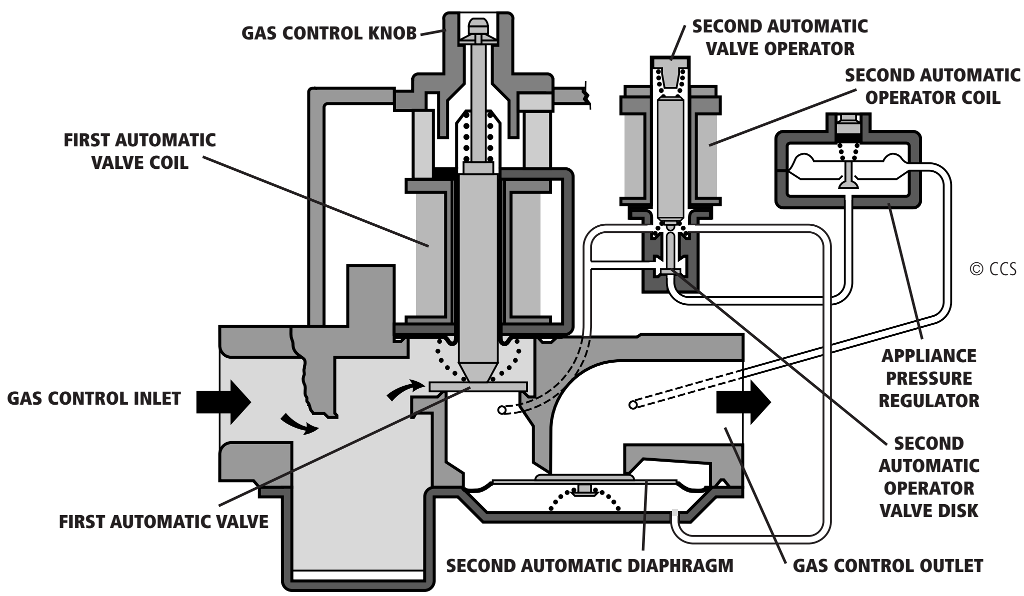
We organize operational sequence by direct ignition control valves and intermittent pilot ignition control valves.

1.6.1 DIRECT IGNITION CONTROL VALVES

First, we look at a generalized overview of direct ignition valve operation, then we follow the sequence in more detail with the two types of direct ignition electronic gas control valves, hot surface and direct spark. We start the operational sequence with the remote switch, control, or thermostat turned off (not set for heat demand) and the electronic gas control in the OFF position. Illustrations are broadly representational and intended as an aid to understanding operation sequence. Components are not shown in their actual positions.

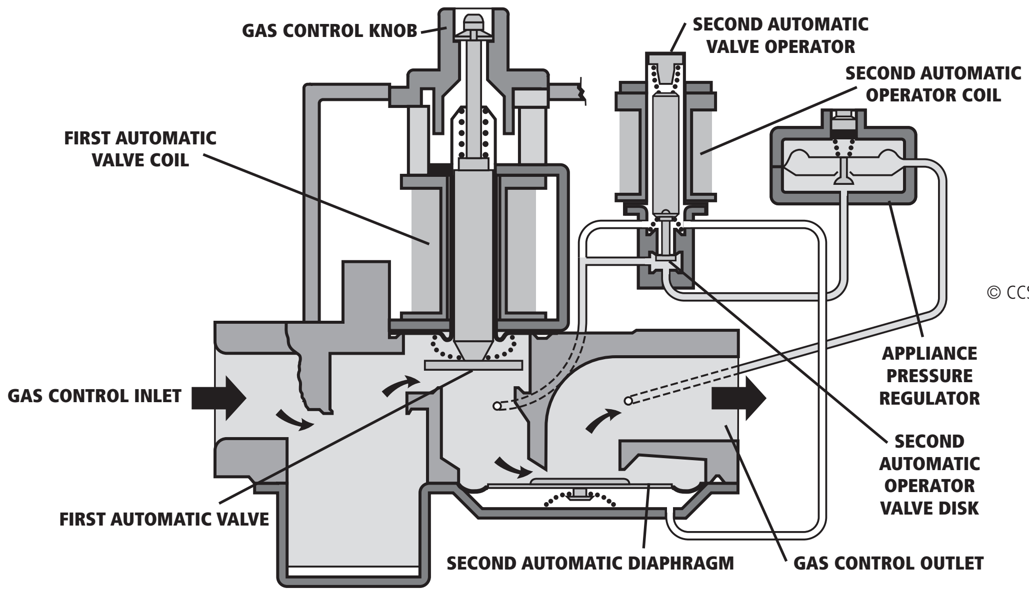
ELECTRONIC VALVE OPERATION OVERVIEW

1. With the control knob in the OFF position, gas cannot flow to burner(s).



CONTROL KNOB POSITION: OFF
HEAT DEMAND: NONE

2. When the control knob is turned to the ON position, the control module sends 24 VAC to the first operator coil to allow gas flow to the pressure regulator, but not to the main burner.



CONTROL KNOB POSITION: ON
HEAT DEMAND: YES

3. When the remote switch, remote control, or thermostat signals heat demand, the control module sends 24 VAC or 110 VAC to the igniter (hot surface or direct spark). At the appropriate time the module sends 24 VAC to the second operator coil to allow gas to flow to the main burner (or to the pilot and main burner with intermittent pilot systems) for ignition. If the control module senses DC microamps from the flame, it continues to supply the power to keep the valve open. When the heat demand is met or the remote switch or control is turned off, the control module stops gas flow to the main burner by ceasing to supply power to the second operator.

If the flame is lost during operation and while there is still heat demand, the control module fails to detect the DC signal and shuts down gas flow.

1.6.1.1 Hot Surface Ignition (HSI) Gas Control Valve Details

- Turning the valve control knob to ON allows gas to flow to the first operator, but no further.
- Setting the wall switch, remote control, or thermostat to demand heat allows the control module to send power to the hot surface igniter.
- The hot surface igniter reaches the desired temperature and the control module sends power to open the portal to allow gas flow to the main burner for about 4-7 seconds.

- If ignition occurs, the control module receives a (flame rectified DC microamp) signal and keeps the valve open until the heat demand is met or the appliance is turned off. It also shuts off the hot surface igniter.
- If ignition fails within 4-7 seconds, the control module shuts off power to the valve and gas flow ceases. Some control modules will have to be reset (no call for heat for 30 seconds or more and/or unplugging and re-plugging the control module power supply) in order to attempt ignition again. Other control modules will wait a specified time period and then re-try ignition for 1 to 3 times.
- When heat demand is met or the appliance turned off, the control module shuts off power to the valve, which shuts off gas flow. A new demand for heat, or turning the appliance on again starts the operational sequence again.

1.6.1.2 Direct Spark Ignition Operation Sequence Details

- Turning the valve control knob to ON allows gas to flow to the first operator, but no further.
- Operating the wall switch, remote control, or thermostat to demand heat allows the control module to send power to the spark generator.
- The spark generator repeatedly sparks and the control module sends power to open the portal to allow gas flow to the main burner for about 4-7 seconds.
- If ignition occurs, the control module receives a (flame rectified DC microamp) signal and keeps the valve open until the heat demand is met or the appliance is turned off. It also shuts off the spark generator.
- If ignition fails within 4-7 seconds, the control module shuts off power to the valve and gas flow ceases. Some control modules will have to be reset (no call for heat for 30 seconds or more and/or unplugging and re-plugging the control module power supply) in order to attempt ignition again. Other control modules will wait a specified time period and then re-try ignition for 1 to 4 times.
- When heat demand is met or the appliance turned off, the control module shuts off power to the valve, which shuts off gas flow. A new demand for heat, or turning the appliance on again starts the operational sequence again.

Appendix D: HOUSE PRESSURE TEST

It is increasingly important with today's tight house construction to assess the environment in which hearth appliances operate. The "Simplified House Pressure Test" offered here is a helpful predictive and diagnostic tool.

1. SIMPLIFIED HOUSE PRESSURE TEST

Research testing by various organizations has demonstrated the spillage resistance of most combustion appliance types. Once you know what level of house depressurization a particular appliance type can tolerate without spilling, you can compare this level to the actual pressure environment of a house.

Using the procedure set out here, you can test the house to find out how depressurized it can become when its exhaust devices are operating. The test results will tell you if the maximum house depressurization level exceeds the spillage resistance pressure of the proposed appliance. At that point you can either choose a more spillage resistant appliance type or install devices to maintain the house pressure within safe bounds.

The general procedure* for the pressure test is to close and latch all exterior doors, windows and other openings to simulate the house condition during cold weather. Then, various exhaust devices are turned on, the level of depressurization is measured, and is compared to the pressure limit for the appliance in question. The test is designed to reveal the pressure drop caused by exhaust systems only, so it does not include a measurement of stack effect. This is because stack effect is entirely dependent on temperature difference. If you want to find out the net influence of exhaust systems and stack effect on chimney/vent performance for the day of the test, measure chimney draft while the exhaust systems are operating. Be aware, however, that the level of chimney/vent draft or stack effect in the house are highly variable, depending on temperature difference and wind effects.

The test may be done at any outdoor temperature, but should only be done when there is little or no breeze; wind speed should not exceed 10 mph so that pressure fluctuations are minimized.

* The procedure outlined here is intended to be used only as a system design and diagnostic tool. It is anticipated that regulatory authorities in some jurisdictions may adopt a standardized approach to house pressure testing in order to assure safe combustion venting in new buildings. The use of the procedure set out here should be discontinued in favor of a standardized approach when such is available.

1.1 House Pressure Test Procedures

> ***Pascal*** *(Pa) is the metric unit of measurement for pressures. One Pa equals 0.004 inches of water column (WC).*

1. Assemble tools and equipment
   - a digital (preferably), or magnehelic, or inclined-tube pressure gauge (manometer) with a resolution of +/-1 Pa and a range of at least 0-60 Pa
   - 30 ft. of plastic tubing to fit pressure gauge taps
   - smoke pencil or other device to illustrate flow direction (a strip of facial tissue works in most cases)
   - electric drill and bit to match flue pipe probe
   - propane camp stove to simulate fire in open fireplace (optional)
2. Put house in heating season condition
   - close and latch all exterior doors and windows; ensure attic hatches are seated, etc.
   - open all interior doors (testing may be done with certain doors closed later in the procedure)
   - turn off all exhaust fans and combustion equipment; ie. turn down thermostats for oil and gas furnaces and water heaters
   - close doors and dampers of woodburning appliances
3. Set up the pressure gauge
   - set up the pressure gauge on the same level of the house and, if possible, in the same room as the combustion appliance of interest
   - connect tubing to the reference or high pressure tap of the gauge and pass it through the corner of a door or window so that the tube is not pinched and leakage is minimized; seal the joint with masking tape if necessary
   - place the end of the tube about 20 feet from the building so there is little or no influence of air turbulence around the building
   - if there is an indoor/outdoor temperature difference, the gauge will read stack pressure, which is of no interest in this test, record the gauge reading so that the stack effect depressurization can be subtracted from later readings; in this way only exhaust depressurization will be measured
4. Test furnace fan effects
   - if the furnace and/or water heater are fuel-fired, set up the gauge in the furnace/utility room; if they are not, set up the gauge where the combustion equipment of interest is located; repeat the test on each story of the house on which there is combustion equipment

- turn the furnace air-circulation fan on high speed to determine if the room pressure is affected; close the furnace room door (if applicable) and read the pressure again
- record both figures; subtract the house effect depressurization reading (for example, if the stack effect reading in step 3 above were 3 Pa, and a reading in step 4 were 5 Pa, the depressurization caused by the furnace fan would be 2 Pa)
- if the operation of the fan causes depressurization, apply corrective measures or leave it on throughout the test

5. The fireplace as an exhaust device

- if a fireplace that would exhaust a large volume of air is never or almost never used because it is inefficient and/or troublesome, close the damper and doors and go on to the next step
- conduct this test if the house includes chimney vented combustion equipment **and** a masonry or factory-built fireplace (wood or gas) that is expected to exhaust a significant amount of air (i.e., no doors or leaky doors, draft hood or air-cooled chimney exhausting from the room, etc.)
- operate the fireplace if it uses gas or propane fuel
- if the fireplace is woodburning, set up the camp stove in the fireplace and heat the fireplace and chimney for at least 15 minutes, making certain that chimney venting has been established; leave the camp stove running for the remainder of the test and treat the fireplace like other exhaust devices; be aware that the camp stove can only simulate a very low fire and so does not represent worst-case conditions; if you want to evaluate worst-case conditions, build a large wood fire

6. Turn on exhaust equipment

- turn on equipment that exhausts to outside such as kitchen and bathroom fans, clothes dryer, HRV with damper defrost, central vacuum, workshop exhaust, etc.
- record the maximum depressurization (subtract the house stack effect measurement for each reading; for example, if the house stack effect reading in step 3 above were 3 Pa, and the reading here were 15 Pa, the effect of the exhaust equipment would be 13 Pa)
- beginning with the exhaust assumed to be the smallest, turn off the exhausts one at a time and record the pressure changes
- operate exhausts in combinations expected to be most common; record the results; worst case is usually considered to be the two largest exhausts

7. Check for combustion spillage
   - while operating exhaust devices in combinations expected to be most common, start up the chimney vented gas or oil fired furnace or water heater
   - check for spillage using the smoke pencil or other means
   - spillage longer than one minute probably indicates a venting problem that should be dealt with
   - (optional) after letting the system warm up for at least five minutes, make a small hole for a metal pressure probe in the flue pipe serving an oil or gas furnace about a foot from the appliance; if the draft reading (minus the house stack effect) is less than -5 Pa, investigate
   - for wood stoves and fireplaces not involved in the test in step 5, determine if there is a standby backdraft
   - record the spillage results
8. Clean up
   - turn off furnace, water heater, exhaust fans, burner in the fireplace; return thermostats to previous settings, cover the hole in the furnace flue pipe.

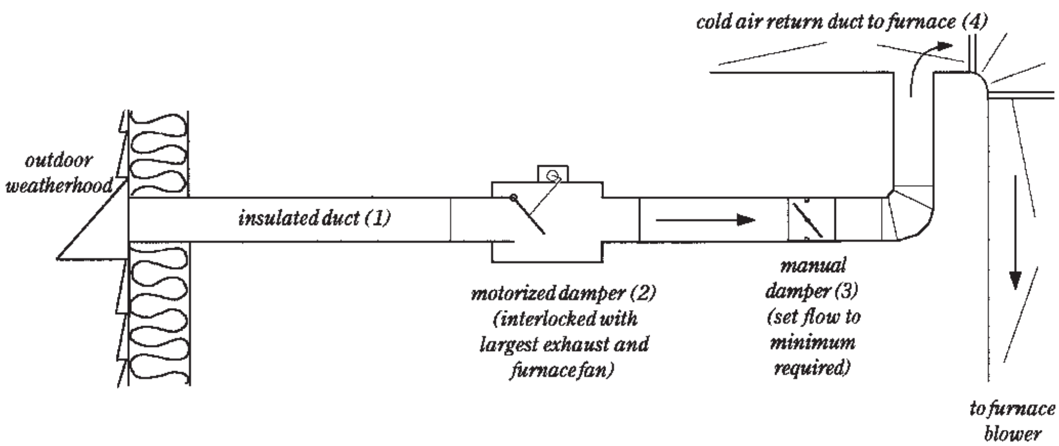
Table 1
Depressurization Limits for Combustion Systems*

	continuous pressure limit (Pa)	intermittent pressure limit (Pa)
OPEN SYSTEMS (chimney vented)		
oil furnace with barometric draft control	5	5
oil-fired water heater with barometric draft control	5	5
gas/propane furnace with draft hood	5	5
gas/propane water heater with draft hood	5	5
gas/propane fireplace B-vented with draft hood		
CLOSED SYSTEMS (chimney vented)		
oil furnace with no barometric draft control	5	10
oil water heater with no barometric draft control	5	10
gas/propane furnace induced draft, no draft hood	5	10
gas/propane water heater, induced draft, sealed flue	5	10
pellet stove with gas-tight vent	5	10
SEALED SYSTEMS (gas-tight, side-wall vented)		
oil furnace, power vented, low temp. side wall vent	10	20
oil water heater, power vented, side wall vent	10	20
gas/propane condensing furnace/boiler	10	20
gas/propane condensing water heater	10	20
gas fireplace or insert, direct vent	10	20
ADVANCED WOOD HEATER (EPA/CSA B415 certified)		
woodburning stove EPA/B415 certified	5	7
woodburning fireplace EPA/B415 certified	5	7
woodburning fireplace insert EPA/B415 certified	5	7
masonry heater	5	7
CONVENTIONAL WOOD HEATER		
wood cooking range	5	5
wood furnace/boiler	5	5
wood fireplace, conventional, with doors	5	5
OPEN WOOD OR GAS FIREPLACE		
open fireplace without doors	5	5

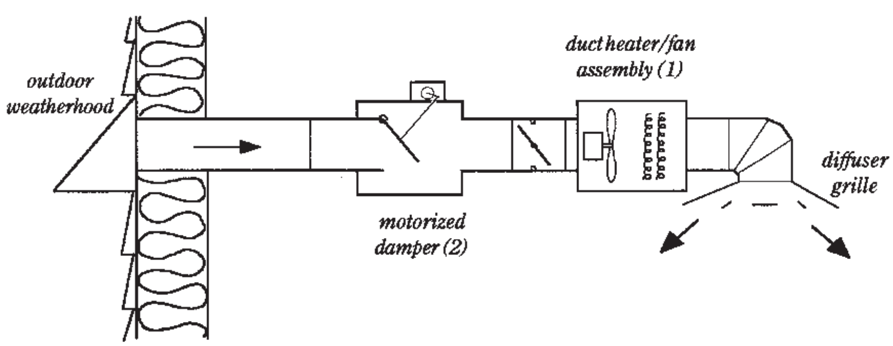
*Note: this table is adapted from the Canadian General Standards Board draft standard CGSB 51.71 "The Spillage Test". As more research is conducted and various jurisdictions codify the requirements, slightly different pressure limits may be chosen. Therefore, the figures in this table should be used as an interim guideline, not as the final word on the tolerance of various system types to house depressurization.

2. SIZING MAKE-UP AIR SYSTEMS

In some houses, and with certain exhaust devices and/or combustion equipment, it is necessary to provide make-up air, a quantity of outside air to make up for the deficit between what is needed and what is available. A make-up air system should be balanced: the quantity of air should be as close to the actual volume needed as possible. Bringing in more cold outside air than is needed wastes energy and may cause discomfort to the occupants. The make-up air system must also be reliable: a powered system (rather than a passive "hole-in-the-wall" approach) may be the only way to ensure adequate combustion air at all times. We offer basic information here to increase familiarity with the process of determining proper sizing for make-up air systems.



TYPICAL MAKE-UP AIR SYSTEM: FORCED AIR HEATING SYSTEM



TYPICAL MAKE-UP AIR SYSTEM: DUCT HEATER/FAN ASSEMBLY

The most accurate way to determine the volume of make-up air required to reduce envelope depressurization by a specific amount is to test the house using the fan depressurization method (blower door). This method would allow the actual make-up air requirement to be measured. However, if this test is not being done on the house for other reasons, the cost is not likely justified. Without such equipment, it is unwise to attempt excessive precision because you could unintentionally create a system that is unable to deliver sufficient make-up air. Ideally, the make-up air system is designed to be slightly larger than necessary so that it can be adjusted to provide the correct flow.

The approximate volume of make-up air that must be supplied can be inferred by using Table 2 and Table 3 in combination with the results of the simplified house pressure test (above). Table 2 provides the estimated air flow of the exhaust devices that are primarily causing the excess depressurization, Table 3 provides insights into the relationships between flow and pressure in houses with various degrees of leakiness (listed in terms of equivalent leak area [ELA]), and the house pressure test tells you exactly how the house pressure is affected by the exhaust flows. Table 4 provides the estimated air flows for standard powered make-up air systems of the type illustrated here.

Table 2.
ESTIMATED AIR FLOWS OF TYPICAL INTERMITTENT EXHAUST DEVICES

	L/s*	CFM
bathroom fan	15-30	32-64
standard kitchen range hood	40-60	85-127
downdraft bbq range exhaust	100-200	212-424
clothes dryer	40	85
central vacuum	25	53
AVERAGE AIR FLOWS OF CHIMNEY VENTED COMBUSTION SYSTEMS		
chimney vented oil furnace	30-50	64-106
B-vented gas furnace	30-50	64-106
B-vented gas fireplace	30-50	64-106
open wood/gas fireplace	80-150	170-318
wood fireplace with doors	30-50	64-106
controlled combustion woodburning appliance	5-15	11-32

**L/s is litres per second, the metric equivalent of cubic feet per minute (CFM). Multiply L/s by 2.12 to get CFM*

EXHAUST DEVICE AIR FLOWS

Table 3
ESTIMATED HOUSE DEPRESSURIZATION FOR VARIOUS EXHAUST FLOW RATES AND ENVELOPE LEAKINESS
(in pascals)

total exhaust flow L/s (CFM)	**total ELA estimate** (diameter in inches)														
	7.4	**8.0**	**8.6**	**9.2**	**9.7**	**10.4**	**11.3**	**12.2**	**13.0**	**13.7**	**14.7**	**16.0**	**17.2**	**18.3**	**19.4**
20 (42)	1.8	1.4	1.1	0.9	0.7	0.6	0.5								
30 (64)	3.4	2.6	2.0	1.7	1.4	1.2	0.9	0.7	0.6	0.5					
40 (85)	5.3	4.0	3.2	2.6	2.2	1.8	1.4	1.1	0.9	0.7	0.6	0.5			
50 (106)	7.5	5.7	4.5	3.6	3.0	2.6	2.0	1.5	1.3	1.0	0.9	0.7	0.5		
60 (127)	10.0	7.5	5.9	4.8	4.0	3.4	2.6	2.0	1.7	1.4	1.2	0.9	0.7	0.6	0.5
70 (148)	12.6	9.5	7.5	6.1	5.1	4.3	3.3	2.6	2.1	1.8	1.5	1.1	0.9	0.7	0.6
80 (170)	15.5	11.7	9.2	7.5	6.3	5.3	4.0	3.2	2.6	2.2	1.8	1.4	1.1	0.9	0.7
90 (191)	18.6	14.0	11.1	9.0	7.5	6.4	4.8	3.8	3.1	2.6	2.2	1.7	1.3	1.1	0.9
100 (212)	21.8	16.5	13.0	10.6	8.8	7.5	5.7	4.5	3.6	3.0	2.6	2.0	1.5	1.3	1.0
110 (233)	25.3	19.1	15.1	12.3	10.2	8.7	6.6	5.2	4.2	3.5	3.0	2.3	1.8	1.5	1.2
120 (254)	28.9	21.8	17.2	14.0	11.7	10.0	7.5	5.9	4.8	4.0	3.4	2.6	2.0	1.7	1.4
130 (276)		24.7	19.5	15.9	13.2	11.3	8.5	6.7	5.5	4.6	3.9	2.9	2.3	1.9	1.6
140 (297)		27.7	21.8	17.8	14.8	12.6	9.5	7.5	6.1	5.1	4.3	3.3	2.6	2.1	1.8
150 (318)			24.3	19.8	16.5	14.0	10.6	8.4	6.8	5.7	4.8	3.6	2.9	2.3	2.0
160 (339)			26.8	21.8	18.2	15.5	11.7	9.2	7.5	6.3	5.3	4.0	3.2	2.6	2.2
170 (360)			29.5	24.0	20.0	17.0	12.9	10.1	8.3	6.9	5.9	4.4	3.5	2.8	2.4
180 (382)				26.2	21.8	18.6	14.0	11.1	9.0	7.5	6.4	4.8	3.8	3.1	2.6
190 (403)				28.5	23.7	20.2	15.3	12.0	9.8	8.2	7.0	5.3	4.1	3.4	2.8
200 (424)					25.7	21.8	16.5	13.0	10.6	8.8	7.5	5.7	4.5	3.6	3.0

⇦ *newer, tight small houses* — *average size houses 20 -50 years old* — *old, leaky large houses* ⇨

The actual leakage rate of a particular house can be determined only through testing. This table shows the effect of exhaust flows on the pressure in houses with leakiness within the range normally encountered. To gain insights into how exhaust flow, house tightness and inside pressure relate, try this: add up the total exhaust flow capacity for the house on the next page using the values in the table on the previous page, then using this table, determine what the maximum house depressurization would be for houses of various degrees of leakiness.

ESTIMATED HOUSE DEPRESSURIZATION CHART

Here is an example of how Table 2, Table 3 and the house pressure test can be used in designing an effective powered make-up air system.

A house contains a factory-built fireplace that can tolerate a depressurization level of 5 Pa. The house pressure test reveals that the clothes dryer causes a 2 Pa depressurization when operating alone and the house pressure changes to -7 Pa when the kitchen range hood exhaust is turned on. From Table 2 it is determined that the total exhaust from these two devices is estimated as:

clothes dryer	85 CFM
range hood	85-127 CFM
total	170-212 CFM

We will use 212 CFM as the worst-case exhaust flow condition. In Table 3, we find that an exhaust flow of 212 CFM produces a 7 Pa depressurization (from the pressure test) in a house with an ELA of about 10.4 inches in diameter. By looking up the 10.4 inch column in Table 3, we determine that an exhaust flow of 148 CFM produces a safe depressurization level of 4.3 Pa. The necessary make-up air flow would be:

actual exhaust	212 CFM
safe exhaust	148 CFM
make-up air	64 CFM

To determine the size of make-up air system required, the negative pressure in the cold air return system is measured. In this example, the return pressure is -20 Pa.

Table 4.
Air flows through various diameters of make-up air systems at a range of return duct pressures
in L/s (CFM)

Cold air return duct pressure in pascals	Diameter of make-up air assembly* 4"	5"	6"	7"	8"
5	6 (13)	9 (19)	16 (34)	20 (42)	34 (72)
10	9 (19)	15 (32)	22 (47)	33 (70)	48 (102)
15	11 (23)	18 (38)	27 (57)	40 (85)	58 (123)
20	13 (28)	21 (45)	32 (68)	48 (102)	68 (144)
25	15 (32)	24 (51)	35 (74)	54 (114)	77 (163)
30	17 (36)	26 (55)	38 (81)	59 (125)	85 (180)
35	18 (38)	28 (59)	42 (89)	64 (136)	91 (193)
40	20 (42)	31 (66)	44 (93)	68 (144)	98 (208)

MAKE-UP AIR SYSTEM DUCT SIZING

Using Table 4, we find that a 6 inch system of the type illustrated at the top of page 68 will flow 68 CFM. If the actual design of the make-up air system is more complicated than the one shown at the top of page 68, or if flex duct is used, it would be wise to increase the diameter of the system to 7 inches. In this example, we used the worst-case estimate of exhaust flow and the safest permissible flow from Table 3, so our make-up air system should be able to flow somewhat more air than we need to maintain the house pressure at or above -5 Pa.

3. ADJUSTING A MAKE-UP AIR SYSTEM

Following on with our example, when the make-up air system installation is completed, the house pressure test is repeated to confirm that the depressurization level is reduced to a level that can be tolerated by the fireplace. The second house pressure test shows that with its manual damper fully open, the make-up air system reduces the depressurization level to 3 Pa. Since it is delivering more air than necessary, the manual damper in the make-up air duct is adjusted so that, with the clothes dryer and kitchen range hood exhaust operating, the house pressure is -5 Pa. This procedure ensures that the house cannot become depressurized to the extent that it compromises the operation of the fireplace, yet only the minimum necessary amount of make-up air is delivered to the house.

Appendix G: PREVIOUS CODE EDITIONS: 1999-2002 NFGC, 2000-2003 IFGC

Codes and standards generally change by evolution, gradually and piecemeal. As these changes occur, some jurisdictions which select and approve the building codes across the country also move slowly. Because earlier editions of the fuel gas codes are still recognized in many areas, as well as for clarity and ease of use, we include in this Appendix Combustion Air Openings and Gas Piping Connections, major issues that have changed significantly and/or differed between the NFGC and IFGC and present the current requirements in the main body of the manual. Regardless of the edition of the code, it may be advisable to consult with local code authorities about requirements.

1. COMBUSTION AIR OPENINGS: 1999-2003 FUEL GAS CODES[1]

The fuel gas codes specify the location, size, connection to duct work, and other details of combustion air openings. See 2006-2012 code requirements in Chapter 9. All of the editions allow ventilated, unheated crawl spaces and ventilated attics to be used as sources for outdoor combustion air.

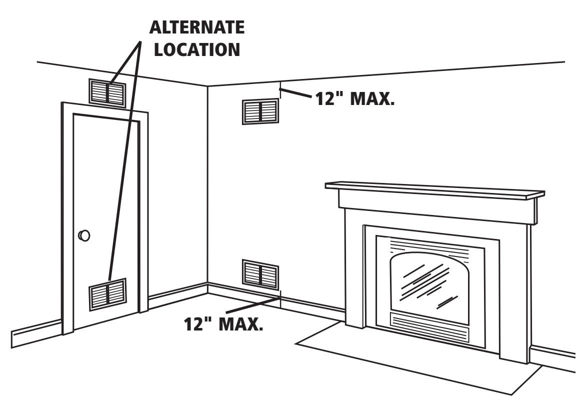
1.1 All Air from Inside the Building

A confined space must be provided with two permanent openings that communicate directly with other spaces of sufficient volume so that the combined volume of all spaces meets the criteria for unconfined space. The total input of all fuel burning appliances in the combined spaces determines the required minimum volume.

1.1.1 OPENING SIZE

Each opening must have

- A minimum free area of not less than 1 square inch per 1,000 Btu per hour of the total input rating of a gas appliances in the confined space, but not less than 100 square inches.
- The minimum dimension of air openings shall not be less than 3 inches. (For example: for an opening that must be at least 120 square inches, if one dimension is 3 inches, the other must be 40 inches [120 ÷ 3 = 40]).



1.1.2 OPENING LOCATION

One opening shall commence within 12 inches of the ceiling and the other within 12 inches of the floor.

1 NFGC-02: 8.3; NFGC-99: 5.3; IFGC-03, -00: 304

OPENING SIZE CALCULATION 1: ALL AIR FROM INDOORS (1999-2000)

1. Enter the input ratings of all appliances in Table 1.

TABLE 1 APPLIANCE RATINGS

Appliance	*Input Rating (Btu/hr)*
Gas Fireplace	*40,000*
Other:	
Total	*40,000*

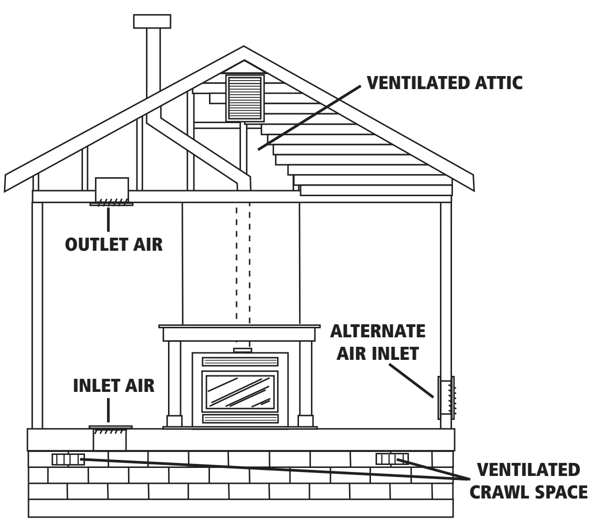
2. Where all air is to be taken from indoors, divide the total input of all gas appliances in the space by 1,000.

Total input:

40,000 ÷ 1,000 = 40 sq. in. for each opening BUT minimum area is ***100 sq. in.*** *for each opening (minimum dimension 3 inches)*

1.2 All Air from Outdoors

The confined space communicates with the outdoors either through one opening or two. In either case, the minimum opening dimension is 3 inches. If ducts are used, they must be of the same cross-sectional area as that of the openings to which they connect.

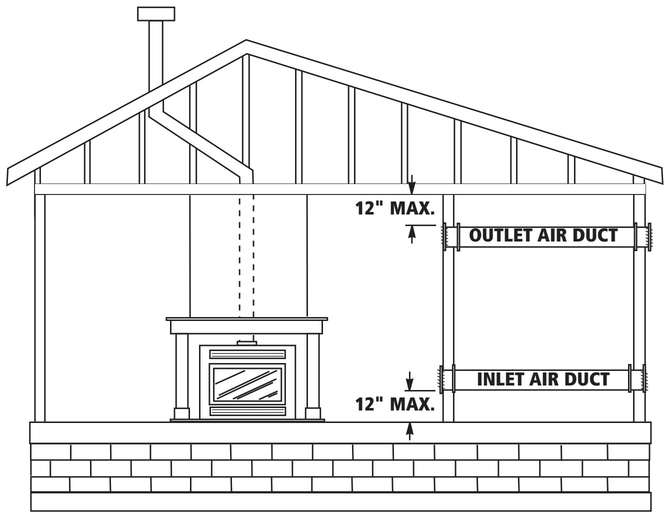


1.2.1 TWO OPENING METHOD

Two permanent openings, once commencing within 12 inches of the ceiling and the other within 12 inches of the floor, communicate directly, or by ducts, with the outdoors or spaces that communicate freely with the outdoors.

- For direct communication or through vertical ductwork to the outdoors, each opening must have a minimum free area of 1 inch per 4,000 Btu/hr total input rating of all equipment in the confined space.

- For communication through horizontal ducts, each opening shall have a minimum free area of not less than 1 square inch per 2,000 Btu/hr of total input rating of all equipment in the confined space.



OPENING SIZE CALCULATION II

All Air from Outdoors: Two Permanent Openings or Vertical Ducts (1999-2000)

1. Enter the input ratings of all appliances in Table 1.

TABLE 1 APPLIANCE RATINGS

Appliance	*Input Rating (Btu/hr)*
Gas Fireplace	*40,000*
Other:	
Total	*40,000*

2. Where all air is to be taken from outdoors, divide the total input of all gas appliances in the space by 4,000.

Total input:

40,000 ÷ 4,000 = 10 sq. in. for each opening

Opening Size Calculation II *continued*

3. If vertical ducts are used, select a duct with the area needed from Table 2.

TABLE 2 SIZES FOR SQUARE AND ROUND DUCTS

Area of Square Ducts		*Area of Round Ducts*	
Side	*Area*	*Diameter*	*Area*
3	*9*	*3*	*7*
4	*16*	*4*	*13*
5	*25*	*5*	*20*
6	*36*	*6*	*28*
7	*49*	*7*	*39*
8	*64*	*8*	*50*
10	*100*	*10*	*79*
12	*144*	*12*	*113*

*For 10 sq. in., select a **4 inch square or 4 inch round** as a minimum size vertical duct or calculate rectangular or other shapes (minimum dimension 3 inches).*

OPENING SIZE CALCULATION III

All Air from Outdoors: Two Permanent Openings via Horizontal Ducts (1999-2000)

1. Enter the input ratings of all appliances in Table 1.

TABLE 1 APPLIANCE RATINGS

Appliance	*Input Rating (Btu/hr)*
Gas Fireplace	*40,000*
Other:	
Total	*40,000*

2. Where all air is to be taken from outdoors, divide the total input of all gas appliances in the space by 2,000.

Total input:

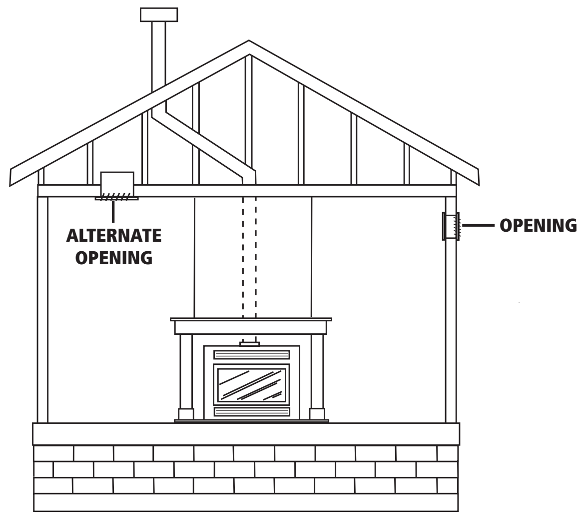
40,000 ÷ 2,000 = 20 sq. in. for each opening

*3. Select a duct with the area needed from Table 2 above. The minimum size horizontal duct would be **5 inches square or 5 inches round** or calculate rectangular or other shapes (minimum dimension 3 inches).*

1.2.2 ONE OPENING METHOD

One permanent opening, commencing within 12 inches of the ceiling is provided. The appliance must have minimum clearances of 1 inch from the sides and back and 6 inches from the front. The opening is required to:

- communicate directly or through a vertical or horizontal duct to the outdoors or a space that freely communicates with the outdoors.
- have a minimum free area of 1 square inch per 3,000 Btu/hr of the total input rating of all equipment locate in the confined space
- be no less than the sum of the areas of all vent connectors in the confined space.



OUTDOORS THROUGH ONE OPENING

1 sq. in. per 3,000 Btu/hr Input Rating

OPENING SIZE CALCULATION IV

All Air from Outdoors: One Opening (1999-2000)

1. Enter the input ratings of all appliances in Table 1.

TABLE 1 APPLIANCE RATINGS

Appliance	*Input Rating (Btu/hr)*
Gas Fireplace	*40,000*
Other:	
Total	*40,000*

2. Where all air is to be taken from outdoors, divide the total input of all gas appliances in the space by 3,000. Total input:

40,000 ÷ 3,000 = 13 sq. in. for each opening. NOTE: the opening must not be less than the sum of the areas of all vent connectors in the space. For example, if the vent connector for this appliance is 5 in. round (and it is the only vented appliance within this space), the opening must be at least 20 square inches (use Table 2, Area of Round Ducts, for area of round vent). The minimum clearances to combustibles of the appliance must be at least 1 inch from sides and back and 6 inches from the front.

1.3 Combination of Air from Inside and Outdoors

The building must be not unusually tight in order to use a combination of indoor and outdoor air in the 1999-2000 fuel gas codes. Any communicating interior spaces containing the fuel burning appliances must meet the requirements for all air from inside the building (1.1 above), except for the volumetric requirements. The required combustion air can be supplemented by outdoor air, utilizing a prorated combination of inside and outdoor air.

The determination of the size of openings to the outdoors is basically calculating the proportion of needed volume for combustion air that the indoor space provides and using that information in outdoor air opening calculation. For each method of calculating size for openings providing all air from outdoors (direct openings, horizontal ducts, and vertical ducts, the size is calculated as if the opening would provide all combustion air and then reduced by the ratio (percentage) of air not provided from indoor air sources.

In the 1999-2000 fuel gas codes, the combination of indoor and outdoor air can only be used for confined spaces in buildings that are NOT of unusually tight construction. There must be two openings provided to the outdoors.

OPENING SIZE CALCULATION V

Combination of Air from Indoors and Outdoors (1999-2000)

1. *Determine the total available room volume:*
   Example installation: 40,000 Btu/hr gas fireplace (no other combustion equipment in the space) in a room 12 x 15 feet with an 8-foot ceiling. No additional indoor spaces can be used to meet combustion air needs.
   Room volume: 12 x 15 x 8 = 1,440 cubic feet
2. *Determine the required volume (see Section 1, this chapter).*
   Divide the input rating by 20: 40,000 ÷ 20 = 2,000 cubic feet minimum volume.
   The indoor volume of 1,440 cubic feet does not meet the required 2,000 cubic feet. Additional air must be provided from outdoors.
3. *Determine the ratio of the available volume to the required volume (what percentage of the required volume is the available volume):*
   1,440 ÷ 2,000 = .72
4. *Determine the reduction factor to be used to reduce the full outdoor opening size (if all air were supplied from outdoors) to the minimum required based on the ratio of indoor spaces (the percentage supplied by indoor spaces):*
   1(total required or 100%) - .72 (% of total required available from indoors from step 3) = .28

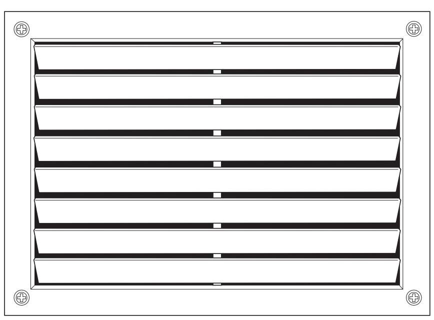
5. Use one of the methods that uses two openings in All Air from Outdoors in 1.2 to determine the size of the outdoor openings if they furnished all combustion air. In this example, two direct openings through horizontal ducts to the outdoors are used (see G.1.2.1 above):
40,000 ÷ 2,000 = 20 square inches

6. Determine the minimum outdoor combustion air opening area:
.28 x 20 = 5.6 square inches, but the minimum dimension size is 3 inches, so each minimum sized square opening and duct would be 9 square inches. (A round duct would need to be at least 3 inches in diameter.)

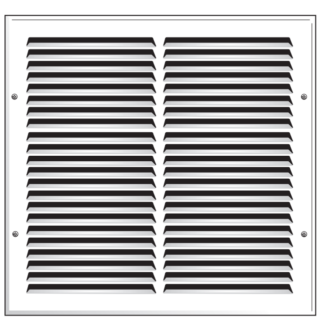
1.4 Louvers and Grilles

The size of louvers and grilles covering combustion air openings is based on their net free area (the total area of the louver or grill less the restricting area of the metal or wood slats or cross-pieces). If the free area is known, it is used in calculations. When it is not known, it is assumed that wood louvers have a 20-25% free area and metal grilles and louvers have a 60-75% free area. Louvers are fixed in the open position, or they must be interlocked with the equipment to ensure they are open during main burner ignition.[2]

CALCULATING LOUVER/GRILLE NET FREE AREA



Wood
8" x 12" = 96" x .25 = 24 square inches free area



Metal
8" x 12" = 96" x .75 = 72 square inches free area

2 NFGC-02: 8.3.7; NFGC-99: 5.3.5; IFGC-03: 304.10; IFGC-00: 304.14

2. GAS PIPING CONNECTIONS: 1999-2003 FUEL GAS CODES

The following table summarizes code requirements for different pipe connection issues in the 1999-2003 editions of NFGC and IFGC. See Chapter 4 for 2006-2012 requirements.

	NFGC 99	IFGC 00	NFGC 02	IFGC 03
Equipment Shutoff Valve	Accessible, upstream of connector Installed within 6' of appliance Can be located in decorative gas fireplace if listed for such use Remove shutoff valves and cap gastight for fireplaces burning solid fuel	Accessible, upstream of connector Installed within 6' of appliance* *For vented decorative appliances and gas log sets, can be located in area remote from appliance if provided with ready access Can be installed in fireplace firebox if installed according to appliance manufacturer's instructions	Accessible, upstream of connector Installed within 6' of appliance Can be located in decorative gas fireplace if listed for such use Remove shutoff valves and cap gastight for fireplaces burning solid fuel	Accessible, upstream of connector Installed within 6' of appliance* *For vented decorative appliances and gas log sets, can be located in area remote from appliance if provided with ready access Can be installed in fireplace firebox if installed according to appliance manufacturer's instructions

	NFGC 99	IFGC 00	NFGC 02	IFGC 03
Fuel Connector	Can be rigid metallic pipe; semirigid metallic tubing; or listed connectors located in the same room as the equipment and protected against physical damage	Can be rigid metallic; semirigid metallic tubing, not exceeding 6 feet and located in the same room as appliance; or listed and labeled connectors located in the same room as the equipment Limited to 3 feet Cannot be concealed in or extend through walls, floors partitions, ceilings or appliance housings* *Can extend into fireplace inserts factory equipped with grommets, sleeves, or other protection in accordance with listing	Can be rigid metallic pipe; semirigid metallic tubing; or connectors listed to ANSI Z21.24 *Connectors for Gas Appliances* and located in the same room as the equipment and only one connector per appliance; CSST where installed in accordance with manufacturer's instructions	Can be rigid metallic; semirigid metallic tubing, not exceeding 6 feet and located in the same room as appliance; or listed and labeled connectors located in the same room as the equipment Limited to 3 feet Cannot be concealed in or extend through walls, floors partitions, ceilings or appliance housings* *Can extend into fireplace inserts factory equipped with grommets, sleeves, or other protection in accordance with listing

Gas Piping Connections *continued*

	NFGC 99	IFGC 00	NFGC 02	IFGC 03
Sediment Trap	Vented decorative appliances and gas log sets are not required to have traps, unless required by the appliance manufacturer If required, vertical gas inlet to top of tee, horizontal out of tee to appliance, sediment trap vertical at bottom of tee, nipple at least 3" plus threading	Trap located as close to inlet of equipment as possible Vertical gas inlet to top of tee, horizontal out of tee to appliance, sediment trap vertical at bottom of tee, nipple at least 3" plus threading	Vented decorative appliances and gas log sets are not required to have traps, unless required by the appliance manufacturer If required, vertical gas inlet to top of tee, horizontal out of tee to appliance, sediment trap vertical at bottom of tee, nipple at least 3" plus threading	Trap located downstream of connector as close to inlet of equipment as possible Vertical gas inlet to top of tee, horizontal out of tee to appliance, sediment trap vertical at bottom of tee, nipple at least 3" plus threading