The provisions of Clause 5.6 do not apply to the following:
a) direct vent water heaters;
b) water heaters for installation in manufactured homes (mobile homes);
c) water heaters for installation in recreational vehicles; and
d) water heaters for outdoor installation.

Method of Test

This test shall be conducted using natural gas only, unless the water heater is for use with LP gas only or if the manufacturer specifies different inputs for natural and LP gas.

The water heater shall be connected to the vent pipe as specified in the water heater manufacturer's instructions. Vent pipe elbows shall be 90 degrees (1.57 rad).

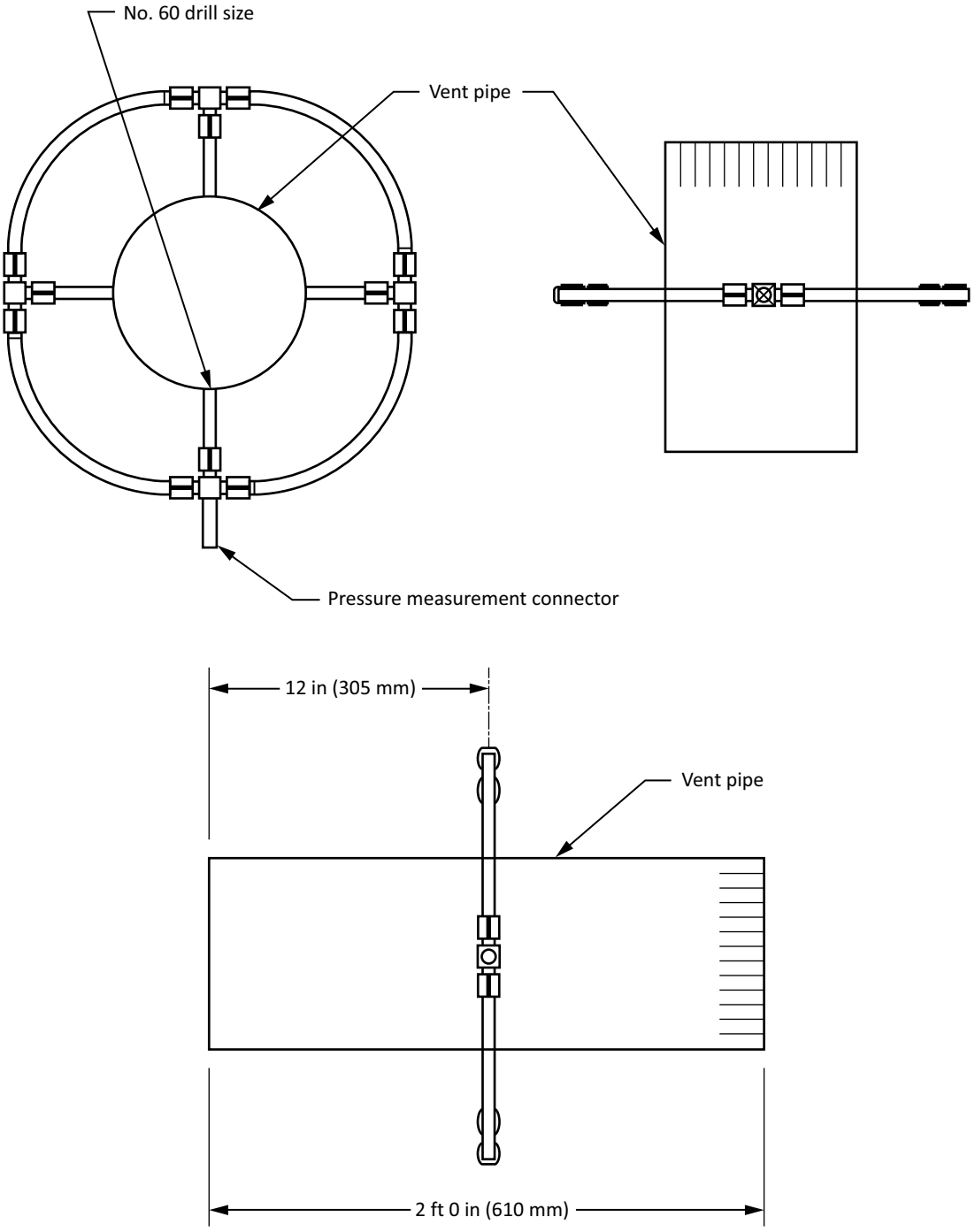
When the flue gases are vented horizontally from the water heater, a 2 ft (610 mm) section of vent pipe extending horizontally, an elbow, and a sufficient length of vertical vent pipe shall be attached to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or point of connection of the venting system to the water heater, to the top of the vertical vent pipe.

When the flue gases are vented horizontally from the water heater, a 2 ft (610 mm) section of vent pipe extending horizontally, an elbow, and a sufficient length of vertical vent pipe shall be attached to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or point of connection of the venting system to the water heater, to the top of the vertical vent pipe.

The horizontal run of vent pipe shall be pitched upward 1/4 inch to the ft (21 mm to the meter).

The vent pipe shall be equipped with (1) a piezo ring (see Figure 4, Piezo ring and details of typical construction) installed at the midpoint of the 2 ft (610 mm) section of vent pipe extending horizontally, and (2) a thermocouple grid (as specified in Clause 5.18, Flue gas temperature) installed 12 in (305 mm) from the outlet of the test vent. A differential pressure gage that can be read directly to 0.005 in wc (1.24 Pa) pressure shall be attached to the piezo ring to measure static pressure. The vent pipe shall be insulated by means of foil-faced R7 material when the flue gases are vented vertically from the water heater, an elbow, a 2 ft (610 mm) section of vent pipe extending horizontally, a second elbow, and sufficient vertical vent pipe shall be attached to the flue outlet to provide a total height of 5 feet (1.52 m) measured from the highest point of the draft hood relief opening(s) or point of connection of the venting system to the water heater to the top of the vertical vent pipe.

Figure 4
Piezo ring and details of typical construction
(See Clause 5.6.1.)



5.6.2
For a water heater having a single input rating

The water heater shall be operated at normal inlet test pressure. Water at a temperature of 70 ± 2 °F (21 ± 1 °C) and at a working pressure of not less than 40 psi (275.8 kPa) shall be supplied to the

appliance through the inlet connection. Water flow shall be regulated to stabilize the outlet water temperature at 140 ± 5 °F (60 ± 3 °C). The appliance shall be operated until equilibrium conditions are attained at which time the temperatures indicated by the thermocouples shall be recorded and a sample of the vent gases shall be secured at the outlet of the test vent and analyzed for carbon dioxide as specified in Clause 5.4.1. The net vent gas temperature shall be determined by subtracting the room temperature from the vent gas temperature. (See Figure 5, Chart for determination of water heater category.)

The static pressure of the vent shall be measured by use of the piezo ring and recorded.

The category of the water heater with respect to the venting system shall be determined using Table 11 (Determination of category) and Figure 5 (Chart for determination of water heater category).

Figure 5
Chart for determination of water heater category
(See Clauses 5.6.1 and 5.6.2.)

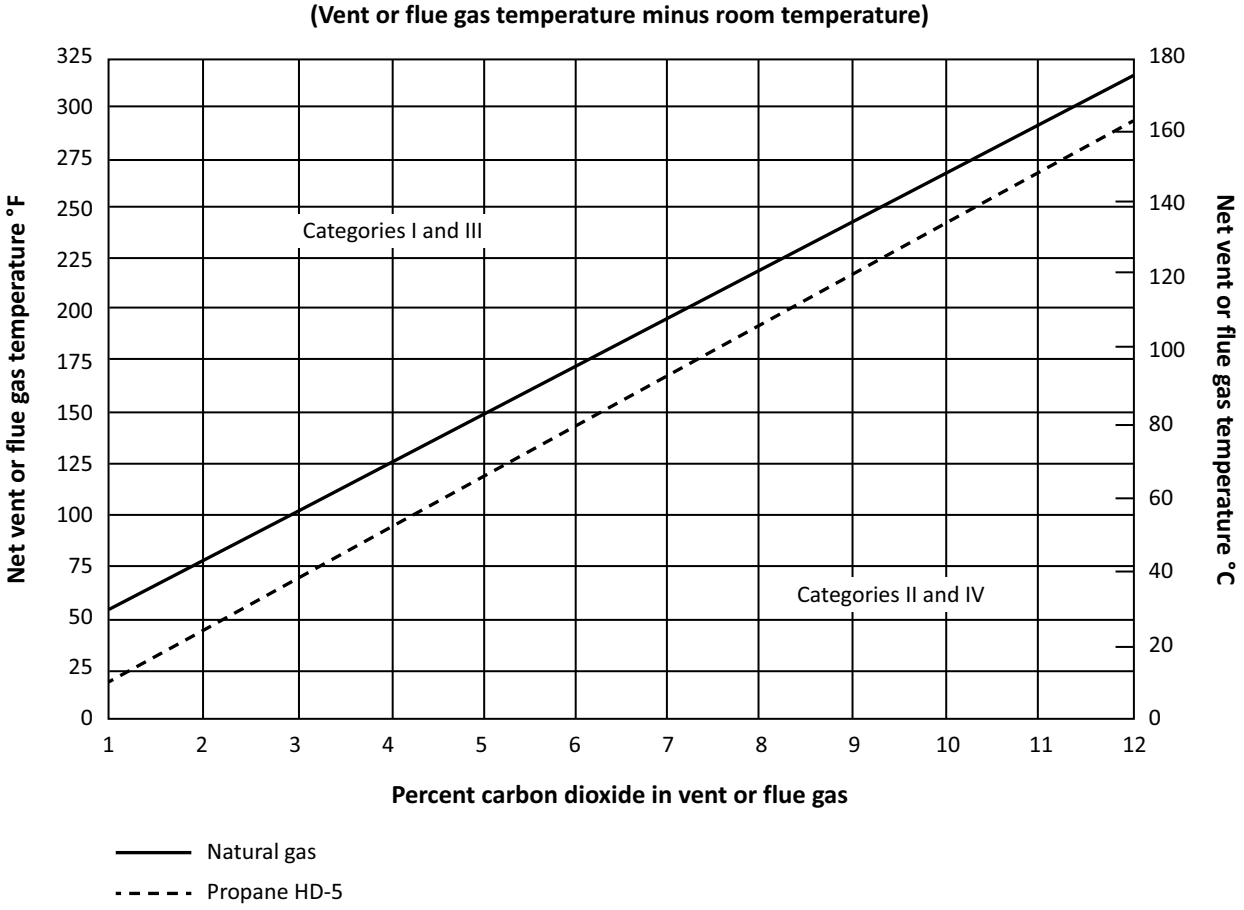


Table 11
Determination of category
(See Clauses 5.6.1 and 5.6.2.)

	Vent pressure	Net flue gas temperature, °F (°C) (See Figure 4)
Category I	Non-positive	On or above curve[1)]
Category II	Non-positive	Below curve[1)]
Category III	Positive	On or above curve[1)]
Category IV	Positive	Below curve[1)]

Note: *Reference American Gas Association Laboratories Report 1509 (Copyright © 1976) with curve based upon a 17 percent flue loss.*

5.6.3
For a water heater having multiple input ratings

This test shall be conducted as specified in Clause 5.6.1 a) above except as follows:

The test to determine the static pressure in the vent shall be conducted at the maximum input rate only.

The net vent gas temperature and carbon dioxide concentration shall be determined at both minimum and maximum input ratings.

Using the data obtained above, the category of the water heater with respect to the venting system shall be determined using Table 11 (Determination of category) and Figure 5 (Chart for determination of water heater category).

If two categories are determined during conduct of this test, the water heater shall be rated at the higher of the two category numbers.

5.7 Piloted ignition systems

5.7.1

The time from initiation of gas flow to proof of supervised flame shall not exceed:

a) 3 minutes for integral valve type automatic gas ignition systems;
b) 5 minutes for electrical contractor type automatic gas ignition systems;
c) 1-1/2 minutes for an automatic gas ignition system requiring a continually applied manual force to assume the “on” position; and
d) 1-1/2 minutes for automatic gas ignition systems that operate every time the main burner(s) with which they are used are turned “on” and “off.”

For purposes of this test, the control manufacturer’s specified maximum flame-establishing period shall be used.

5.7.2

According to the following Method of Test, the pilot(s) shall effect safe ignition of gas at the main burner(s) after gas reaches the main burner port(s). Continuous pilots shall not become extinguished

and remain extinguished when the gas to the main burner(s) is turned on and off in a normal manner. This provision does not apply to interrupted type pilots or to intermittent type pilots when the gas to the main burner(s) is turned off.

Method of Test

This test shall be conducted over the range of inlet test pressures specified in Clause 5.3.1 for each type of gas selected.

At least 25 successive ignition tests shall be conducted. The thermostat shall be manually cycled to provide a 30-second “on” time, beginning with the initial ignition of main burner gas, and a 30-second “off” time, beginning after any post purge function ceases. Failure to effect safe ignition after gas reaches the main burner port(s) in any one instance, continued extinction of the pilot, or a lockout of the automatic ignition system shall be considered as noncompliance with this provision.

5.7.3

When an interrupted ignition source is provided, the time required for the main burner flame to be proved from the initiation of main gas flow shall not exceed 90 seconds when the water heater is operated at normal inlet test pressure.

For purposes of this test, the control manufacturer’s specified maximum main burner flame-establishing period for the automatic gas ignition system shall be used.

5.7.4

The time required for the automatic gas ignition system to shut off the main gas supply following loss of supervised flame shall not exceed 3 minutes.

For purposes of the following Method of Test, the control manufacturer’s specified maximum flame failure response time shall be used.

Method of Test

The thermostat, if of the adjustable type, shall be set at the maximum temperature setting.

With the water at 70 ± 2 °F (21 ± 1 °C) at the start of the test, the main burner(s) gas shall be lighted and permitted to burn for 1 hour at normal inlet test pressure or until the thermostat starts to reduce the main gas supply.

The gas supply to the main burner(s) and water to the appliance shall then be shut off and the gas flow to a continuous or intermittent pilot immediately re-established but not ignited. The combined flame failure response time and valve closing time shall not exceed 3 minutes. An interrupted pilot having a separate sensing device from that for the main burner flame shall also be tested by turning off all gas after the pilot has been proved but before the main burner gas is ignited. The gas flow to the interrupted pilot shall be immediately re-established but not ignited. The combined flame failure response time and valve closing time shall not exceed 3 minutes.

5.7.5

When the automatic gas ignition system is designed to shut off the pilot gas supply also, the time and conditions specified in Clause 5.7.4 shall apply.

5.7.6

The pilot shall effect ignition of the gas at the main burner(s) when the gas supply to the pilot is reduced to a point where the flame is just sufficient to keep the valve of the automatic gas ignition system open, or just above the point of flame extinction, whichever represents the higher pilot gas rate.

For purposes of this test, the control manufacturer's specified maximum flame failure response time shall be used.

A pilot that becomes extinguished after having completed main burner ignition is considered as complying with this provision. If the pilot becomes extinguished when the main burner gas is turned on and before igniting the main burner gas, the condition shall be deemed safe, but additional tests shall be made at increasing pilot rates to determine that no condition exists where the pilot will remain lighted without igniting the main burner gas.

The following tests shall be conducted at normal inlet test pressure:

a) Single-flame pilot burners (pilot burners that produce a single flame with substantially uniform contour under turndown conditions).

   The pilot shall effect ignition of the gas within 4 seconds from the time gas is admitted to the main burner(s), without excessive flame flash-out or damage to the water heater, when the pilot gas supply is reduced to an amount just sufficient to keep the valve of the automatic gas ignition system open, or just above the point of flame extinction, whichever represents the higher pilot gas rate.

   A flame can be considered as being equivalent to a substantially uniform contour flame if its deviation from uniform contour is occasioned by a flame baffle(s) or channel(s).

b) Multi-flame pilot burners (pilot burners that produce a flame(s) with substantial variation in contour under turndown conditions).

   The pilot shall effect ignition of the gas within 4 seconds from the time gas is admitted to the main burner(s), without excessive flame flash-out or damage to the appliance, when all the pilot flame ports except those for heating the thermal element are blocked and the pilot gas supply is reduced to an amount just sufficient to keep the valve of the automatic gas ignition system open, or just above the point of flame extinction, whichever represents the higher pilot gas rate.

c) Pilot burner and thermal element assemblies which supply electrical energy for an automatic control system.

   When the thermal element is the only source of electric power for operation of the system, the tests under a) and b) above shall be conducted with the pilot adjusted to the minimum size (pull-in voltage) required to open the valve. This condition shall be based on the performance of the system when only the thermal element and valve are present. Under these conditions, the pilot shall effect ignition of the gas within 4 seconds after the gas reaches the main burner(s) without excessive flame flash-out or damage to the appliance.

   System components other than the valve shall be excluded during this test.

   When a multi-flame pilot burner is provided, the tests outlined under b) above at increased pilot input ratings shall also be conducted.

d) Recycling pilot burners.

   In the case of a pilot burner that operates every time the main gas burner is turned on or off, either manually or by automatic controls, the ignition flame shall provide ignition of the gas at the main burner(s) within 4 seconds from the time gas is admitted to the main burner(s), without excessive flame flash-out or damage to the appliance, when the gas supply to the ignition flame is just sufficient to allow main burner gas to flow.

   When an escapement pilot is used in the control system, it shall be disconnected before applying the test.

5.7.7

Under the conditions of voltage variation and pilot rate reduction specified in the following Method of Test, an automatic pilot ignition system shall ignite the pilot burner gas within 30 seconds after gas reaches the pilot burner port(s).

Method of Test

These tests shall be conducted at normal inlet test pressure under the following voltage and pilot input rate conditions:

a) Undervoltage
   The voltage to the appliance shall be adjusted to 85 percent of the appliance rating plate voltage.
b) Overvoltage
   The voltage to the appliance shall be adjusted to 110 percent of the appliance rating plate voltage.
c) Reduced pilot input rate
   The pilot gas supply shall be reduced to an amount just sufficient to keep the valve of the safety shutoff device open or to an amount just above the point of flame extinction, whichever represents the higher pilot gas flow, and the appliance rating plate voltage shall be supplied to the appliance.

Under the conditions specified in a), b), and c) above, ignition cycles shall be repeated 10 times.

In each case, the pilot igniter shall ignite the pilot burner gas within 30 seconds after gas reaches the pilot burner port(s).

5.7.8

Any type of pilot equipped with an automatic igniter shall not cause excessive flame flash-out or damage to the water heater.

For purposes of the following Method of Test, the control manufacturer's specified maximum flame failure response time in combination with the control manufacturer's specified minimum recycle time shall be used.

Method of Test

The pilot igniter shall be rendered inoperative.

The appliance shall be instrumented with a sampling tube(s) to measure the gas-air ratio at various points in the appliance. This sampling tube(s) shall be connected to a gas-air analyzer coupled to a chart-type single-point recording potentiometer in order to produce a constant trace of the gas-air ratio at the sample point for sufficient time to allow a complete evaluation of the system. The gas-air ratio trace shall be developed with the appliance both hot and cold and with all test gases for which the appliance is tested. Supplemental natural gas tests with Test Gas G need not be conducted.

Unburned gas shall be allowed to flow into the appliance for a time equivalent to the control manufacturer's specified maximum flame failure response time. Immediately following shutoff of the gas supply, an ignition cycle shall be initiated and continued until the pilot igniter would be energized, as determined by the control manufacturer's specified minimum recycle time.

If the gas-air ratio at the time at which the pilot igniter would be energized does not exceed the lower explosive limit, the appliance shall be considered as complying with this provision. If this ratio is above the lower explosive limit, sufficient ignition tests shall be conducted between the time of energization of the ignition means and when the atmosphere within the appliance returns to below the lower

explosive limit to determine that the automatic igniter does not cause excessive flame flash-out or damage to the appliance.

Appliances with control systems not providing complete gas shutoff, but having a purge period of 5 minutes or longer, shall be tested as specified above except the purge time shall be 4-1/2 minutes. Pilot gas shall be allowed to flow during the purge period.

Appliances with control systems providing complete gas shutoff and a purge period of 5 minutes or longer shall be deemed to comply with this provision.

5.7.9

A pilot not provided with automatic shutoff when the presence of the ignition source is not proved shall not cause excessive flame flash-out or damage to the water heater according to the following Method of Test.

Method of Test

The pilot igniter shall be rendered inoperative. Main burner gas flow shall be shut off.

This test shall be conducted in a draft-free environment.

The appliance shall be instrumented with a sampling tube(s) to measure the gas-air ratio at various points in the appliance. This sampling tube(s) shall be connected to a gas-air analyzer coupled to a chart-type single-point recording potentiometer in order to produce a constant trace of the gas-air ratio at the sample point for sufficient time to allow a complete evaluation of the system. The gas-air ratio trace shall be developed with the appliance both hot and cold and with all test gases for which the appliance is tested. Supplemental natural gas tests with Test Gas G need not be conducted.

Unburned pilot gas shall be allowed to flow into the appliance until equilibrium of the gas-air ratio is obtained. If the gas-air ratio during this time does not exceed the lower explosive limit, the appliance shall be considered as complying with this provision. If this ratio is above the lower explosive limit, sufficient ignition tests shall be conducted at any time up to 1 hour of pilot gas flow to determine that the unsupervised pilot system does not cause excessive flame flash-out or damage to the appliance.

5.7.10

Flames shall travel freely to all pilot burner ports when the gas is ignited at any one port according to the following Method of Test.

Method of Test

The average temperature of the water in the storage vessel shall be 10 ± 2 °F (5.5 ± 1 °C) above room temperature. Inlet water temperature shall not be less than 10 °F (5.5 °C) above room temperature.

The gas rate to the pilot shall be adjusted at normal inlet test pressure to the manufacturer's hourly Btu input rating and the gas ignited. The gas pressure shall then be reduced to a point at which only sufficient gas is being consumed to cause the safety shutoff device to remain in the position required of it in service for turning on the gas supply.

The flames shall then be extinguished and the gas from the ports, which serve to heat the thermal element of the safety shutoff device, immediately reignited. The flames shall travel freely to all other ports on the pilot burner.

5.7.11

The temperatures developed on an automatic gas ignition system component shall not exceed those for which the component is designed as per the following Method of Test.

Method of Test

Thermocouples shall be peened into or brazed to the following points which are applicable to the component provided:

a) pilot burner tip;
b) pilot burner orifice fittings;
c) electric igniter;
d) flame sensor;
e) spark electrode;
f) surfaces of the hot and cold junction of thermoelectric types;
g) valve body;
h) electric switch;
i) spark generator;
j) contact mechanism; and
k) magnetic assembly.

The main burner(s) and pilot burner(s) shall be operated at normal inlet test pressure until equilibrium pilot temperatures have been attained, at which time the temperatures at the points listed above shall be recorded.

5.8 Proved igniter systems

5.8.1

This Clause is applicable to a proved igniter system that provides for ignition of the main burner gas.

5.8.2

The proved igniter system shall effect ignition of the gas at the main burner(s) when tested in accordance with the Method of Test specified in Clause 5.7.2.

5.8.3

Under the conditions of voltage variation specified in the following Method of Test, the proved igniter system shall ignite main burner gas within 4 seconds after gas reaches the main burner port(s). These tests shall be conducted at normal inlet test pressure under the following voltages.

Method of Test

The following voltages shall be used during conduct of this test:

a) Undervoltage
   The voltage to the appliance shall be adjusted to 85 percent of the appliance rating plate voltage.
b) Overvoltage
   The voltage to the appliance shall be adjusted to 110 percent of the appliance rating plate voltage.

Under the conditions specified in a) and b) above, ignition cycles shall be repeated 25 times.

In each case, the proved igniter system shall ignite main burner gas within 4 seconds after gas reaches the main burner port(s).

5.8.4

The proved igniter system shall effect ignition of the gas at the main burner(s) under the following conditions:

The test shall be conducted at normal inlet test pressure and with the appliance both hot and cold.

The proved igniter system shall be placed in operation with the igniter proving characteristic reduced to the minimum value specified by the control manufacturer. Under these conditions, the proved igniter system shall effect ignition of the gas within 4 seconds after gas reaches the main burner port(s) without damage to the appliance or excessive flame flash-out. While maintaining these conditions, the ignition cycle shall be repeated for a total of 25 times.

5.8.5

For proved igniter systems that incorporate an interrupted ignition source together with main burner flame proving, the time required for the system to shut off the main burner gas supply following loss of the supervised main burner flame shall not exceed 90 seconds.

For the purposes of the following Method of Test, the control manufacturer's specified maximum flame failure response time for the proved igniter system shall be used.

Method of Test

The appliance shall be operated for a period of 30 minutes at normal inlet pressure. All gas shall then be turned off and the gas flow immediately re-established, but not ignited. The time for the main burner gas to be shut off shall be recorded and shall not exceed 90 seconds.

5.8.6

A proved igniter system that incorporates an interrupted ignition source together with main burner flame proving shall not cause excessive flame flash-out or damage to the appliance.

For the purposes of the following Method of Test, the control manufacturer's specified maximum flame failure response time in combination with the control manufacturer's specified minimum recycle time for the proved igniter system shall be used.

Method of Test

The appliance shall be instrumented with a sampling tube(s) to measure the gas-air ratio at various points in the appliance. This sampling tube(s) shall be connected to a gas-air analyzer coupled to a chart-type single-point recording potentiometer in order to produce a constant trace of the gas-air ratio at the sample point for sufficient time to allow a complete evaluation of the system. The gas-air ratio trace shall be developed with the appliance both hot and cold and with all test gases for which the appliance is tested. Supplemental natural gas test with Test Gas G need not be conducted.

Unburned gas shall be allowed to flow into the appliance for the control manufacturer's maximum specified flame failure response time plus the valve closing time. Immediately following shut off of the gas supply, an ignition cycle shall be initiated at normal rated voltage and continued until the igniter would be energized, as determined by the control manufacturer's specified minimum recycle time.

If the gas-air ratio at the time at which the igniter would be energized is below the lower explosive limit, the appliance shall be considered as complying with this provision. If this ratio is above the lower explosive limit, sufficient ignition tests shall be conducted between the time of energization of the