Good adhesion and legibility qualities shall be obtained for all samples under the above specified test conditions.

Final acceptance of marking materials shall be based on the suitability of the marking material on the appliance.

5.37 Flammable vapors ignition resistance

5.37.1

The design of a water heater shall be such that it shall not ignite flammable vapors outside the water heater created by the spilling of both winter and summer blends of gasoline onto the floor of the test room described in the following Method of Test. This provision does not apply to water heaters for installation in recreational vehicles only. The gasoline shall be tempered to 70 °F ± 2 °F (21 °C ± 1 °C).

Method of Test

These tests shall be conducted at normal inlet test pressure and input rating. The tests shall be conducted under the following three conditions with summer blend gasoline with a Reid vapor pressure of no more than 8 psi (55.2 kPa) and winter blend gasoline with a Reid vapor pressure not less than 13 psi (89.6 kPa).

Gasoline should follow SAE, API, and ASTM volatility grade definitions.

Prior to the first spill only, the water heater shall be filled with water at 70 °F ± 2 °F (21 °C ± 1 °C) and operated for 15 minutes at normal inlet test pressure. A sample of the flue gases shall then be secured at a point immediately preceding their discharge from the flue outlet of the water heater. The sample shall be analyzed and the carbon monoxide shall not be in excess of 0.04 percent, on an air-free basis.

5.37.2

Test condition 1 (Main burner operation)

The water heater shall be installed according to the manufacturer's instructions in a 6 ft × 10 ft × 8 ft (1.8 m × 3 m × 2.4 m) high room equipped with a suitable access door. The walls, ceiling, and door of the room shall be constructed of fire-resistant materials and the floor shall be made of corrosion-resistant metal and leveled to prevent gasoline from forming puddles. A diagram of the test room is shown in Figure 15, Flammable vapors test room. The test room shall have:

a) Means to control temperature of the floor to 75 °F ± 5 °F (24 °C ± 3 °C).
b) For water heaters that require air for combustion, ventilation, and dilution of flue gases from within the building:
   A combustion and ventilation air opening of one (1) in^2 (645 mm^2) per 1000 Btu/hr of input located 12 in (305 mm) from the ceiling in the area of the wall shown in Figure 15.
c) Means to spill gasoline onto the floor (without splashing on the water heater), using the one (1) gallon (3.79 L) gasoline container shown in Figure 16, Standard one gallon (3.79 L) gasoline can.
d) Provisions to provide pressure relief of the test room as shown in Figure 15.
e) A three-dimensional mannequin, as shown in Figure 17, Mannequin, measuring approximately 46 in (1 168 mm) in height. The mannequin shall be standing with its legs spread apart a distance of approximately 17 in (432 mm) with hands on hips. The width of the mannequin shall be approximately 20 in (508 mm). The depth of the mannequin shall be approximately 9 in (299 mm).
f) The mannequin shall be equipped with means to move it back and forth over a straight 3 ft (0.91 m) path at a velocity of 3 ft (0.91 m) per second.

g) Instruments to continuously measure the following:
   i) average floor temperature;
   ii) ambient air temperature;
   iii) the water heater's flue gas temperature;
   iv) the bottom of flue gas baffle temperature (if applicable);
   v) the inlet supply water temperature;
   vi) the millivoltage output of the pilot (if applicable); and
   vii) the hydrocarbon concentrations at the four (4) tube sample locations in the room, shown in Figure 18, Setup for vent location of hydrocarbon sampling points.
h) Closed viewing means to observe the water heater under test from outside the room.
i) A suitable fire extinguishing system.
j) Means to verify the Reid vapor pressure of the gasoline prior to testing.
k) Means to control ambient air temperature inside the test room at the start of each test to 75 °F ± 5 °F (24 °C ± 3 °C). The ambient air temperature outside the test room before, during, and after each test shall be controlled to 75 °F ± 5 °F (24 °C ± 3 °C).

The water heater shall be located in the test room in the location shown in Figure 15. The water heater shall be tested with the venting arrangements shown in Figure 18 except as follows. When a manufacturer's supplied terminal(s) for either the air intake, vent exhaust, or both are designed for installation so that all air is derived from the outside atmosphere, or all flue gases discharge to the outside atmosphere, or both, then the terminal(s) shall be installed in accordance with the manufacturer's installation instructions and terminate outside the test room. The water heater shall be tested with all access doors in their normal position. If the lighting instructions call for the opening or removal of any door(s) to light the pilot and if the main burner(s) will operate with those door(s) removed or opened, the tests shall be repeated with removable door(s) removed and sliding or hinged door(s) left in a fully open position unless self-closing.

The water heater shall be supplied with water at a temperature of 70 ± 2 °F (21 ± 1 °C).

Figure 15
Flammable vapors test room
(See Clauses 5.34.2 and 5.37.2.)

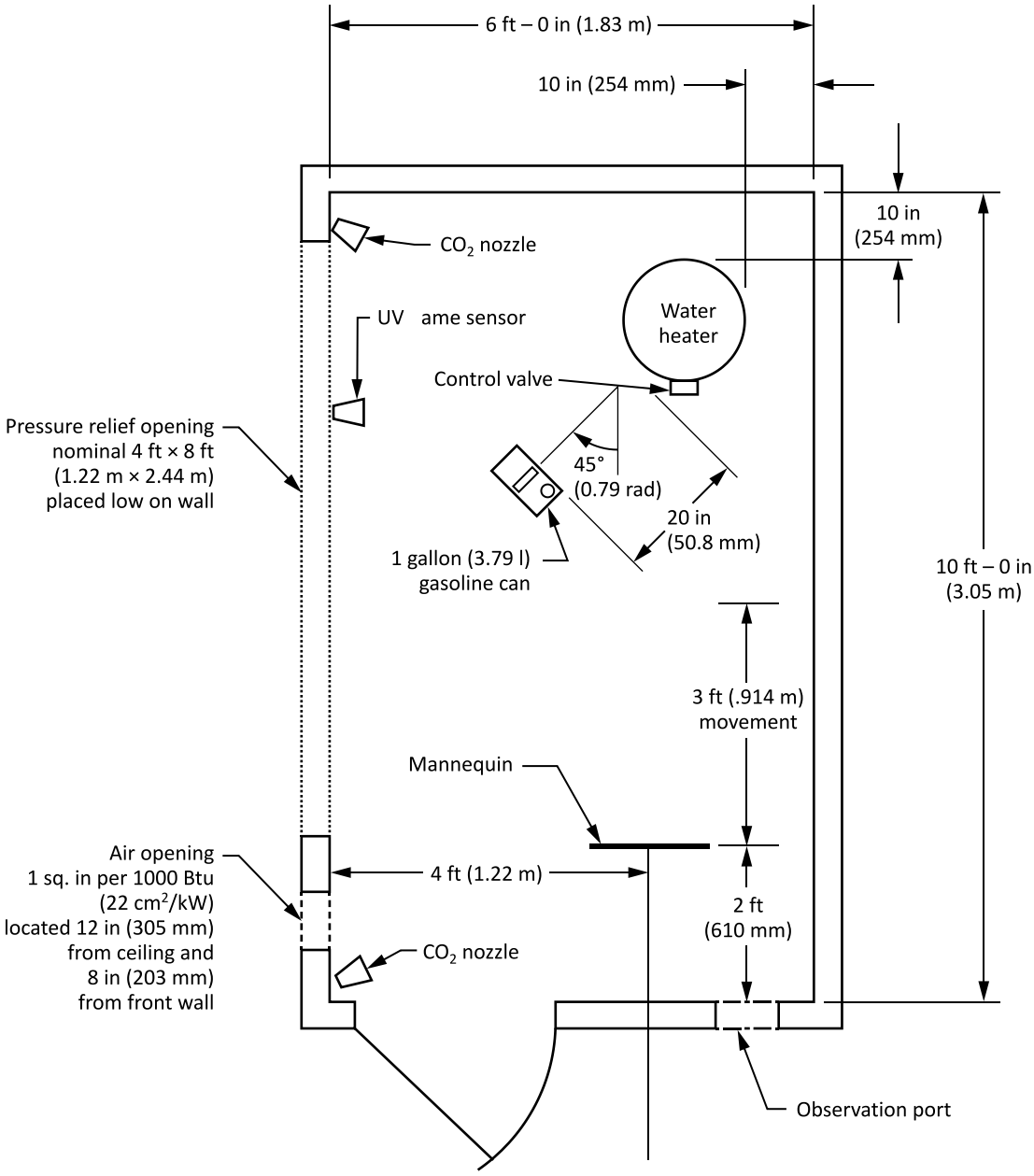
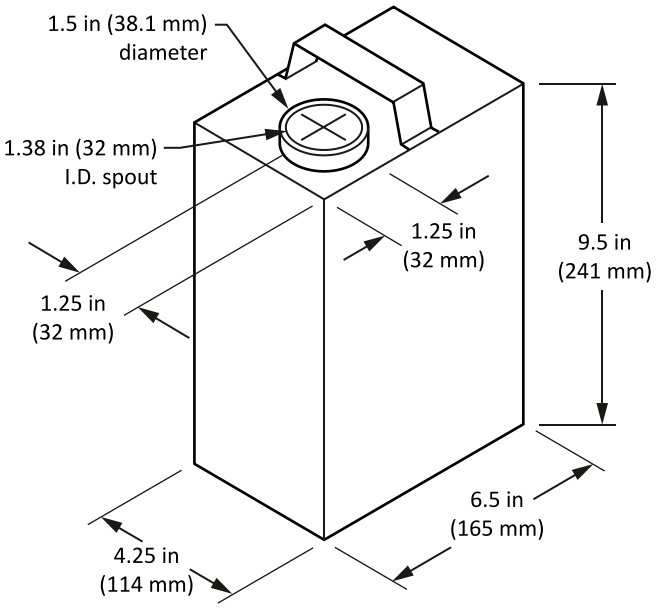


Figure 16
Standard one gallon (3.79 L) gasoline can
(See Clauses 5.34.2 and 5.37.2.)



Tipped position with opening at floor

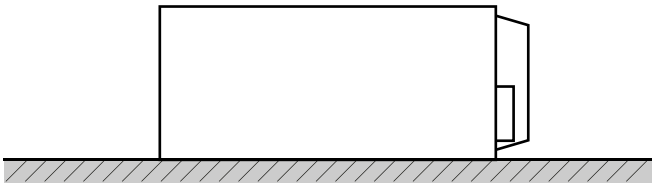


Figure 17
Mannequin
(See Clause 5.37.2.)

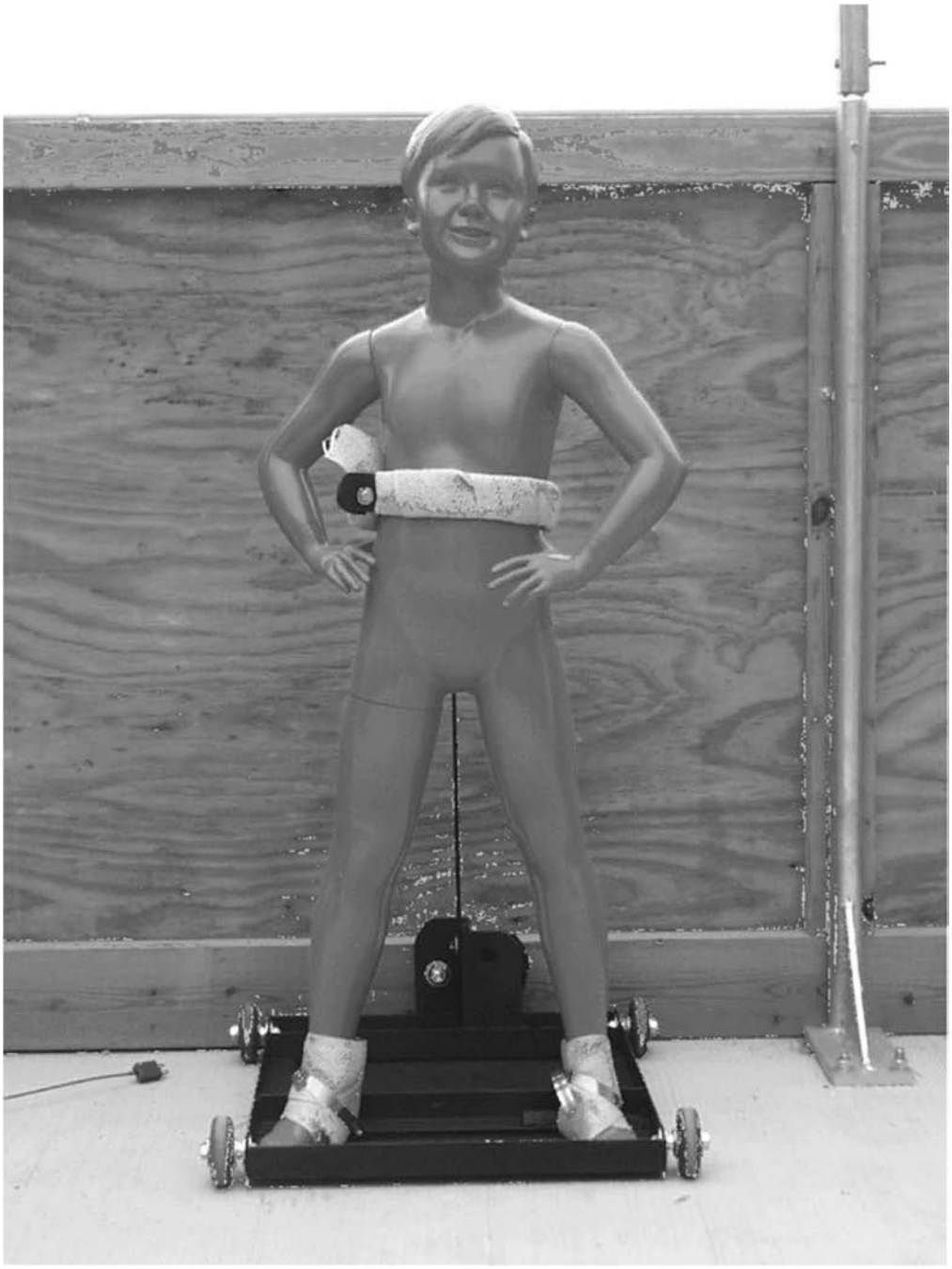
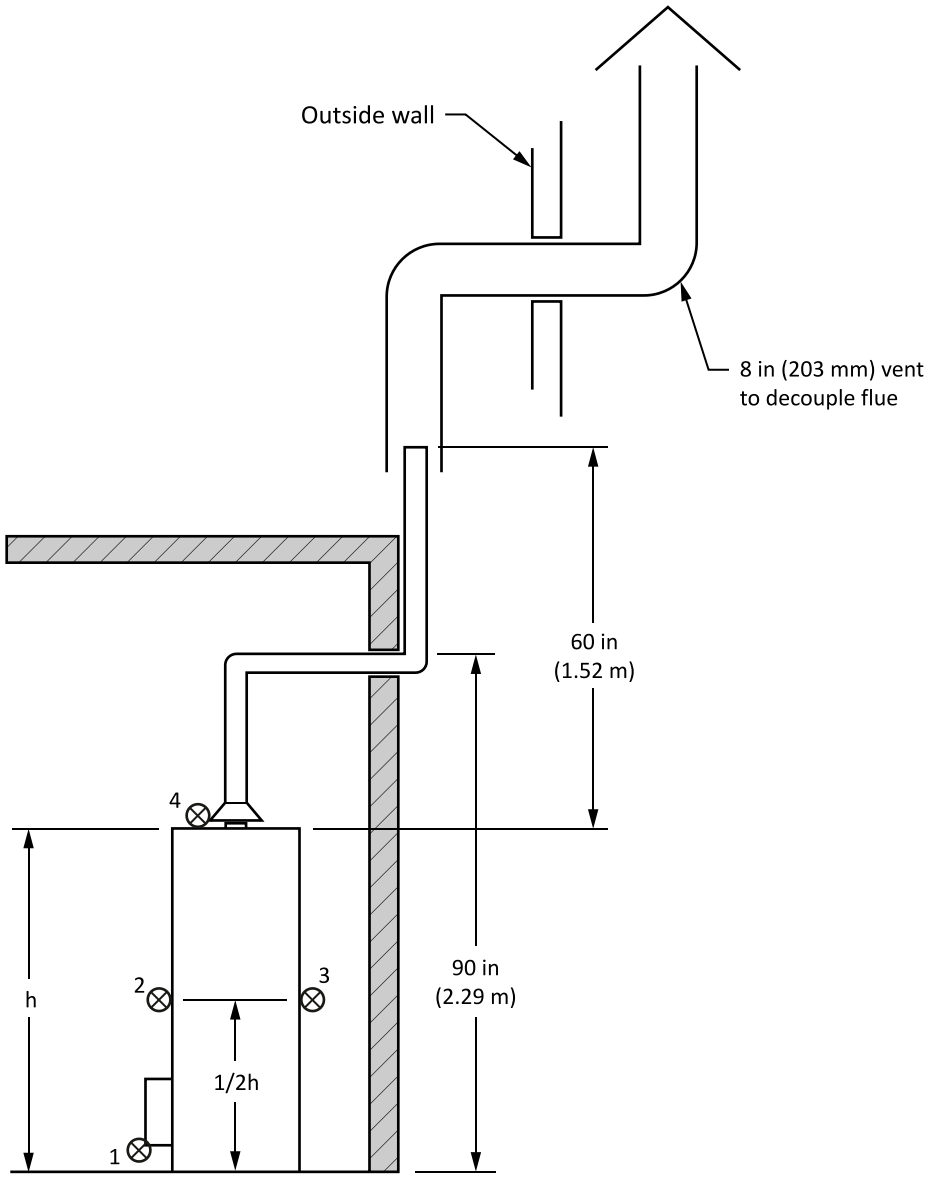


Figure 18
Setup for vent location of hydrocarbon sampling points
(See Clause 5.37.2.)



l) Hydrocarbon sample tubes shall be located In the test room on the water heater at the following locations (see Figure 18):
   i) At the lowest point in front of the water heater, on the side of the jacket not less than two (2) in (51 mm) from the floor.
   ii) On the front of the water heater at a midpoint of the floor to jacket top height.
   iii) On the rear of the water heater at a midpoint of the floor to jacket top height.
   iv) On the top of the water heater's jacket.

m) If a manufacturer's supplied terminal for either the combustion air inlet and/or exhaust is designed for installation so that all combustion air is derived directly from the outside atmosphere and/or all flue gases discharge to the outside atmosphere, then the terminal shall be isolated from vapor concentrations.

A quick acting water valve shall be installed on the outlet water line located outside the test room. A flow-restricting device shall be connected to the outlet of this valve. The flow-restricting device shall be adjusted or constructed to maintain a flow rate of 3 ± 0.25 gallons (11.36 ± 0.95 liters) per minute during water draw periods.

The water heater shall be filled with water at 70 ± 2 °F (21 ± 1 °C) and the thermostat set to the 120 °F (49 °C) mark. The water heater shall be operated until the gas supply to the main burner(s) is reduced to a minimum. Set a 1 gallon (3.785 liter) gasoline container, full of winter blend gasoline, 20 in (51 mm) from the water heater. The spout of the container should be toward the water heater in the direction of the tip. (See Figure 15) Water shall then be drawn off at the specified flow rate until the thermostat functions and the main burner(s) ignite. Immediately upon ignition of the main burners, the water flow shall be shut off. Begin recording the flue gas temperatures, bottom of flue baffle temperatures (if applicable), the millivoltage output of the pilot (if applicable), and hydrocarbon concentrations at the 4 sample tube locations. After the burners(s) have been in operation for at least 1 minute, tip the gasoline container toward the water heater. (See Figure 16.) One (1) minute after the spill, move the mannequin 3 times back and forth over a straight 3 ft (0.91 meter) path at a velocity of 3 ft (0.91 meter) per second. Repeat the mannequin movement after one (1) minute elapses and at 1-minute intervals until the end of test. If the water heater cycles off on the thermostat, repeat the water draw cycle procedure. Allow the test to continue until either: a) the water heater's burner(s) are extinguished and there is no evidence of flame presence; b) the hydrocarbon concentrations at all 4 sample tube locations shown in Figure 18 are below 50 percent of the 1.8 percent lower flammability limit (LFL) of Butane; c) the water heater has operated in a flammable vapor rich environment for a substantial period of time and in the judgment of the testing agency the water heater will not ignite flammable vapors if allowed to continue to operate; or d) ignition of flammable vapors has occurred outside the water heater.

Following this test, it shall be determined that either the water heater is not capable of being returned to normal operation or, if the water heater is capable of normal operation, there is no damage other than that of a superficial nature to the water heater wiring and controls and no safety control (function) has been rendered inoperative. If the water heater is capable of normal operation, it may be used for the remaining tests described in this clause. Components intended by the manufacturer to be field serviceable may be replaced between tests. If the water heater is not capable of being returned to normal operation, a new water heater may be used for the remaining tests.

n) The previous test shall then be repeated using the summer blend gasoline. The test procedure is the same as that described above for the winter blend gasoline except for the following:
   i) summer blend gasoline replaces winter blend;
   ii) there is no movement of the mannequin; and
   iii) the gasoline container shall be tipped away from the water heater with the spout pointed in the direction of the tip.

   Following each of the above tests, if the water heater is capable of normal operation, then the water heater shall be filled with water at 70 ± 2 °F (21 ± 1 °C). The water heater shall then be operated for 15 minutes at which time a sample of the flue gases shall be secured at a point immediately preceding their discharge from the flue outlet of the water heater. The sample shall then be analyzed and the carbon monoxide shall not be in excess of 0.04 percent on an air-free basis, and the spread in CO_2 content in the flue gas sample measured before and after each test condition shall not exceed 0.4 percent.

5.37.3

Test condition 2 (Main burner cycling)

(This test condition does not apply to water heaters equipped with a continuous ignition source.)

The water heater shall be installed as described under Test Condition 1. The thermostat shall be set at the 120 °F (49 °C) mark and the water heater permitted to operate until the thermostat acts to reduce the gas supply to the main burner(s) to a minimum. Set a 1 gallon (3.785 liter) gasoline container, full of winter blend gasoline, 20 in (51 mm) from the water heater. The spout of the container should be toward the water heater in the direction of the tip. (See Figure 15, Flammable vapors test room). Begin recording the flue gas temperatures, bottom of flue baffle temperatures (if applicable), the millivoltage output of the pilot (if applicable), and hydrocarbon concentrations at the 4 sample tube locations. Tip the gasoline container toward the water heater. [See Figure 16, Standard One Gallon (3.79 L) Gasoline Can]. Water shall then be drawn off at the specified flow rate. One (1) minute after the spill, move the mannequin 3 times back and forth over a straight 3 ft (0.91 meter) path at a velocity of 3 ft (0.91 meter) per second. Repeat the mannequin movement after 1 minute elapses and at 1-minute intervals until the end of the test. If the water heater cycles off on the thermostat, repeat the water draw cycle procedure. Allow the test to continue until either: a) the water heater's burner(s) are extinguished and there is no evidence of flame presence; b) the hydrocarbon concentrations at all 4 sample tube locations shown in Figure 18, Setup for vent location of hydrocarbon sampling points, are below 50 percent of the 1.8 percent lower flammability limit (LFL) of Butane; c) the water heater has operated in a flammable vapor rich environment for a substantial period of time and in the judgment of the testing agency the water heater will not ignite flammable vapors if allowed to continue to operate; or d) ignition of flammable vapors has occurred outside the water heater.

Following this test, it shall be determined that either the water heater is not be capable of being returned to normal operation or, if the water heater is capable of normal operation, there is no damage other than that of a superficial nature to the water heater wiring and controls and no safety control (function) has been rendered inoperative. If the water heater is capable of normal operation, it may be used for the remaining tests described in this clause. Components intended by the manufacturer to be field serviceable may be replaced between tests. If the water heater is not capable of being returned to normal operation, a new water heater may be used for the remaining tests.

The previous test shall then be repeated using the summer blend gasoline. The test procedure is the same as that described above for the winter blend gasoline except for the following:

a) summer blend gasoline replaces the winter blend;
b) there shall be no movement of the mannequin; and
c) the gasoline container shall be tipped away from the water heater with the spout pointed in the direction of the tip.

Following each of the above tests, if the water heater is capable of normal operation, then the water heater shall be filled with water at 70 ± 2 °F (21 ± 1 °C). The water heater shall then be operated for 15 minutes at which time a sample of the flue gases shall be secured at a point immediately preceding their discharge from the flue outlet of the water heater. The sample shall then be analyzed and the carbon monoxide shall not be in excess of 0.04 percent, on an air-free basis and the spread in CO_2 content in the flue gas sample measured before and after each test condition does not exceed 0.4 percent.

5.37.4

Test condition 3 (Standby)

(This test condition only applies to water heaters equipped with a continuous ignition source.)

The water heater is installed as described under Test Condition 1. The thermostat shall be set at the 120 °F (49 °C) mark and the water heater permitted to operate until the thermostat acts to reduce the gas supply to the main burner(s) to a minimum. The main burner(s) shall not operate during this test. Set a 1 gallon (3.785 liter) gasoline container, full of winter blend gasoline, 20 in (51 mm) from the water heater. The spout of the container should be toward the water heater in the direction of the tip (see Figure 15, Flammable vapors test room). Begin recording the flue gas temperatures, bottom of flue baffle temperatures (if applicable), the millivoltage output of the pilot (if applicable), and hydrocarbon concentrations at the 4 sample tube locations. Tip the gasoline container toward the water heater [see Figure 16, Standard one gallon (3.79 L) gasoline can]. One (1) minute after gasoline is spilled, move the mannequin 3 times back and forth over a straight 3 ft (.91 meter) path at a velocity of 3 ft (.91 meter) per second. Repeat the mannequin movement after 1 minute elapses and at 1 minute intervals until the end of test. Allow the test to continue until either; a) the water heater's burner(s) are extinguished and there is no evidence of flame presence; b) the hydrocarbon concentrations at all 4 sample tube locations shown in Figure 18, Setup for vent location of hydrocarbon sampling points, are below 50 percent of the 1.8 percent lower flammability limit (LFL) of Butane; c) the water heater has been in the flammable vapor rich environment for a substantial period of time and in the judgment of the testing agency the water heater will not ignite flammable vapors if the test were to continue; or d) ignition of flammable vapors has occurred outside the water heater.

Following this test, it shall be determined that either the water heater is not capable of being returned to normal operation or, if the water heater is capable of normal operation, there is no damage other than that of a superficial nature to the water heater wiring and controls and no safety control (function) has been rendered inoperative. If the water heater is capable of normal operation, it may be used for the remaining tests described in this clause. Components intended by the manufacturer to be field serviceable may be replaced between tests. If the water heater is not capable of being returned to normal operation, a new water heater may be used for the remaining tests.

The previous test shall then be repeated using the summer blend gasoline. The test procedure is the same as that described above for the winter blend gasoline except for the following:

a) summer blend gasoline replaces the winter blend;
b) there shall be no movement of the mannequin; and
c) the gasoline container shall be away from the water heater with the spout pointed in the direction of the tip.

Following each of the above tests, if the water heater is capable of normal operation, then the water heater shall be filled with water at 70 ± 2 °F (21 ± 1 °C). The water heater shall then be operated for 15 minutes at which time a sample of the flue gases shall be secured at a point immediately preceding their discharge from the flue outlet of the water heater. The sample shall then be analyzed and the carbon monoxide shall not be in excess of 0.04 percent on an air-free basis, and the spread in CO_2 content in the flue gas sample measured before and after each test condition shall not exceed 0.4 percent.

5.37.5

Test condition 4

(This test does not apply to water heaters equipped with a continuous ignition source.)

The water heater shall be installed as described under Test Condition 1. The thermostat shall be set at the 120 °F (49 °C) mark and the water heater permitted to operate until the thermostat acts to reduce the gas supply to the main burner(s) to a minimum. Set a 1 gallon (3.79 L) gasoline container full of winter blend gasoline, 20 in (508 mm) from the water heater. The spout of the container should be

toward the water heater in the direction of the tip. (See Figure 15, Flammable vapors test room.) Begin recording the flue gas temperature, bottom of the flue baffle temperatures (if applicable), the millivoltage output of the pilot (if applicable), and hydrocarbon concentrations at the 4 sample tube locations. Tip the gasoline container toward the water heater. (See Figure 16, Standard one gallon (3.79 L) gasoline can.) One minute after the spill, move the mannequin 3 times back and forth over a straight 3 ft (0.91 m) path at a velocity of 3 ft (0.91 m) per second. Repeat the mannequin movement after 1 minute elapsed and at 1-minute intervals until the end of the test. Fifty-five minutes after the spill, draw water off at the specified flow rate. If the water heater cycles off on the thermostat, repeat the water draw cycle procedure. Allow the test to continue until any of the following conditions occurs: a) the water heater burner(s) is extinguished and there is no evidence of flame presence; b) the hydrocarbon concentrations at all 4 sample tube locations are below 50 percent of the 1.8 percent lower flammability limit (LFL) of Butane; c) the water heater has operated in a flammable vapor rich environment for a substantial period of time and in the judgment of the testing agency the water heater will not ignite flammable vapors if allowed to continue to operate; or d) the ignition of flammable vapors has occurred outside of the water heater.

Following this test, it shall be determined that either the water heater is not capable of being returned to normal operation or, if the water heater is capable of normal operation, there is no damage other than that of a superficial nature to the water heater wiring and controls and no safety control (function) has been rendered inoperative. If the water heater is capable of normal operation, it may be used for the remaining tests described in this clause. Components intended by the manufacturer to be field serviceable may be replaced between tests. If the water heater is not capable of being returned to normal operation, a new water heater may be used for the remaining tests.

The previous test shall then be repeated with summer blend gasoline. The test procedure is the same as that described above for winter blend gasoline, except for the following:

a) summer blend gasoline replaces winter blend.
b) there shall be no movement of the mannequin; and
c) the gasoline container shall be tipped away from the water heater with the spout pointed in the direction of the tip.

Following each of the above tests, if the water heater is capable of normal operation, then the water heater shall be filled with water at 70 °F ± 2 °F (21 ± 1 °C). The water heater shall then be operated for 15 minutes at which time a sample of flue gases shall be secured at a point immediately preceding their discharge from the flue outlet of the water heater. The sample shall then be analyzed and the carbon monoxide shall not be in excess of 0.04 percent on an air-free basis, and the spread of CO_2 content in the flue gas sample measured before and after each test condition shall not exceed 0.4 percent.

5.38 Resistance to lint, dust and oil accumulation

Water heaters shall not produce flue gases that contain carbon monoxide in excess of 0.04 percent on an air-free basis, in a sample of the flue gases when exposed to lint, dust, and oil under the following Method of Test. This requirement shall be considered met when:

a) the water heater completes the burner cycle sequence and the carbon monoxide concentration reaches equilibrium, as defined in the following Method of Test; or
b) the water heater shuts down and requires a manual restart to resume operation.

This provision does not apply to direct vent water heaters, to water heaters for installation in recreational vehicles, or to water heaters intended for installation outdoors.