

Figure 53.4 Nuisance alarm test profile (CO vs OBS)

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53.2.3 The test shall be considered invalid and terminated if more than 5 flashes of a light (similar to a spark) are observed or a flame is observed within the electric range.

### 53.3 Electric range

53.3.1 An electric range shall be used for this test. The electric range shall consist of electric coils within the range, that are used for broiling, that can be adjusted for operation necessary to achieve the smoke profiles specified in 53.10. The electric range shall not be located more than 2 ±0.5 in. (5 ±1.27 cm) from the back wall as noted in Figure 53.5.



Fire test room electric range and smoke alarm placement

Figure 53.5

#### 53.4 Hamburger mixture and freezing

53.4.1 Each fresh hamburger is to consist of a mixture of 75 percent lean beef and 25 percent suet by weight ground together at least twice in succession. Each fresh hamburger is to be approximately 3/4 in. (19 mm) thick with an approximate diameter of 4 inches (102 mm) before cooking. Overall fresh hamburger size may vary based on templates from the butcher and packaging.

53.4.2 Before being used for testing, the hamburger shall be frozen in an ambient temperature ranging from minus 20 to minus 25°C (minus 4 to minus 13°F) for at least 72 hours. After freezing, the test hamburger shall be referred to as a "fresh-frozen hamburger."

#### 53.5 Test procedure

#### 53.5.1 Test room

53.5.1.1 The fire test room specified in <u>50.5</u>, shall be used for this test. The room shall be modified so that the wall closest to the back of the electric range shall be a flat surface that is perpendicular to the ceiling and free of any obstructions that may affect air entrainment. A separate wall placed behind the electric range may be added but shall not reduce the length of the room by more than 165 cm (65 in). See <u>Figure 53.5</u> for placement of the electric range within the room. Also reference <u>Figure 53.6</u> for placement of the smoke alarms on the ceiling.

#### Figure 53.6

#### Alternate Smoke Alarm and CO Sample Locations



53.5.1.2 The electric range shall be elevated from the floor so that the top of the cooking surface of the electric range is  $154 \pm 2.5$  cm (60.5  $\pm 1$  in) from the ceiling.

# 53.6 Fresh-frozen hamburger placement

53.6.1 Two fresh-frozen hamburgers shall be equally spaced on the center of a broiler tray that is equally spaced in the center of a baking rack inside the oven of the electric range. The door to the oven on the electric range shall be closed such that the opening between the "Inside Surface of Range Door" and the "Front Surface" of the oven door of the electric range maintains a gap of 11.5 ±2.54 cm (4.5 ±1 in). The opening between the "Inside Surface" of the oven door of the electric range Door" and the "Front Surface" of the oven door of the duration of the test. See Figure 53.7 for details.

### Figure 53.7

# Electric range door opening description

Front Surface

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### 53.7 Smoke alarms

53.7.1 Four smoke alarms shall be used for this test. Each of these alarms shall be calibrated to the maximum smoke sensitivity anticipated in production and shall be oriented in the most favorable position facing the fire as determined in the Directionality Test.

53.7.2 The smoke alarms shall be placed on the ceiling,  $304.8 \pm 5.1 \text{ cm} (120 \pm 2 \text{ in})$  along the ceiling from the horizontal plane of the "Front of Cooktop/Range". The smoke alarms shall be centered and installed flush to the ceiling.

53.7.3 Carbon monoxide shall be measured and recorded and shall not exceed the limit specified in 53.10.1 when conducting this test. The CO measuring equipment shall either be range selectable by the user or have auto range capability for measuring up to 10 ppm of carbon monoxide. The sample draw for the CO monitor location shall not exceed 3.3 L/min (0.12 ft<sup>3</sup>/min)

53.7.4 The carbon monoxide sampling tube shall be centered between the 2nd and 3rd smoke alarm as illustrated in <u>Figure 53.6</u>. The sample tube shall not be larger than the rated 6.4 mm (1/4 in) O.D. tubing,

and shall protrude from the ceiling surface 25.4  $\pm$ 3.2 mm (1  $\pm$ 0.125 in) into the room from the ceiling surface. Centering of the test samples (alarms) and CO sample tube shall be within  $\pm$ 10% of the specified dimensions illustrated in Figure 53.5 and Figure 53.6.

53.7.5 Beam and MIC placement shall be located in the 10-foot location as noted in <u>Figure 53.5</u>, with the same Beam and MIC placement as specified in <u>Figure 50.7</u> – Fire Test Room," items C, D, E and F.

### 53.8 Electric range broiler

53.8.1 Full power to the heating coils shall be applied within 1 second from turning on the power. Test power will vary based on the make and model of the electric range used. However, smoke build-up rates shall be within the profile limits specified in  $\underline{53.6}$ .

### 53.9 Test termination

53.9.1 The test shall be terminated after the smoke alarm

- a) Has activated, or
- b) The smoke obscuration has reached the acceptance criteria in <u>53.2</u>.

### 53.10 Smoke profile criteria

53.10.1 Unless otherwise specified, the development of the combined smoke and carbon monoxide from a broiling hamburger shall be such that the curve of the measured data falls between the upper and lower limits specified in the figures below:

- a) Figure 53.1, OBS vs. Time
- b) Figure 53.2, MIC vs. Time
- c) Figure 53.3, OBS vs. MIC

53.10.2 For Figure 53.4, CO vs. OBS, the curve of the measured data may fall between the upper and lower limits but shall not exceed the upper limit specified in the figure.

### 54 Go/No Go Flaming Polyurethane Foam Test

### 54.1 General

54.1.1 The Flaming Polyurethane Foam test requirements outlined in  $\underline{50.4}$  shall be conducted with the acceptance criteria applying to the 17 ft test location. Test samples shall not be located at the 17 ft location. As defined in  $\underline{50.4.1}$  and  $\underline{50.4.3}$ , the samples located at the 10 ft test location shall produce an alarm signal before the Flaming Polyurethane Foam acceptance criteria at the 17 ft location has been reached.

54.1.2 While conducting the entirety of this test, the room shall remain in static mode, i.e. no air movement caused by opening doors, ventilation systems or air movement caused by sources other than the electric cooking appliance and PU foam burning.

# 54.2 Test method

54.2.1 The smoke alarm calibration and orientation shall be the same as specified in <u>53.7.1</u> and <u>53.7.2</u>.

54.2.2 The Cooking Nuisance test and Flaming Polyurethane acceptance criteria shall be conducted as specified in Section <u>54.3</u> except for the following:

Immediately after achieving the 1.5 %/ft OBS during the Cooking Nuisance Test:

a) The samples located at the 10 ft location shall remain powered and shall not be modified via software, mechanical intervention or electrically during the entirety of the test.

b) The Flaming Polyurethane Foam Test as outlined in 50.4 shall be conducted

c) The polyurethane foam used for the Flaming Polyurethane Foam Test, <u>50.4</u> shall be ignited within 10 seconds of achieving 1.5 %/ft OBS during the Cooking Nuisance Test.

d) The electric range used for the Cooking Nuisance Smoke Test shall be turned off once ignition of the foam has been confirmed.

#### 54.3 Acceptance criteria

54.3.1 When conducting the Cooking Nuisance test, the four smoke alarm samples located at the 10 ft location shall not produce an alarm signal as specified in <u>53.2</u>, but all four samples located at the 10 ft location shall produce an alarm signal once the 5 %/ft OBS acceptance criteria defined in <u>50.4.4</u> has been achieved.

#### 55 Selectivity Test – Multicriteria Smoke Alarms Incorporating Gas Sensor(s)

55.1 The smoke alarm shall not alarm or have its gas sensitivity performance affected when exposed sequentially, as described in 55.2 - 55.6, to the concentrations of gases and vapors shown in Table 55.1, Gas and vapor concentrations. These substances are intended to represent air contaminants found in the vicinity of an installed smoke alarm.

Substance	Concentration, ppm
Methane	500 ±50
n-Butane	300 ±30
n-Heptane	500 ±50
Ethyl acetate	200 ±20
Isopropyl alcohol	200 ±20
Carbon dioxide	5000 ±500
Ammonia	100 ±10
Ethanol	200 ±20
Toulene	200 ±20
Trichloroethane	200 ±20
Acetone	200 ±20
hexamethyldisiloxane	10 ±3
Hydrogen	30 ±3
Manufacturer Defined Gases	Provided By Manufacturer

#### Table 55.1 Gas and vapor concentrations

55.2 Calculate the interior volume of the test chamber used in <u>42.8.1.2</u>. From this volume, calculate the amount of each test substance necessary to supply the concentrations given in <u>Table 55.1</u>, Gas and vapor concentrations.

55.3 Ensure that the chamber has been well ventilated with fresh air. Place the smoke alarm in operation inside the chamber and allow it to run for 15  $\pm$ 5 minutes. Close and seal the chamber to prevent air infiltration.

55.4 Using a syringe or equivalent device, add the calculated amount of the first substance into the chamber at a rate and in a location such that it is well mixed with the air within 30 seconds and does not cause localized high concentrations.

55.5 Allow the smoke alarm to remain in the chamber for 2 hours. Unless specifically designated to detect the gas under test, during the two hours of exposure the smoke alarm shall not produce an alarm signal or aid in the signaling of an alarm when combined with the multi-detection properties of the multi-criteria smoke alarm.

55.6 Resistance to background gases shall be demonstrated by monitoring the appropriate output signal of a multi-criteria smoke alarm and/or the firmware logic that is used to determine the smoke alarm's alarm condition. The manufacturer shall provide the necessary equipment and/or information to monitor the output signal.

55.7 If the gas under test has not been identified to be integral to the sensitivity performance of the smoke alarm, an output signal from the sensor(s) is permitted for each specific gas and its designated concentration, but shall not result in an alarm signal or result in an increase or decrease of the smoke alarm performance.

55.8 Purge the chamber with clean air to remove all of the test atmosphere. Maintain clean air in the chamber for a recovery time of 16 hours, or as specified by the manufacturer. In no case shall recovery time exceed 16 hours. Reseal the chamber and repeat the test using another substance from <u>Table 55.1</u>, Gas and vapor concentrations, until the smoke alarm has been exposed to all substances. It is not required that exposure to the substances be in any particular order.

55.9 Following each selectivity test gas exposure and recovery, the gas sensitivity of each sensor shall be assessed in accordance with 42.8, Sensitivity test – gas sensor of a multi-criteria smoke alarm. Alternatively, the manufacturer may choose to conduct the gas sensitivity test following the sequential test gas exposure and recovery time for all selectivity gases.

### 56 Circuit Measurement Test

### 56.1 General

56.1.1 Except for a battery-operated smoke alarm, the input current of a smoke alarm shall not exceed the marked rating of the smoke alarm by more than 10 percent when operated under conditions of intended use and with the smoke alarm connected to a source of supply as specified in 37.3, Test voltages. Measurements shall also be made of components such as capacitors to determine that they are being employed within the manufacturer's ratings.

56.1.2 For each smoke alarm with an external power supply, surge current, start-up time, normal supervisory current, and alarm current shall be measured at the:

- a) Smoke alarm's rated input voltage values and
- b) Nominal voltage value.

The measured current values shall be within the rated values.

## 56.2 Battery trouble voltage determination

56.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a battery employed as the primary source of power to a smoke alarm shall not impair operation for an alarm signal before a trouble signal is obtained. In addition, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination measured over a 1-year period in the room ambient of the Battery tests, <u>86.3</u>.

56.2.2 The trouble level of a battery-operated smoke alarm shall be determined (using the test circuit in <u>Figure 56.1</u>, Test circuit, and the voltage-resistance curves of <u>Figure 56.2</u>, Trouble level determination, for each of the following voltages:

- a) Rated battery voltage,
- b) Trouble level voltage (assuming minimal or no series resistance), and
- c) Voltages between rated and trouble level voltage.



### Figure 56.1

### Test circuit for battery trouble voltage determination

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A - Rated battery voltage.

- B Trouble level voltage (assuming minimal resistance).
- C Voltage value between rated and trouble level.
- D Trouble level resistance at rated battery voltage.
- E Trouble level resistance at voltage value C.
- F Maximum permissible battery resistance and minimum voltage after 1 year in long-term battery test.

Curve A – Sample plot of voltage vs. resistance (Alarm Trouble Level Curve) at which a trouble signal in a smoke alarm is obtained. Audibility measurement is to be made at points between D and F.

Curve B – Sample plot of battery internal resistance vs. battery open circuit voltage derived from long term (minimum 1 year) battery test. Shape and slope of curve, as well as point of intersection with Curve A, varies based on battery used.

56.2.3 To determine compliance with <u>56.2.1</u> each of three smoke alarms is to be connected in series with a variable regulated direct current power supply and a variable resistor as illustrated in <u>Figure 56.1</u>, Test circuit for battery trouble voltage determination. The trouble level is to be determined by the following steps:

a) Rated Battery Voltage – The voltage of the power supply is to be set at the rated battery voltage and the series resistor at 0 ohm. The resistor is to be increased in increments of 0.1 - 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The smoke alarm is to be tested for alarm operation at each resistance level and at the trouble level.

b) Trouble Level Voltage – With the variable resistor set at 0 ohm, the voltage of the power supply connected to the smoke alarm is to be reduced in increments of 1/10 volt per minute to the level where the trouble signal is obtained. The smoke alarm is to be tested for alarm operation at each voltage level and at the trouble signal level.

c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at prespecified voltages between the rated battery voltage and the trouble level voltage. The series resistor is then to be increased in increments of 0.1 - 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The smoke alarm is to be tested for alarm operation at each resistance and voltage level and at the trouble voltage level. A number of voltage values shall be used to determine the shape of the trouble level curve.

d) Internal Resistance Increase With Constant Terminal Voltage – The voltage of the power supply is to be set at the battery rated voltage (terminal voltage of new battery under normal standby current drain) and the resistance increased from zero ohms until the smoke alarm trouble signal is obtained. The rate of resistance change prior to the trouble point shall be reduced to a value required to eliminate any error due to any time lag in the trouble circuit of the smoke alarm.

e) Terminal Voltage Decrease With Constant Internal Resistance – With the variable resistance set at zero ohms, the power supply voltage is to be decreased until the smoke alarm trouble signal is obtained. The rate of voltage change prior to the trouble point shall be reduced to a value required to eliminate any error due to any time lag in the trouble circuit of the smoke alarm.

f) Variable Internal Resistance With Variable Terminal Voltage – The test of (a) is to be repeated with the power supply voltage set to values equal to the 25 percent, 50 percent and 75 percent points of the voltage range determined in (b).

56.2.4 To determine that a battery is capable of supplying alarm and trouble signal power to the smoke alarm for at least 1 year under the room ambient condition described in Battery tests, <u>86.3</u>. Curve A of Figure 56.2, Trouble level determination, is to be plotted from the data obtained in the measurements described in <u>56.2.3</u> and compared to Curve B of Figure 56.2, which is plotted from data generated in the 1-year battery test. The intersection of Curves A and B shall not occur before 1 year and all points of Curve B to the right of point F (extended to the base line), shall be below Curve A.

# 57 Overvoltage and Undervoltage Tests

# 57.1 Overvoltage test

57.1.1 A smoke alarm, other than one operating from a main battery power supply, shall operate as intended in the standby condition at maximum and minimum sensitivity settings and perform its intended signaling function, while connected to a supply source of 110 percent of the rated voltage. When a nominal rated voltage value is specified, the overvoltage shall be 110 percent of the rated voltage specified in <u>37.3</u>, Test voltages. When an operating voltage range is specified, the overvoltage shall be either 110 percent of the rated voltage specified in <u>37.3</u>, Test voltages, whichever is higher. Three samples are to be subjected to the specified increased voltage in the

normal standby condition for at least 16 hours, or until stabilized temperatures have been reached, and then tested for normal signaling operation and sensitivity.

57.1.2 Sensitivity measurements at the increased voltage shall vary not more than specified in Sensitivity shift criteria, <u>38.3</u>. For smoke alarms intended to be energized from a separate power supply, as described in <u>35.1</u>, Primary power supply, the overvoltage shall be applied to the input of the power supply.

57.1.3 For alarms intended for connection in a multiple station configuration, the minimum number of alarms specified by the manufacturer's published instructions are to be interconnected with zero line resistance between alarms and tested for their intended operation.

# 57.2 Undervoltage test

57.2.1 An alarm shall operate for its intended signaling performance while energized from a supply of 85 percent of the test voltage specified by the manufacturer and while at both maximum and minimum sensitivity settings. For units powered from a primary battery, the test shall be conducted at the battery trouble signal voltage level. Sensitivity measurements at the reduced voltage shall vary not more than specified in Sensitivity shift criteria, <u>38.3</u> from the readings measured at rated voltage. Refer to the Audibility Test, Section <u>84</u>.

57.2.2 For smoke alarms intended for connection in a multiple station configuration, the maximum number of alarms specified by the manufacturer's published instructions are to be interconnected with either 10 ohms resistance between alarms, or the maximum resistance specified in the manufacturer's published instructions, and tested for intended operation.

57.2.3 When the smoke alarm is provided with a standby battery the test is to be conducted at 85 percent of the charged battery voltage. When the standby battery provides a trouble signal requiring replacement at higher than 85 percent of the charged battery voltage, the test is to be conducted at the battery trouble signal voltage level.

57.2.4 For operation at the reduced voltage, three smoke alarms are to be energized from a source of supply in accordance with Test voltages, <u>37.3</u>, following which the voltage is to be reduced to 85 percent of the test voltage specified in Test voltages, <u>37.3</u> for AC operated smoke alarms, or the battery trouble level voltage for battery operated smoke alarms, and then tested for signaling operation and sensitivity. For units intended to be energized from a separate power supply, as described in <u>35.1</u>, Primary power supply, the undervoltage shall be applied to the input of the power supply.

# 58 Temperature Test

58.1 The materials or components employed in a smoke alarm shall not be subjected to a temperature rise greater than the values indicated in <u>Table 58.1</u>, Maximum temperature rises, under any condition of intended operation.