37.3 Test equipment

37.3.1 The visible aerosol obscuration (optical density) in the test compartment is to be measured by means of a DC type micrometer having a maximum internal resistance of 100 ohms and full scale reading of 100 μA used with a barrier type selenium photovoltaic cell, enclosed in a hermetically sealed case.[a] An equivalent meter consists of a digital voltmeter having a minimum input impedance of 10 megohms in parallel with a 100 ohms resistance, and a 500 ohms potentiometer. The meter and cell are to be used in conjunction with the light produced by a tungsten filament automotive type lamp (such as a prefocused spotlight bulb) energized from a constant current source at half rated voltage to provide a light beam of uniform flux density. The photoelectric cell and lamp are to be spaced 5 feet (1.5 m) apart. The following equations are to be used (Appendix B is provided for reference):

a) At any distance, the percent obscuration per foot (or per meter) is:

$$O_u = \left[1 - \left(\frac{T_s}{T_c}\right)^{\frac{1}{d}}\right] 100$$

in which:

O_u is the percent obscuration per foot (or per meter).

T_s is the aerosol density meter reading with smoke.

T_c is the aerosol density meter reading with clear air.

d is the distance in feet (or meters).

b) The percent obscuration of light for the full length beam at any distance is:

$$O_d = \left[1 - \frac{T_s}{T_c}\right] 100$$

in which:

O_d is the percent obscuration at distance d.

T_s is the aerosol density meter reading with smoke.

T_c is the aerosol density meter reading with clear air.

c) The percent transmission of light for the full length beam at any distance is:

$$T_d = \left[\frac{T_s}{T_c}\right] 100$$

in which:

T_d is the percent transmission at distance d.

T_s is the aerosol density meter reading with smoke.

T_c is the aerosol density meter reading with clear air.

d) When the percent obscuration per foot (or per meter) is known, it is possible to determine the percent obscuration for the full length of any longer beam by the following:

$$O_d = \left[1 - \left(1 - \frac{O_u}{100}\right)^d\right] 100$$

in which:

O_d is the percent obscuration at distance d.

O_u is the percent obscuration per foot (or per meter).

d is the distance in feet (or meters).

e) At any distance the total optical density is:

$$OD_t = Log_{10}\left(\frac{T_c}{T_s}\right)$$

in which:

OD_t is the Optical Density.

T_c is the aerosol density meter reading with clear air.

T_s is the aerosol density meter reading with aerosol.

f) At any distance, the optical density per foot (or per meter) is:

$$OD = \frac{Log_{10}\left(\frac{T_c}{T_s}\right)}{d}$$

in which:

OD is the Optical Density per foot (or per meter).

T_c is the aerosol density meter reading with clear air.

T_s is the aerosol density meter reading with smoke.

d is the distance in feet (or meters).

[a]A meter used for this purpose is Weston Instrument, Model 622, in conjunction with a Weston Instrument, Model 594 RR Photronic Cell.

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37.3.2 A Measuring Ionization Chamber (MIC)[b] is to be used to measure the relative buildup of particles of combustion during each trial. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump.

[b]Electronikcentralen, Horsholm Denmark, Measuring Ionization Chamber (MIC), Type EC 23095.

37.3.3 A typical test chamber consists of the following items. It is not prohibited for different chamber configurations to be used as long as they provide a homogeneous aerosol mix and a laminar air flow across the alarm, adjustable from 30 to 150 feet per minute (0.16 to 0.76 m/s).

a) Outer Cabinet – Constructed of 3/4-inch (19.1-mm) exterior grade plywood, has overall inside dimensions of 65-3/4 inches (1.67 m) long by 19-1/4 inches (490 mm) deep by 18-1/8 inches (460 mm) wide. Has a centrally located gasketed hinged top door 33-7/8 inches (860 mm) wide in the top with a 12 by 24 inch (305 by 610 mm) clear plastic window. A 1/4-inch (6.4-mm) diameter hole is located in the window center for air flow measurement. Box is provided with a 7-inch (178-mm) diameter exhaust port in the right end centered 4-1/2 inches (114 mm) above the bottom and employed with a sliding or hinged wooden cover.

b) Inner Compartment – Constructed of 3/4-inch (19.1-mm) exterior grade plywood, inside dimension 41-3/4 inches (1.06 m) long by 11-1/2 inches (292 mm) high covering the entire width of the inside of the outer cabinet. The left end has a 4-inch (102-mm) diameter hole for the 30 – 35 fpm circulating fan centered 4-1/2 inches (114 mm) from the side and 3-7/8 inches (98 mm) from the bottom near corner, a 5-3/4-inch (146-mm) diameter hole for the 150 fpm circulating fan centered 3-7/8 inches (96.1 mm) above the bottom and a 4-inch (102-mm) diameter hole for the light beam centered 3 inches (76.2 mm) in either direction from the top back corner. The right end is the same as the left end except it has one additional 4-inch (102-mm) diameter hole centered 3 inches (76.2 mm) in either direction from the top front corner. Molding strips nominal 5/8-inch (15.9-mm) are used to secure the end pieces and the top. All interior surfaces are painted with a flat black paint.

c) Circulating Fan[c] (30 – 35 fpm, not shown) – 110 cfm (0.05 m3/s); rated 8 – 28 volts DC (24 volts DC nominal), 6 watts (at 24 volts DC), 4.69 inches (119 mm) square. The fan is connected to a regulated DC power supply.

d) Circulating Fan[d] (150 fpm) – 250 cubic feet per minute (cfm) (0.12 m^3/s) rated 115 volts, 60 hertz, 5-3/4-inch (146-mm) diameter. The fan shall be located on either side of the opening. The fan is connected to a motor controller (o) for variable speed adjustment.

Alternate Fan[e] (150 fpm) – 550 cfm (0.26 m^3/s), rated 115 volts, 50/60 hertz, 10-inch (254-mm) diameter.

e) Exhaust Fan – Same as (d), except speed not adjustable.

f) Photocell[f] – Selenium barrier layer type, 1.5-inch (38-mm) diameter for active area. Photovoltaic cell active material is sealed against environment and mounted on a 3/4-inch (19.1-mm) plywood bracket 5 inches (127 mm) behind a panel that has a 2-1/2-inch (63.1-mm) diameter hole to limit the detection of forward-scattered light. Photocell has a 25 percent maximum deviation from true linearity at 200 foot-candles (2152 lm/m^2) with a 200 ohm load resistance, and has a sensitivity of 4.4 ±0.3 microamperes per foot-candle (0.416 ±0.046 microamperes per lm/m^2) flowing through a 200 ohm load (meter resistance or other). The photocell (in use) is loaded with a nominal 100 ohm, 1 percent load, trimmed with a 5000 ohm, ten turn potentiometer, and is nominally illuminated at 22 foot-candles (236.7 lm/m^2). Spectral response peak is between 530 and 580 nanometer with 30 percent sensitivity response at 350 and 660 nanometer.

g) Airstream Deflector – Sheet aluminum, 18 inches (457 mm) wide by 15-1/2 inches (394 mm) long secured at each end by screws to two 3/4-inch (19.1-mm) thick plywood sections; each section is to be 8-5/8 inches (219 mm) high, 9-1/4 inches (235 mm) long (adjacent to top of test box), and a 10-inch (254-mm) radius curved section to which the deflecting plate is to be attached. The plate is to extend 1 inch (254.4 mm) beyond the upper edge and 5/8 inch (15.9 mm) beyond the lower edge. Each plywood cutout is to be secured to the side wall of the test compartment.

h) Airstream Straightener[g] – Aluminum honeycomb nominal 1/4 inch (6.4 mm) cell size; overall dimensions are to be 7 by 18 by 3 inches (178 by 457 by 76 mm). When an equivalent honeycomb is employed, the cell size length to diameter ratio shall be greater than 10.

i) Screen – Screening material of aluminum wire 0.01-inch (0.3-mm) diameter, having nominal 1/16 inch (1.6 mm) square openings 18-1/8 inches (464 mm) long by 7 inches (178 mm) wide. To be wedged adjacent to airstream straightener.

j) Monitoring Head[h] – Measuring Ionization Chamber mounted on backwall adjacent to test sample area 1 inch (25 mm) above test platform. Employed with (p).

k) Detector Under Test – Located in center on inner compartment top. Positioned to rest on back (as illustrated) or inverted and suspended from the box cover. Samples spaced at least 2 inches (51 mm) from the nearest edge of the monitoring head. Located so that least favorable position for aerosol entry faces oncoming air flow.

l) Outlets – 120-volt receptacles for test samples, controlled by a variable autotransformer on the control cabinet.

m) Lamp – Low-voltage automotive spot-light type 4515 or equivalent, rated at 6 volts DC, and mounted on 3/4-inch (19.1-mm) plywood bracket 4 inches (102 mm) from the side wall in-line with the photocell. The distance from the lamp (lens face) to photocell is to be exactly 5 feet (1.52 m). The lamp is to be operated from a regulated voltage supply typically 2.40 volts which yields a lamp color temperature of 2373 ±50 Kelvin. At that level, the photocell current is to be 100 ±25 microamperes into 100 ohms. The lamp is not to result in random meter fluctuations.

n) Meter Assembly – Digital micrometer assembly consisting of a voltmeter having a minimum impedance of 10 megohms (clear air condition is indicated as 10 millivolts), and a trim potentiometer for adjustment of the meter. Connected directly to photocell (e). An analog direct current micrometer, having a maximum impedance of 100 ohms and a linearity of 1 percent or better over a range of 50 – 100 microamperes, is also appropriate for use.

o) Control Cabinet – Cabinet for mounting timers, switches, variable autotransformer for varying supply voltage to outlets (l), and potentiometer for speed control of circulating fan (c).

p) Monitor Head Meter[i] – High impedance meter 100 picoamperes full scale. Employed with (j) and (r).

q) Air Diffuser – Same type of screening material as described in (i). To be wedged between the underside of the air stream straightener and the deflector at a 45-degree angle with the horizontal.

r) Control Equipment (Monitoring Head) – Consists of a suction control unit employed with a vacuum pump and an amplifier with power supply. Employed with (j) and (p).

s) Recorder[j] – X-Y plotter. Records buildup of visible smoke versus MIC output.

t) Velometer[k] – Velocity measuring instrument with probe sensor. Probe inserted through hole in plastic window to measure air flow 1 inch (25.4 mm) above platform.

u) Power Supply (Not Shown) – Variable, regulated DC supply, 0 – 40 volt output. Employed with (c), 30 – 35 fpm circulating fan.

[c]Rotron, Model MD24B2, or equivalent.

[d]A fan used for this purpose is Model 7600, rated 115 volts, 60 hertz, by Pamoter, Inc. or equivalent.

[e]E G & G Rotron, Model CL2L2, or equivalent.

[f]A photocell used for this purpose is Weston Instruments, Model 594 RR.

[g]Expanded Commercial Grade Honeycomb 1/4 CGH – 5.2 N American Cyanamid Company, is appropriate for this purpose.

[h]An instrument used for this application is a Measuring Ionization Chamber (MIC), Type EC 23095, and control equipment manufactured by Electronikcentralen, Horsholm Denmark.

[i]Fluke, Model 8022A multimeter, or equivalent.

[j]Heath, Model SR-207, rated 120 volts, 50/60 cycles, 35 watts, or equivalent.

[k]Alnor Instrument Co., Type 8500, or equivalent.

37.4 Test method

37.4.1 The test is to be conducted in an ambient temperature of 23 ±3°C (73.4 ±5°F) at a relative humidity between 50 ±20 percent and a barometric pressure of 760 ±30 mm (93.3 kPa) of mercury.

37.4.2 A minimum of 12 samples of the alarm, previously energized from a source of supply in accordance with 33.3.1 for at least 16 hours or for a time interval as specified by the manufacturer, are to be subjected to this test. The alarm under test is to be tested in the least and most favorable horizontal positions of aerosol entry. See 39.1.

37.4.3 The air velocity in the test compartment is to be maintained at 32 ±2 fpm (0.16 ±0.001 m/s), as measured 1 inch (25.4 mm) in front (upstream) of the middle section of the alarm with a hot wire anemometer, or equivalent air velocity measuring instrument. The velocity measurement is to be made with the alarm removed.

37.4.4 The aerosol is to be admitted into the test chamber and operation is to be continued until the alarm is actuated in a continuous (steady or pulsing) alarm condition. For units whose alarm is nonpulsing and which emit alarm pulses with the initial entry of smoke, a continuous alarm condition is one that is continuous (nonpulsing) for not less than 5 seconds. The MIC/light relationship and the visible smoke build-up rate is to remain within the limits represented by the curves illustrated in Figures 37.1 and 37.2. When the trial-to-trial variation in percent light transmission at alarm is ±0.2 or less, only three trials are required to be conducted on each sample. When the variation is greater than ±0.2, five trials are to be performed. The test chamber is to be exhausted between each trial until the MIC and light beam indicate a clear condition. The airflow is to be let to stabilize for at least 30 seconds before each test trial.

37.4.5 The final value used for the sensitivity shall be the average of the total number of readings. The following readings are to be recorded for each trial at the moment of actuation:

a) Visible Aerosol Obscuration (percent light transmission),

b) Measuring Ionization Chamber (MIC) Meter Reading, and

c) Time of test trial.

For combination smoke alarms, the sensitivity of each principle of operation is to be recorded. For an alarm which has a variable sensitivity setting, test trials are to be made at the maximum and minimum sensitivity settings.

38 Velocity-Sensitivity Test

38.1 The sensitivity of an alarm shall not vary more than specified in 34.4.1, using aerosol, when tested in accordance with the sensitivity test at air velocities of 32 and 150 fpm (0.16 and 0.76 m/s) ±10 percent. In no case shall the sensitivity exceed the limits specified in 37.1.1 for aerosol.

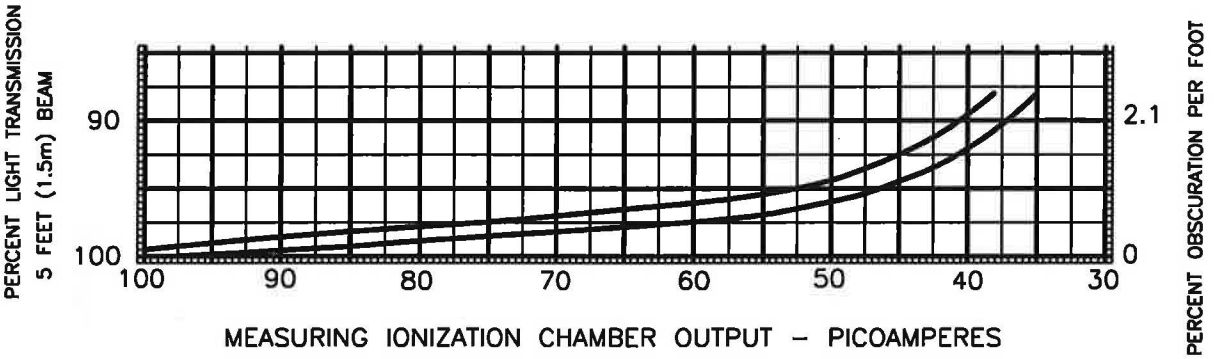
38.1 revised and effective date changed from August 21, 1998 to August 10, 1998

38.2 Two alarms, one at maximum and one at minimum sensitivity are to be subjected, in turn, to the sensitivity test; first at a velocity of 32 fpm (0.16 m/s), and then at a velocity of 150 fpm (0.76 m/s). At 150 fpm, the aerosol buildup is to be such that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curve illustrated in Figure 38.1. The aerosol buildup rate is to be maintained within the limits of Figure 38.2.

38.3 For this test the alarms are to be oriented, in turn, in the least favorable and then the most favorable position for aerosol entry.

Figure 38.1
Smoke entry test limits – aerosol – 150 fpm

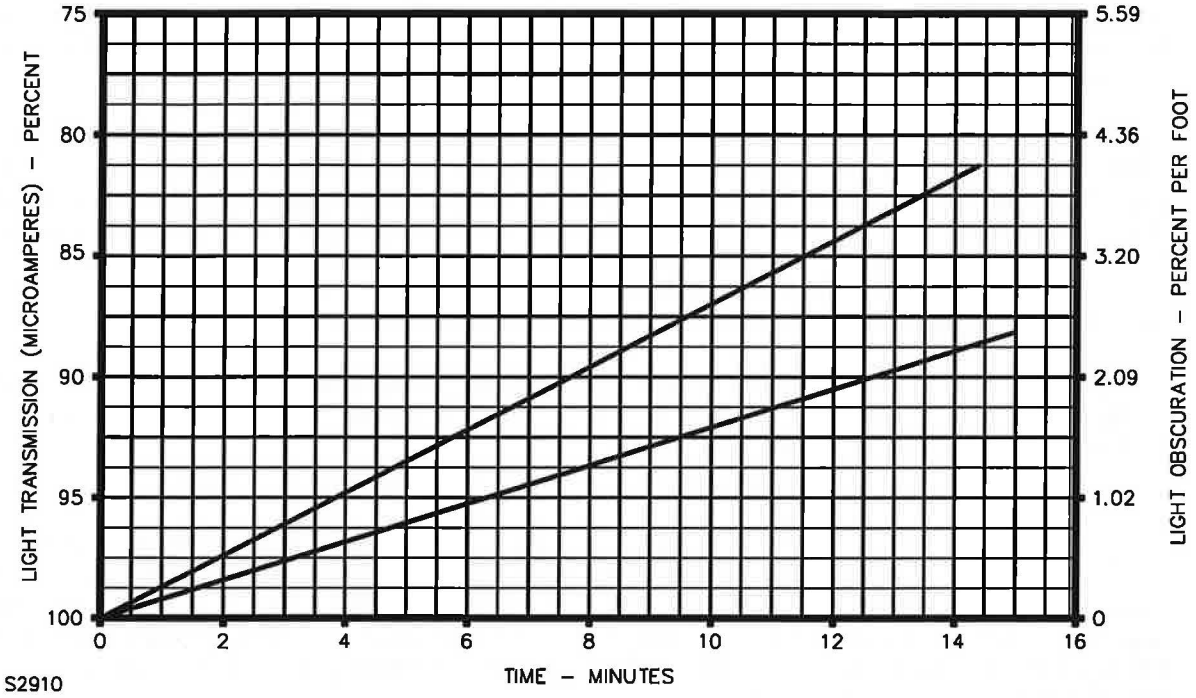
Figure 38.1 revised January 4, 1999



S2216

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Figure 38.2
Smoke build-up rate – velocity-sensitivity test – aerosol – 150 fpm



39 Directionality Test

39.1 The sensitivity of the alarm shall comply with the requirements of 37.1.1 for aerosol, in any orientation with the air flow in the chamber. The alarm shall be tested at a 30 – 35 fpm (0.15 – 0.18 m/s) air velocity in its least favorable position and at each 90 degree angle from the position. The positions include all four compass points with the detector in a horizontal position with the oncoming air directed to each of four sides and with the detector positioned on edge with the alarm front facing the oncoming air. The locations of the least and most favorable smoke entry positions are to be marked on all alarms to be used in subsequent Sensitivity Tests, Section 37; the Fire Tests, Section 44; and the Smoldering Smoke Test, Section 45.

39.2 Two samples, one employing a maximum sensitivity, and one employing a minimum sensitivity, are to be employed for this test. An alarm positioned on edge is to be mounted on a wooden board so that the edge of the alarm rests on the mounting platform. The mounting board is to extend a maximum of 2 inches (50.8 mm) beyond the vertical sides of an alarm and no extension beyond the top edge.

39.3 When the height of an alarm is too great to be accommodated in the platform test area, it is to be located adjacent to the left edge of the mounting platform with the top edge touching the roof of the test compartment and corresponding adjustments made in the location of the velocity measurement. See 37.4.3.

40 Sensitivity Test Feature

40.1 A sensitivity test feature shall be provided on a smoke alarm, to simulate either mechanically or electrically a specified level of smoke in the sensing chamber. The test feature shall be accessible from outside the alarm, with the alarm installed as intended. The maximum permissible measured level shall not exceed 6 percent per foot [0.027 OD/foot (0.088 OD/m)] obscuration using aerosol.

40.2 Four samples, two at maximum and two at minimum sensitivity, shall be subjected to this test. Each sample is to be connected to a rated supply voltage, except that an alarm employing a battery as the main supply shall be tested at the test voltage level (rated or trouble level voltage) that results in the lowest sensitivity measurement. The sensitivity is to be determined by conducting a curve plot of obscuration versus an instrument (meter) reading, or equivalent.

41 Smoke Entry (Stack Effect) Test

41.1 The sensitivity of a smoke alarm shall not vary by more than specified in 34.4.1 when subjected to the test conditions described in 41.2 – 41.4, which simulate air passing through an electrical conduit system that is connected to a smoke alarm.

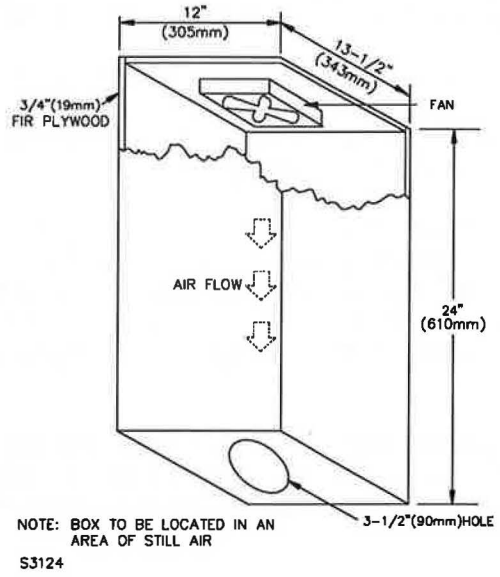
41.1 revised and effective date changed from August 21, 1998 to August 10, 1998

41.2 The test box shown in Figure 41.1 is to be employed. Fan operation is to be adjusted so that the free flow air velocity at the center of the hole in the base is 300 feet per minute (91.4 mpm) and with the hole covered, the fan shall produce a back pressure measuring between 0.012 – 0.015 inches (0.304 – 0.381 mm) of water. The fan is then to be turned off. A smoke alarm is to be installed in accordance with the manufacturer's installation instructions, facing downward and covering the hole in the base of the test box, to simulate installation in a ceiling.

41.3 The entire test box smoke alarm assembly is to be placed (alarm side down) in an opening provided in a modified top door of the test chamber described in the Sensitivity Test, Section 37. The alarm shall then be tested for sensitivity while in this position. Two samples are to be tested, one at maximum, and one at minimum sensitivity.

41.4 The procedure described in 41.2 and 41.3 is to be repeated on both alarms, except the fan is to be turned on.

Figure 41.1
Test apparatus – smoke entry (stack effect) test



Note: The box shall be located in an area having still air.

42 Lamp Interchangeability Test (Photoelectric)

42.1 The sensitivity of an alarm employing a replaceable light source shall vary not more than specified in 34.4.1 using aerosol and shall comply with the requirements of the Sensitivity Test, Section 37, when tested with the intended replacement lamps.

42.1 revised and effective date changed from August 21, 1998 to August 10, 1998

42.2 Three samples, set at the minimum sensitivity setting, are to be subjected to the Sensitivity Test, Section 37. The alarms then are to be de-energized, the photocell illuminating lamp replaced, reenergized, and again subjected to the Sensitivity Test.

43 Stability Tests

43.1 There shall be no false alarms of a smoke alarm set at the maximum sensitivity setting when two representative samples are subjected to the following test conditions. Different alarms are to be employed for each test. A test is not required when the principle of operation is such that conducting the test has no possible effect. Alarms whose sensitivity is affected by air velocity are to be tested in the horizontal position in which a false alarm is most probable. Momentary energization of the alarm (maximum of 1 second) is not prohibited during this test.

a) Operation for 90 days in a clean atmosphere in an air stream having a velocity of 300 ±25 fpm (1.5 ±0.13 m/s) in an ambient of 23 ±2°C (73.4 ±3°F) and 30 – 50 percent relative humidity.

b) Three plunges from an ambient humidity of 20 ±5 percent relative humidity to an ambient of 90 ±5 percent relative humidity at 40 ±2°C (73.4 ±4°F).

c) Ten cycles of temperature variation between 0°C (32°F) and 49°C (120°F).

d) Ten cycles of change of air velocity from 0 – 300 fpm (0 – 1.5 m/s) ±25 fpm (±0.13 m/s).

e) Ten cycles of a 2 inch (50.8 mm) change of air pressure starting from 31 – 29 inches (787 – 737 mm) ±0.5 inches (±12.7 mm) of mercury.

f) Fifty cycles of momentary (1/2 second) interruption of the detector power supply at a rate of not more than 6 cycles per minute followed by 10 cycles of very rapid OFF-ON switching (each consisting of 3 OFF-3 ON sequences in 1-1/2 seconds) to simulate a loose wire connection in the home or an automatic reclosing circuit in the distribution line, at not more than 1 cycle per minute. Battery operated alarms are capable of being tested in conjunction with the Battery Replacement Test, Section 68.

g) Twenty cycles subjected to high light intensity from a distance of 1 foot (0.3 m), 10 cycles using a 150-watt incandescent lamp, 10 cycles using a 4 light fluorescent fixture with 40-watt daylight lamps at a rate of 4 cycles per minute. Each cycle is to consist of 10 seconds ON and 5 seconds OFF.

43.2 Two alarms, employing a maximum sensitivity setting, are to be mounted in a position of normal use, energized from a source of supply in accordance with 33.3.1 and subjected to each of the above test conditions.

43.3 For 43.1 (b), the alarm is to be plunged from one humidity level to the other in not more than 3 seconds per plunge and maintained at each humidity level for not less than 1/2 hour between plunges.

43.4 For 43.1 (c), the time of cycling from one extreme to the other shall be a maximum of 1 hour and a minimum of 5 minutes and not less than 15 minutes at each temperature level. For (d) the air velocity is to be turned on and off abruptly with a maximum of 1 hour between applications. For (e), the time of change from one pressure to the other is to be 30 seconds. For (g), the alarm is to be positioned in a plane to permit the maximum entry of light into the chamber. Each cycle is to start at one test condition, changing to the other extreme, and returning to the original test condition.

43.5 For 43.1 (g) the peak luminous intensity of the incandescent lamp test shall be 175 candela. The peak luminous intensity of the fluorescent fixture test shall be 424 candela.

43.6 The test samples subjected to (a) – (g) of 43.1 are to be tested for sensitivity, using aerosol (see the Sensitivity Test, Section 37), following the completion of each test. The response of any alarm, when tested in accordance with the Sensitivity Test, shall vary not more than specified in 34.4.1.

43.6 revised and effective date changed from August 21, 1998 to August 10, 1998

44 Fire Tests

44.1 General

44.1.1 Each alarm subjected to the tests specified in 44.2.1 – 44.4.1 shall operate for alarm when installed as intended in service and exposed to the following four types of controlled test fires. The maximum response time shall be 4 minutes for Tests A and B, 3 minutes for Test C, and 2 minutes for Test D. All combustibles shall be ignited with the device as described. The bottom of the container

for all combustibles is to be 3 feet (0.9 m) above the floor. Both the paper and wood brand are to be preconditioned in a relative humidity of 50 ±5 percent at a temperature of 23 ±2°C (73.4 ±3°F) for at least 48 hours prior to the test.

44.1.2 With reference to the requirements of 44.1.1, smoke alarms with precalibrated alarm settings are not required when alarms are employed which are equipped with a means to provide an analog output (electrical measurement) of the alarm sensitivity during the course of the test trials. The alarms then are to be subjected to the Sensitivity Test, Section 37, in the smoke box with the analog output recorded to translate the electrical reading into an obscuration measurement. With this type of arrangement the minimum production sensitivity setting is obtained without conducting repeat tests after recalibration. This method is also appropriate for the Soldering Smoke Test, Section 45.

44.1.3 Effective date for deleted 44.1.3 changed from August 21, 1998 to August 21, 1999

44.2 Paper fire – Test A

44.2.1 The following materials and procedures shall be used for the paper fire test:

a) Combustible – Shredded newsprint (black printing only) is to be cut in strips 1/4 to 3/8 inch (6 to 10 mm) wide, 1 to 4 inches (25.4 to 102 mm) long, total weight 1-1/2 oz (42.6 g). The paper is to be poured into the receptacle, see (b), with the bottom covered temporarily by a flat plate. The receptacle is to be tamped periodically during the pouring operation until the paper contents are even with the top of the receptacle. The paper is then to be further tamped by hand or by a rod 1 inch in diameter until the paper level is 4 inches below the top edge of the receptacle. A hole 1 inch diameter is to be formed through the center from top to bottom of the paper. The temporary bottom plate is then to be removed and the assembly mounted 3 feet (0.9 m) above the floor on a 5-inch (127-mm) diameter ring support.

b) Receptacle – To be formed of 1/32 inch (0.79 mm) thick sheet metal, 4 inches (102 mm) in diameter and 12 inches (0.3 m) high and seamed together, with no air gap at the seam, with support rods at the bottom.

c) Point of Ignition – The probe tips of the igniter are to be placed at the bottom center of the receptacle touching the paper and arcing sustained for up to 5 seconds.

d) Smoke Profile – For this test the following conditions apply:

1) Flame breakthrough shall occur between 1 and 3 minutes.

2) The first principal peak of light obscuration shall occur between 1 and 3 minutes.

3) Smoke shall peak between 27 and 37 percent per foot obscuration [0.137 and 0.2 OD/foot (0.45 and 0.66 OD/m)] at the ceiling alarm location; and between 21.5 and 37 percent per foot [0.105 and 0.2 OD/foot (0.345 and 0.66 OD/m)] at each sidewall alarm location.

4) There shall be between 20 and 40 seconds of 4 percent per foot [0.018 OD/foot (0.058 OD/m)] or higher obscuration at the ceiling alarm location; and between 10 and 30 seconds of 10 percent per foot [0.045 OD/foot (0.15 OD/m)] or higher obscuration at the sidewall alarm locations.

5) The secondary peak shall not exceed 13 percent per foot obscuration [0.061 OD/foot (0.2 OD/m)] at any alarm location.

6) Length of test shall be 4 minutes.

44.3 Wood fire – Test B

44.3.1 The following materials and procedures shall be used for the wood fire test:

a) Combustible[1] – A wood brand formed of three layers of kiln dried fir strips, each strip 3/4 inch (19.1 mm) square in cross section, 6 inches (152 mm) long with six strips in each layer, is to be used. Wood strips are to be nailed or stapled together with adjacent layers at right angles to each other. Overall dimensions of the wood brand are to be 6 by 6 by 2-1/2 inches (152 by 152 by 64 mm). The brand is to be supported on a 5-inch (127-mm) diameter ring support 3 feet (0.9 m) above the test room floor.

b) Promoter – The wood brand is to be ignited by burning 4 milliliters of denatured alcohol consisting of 190 proof (95 percent) ethanol to which 5 percent methanol is added as a denaturant. The alcohol is to be placed in a 1-1/2 inch (38 mm) diameter, 1-inch (25.4-mm) deep metal container, the bottom of which is to be 3-1/2 inches (89 mm) below the bottom of the wood brand and centered so that the flame does not break through the top of the wood brand. The container is to be supported by a 1/4-inch (6.4-mm) hardware cloth. The alcohol is to be placed in the container no earlier than 30 seconds prior to ignition.

c) Point of Ignition – Ignition is to be by probes in alcohol. Probe tips of the igniter are to be placed as near the container lip as possible without arcing to the sides.

d) Smoke Profile – For this test the following conditions apply:

1) Smoke buildup shall begin between 80 and 120 seconds at the ceiling alarm location; and between 60 and 120 seconds at each sidewall alarm location.

2) There shall be at least 60 seconds of 4 percent per foot obscuration [0.018 OD/foot (0.058 OD/m)] at all alarm locations.

3) Maximum obscuration shall not exceed 17 percent per foot [0.081 OD/foot (0.265 OD/m)] at the ceiling alarm location; and 27.5 percent per foot [0.14 OD/foot (0.46 OD/m)] at either sidewall alarm location.

4) Flame breakthrough shall occur between 150 and 190 seconds.

5) Length of test shall be 4 minutes.

[1]Douglas Fir, S4 (smooth on all sides), clear of knots and holes, weight – 1.05 – 1.32 pounds per 10 foot length.

44.4 Flammable liquid fire – Test C

44.4.1 The following materials and procedures shall be used for the gasoline fire test:

a) Combustible – Consists of a mixture of 25 percent toluene and 75 percent heptane which is to be burned in a metal receptacle in a large enough quantity to generate curves within the limits specified by Figure 44.1.

b) Receptacle – To be formed of 0.025-inch (0.635-mm) stainless steel, 6-1/4 inches (158 mm) in diameter and 1-1/4 inches (32 mm) deep, the bottom having 1/2 inch (12.7 mm) rounded base, located 3 feet (0.9 m) above the test room floor and centered with a ring support. The liquid is to be poured into the receptacle 30 seconds prior to ignition.

c) Point of Ignition – The probe tips of the igniter are to be placed so that they are above the lip of the pan and not extending into the pan. This results in ignition of the vapors above the liquid.

d) Smoke Profiles – For this test the following conditions apply:

1) Maximum obscuration shall not exceed 13 percent per foot [0.061 OD/foot (0.199 OD/m)] or 17 percent per foot [0.081 OD/foot (0.265 OD/m)] at either side wall alarm location.

2) Length of test shall be 4 minutes.

Effective date for 44.4.1 changed from August 21, 1998 to August 21, 1999

44.5 Polystyrene fire – Test D

44.5.1 *Effective date for deleted 44.5.1 changed from August 21, 1998 to August 21, 1999*

44.6 Igniter assembly

44.6.1 The igniter assembly is to consist of the following or equivalent components:

a) Igniter Probes – The metal probes, 1/4 inch (6.4 mm) diameter and tapered at the ends to form a point and maintained 1/2 inch (12.7 mm) apart, are to be connected to the high-voltage insulated output leads of an oil burner ignition transformer, see (c). Adjustment and support for the probes is to be provided by metal clamps affixed to a vertical steel bar integral with the igniter assembly.

b) Support – A ring clamp, 5 inches (127 mm) in diameter is clamped to a ring stand to support the container holding the combustible.

c) Ignition Source – Consists of a 120 volt, 60 hertz primary, 10,000 volt, 23 milliamperes secondary oil burner ignition transformer, the output of which is to be connected to the igniter probes. The arc used for ignition is to be obtained by the closure of a remote, low-voltage, momentary contact switch which energizes a relay whose contacts control the transformer primary.

44.7 Test conditions

44.7.1 The fire tests are to be conducted in a 36 foot long by 22 foot wide by 10 foot high (10.9 by 6.7 by 3.1 m) room having a smooth ceiling with no physical obstructions. Air movement in the test room shall be zero. The distance from the base of the combustible to the ceiling is to be 7 feet (2.1 m). The room is to be provided with a means for the removal of smoke. Where required, heating, humidity, and air conditioning are to be provided for maintaining the room ambient, and are to be shut down during the test trial. See Figure 44.2.

Figure 44.1
Flaming liquid fuel profile

Effective date for Figure 44.1 changed from August 21, 1998 to August 21, 1999

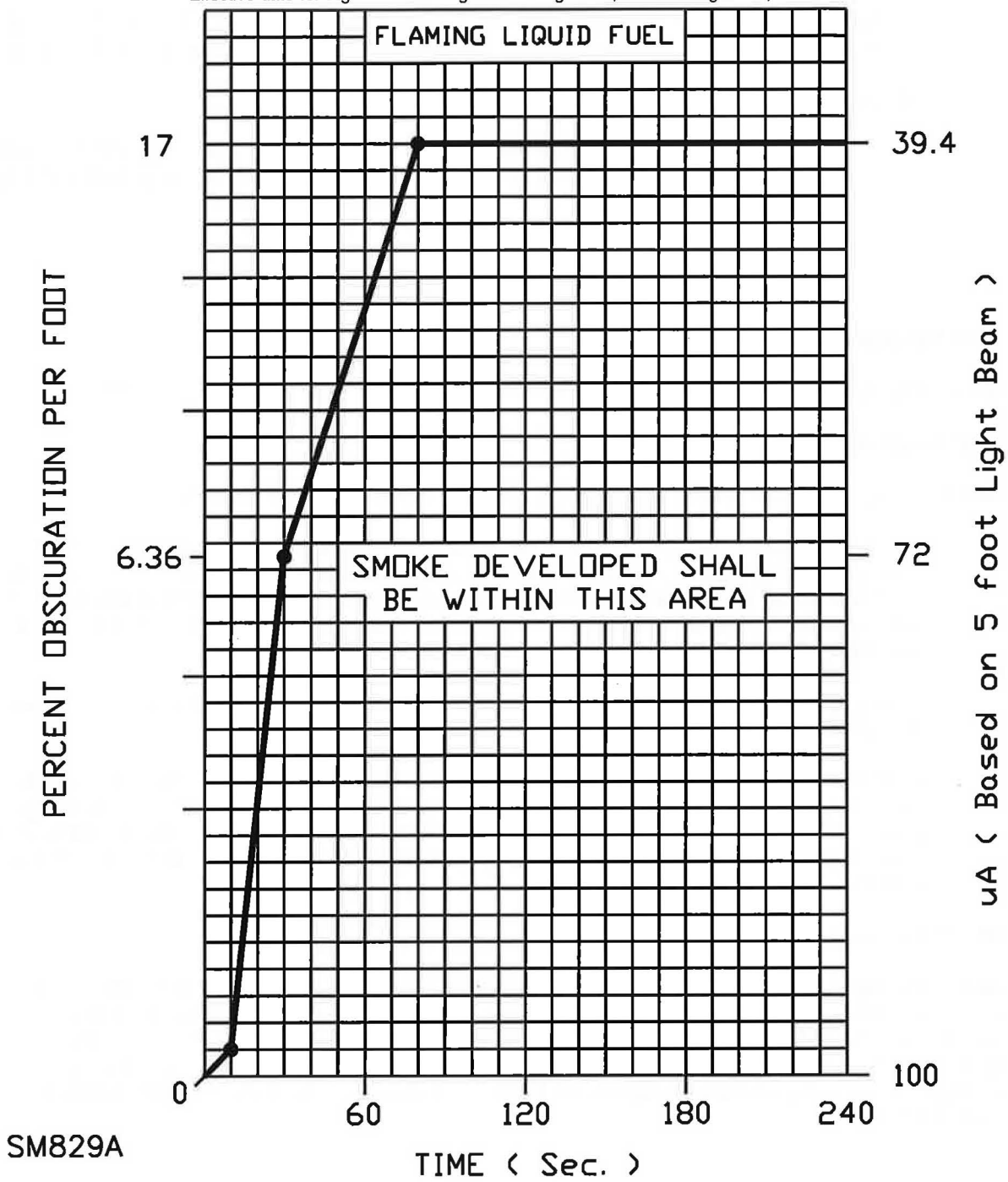
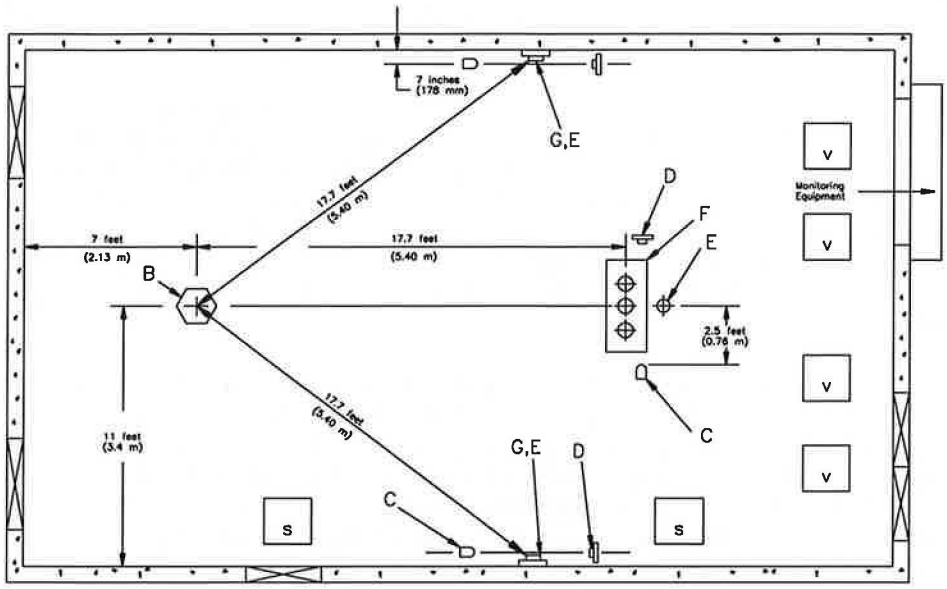


Figure 44.2
Fire test room



S2300A

A. Fire Test Room Dimensions

1. Length – 36 feet (11 m)

2. Width – 22 feet (6.7 m)

3. Ceiling – height 10 feet (3.0 m) suspended type. Consists of 2 by 4 feet (0.6 by 1.2 m) by 5/8 inch (15.9 mm) thick incombustible fissured mineral fiber layer in panels.

B. Test Fire

1. 3 feet (0.91 m) above floor for the Fire Tests, Section 44

2. 8 inches (203 mm) above floor for the Smoldering Smoke Test, Section 45

C. Lamp Assembly – 4 inches (102 mm) below ceiling, 7 inches (178 mm) from each side wall.

D. Photocell Assembly – Spaced 5 feet (1.5 m) from lamp, photocell center 4 inches (102 mm) below ceiling, 7 inches (178 mm) from each side wall.

E. Measuring Ionization Chamber (MIC) – See 45.8.

F. Test Panel, Ceiling Mounted Alarms – see Figures 44.3 and 44.5.

G. Test Panel, Sidewall Mounted Alarms – see Figures 44.4 and 44.5.

S. Air Supply

V. Exhaust Vents

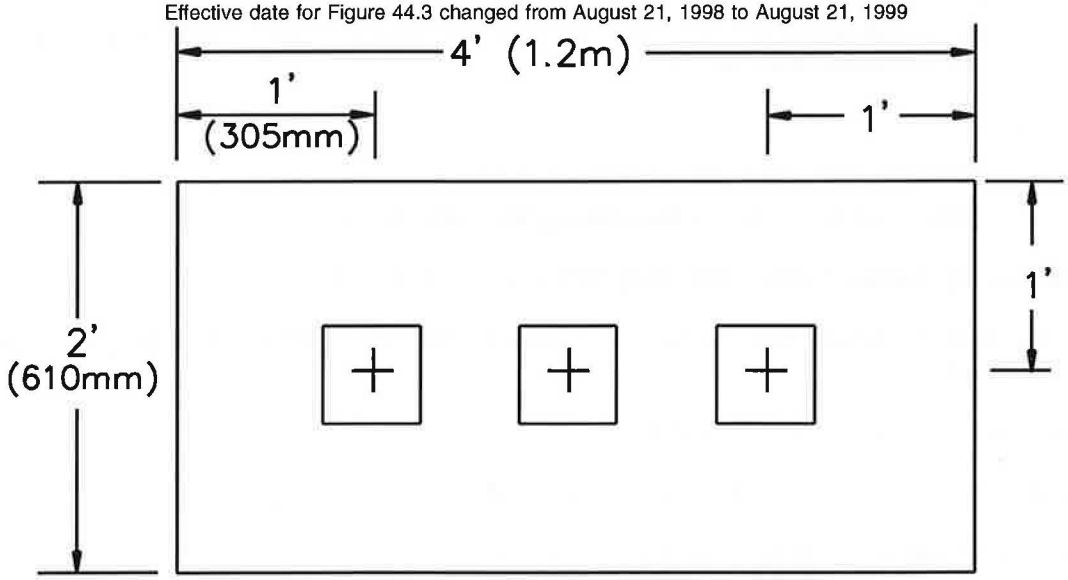
44.7.2 The tests are to be conducted in an ambient temperature between 20.0 and 25.5°C (68 and 78°F) and a relative humidity of 50 ±10 percent. The alarm samples are to be energized from a source of supply in accordance with 33.3.1 except that alarms powered from a battery shall be energized by batteries depleted to their trouble signal voltage levels unless the minimum sensitivity is measured at rated voltage.

44.7.3 When intended for ceiling mounting only, three alarms are to be tested on a ceiling panel. See Figure 44.2. When intended for wall mounting only, two alarms are to be tested, one on each sidewall. See Figure 44.3. For detectors intended for both wall and ceiling mounting, five alarms are to be tested: three on the ceiling and one on each side wall. See Figure 44.5. For alarms intended as portable (travel) alarms, two units are to be mounted, one on each side wall, 16 inches (406 mm) from the ceiling to the top of the alarm. The ceiling mounted alarms are to be mounted such that the least favorable position of one sample faces the oncoming smoke flow, with the remaining two samples rotated 120 and 240 degrees, respectively.

44.7.4 All alarm samples, each adjusted to its minimum sensitivity setting, shall respond to each combustible. The test time is to start at ignition. Each alarm shall operate for continuous (steady or pulsing) alarm. For units whose alarm is nonpulsing and that emit alarm pulses with the initial entry of smoke, a continuous alarm is one that is continuous (nonpulsing) for not less than 5 seconds. The smoke obscuration level at each of three alarm locations (ceiling and each side wall) is to be monitored by a photocell-light-beam assembly, mounted directly on the ceiling and spaced 5 feet (1.52 m) apart. See 37.3.3 (e) and (l) for a description of this assembly. Combination smoke alarms are to be provided with means for monitoring each principle of operation during testing. Each principle shall contribute in response, either wholly or partially, to at least one of the test fires, or the Smoldering Smoke Test, Section 45, or to both.

Figure 44.3
Ceiling panel size and sample location for ceiling mounting of alarms

Effective date for Figure 44.3 changed from August 21, 1998 to August 21, 1999

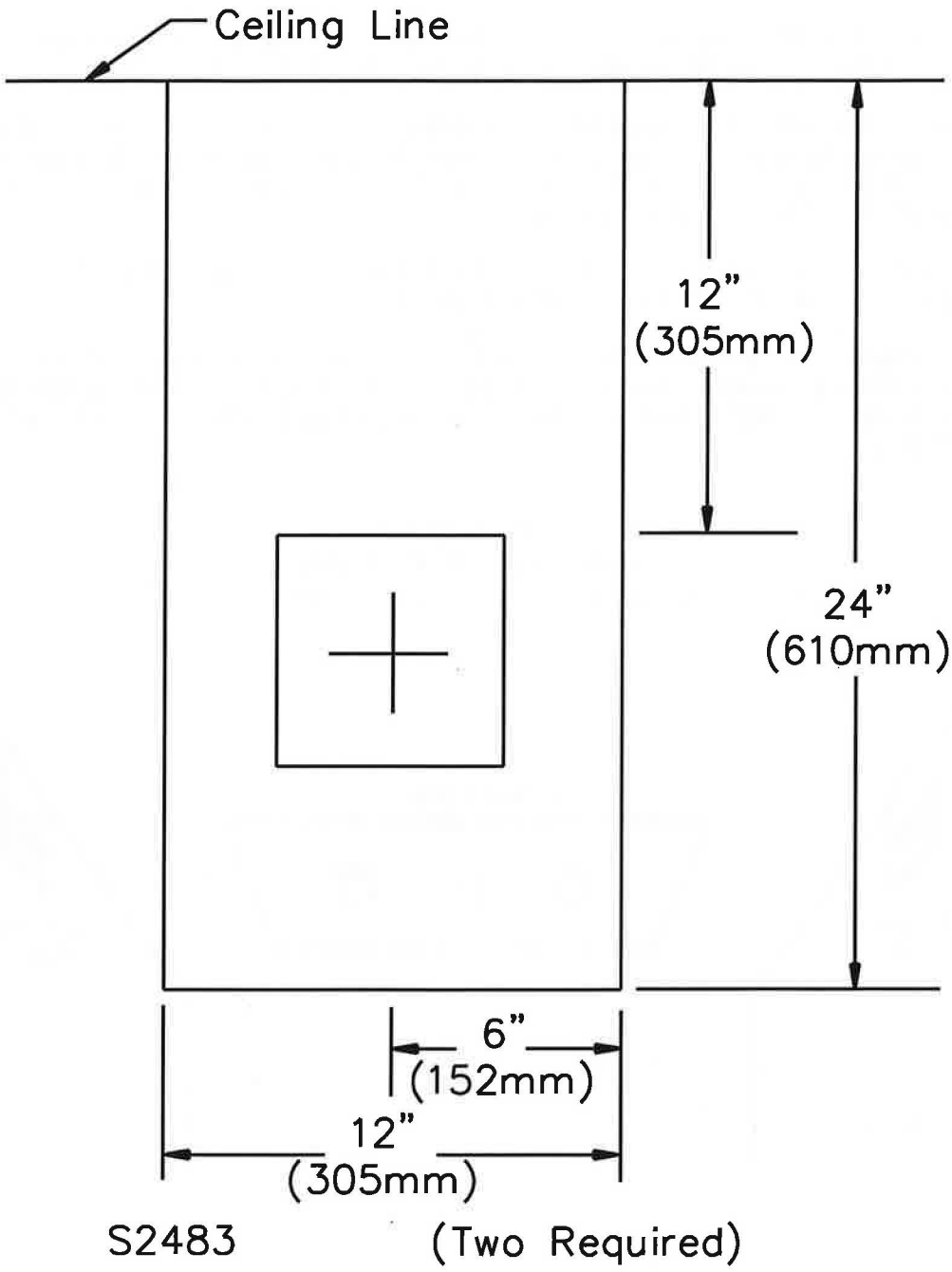


(panel mounted flush in the test room ceiling)

S2482A

Figure 44.4
Sidewall panel size and sample location for wall mounting of alarms

Figure 44.4 revised January 4, 1999



NOTE – Distance less than 12 inches and not less than 4 inches to the top of the alarm shall be so specified in the installation instructions.

44.7.5 An alarm intended for flush mounting is to be mounted flush with the mounting base. Both wall and ceiling mounted alarms are to be placed in the least favorable position of smoke entry with respect to the oncoming smoke flow unless the manufacturer's installation instructions indicate a specific mounting arrangement, or the mounting position is obvious.

44.7.6 To determine the acceptability of each test fire, the smoke profile curves as described in each fire test shall be obtained for the application combustible. See Figures 44.1, 44.6, and 44.7.

44.7.7 Measuring Ionization Chambers (MIC's) are to be used to measure the relative buildup of particles of combustion during each trial at each detector location. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump. A monitoring head is to be located at each alarm location as shown in Figure 44.2.

44.7.8 Prior to each test, each MIC is to be calibrated in clean air for a value of 100 picoamperes. As the smoke level increases during the test, the meter reading decreases.

44.7.9 To determine the acceptability of the test trial for each combustible and each detector location, the relationship between the MIC output (ordinate) and the percent light obscuration (abscissa) is to be plotted. The data generated shall remain within the limits represented by the curves illustrated in Figures 44.9 – 44.12.

Figure 44.5
Panel mounting for fire tests

Effective date for Figure 44.5 changed from August 21, 1998 to August 21, 1999

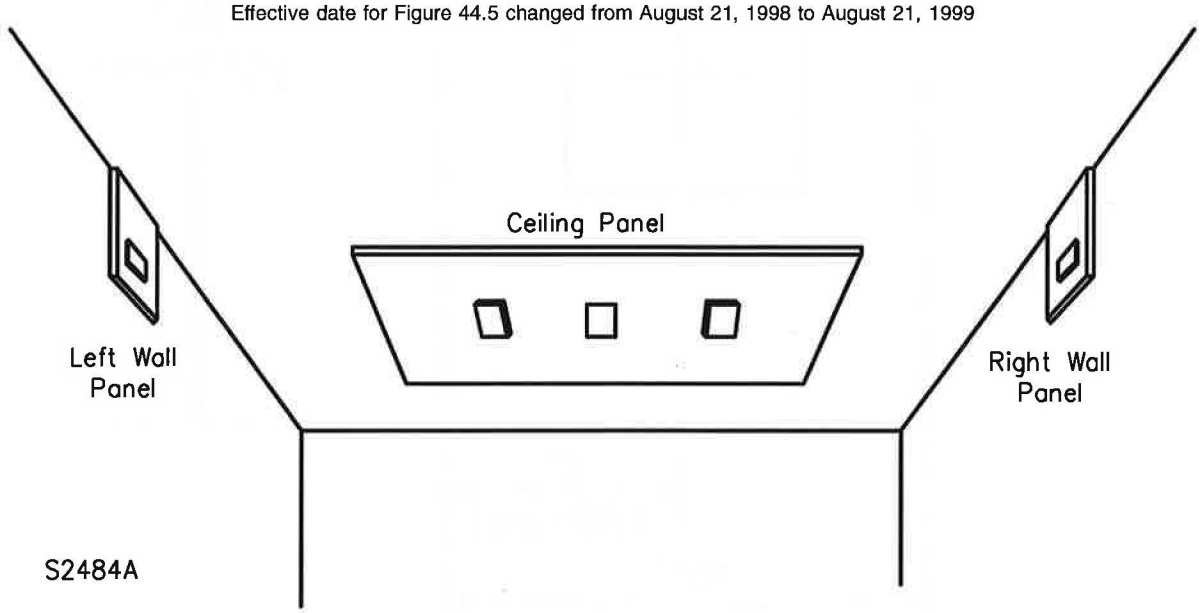
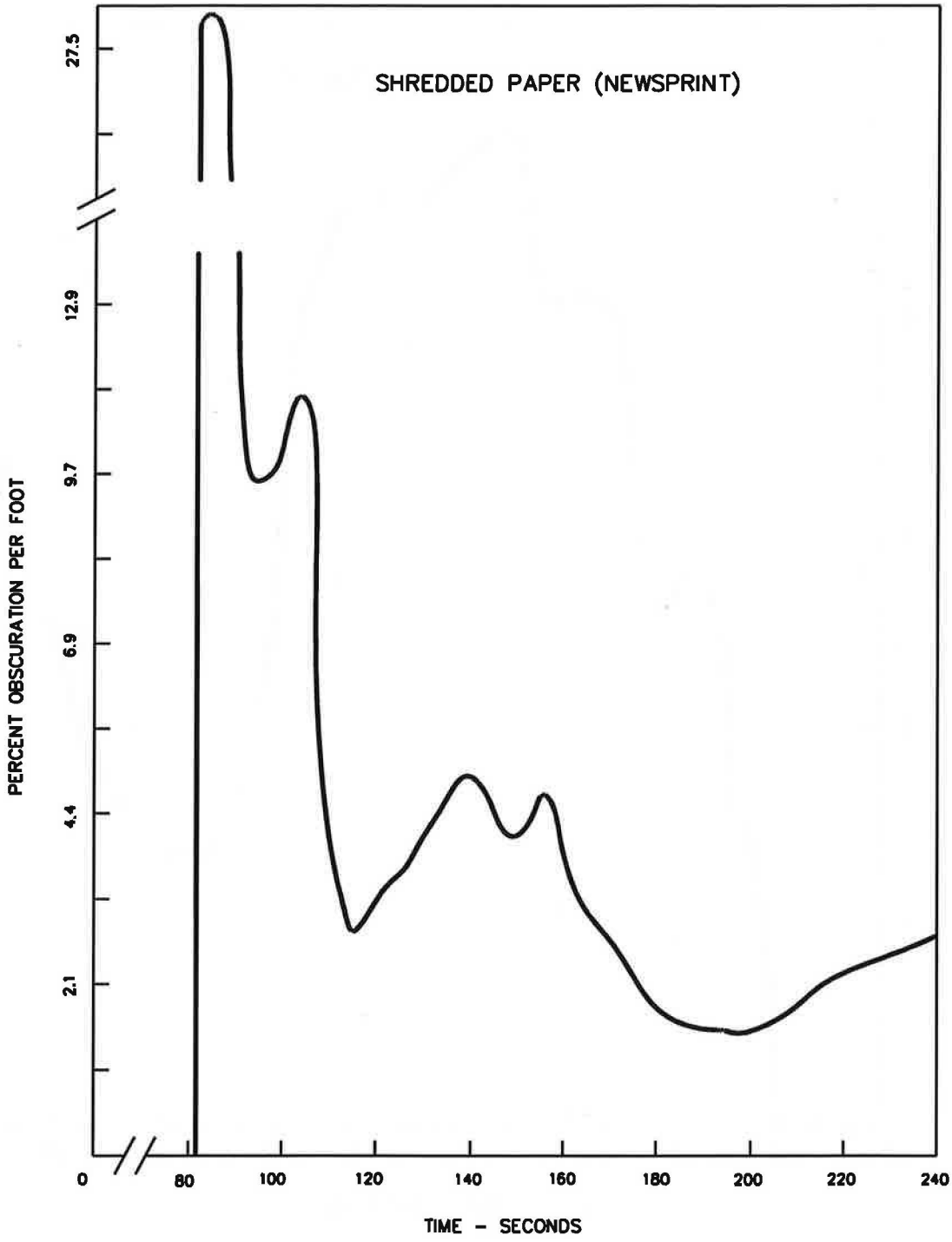


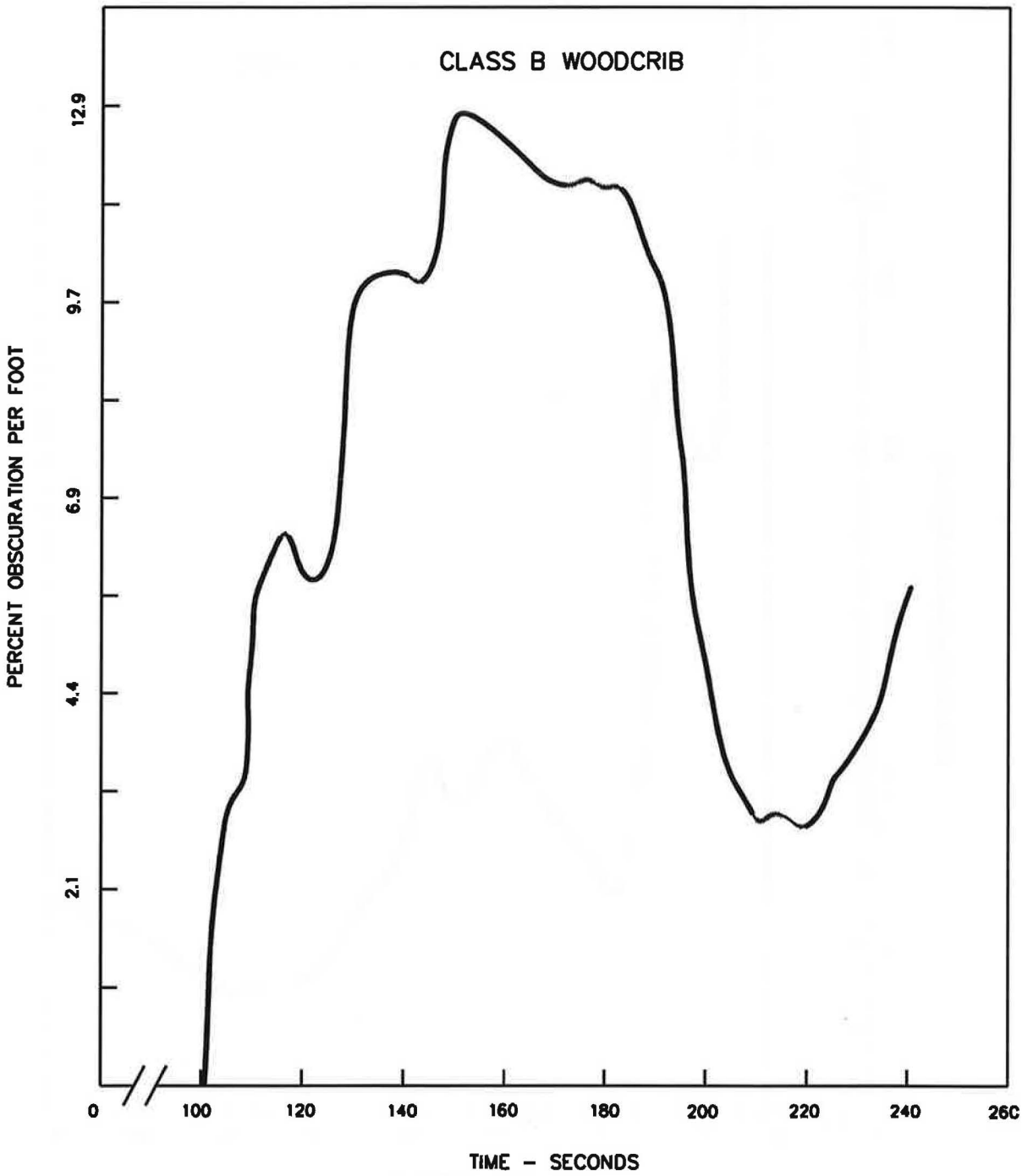
Figure 44.6
Shredded paper (newsprint) profile



S2485A

Figure 44.8

Figure 44.7
Woodcrib profile



Effective date for deleted Figure 44.8 changed from August 21, 1998 to August 21, 1999

Figure 44.9
Paper fire – ceiling location

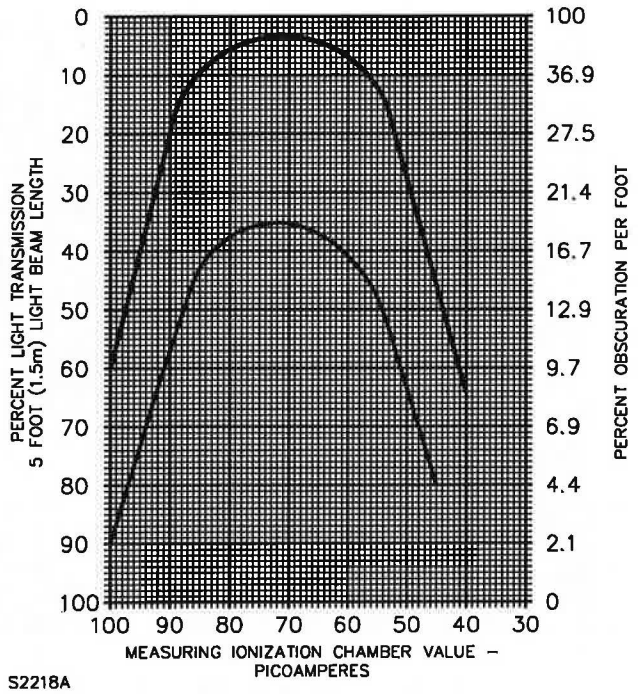


Figure 44.10
Paper fire – wall location

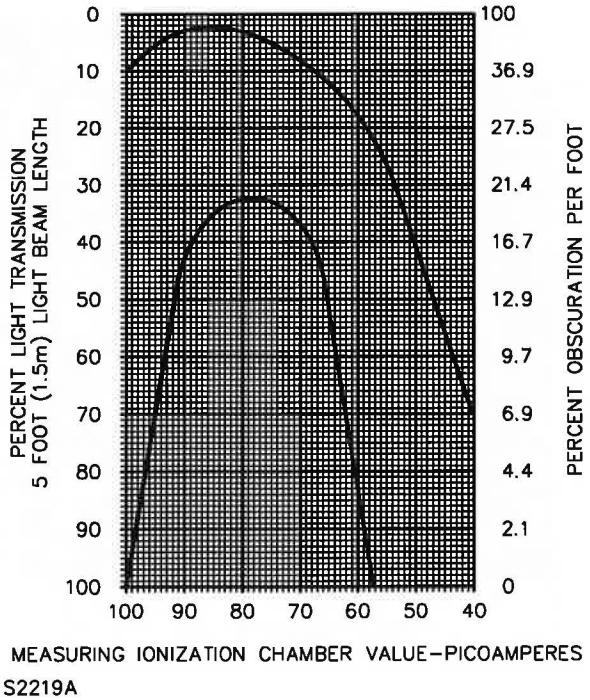


Figure 44.11
Wood fire – ceiling location

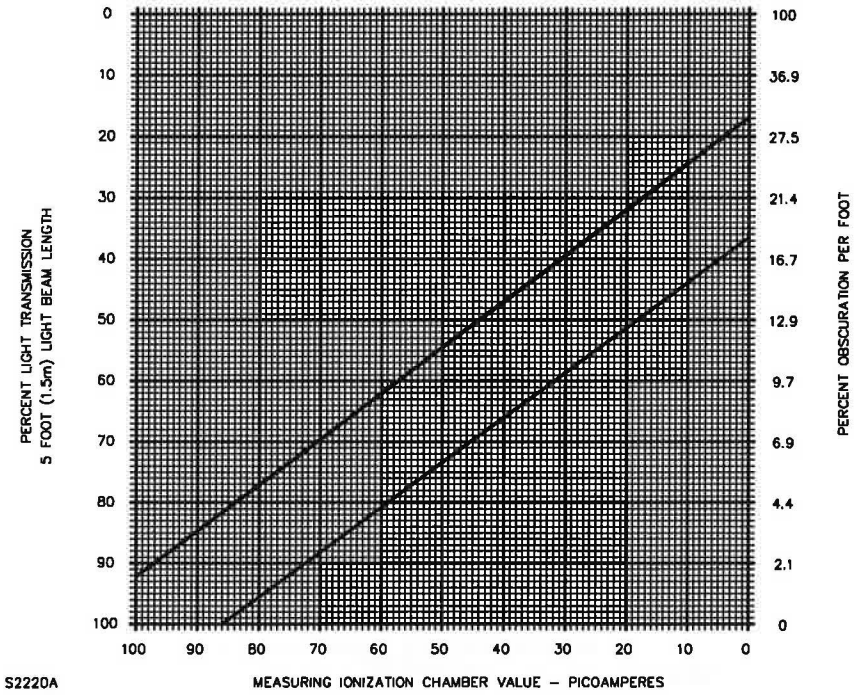


Figure 44.12
Wood fire – wall location

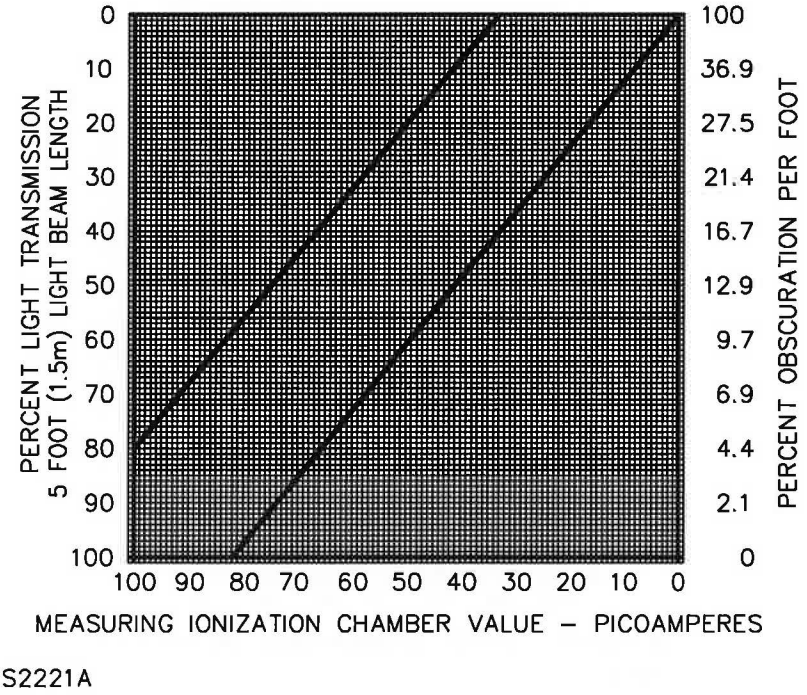


Figure 44.13
Gasoline fire – ceiling location

Effective date for deleted Figure 44.13 changed from August 21, 1998 to August 21, 1999

Figure 44.14
Gasoline fire – wall location

Effective date for deleted Figure 44.14 changed from August 21, 1998 to August 21, 1999

Figure 44.15
Polystyrene fire – ceiling location

Effective date for deleted Figure 44.15 changed from August 21, 1998 to August 21, 1999

Figure 44.16
Polystyrene fire – wall location

Effective date for deleted Figure 44.16 changed from August 21, 1998 to August 21, 1999

45 Smoldering Smoke Test

45.1 Each smoke alarm shall operate for continuous (steady or pulsing) alarm when installed as intended in service, and exposed to the following controlled smoldering smoke condition. For a smoke alarm whose alarm is nonpulsing, yet emits alarm pulses with the initial entry of smoke, a continuous alarm condition is one that is continuous (nonpulsing) for not less than 5 seconds.

45.2 Unless specifically indicated otherwise in the alarm installation instructions, the alarms are to be installed in the least favorable position for smoke entry (except where noted in 44.7.3) with respect to the smoldering smoke source as determined by the Directionality Test, Section 39. Detectors adjusted to the minimum production sensitivity are to be employed for this test.

45.3 The combustible for this test is to be ten ponderosa pine sticks (nonresinous, free from knots or pitches) placed in a spoke pattern on the hotplate such that the sticks are 36 degrees (0.63 rad) apart. The end of each stick is to be flush with the edge of the hotplate. Each stick is to be 3 by 1 by 3/4 inches (76.2 by 25.4 by 19.1 mm) with the 3/4 by 3 inch (19.1 by 76.2 mm) face in contact with the hotplate. All surfaces of each stick are to be smooth and free from burrs or holes. The grain of the wood is to be parallel to the stick length. Each stick is to be conditioned for not less than 48 hours at 52°C (125°F) in an air-circulating oven. The stick weight is to be 16 ±2 grams (0.56 ±0.07 oz) following the oven conditioning.

45.4 The heat source is to be a 240 volt, 1550 watt hotplate[m] having a steel plate 8-1/2 inch (216 mm) diameter by 1/4 inch (6.4 mm) thick, the topmost portion of which is 8 inches (200 mm) above the floor. The temperature of the hotplate is to be monitored by an iron-constantan No. 30 AWG (0.05 mm^2) (Type J) thermocouple attached to the edge of the steel plate by placing its junction in a hole 0.015 inch (0.38 mm) in diameter and 1/4 inch (6.4 mm) deep and peening over the opening to secure it. The thermocouple is to be connected to a proportioning temperature controller which is able to be precisely set for the specified hotplate temperature. The controller sensitivity is adjusted so that all conditions for this test are met. Once set for a specific temperature, the hotplate shall be maintained at that temperature (as monitored by a temperature measuring meter). Prior to the start of the test, the hotplate temperature is to be 23 ±2°C (73 ±4°F). The initial proportioning controller temperature setting is to

be 205°C (401°F). The hotplate and controller then are to be energized and the test time started (T=0). The proportioning controller setting is to be increased to obtain the temperature sequence included in Table 45.1 and Figure 45.1. (The hotplate temperature normally lags the controller setting by 2 minutes during incremental increases.)

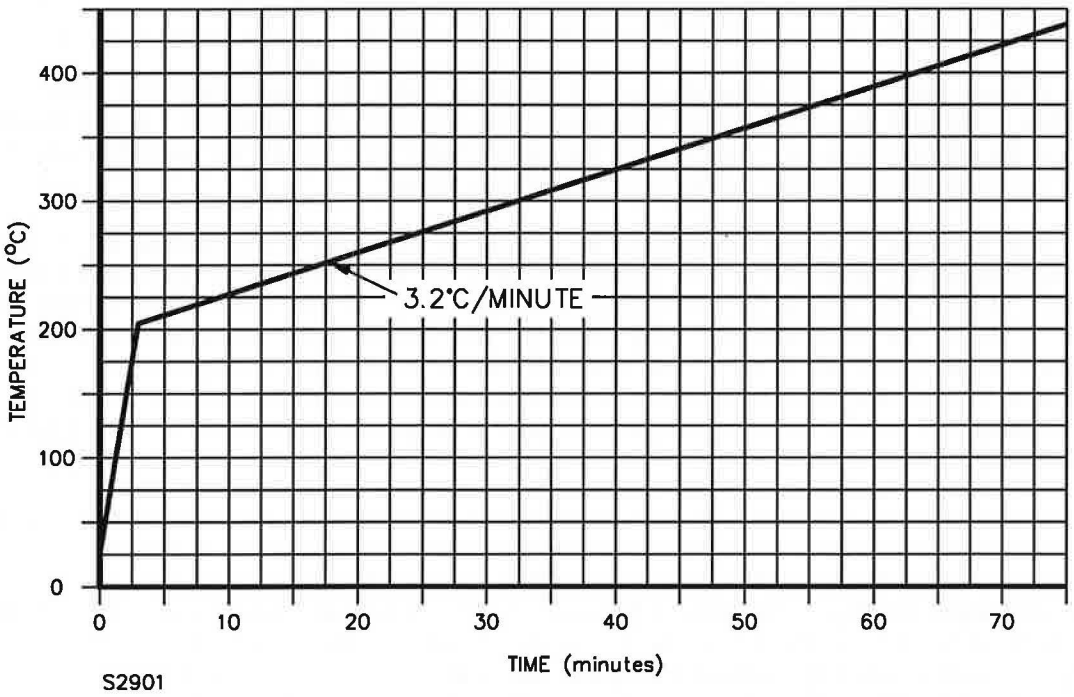
[m]A hotplate for this purpose is Emerson Electric Co., Series PH-400 Chromalox.

45.5 The Smoldering Smoke Test is to be conducted in the same room and ambient conditions and under the same mounting conditions as employed for the Fire Tests. See 44.7.1 – 44.7.3 and 44.7.5. The alarm samples are to be energized from a source of supply in accordance with 33.3.1 except that alarms powered from a battery shall be energized by batteries that are depleted to their trouble signal voltage levels unless the minimum sensitivity is measured at rated battery voltage.

Table 45.1
Hotplate temperature

Time (minutes)	Hot plate temperature
0	23 ±2°C (73 ±4°F)
0 – 3	Increased 60.7°C (109°F) per minute to 205°C (401°F)
3 +	Increased 3.2°C (5.8°F) per minute for remainder of test

Figure 45.1
Hotplate temperature profile



45.6 All alarms shall respond to the test trial before the obscuration level exceeds 10.0 percent per foot (29.26 percent per meter) [0.0458 OD/foot (0.15 OD/m)] at the alarm location as measured by the photocell-lamp assembly described in 37.3.3 (f) and (m). Flaming of the wood shall not occur before the obscuration level is reached.

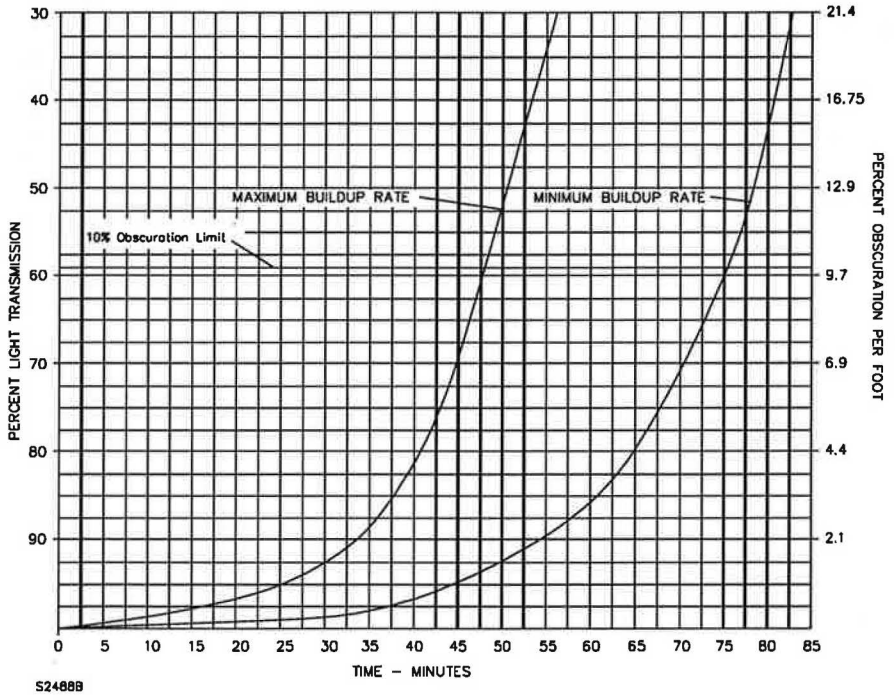
45.7 For this test, the visible smoke buildup rate is to be maintained within the limits illustrated in Figure 45.2. At no time during the test trial shall the buildup rate exceed 5 percent obscuration per minute as measured over the length of the 5 foot (1.5 m) light beam.

45.8 A Measuring Ionization Chamber (MIC)[n] is to be used to measure the relative buildup of particles of combustion during the test. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump. The monitoring head is to be located as shown in Figure 44.2.

[n]Cerberus Ltd., Mannedorf, Switzerland, or Electronikcentralen, Horsholm, Denmark, Measuring Ionization Chamber (MIC), Type EC 23095.

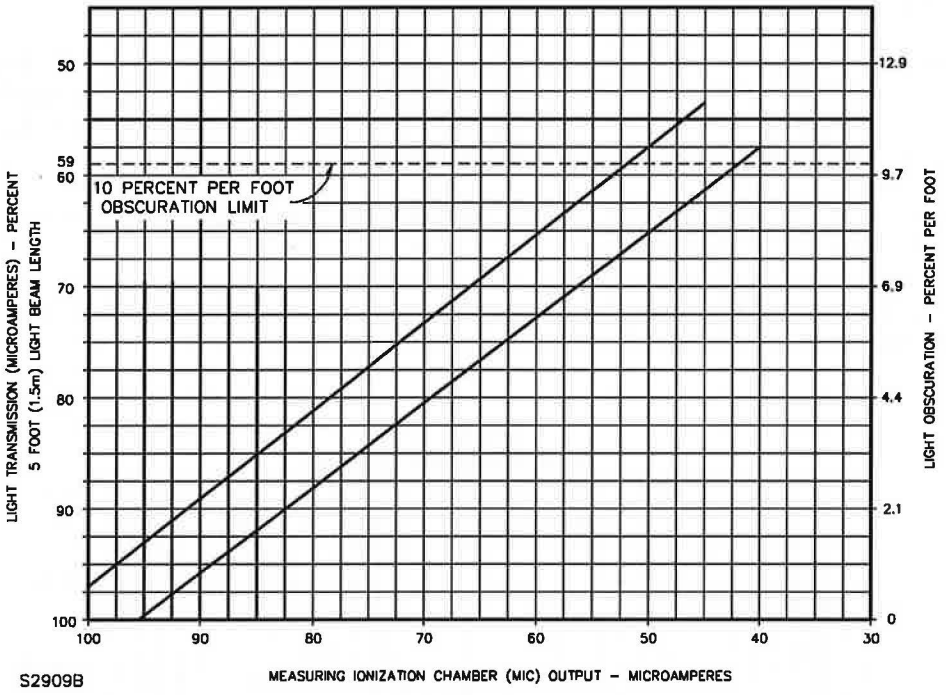
45.9 Prior to the test, the MIC shall be calibrated in clean air for a value of 100 picoamperes. As the smoke level increases during the test, the meter reading decreases.

Figure 45.2
Smoldering test profile



45.10 To determine the acceptability of the test trial, the relationship between the MIC output (ordinate) and the percent light transmission (abscissa) shall be plotted at 1 minute intervals during the test. The points generated shall remain within the curves illustrated in Figure 45.3.

Figure 45.3
Smoldering smoke test measuring ionization chamber/light beam limits



46 Smoldering Smoke Test (Maximum Obscuration Without Alarm)

46.1 Each of four alarms, calibrated to the maximum sensitivity anticipated in production, shall not alarm prior to an obscuration level of 0.5 percent per foot (1.65 percent/m), or less, measured in the alarm area when subjected to the Smoldering Smoke Test, Section 45.

46.2 All conditions for this test are to be as described for the Smoldering Smoke Test, Section 45, except that the four samples subjected to this test are to be adjusted to the maximum production sensitivity and the samples are to be oriented in the most favorable position facing the fire as determined in the Directionality Test, Section 39.

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47 Temperature Test

47.1 The materials or components employed in an alarm shall not be subjected to a temperature rise greater than that indicated in Table 47.1, under any condition of operation.

Exception: When failure of a component results in an audible trouble signal resulting in the temperature rise of the component in the standby condition to exceed the limits in Table 47.1, in no case shall it be greater than the temperature permitted under an alarm condition.

47.2 Except as noted in 47.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures, usually not higher than 25°C (77°F).

47.3 When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is to be made at the higher ambient temperature, and temperature rises specified in Table 47.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C (77°F).

47.4 Temperature measurements on equipment intended for recessed mounting are to be made with the unit installed in an enclosure of nominal 3/4-inch (19.1-mm) wood having clearance of 2 inches (50.8 mm) on the top, sides and rear, and the front extended to be flush with the smoke alarm cover.

47.5 A temperature is constant when three successive readings, taken at not less than 5 minute intervals, indicate no change.

47.6 Temperatures are to be measured by means of thermocouples consisting of wires not larger than No. 24 AWG (0.21 mm^2). The method of measuring the temperature of a coil shall be either the thermocouple or change-in-resistance method. The thermocouple method is not to be used for a temperature measurement at any point where supplementary thermal insulation is employed.

47.7 Thermocouples consisting of No. 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever referee temperature measurements by thermocouples are required.

47.8 The thermocouple wire is to comply with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

47.8 revised October 12, 2001

47.9 The temperature of a copper coil winding is determined by the change-in-resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the equation:

$$T = \frac{R}{r}(234.5 + t) - 234.5$$

in which:

T is the temperature to be determined in degrees C,

R is the resistance in ohms at the temperature to be determined,

r is the resistance in ohms at the known temperature,

t is the known temperature in degrees C.

Table 47.1
Maximum temperature rises

Device or material		Normal standby, °C	Normal standby, (°F)	Alarm condition, °C	Alarm condition, (°F)
A. COMPONENTS					
1. Capacitors		25	45	40	72
2. Fuses		25	45	65	117
3. Rectifiers – At any point					
a. Germanium		25	45	50	90
b. Selenium		25	45	50	90
c. Silicon	(1) Maximum 60 percent of rated volts	50	75	75	135
	(2) 60 percent > rated volts	25	45	75	135
4. Relays and other coils with:					
a. Class 105 insulated windings					
Thermocouple method		25	45	65	117
Resistance method		35	63	75	135
b. Class 103 insulated windings					
Thermocouple method		45	81	85	153
Resistance method		55	99	95	171
5. Resistors[a]					
a. Carbon		25	45	50	90
b. Wire wound		50	90	125	225
c. Other		25	45	50	90
6. Sealing compounds		15°C (27°F) less than its melting point			
7. Solid state devices		See Note[b]			
B. INSULATED CONDUCTORS[c]					
1. Appliance wiring material		25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord		35	63	35	63
C. ELECTRICAL INSULATION – GENERAL					
1. Fiber used as electrical insulation or cord bushings		25	45	65	117
2. Phenolic composition used as electric insulation or as parts where deterioration results in a risk of fire or electric shock		25	45	125	225

Table 47.1 Continued on Next Page

Table 47.1 Continued

Device or material	Normal standby, °C	Normal standby, (°F)	Alarm condition, °C	Alarm condition, (°F)
3. Varnished cloth	25	45	60	108
D. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood or other combustible material	25	45	65	117

[a] When the temperature rise of a resistor other than a line voltage dropping resistor exceeds the value shown, the power dissipation shall be 50 percent or less of the resistor manufacturer's rating.

[b] The temperature of a solid state device (for example, transistor, SCR, integrated circuits), shall not exceed 50 percent of its rating during the Normal Standby Condition. The temperature of a solid state device shall not exceed 75 percent of its rated temperature under the Alarm Condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) is 0 percent. For integrated circuits the loading factor shall not exceed 50 percent of its rating under the Normal Standby Condition and 75 percent under any other condition of operation. Both solid state devices and integrated circuits are be operated up to the maximum ratings under any one of the following conditions:

1. The component complies with the requirements of MIL-STD. 883C.

2. A quality control program is established by the manufacturer consisting of inspection and test of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.

3. Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by a recalibration of the sensitivity and retested.

[c] For standard insulated conductors other than those identified, reference shall be made to the National Electrical Code, ANSI/NFPA 70 : the maximum temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

47.10 As it is required to de-energize the winding before measuring R, it is appropriate for the value of R at shutdown to be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time shall be plotted and extrapolated to give the value of R at shutdown.

47.11 To determine compliance with this test, an alarm is to be connected to a source of supply in accordance with 33.3.1 and operated under the following conditions:

a) Standby – 16 hours minimum. Constant temperatures.

b) Alarm – 1 hour.

c) Alarm – 7 hours or to battery depletion. Abnormal test.

47.12 When the temperature limits for 47.11 (c) are exceeded there shall be no manifestation of a fire or approaching failure, and the alarm shall operate as intended following the test.

47.13 The alarm is to be subjected to the Dielectric Voltage-Withstand Test, Section 54, following 47.11 (b) or (c).

48 Overload Test

48.1 Detector

48.1.1 An alarm other than that operating from a primary battery shall be capable of operating as intended after being subjected to 50 cycles of alarm signal operation at a rate of not more than 6 cycles per minute with the supply circuit to the detector at 115 percent of the rated test voltage. Each cycle shall consist of starting with the alarm energized in the standby condition, initiation of an alarm by smoke or equivalent means, and restoration of the alarm to standby.

48.1.2 Rated test loads are to be connected to those output circuits of the alarm which are energized from the alarm power supply, such as remote indicators, relays, and other devices. The test loads shall be those devices, or the equivalent, normally intended for connection. When an equivalent load is employed for a device consisting of an inductive load, a power factor of 60 percent is to be employed. The rated loads are established initially with the alarm connected to a source of supply in accordance with 33.3.1 following which the voltage is increased to 115 percent of rating.

48.1.3 For direct current rated signaling circuits, an equivalent inductive test load is to have the required DC resistance for the test current and the inductance (calibrated) to obtain a power factor of 60 percent when connected to a 60 hertz AC potential equal to the rated DC test voltage. When the inductive load has both the required DC resistance and the required inductance, the current equals 0.6 times the current measured with the load connected to a DC circuit when the voltage of each circuit is the same.

48.2 Separately energized circuits

48.2.1 Separately energized circuits of an alarm, such as dry contacts, shall be capable of operating as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cycles per minute while connected to a source of supply in accordance with 33.3.1, with 150 percent rated loads at 60 percent power factor applied to output circuits which do not receive energy from the alarm. There shall be no electrical or mechanical failure of the switching circuit.

48.2.2 The test loads shall be set at 150 percent of rated current while connected to a separate power source of supply in accordance with 33.3.1.

49 Endurance Test

49.1 Smoke alarm

49.1.1 An alarm shall operate as intended after being subjected to 6000 cycles of 5 second alarm signal operation, at a rate of not more than 10 cycles per minute, with the alarm connected to a source of supply in accordance with 33.3.1 and with related devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical failure or evidence of failure of the alarm components. It is appropriate for battery operated units to be connected to an equivalent filtered DC power supply source for this test.

49.1.2 Sensitivity measurements, using aerosol, are to be recorded before and after the Endurance Test, in accordance with the Sensitivity Test, Section 37. The sensitivity values shall vary not more than specified in 34.4.1.

49.1.2 revised and effective date changed from August 21, 1998 to August 10, 1998

49.2 Separately energized circuits

49.2.1 Separately energized circuits of an alarm shall operate as intended, when operated for 6000 cycles at a rate of not more than 10 cycles per minute at a 50 percent duty cycle. When an electrical load is involved, the contacts of the device shall be made to make and break the normal current at the voltage specified by 33.3.1. The load is to represent that which the device is intended to control. The Endurance Tests of the separately energized circuits shall be conducted either separately or in conjunction with the Endurance Test of the alarm. There shall not be electrical or mechanical malfunction of the alarm nor malfunction or welding of any relay contacts.

Exception: When the contact rating is at least twice that of the load controlled, this test is not required.

49.3 Audible signaling appliance

49.3.1 The audible signaling appliance of each of two alarms shall operate as intended when the alarms are operated for 8 hours of alternate 5-minute periods of energization and de-energization in the standby and alarm conditions, followed by 72 hours of continuous energization in an alarm condition. For this test, the alarms are to be connected to a source of rated voltage and frequency. For a battery operated alarm, a filtered DC supply is to be employed that has an output voltage equivalent to the fresh battery voltage.

49.4 Test means

49.4.1 A sensitivity adjustment switch, test means, alarm silencing means, or reset switch provided on an alarm shall operate as intended after being operated for 1500 cycles at the rate of not more than 10 cycles per minute. The time of actuation of a test means is to be long enough to obtain at least 1 second of alarm. For this test one alarm is to be connected to a rated source of supply voltage and frequency. This test is to be conducted either separately or in conjunction with the Endurance Test of the alarm.

50 Variable Ambient Temperature Test

50.1 Operation in high and low ambient

50.1.1 An alarm shall operate for its intended signaling performance when tested in an ambient temperature of 0 and 49°C (32 and 120°F) at a relative humidity of 30 to 50 percent. Two alarms, one at maximum and one at minimum sensitivity, are to be maintained at each ambient temperature for at least 3 hours so that thermal equilibrium is reached. The units then are to be tested for sensitivity while connected to a source of supply in accordance with 33.3.1.

50.1.2 Sensitivity measurements shall be recorded before and during exposure to each ambient temperature in accordance with the Sensitivity Test, Section 37, except that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figures 50.1 and 50.2 for the 0°C (32°F) and 49°C (120°F) ambients, respectively. The visible smoke buildup rates are to be maintained within the limits illustrated in Figures 50.3 and 50.4 for the 0 and 49°C ambients, respectively.

50.1.3 Each unit shall operate as intended in each ambient. The sensitivity readings using gray smoke measured in each ambient temperature shall vary not more than specified in 34.4.1 from the value recorded prior to the Variable Ambient Temperature Test, Section 50, and shall not, in any case, exceed the limits specified in 37.1.1.

50.1.3 revised and effective date changed from August 21, 1998 to August 10, 1998

Figure 50.1
Sensitivity test limits – 0°C ambient – aerosol – 32 fpm

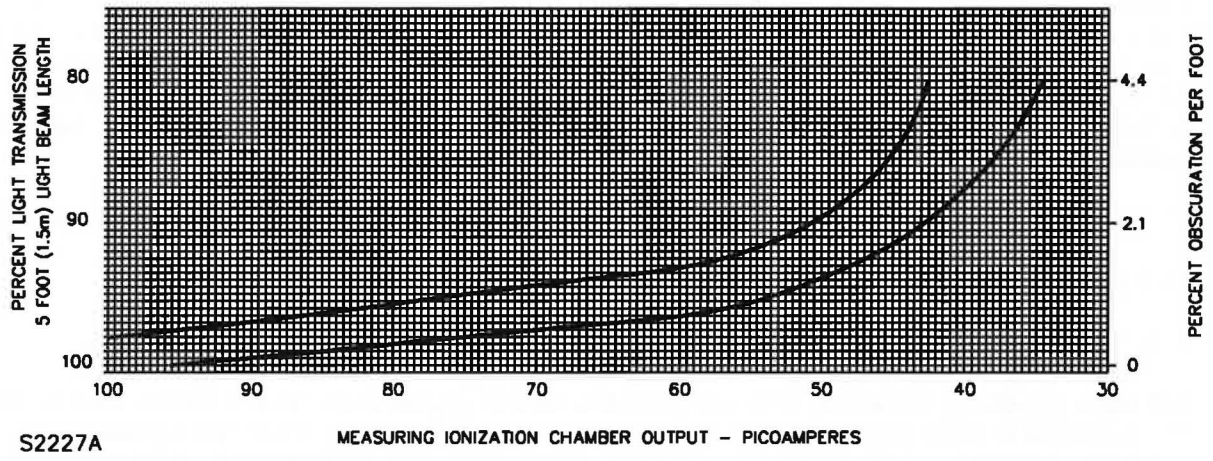


Figure 50.2
Sensitivity test limits – 49°C ambient – aerosol – 32 fpm

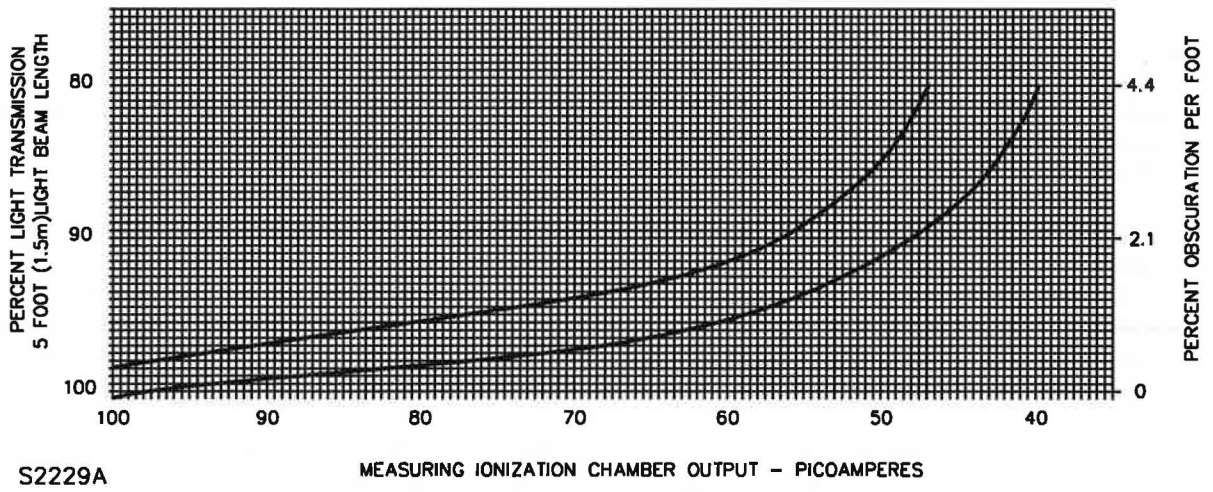


Figure 50.3
Smoke build-up rate – sensitivity test – 0°C ambient – aerosol – 32 fpm

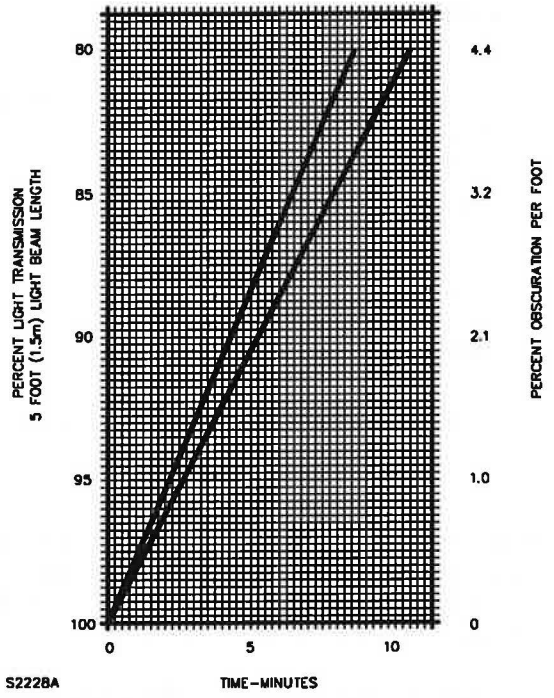
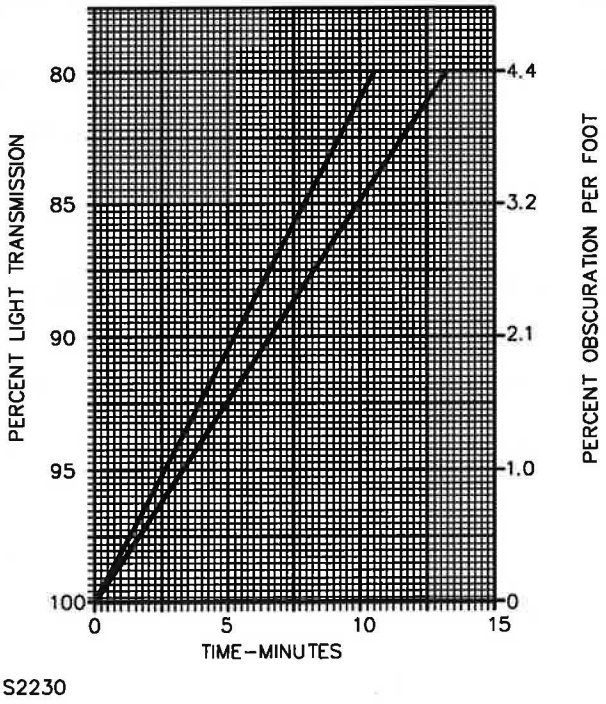


Figure 50.4
Smoke build-up rate – sensitivity test – 40°C ambient – aerosol – 32 fpm



50.2 Effect of shipping and storage

50.2.1 The sensitivity of an alarm shall not be impaired by exposure to high and low temperatures representative of shipping and storage.

50.2.2 Two alarms, one at maximum and one at minimum sensitivity, are to be subjected, in turn, to a temperature of 70°C (158°F) for a period of 24 hours, let to cool to room temperature for at least 1 hour, exposed to a temperature of minus 30°C (minus 22°F) for at least 3 hours, and then permitted to warm up to room temperature for at least 3 hours. The alarms then are to be tested for sensitivity using aerosol while connected to a source of supply in accordance with 33.3.1.

50.2.3 Sensitivity measurements are to be recorded, before and after exposure to both ambient conditions, in accordance with the Sensitivity Test, Section 37.

50.2.4 The sensitivity readings using aerosol measured after exposure shall vary not more than specified in 34.4.1.

50.2.4 revised and effective date changed from August 21, 1998 to August 10, 1998

51 Humidity Test

51.1 Two alarms, one at maximum and one at minimum sensitivity, shall operate for their intended signaling performance when exposed for 168 hours to air having a relative humidity of 93 ±2 percent at a temperature of 40 ±2°C (104 ±4°F) while energized from a source of supply in accordance with 33.3.1. There shall not be false alarms during the exposure.

51.2 Sensitivity measurements shall be recorded before and during exposure to the humidity condition in accordance with the Sensitivity Test, Section 37, except that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figure 37.2. The buildup rate is to be maintained within the limits represented by the curves illustrated in Figure 37.1.

51.3 The sensitivity values shall not vary more than specified in 34.4.1 from the value recorded prior to the Humidity Test.

51.3 revised and effective date changed from August 21, 1998 to August 10, 1998

51.4 Following the Humidity Test, a detector other than that operating from a primary battery, shall be subjected to the Leakage Current Test, Section 52.

52 Leakage Current Test

52.1 The leakage current of an alarm not operating from a primary battery shall not exceed 0.5 milliampere, AC or DC, after being subjected to the Humidity Test, Section 51, when measured as follows:

a) Between any exposed surface of an alarm that is contacted by a person and earth ground, and

b) Between any interior parts of an alarm that are contacted by a person during servicing and earth ground.

All grounding connections to the unit being tested are to be disconnected prior to making the measurement. The leakage current measurement is to be made at the supply connection polarity indicated on the installation wiring diagram supplied with the alarm and also with the polarity reversed. See Figure 52.1.

Revised 52.1 effective October 13, 2003

52.2 For this test the alarm is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. The leakage measurement then is to be made within 5 minutes of energization while in the standby and alarm conditions. The leakage current value is to be rms values for DC (nonfiltered rectified AC) and sinusoidal waveforms up to 1 kilohertz. For frequencies above 1 kilohertz the leakage current limit is to be the value given multiplied by the frequency in kilohertz up to a maximum multiplier of 100.

52.3 The test meter employed to measure the leakage current is to be an average responding AC milliammeter that indicates the rms value of a pure sine wave, having an error of not greater than 5 percent, and a maximum input impedance of 1000 ohms. For AC measurements, a DC milliammeter, with a maximum impedance of 1000 ohms in the test circuit, is to be employed.

52.4 When a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters (4 by 8 inches) placed in contact with the surface. Where the surface is less than 10 by 20 centimeters (4 by 8 inches), the metal foil is to be the same size as the surface. The metal foil is not to be pressed into openings and is not to remain in place long enough to affect the temperature of the sample.

52.5 When an alarm is intended for multiple station connection, leakage currents are to be measured with the maximum number of alarms intended to be interconnected, unless it is established by circuit analysis that the leakage current is independent of interconnection.

53 Transient Tests

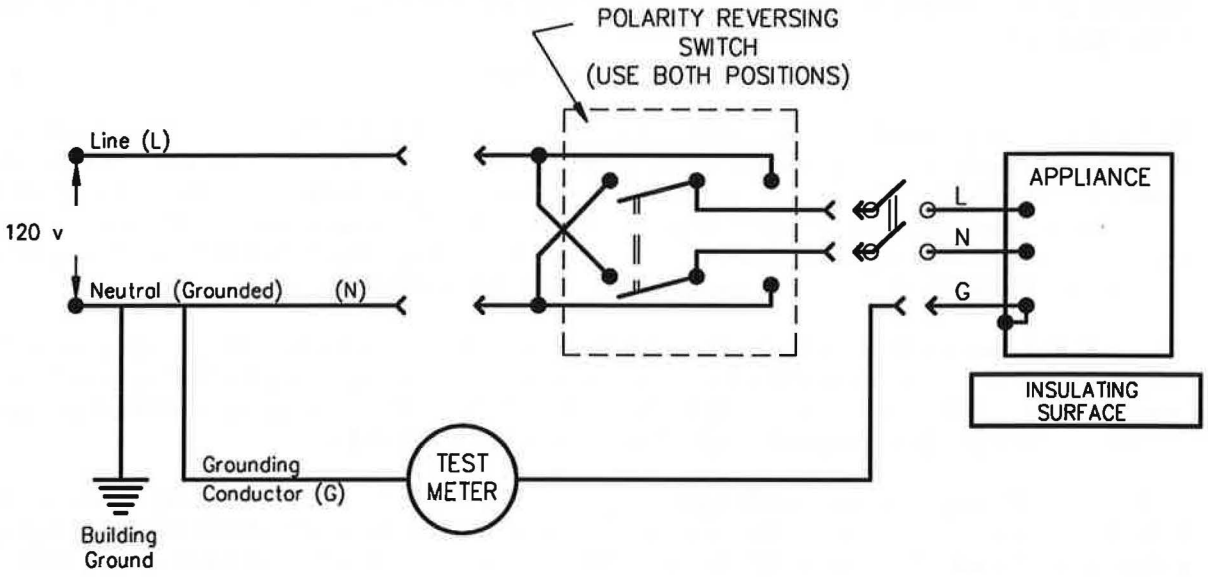
53.1 General

53.1.1 An alarm shall operate for its intended signaling performance with its sensitivity not affected adversely when two representative samples (one preset to the maximum and one preset to the minimum production sensitivity) are subjected to 500 supply line (high-voltage) transients, 500 internally induced transients, extraneous transients, and 60 supply line (low-voltage) circuit transients, while energized from a source of supply in accordance with 33.3.1 and connected to the device(s) intended to be used with the alarm.

53.1.2 Different alarms are to be used for each test. The alarms shall not false alarm for more than 1 second. Alarms using a primary battery as a power supply are to be subjected to the extraneous transients test only. When an alarm is intended for multiple-station connection, the transient tests are to be conducted with the maximum number of alarms intended to be connected.

53.1.3 Sensitivity measurements using aerosol, recorded before and after each transient condition, shall not vary more than specified in 34.4.1.

Figure 52.1
Leakage current measurement circuit



S2489

53.2 Supply line (high-voltage) transients

53.2.1 For this test, the alarm is to be connected to a transient generator, consisting of a 2 kilovolt-amperes isolating power transformer and control equipment capable of producing the transients described in 53.2.2. See Figure 53.1. The output impedance of the transient generator is to be 50 ohms.

53.2.2 The transients produced are to be oscillatory and have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transients are to decay to a value of no more than 50 percent of the value of the preceding peak. Each transient is to have a total duration of 20 microseconds.

53.2.3 Each unit is to be subjected to 500 oscillatory transient pulses induced at a rate of once every 10 seconds. Each transient pulse is to be induced 90 degrees into the positive half of the 60 hertz cycle.

53.3 Internally induced transients

53.3.1 The alarm is to be energized in the standby condition while connected to a source of supply in accordance with 33.3.1. The supply is to be interrupted for 1 second at a rate of not more than 6 cycles per minute for a total of 500 cycles. Following the test the alarm is operated for its intended signaling performance.

53.4 Extraneous transients

53.4.1 Single or multiple station smoke alarms shall not false alarm and their intended operation shall not be impaired when subjected to extraneous transients generated by the devices and appliances described in 53.4.2. In addition, the alarm shall respond to smoke during application of the transient condition.

53.4.2 Two single and two sets of multiple station smoke alarms are to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 1 foot (305 mm) from the alarm, interconnecting wires, or both. The time of application for the

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condition specified in (a) is to be at least 2 minutes. The conditions specified in (c), (d), and (e) are to be applied for 10 cycles, each application of 2 seconds duration, except the last application shall be of a 10-minute duration. Near the end of the last cycle, an abnormal amount of smoke is to be introduced into the alarm chamber to determine whether the unit is operational for smoke with the transient applied.

a) Sequential arc (Jacob's ladder) generated between two 15 inch (381 mm) long, No. 14 AWG (2.1 mm^2) solid copper conductors attached rigidly in a vertical position to the output terminals of an oil burner ignition transformer or gas tube transformer rated 120 volts, 60 hertz primary; 10,000 volts, 60 hertz, 23 milliamperes secondary. The two wires are to be formed in a taper starting with an 1/8 inch (3.2 mm) separation at the bottom (adjacent to terminals) and extending to 1-1/4 inches (31.8 mm) at the top.

b) Energization and transmission of random voice message of five separate transmitter-receiver units (cellular phones) in turn, and operating in the following nominal frequencies:

1) 27 megahertz,

2) 150 megahertz,

3) 450 megahertz,

4) 866 megahertz, and

5) 910 megahertz.

A total of six energizations in each of two orientations are to be applied from each transmitter-receiver; five to consist of 5 seconds on and 5 seconds off, followed by one consisting of a single 15-second energization. For this test, the cellular phones are to be in the same room and on the same plane as the detector under test. The cellular phones are to be positioned to generate a field strength of 20 volts/meter at the surface of the detector's printed-wiring board. The test is to be conducted with the antenna tip pointed directly at the detector, and at right angle to the first position centered on the detector.

c) Energization of an electric drill rated 120 volts, 60 hertz, 2.5 amperes.

d) Energization of a soldering gun rated 120 volts, 60 hertz, 2.5 amperes.

e) Energization of a 6-inch (152-mm) diameter solenoid-type vibrating bell° with no arc suppression and rated 24 volts.

°Edwards, Model 439D-6AW, vibrating bell rated 0.075 amperes, 20/24 volts DC or equivalent.

Effective date for 53.4.2 changed from August 21, 1998 to August 21, 1999

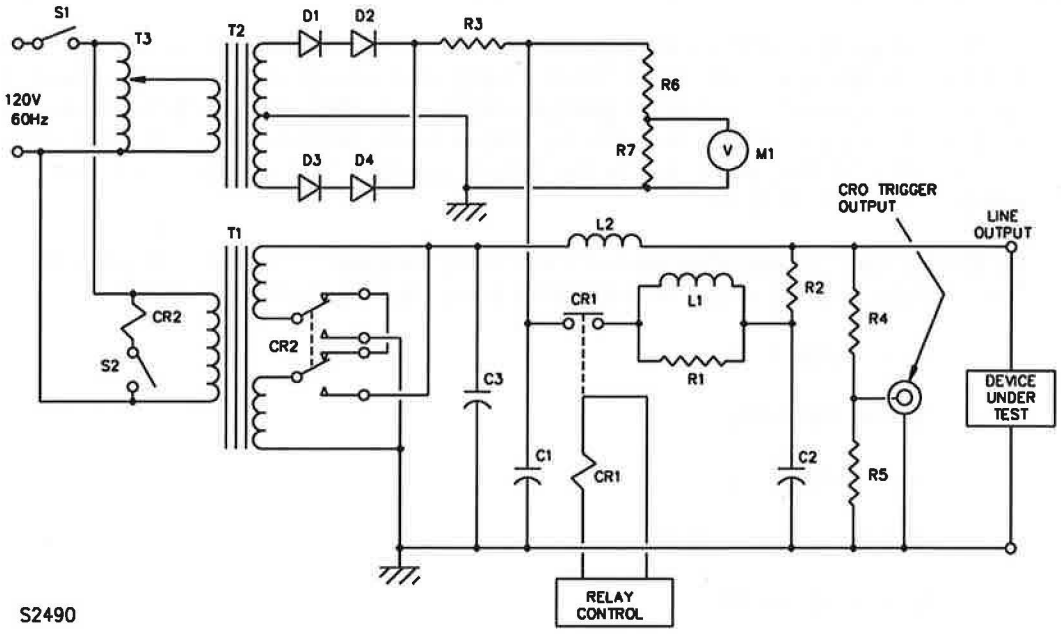
53.5 Supply line (low-voltage) circuit transients

53.5.1 Each of two low-voltage smoke alarms is to be subjected to 60 transient voltage pulses. The pulses are to be induced into:

a) The smoke alarm circuit intended to be connected to the low-voltage initiating device circuit of a system control unit and

b) The low-voltage power supply circuit of the alarm.

Figure 53.1
Surge generator circuit



C1	– Capacitor, 0.025 µF, 10 kV
C2	ndash; Capacitor, 0.006 µF, 10 kV
C3	– Capacitor, 10 µF, 400 V
CR1	– Relay, coil 24 VDC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 VAC maximum, all three poles wired in series.
CR2	– Relay, coil 120 VAC. Contacts DPDT. Provides either 120 V or 240 V test circuit.
D1	– D4 – Diodes, 25 kV PIV each
L1	– Inductor 15 µH [33 turns, No. 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]
L2	– Inductor, 70 µH [45 turns, No. 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]
M1	– Meter, 0 – 20 VDC
R1	– Resistor, 22 Ohms, 1 W, composition
R2	– Resistor, 12 Ohms, 1 W, composition
R3	– Resistor, 1.3 megohms, (12 in series, 110K ohms each, 1/2 W)
R4	– Resistor, 47K ohms (10 in series, 4.7K ohms each, 1/2 W)
R5	– Resistor, 470 ohms, 1/2 W
R6	– Resistor, 200 megohms, 2 W, 10 kV
R7	– Resistor, 0.2 megohms (2 in series, 100K ohms each, 2 W, carbon composition)
S1	– Switch, SPST
S2	– Switch, SPST, key-operated, 120 VAC, 1 A
T1	– Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)
T2	– Transformer, 90 VA, 120/15,000 V
T3	– Variable autotransformer, 2.5 A

53.5.2 For this test, each circuit is to be subjected to five different transient waveforms having peak voltage levels in the range of 100 to 2400 volts, as delivered into a 200 ohm load. A transient waveform at 2400 volts shall have a pulse rise time of 100 volts per microsecond, a pulse duration of 80 microseconds, and an energy level of 1.2 joules. Other applied transients shall have peak voltages representative of the entire range of 100 to 2400 volts, with pulse durations from 80 to 110 microseconds, and energy levels not less than 0.3 joule or greater than 1.2 joules.

53.5.3 The alarm is to be subjected to 60 transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (two at each transient voltage level specified in 53.5.2) between each circuit lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses) and

b) Twenty pulses (two at each transient voltage level specified in 53.5.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

53.5.4 At the conclusion of the test, the alarm shall comply with the requirements of the Normal Operation Test, Section 34, and the Sensitivity Test, Section 37.

54 Dielectric Voltage-Withstand Test

54.1 An alarm shall withstand for 1 minute, without breakdown, the application of a sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between high-voltage live parts and exposed dead metal parts, and live parts of high- and low-voltage circuits. The test potential is to be:

a) For an alarm rated 30 volts AC rms (42.4 volts DC or AC peak) or less – 500 volts (707 volts, when a DC potential is used).

b) For an alarm rated between 31 and 250 volts AC rms – 1000 volts (1414 volts, when a DC potential is used).

c) For an alarm rated more than 250 volts AC rms – 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, when a DC potential is used).

54.2 Any reference grounds are to be disconnected prior to the test applications.

54.3 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is capable of preventing maintenance of the specified AC test potential, The capacitors and capacitor-type filters are to be tested using a DC potential in accordance with 54.1.

54.4 The test potential is obtained from any convenient source having the capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. Starting at zero, the applied potential is to be increased at a rate of 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

54.5 A printed-wiring assembly or other electronic-circuit component that short circuits or is damaged by application of the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. It is not prohibited for a representative subassembly be tested instead of an entire unit.

55 Abnormal Operation Test

55.1 An alarm shall operate continuously under abnormal (fault) conditions without resulting in a risk of fire or electric shock.

55.2 To determine that an alarm complies with the requirement of 55.1, it is to be operated under the most severe circuit fault conditions to be encountered in service while connected to a source of supply in accordance with 33.3.1. There shall not be emission of flame or molten metal, or any other manifestation of a fire, or dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 54, after the abnormal test.

55.3 In determining that an alarm complies with the requirement with respect to circuit-fault conditions, the fault condition is to be maintained continuously until constant temperatures are attained, or until burnout occurs, when the fault does not result in the operation of an overload protective device. Shorting of the secondary of the power supply transformer and shorting of a limited-life electrolytic capacitor represents typical fault conditions. See 71.3.2.

56 Overvoltage and Undervoltage Tests

56.1 Overvoltage test

56.1.1 An alarm other than one operating from a main battery power supply shall operate as intended in the standby condition at both maximum and minimum sensitivity settings and while performing its signaling function and connected to a supply source of 110 percent of rated value. When a nominal rated voltage value is specified, the overvoltage shall be 110 percent of the test voltage specified in 33.3.1. When an operating voltage range is specified, the overvoltage shall be either 110 percent of the high value of the voltage range or 110 percent of the test voltage specified in 33.3.1, whichever is higher. Sensitivity measurements at the increased voltage shall vary not more than specified in 34.4.1.

56.1.1 revised and effective date changed from August 21, 1998 to August 10, 1998

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

56.1.3 For operation at the higher voltage, three alarms are to be subjected to the specified increased voltage in the standby condition for at least 16 hours, or as specified by the manufacturer, and then tested for their intended signaling operation and sensitivity.

56.2 Undervoltage test

56.2.1 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 34.4.1 from the readings measured at rated voltage.

56.2.1 revised and effective date changed from August 21, 1998 to August 10, 1998

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

56.2.3 When the 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.

56.2.4 For operation at the reduced voltage, three alarms are to be energized from a source of supply in accordance with 33.3.1, following which the voltage is to be reduced to 85 percent of the test voltage specified in 33.3.1 for AC operated alarms, or the battery trouble level voltage for battery operated alarms, and then tested for signaling operation and sensitivity.

57 Dust Test

57.1 The sensitivity of an alarm shall not be reduced abnormally by an accumulation of dust, without an alarm or audible trouble signal being produced.

57.2 To determine compliance with 57.1, a sample in its intended mounting position, is to be placed, de-energized, in an air tight chamber having an internal volume of at least 3 cubic feet (0.09 m^3).

57.3 Two ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of 23 ±2°C (73.4 ±3°F) at 20 – 50 percent relative humidity and capable of passing through a 200 mesh screen, is to be circulated for 15 minutes by means of compressed air or a blower so as to completely envelop the sample in the chamber. The air flow is to be maintained at an air velocity of 50 fpm (0.25 m/s).

57.4 Following the exposure to dust, the alarm is to be removed carefully, mounted in its intended position, energized from a source of supply in accordance with 33.3.1, and tested for sensitivity using gray smoke, unless a trouble signal or a false alarm is obtained. Sensitivity measurements following this test shall not vary by more than specified in 34.4.1. For those units whose sensitivity varies by more than 50 percent in the direction of high sensitivity, the unit shall be capable of being returned to its initial sensitivity value (plus or minus 0.25 percent per foot obscuration) after following the manufacturers specified cleaning procedure.

57.4 revised and effective date changed from August 21, 1998 to August 10, 1998

58 Static Discharge Test

58.1 The components of an alarm shall be shielded so that its operation is not adversely affected when subjected to static electric discharges. Operation of the trouble circuit during this test is not a failure when the subsequent operation of the alarm is not impaired. During the test a 5 second or less false alarm is permitted. The test is to be conducted in an ambient temperature of 23 ±3°C (73 ±5°F), at a relative humidity of 10 ±5 percent, and a barometric pressure of not less than 700 mm of mercury (194 kPa).

58.2 Each of two alarms is to be mounted in its intended mounting position and connected to a source of supply in accordance with 33.3.1. When an alarm is intended to be installed on a metal back box, the box is to be connected to earth ground. A 250 picofarad low leakage capacitor, rated 10,000 volts dc, is to be connected to two high-voltage insulated leads, 3 feet (0.9 m) long. A 1500 ohm resistor is to be inserted in series with one lead. The end of each lead is to be attached to a 1/2 inch (12.7 mm) diameter metal test probe with a spherical end mounted on an insulating rod. The capacitors are to be charged by touching the ends of the test leads to a source of 10,000 volts DC for at least 2 seconds for each discharge. One probe is to be touched to the alarm and the other probe is then to be touched to earth ground.

58.3 Ten discharges are to be applied to different points on the exposed surface of the alarm, recharging the capacitors for each discharge. Five discharges are to be made with one lead connected to earth ground and the other lead probed on the alarm surface followed by five discharges with the polarity reversed. For an alarm intended to be serviced by the consumer, ten additional discharges shall be applied as described above except each lead shall be probed, in turn, on all internal parts subject to contact by the user.

58.4 Following the discharges, the alarm is to be tested for sensitivity. Sensitivity measurements shall be as specified in 34.4.1.

58.4 revised and effective date changed from August 21, 1998 to August 10, 1998

59 Vibration Test

59.1 An alarm shall withstand vibration without breakage or damage of parts. Following the vibration, the alarm shall operate for its intended signaling operation.

59.2 To determine compliance with 59.1, sensitivity measurements following the vibration shall vary not more than specified in 34.4.1.

59.2 revised and effective date changed from August 21, 1998 to August 10, 1998

59.3 Two samples, one at the maximum and one at the minimum sensitivity setting, are to be secured in their intended mounting position on a mounting board and the board, in turn, securely fastened to a variable speed vibration machine having an amplitude of 0.01 inch (0.25 mm). The frequency of vibration is to be varied from 10 to 35 cycles per second in increments of 5 cycles per second until a resonant frequency is obtained. The samples are then to be vibrated at the maximum resonant frequency for a period of 1/4 hour. In cases where no resonant frequency is obtained, the samples are to be vibrated at 35 cycles per second for a period of 4 hours.

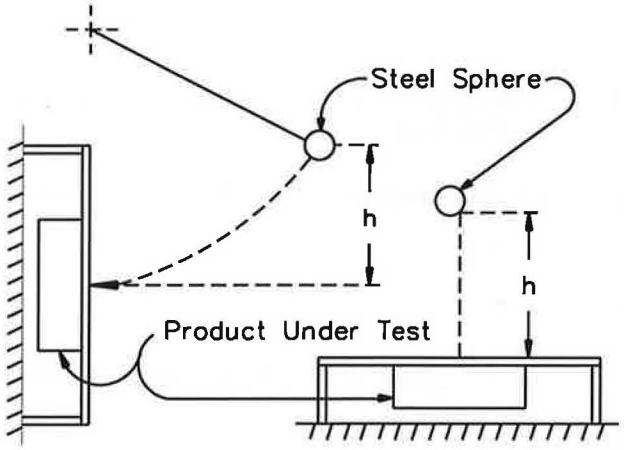
59.4 For tests, amplitude is defined as the maximum displacement of sinusoidal motion from a position of rest or one-half of the total table displacement. Resonance is defined as the maximum magnification of the applied vibration.

60 Jarring Test

60.1 An alarm shall withstand jarring resulting from impact and vibration such as experienced in service, without causing an alarm signal, without dislodgement of any parts, and without adversely affecting its subsequent operation. A momentary audible trouble signal, resulting from the jarring shall not occur unless the detector operation is not affected. Dislodgement of parts shall not occur unless the dislodged part(s) does not affect the operation of the unit, there are no high-voltage parts exposed, and the condition is visually obvious.

60.2 The alarm and any associated equipment are to be mounted in a position of intended use, see Figure 60.1, to the center of a 6 by 4 foot (1.8 by 1.2 m), nominal 3/4-inch (19.1-mm) thick plywood board which is secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound (0.54 kg), 2-inch (50.8-mm) diameter steel sphere either swung through a pendulum arc from a height (h) of 2.54 feet (775 mm), or dropped from a height (h) of 2.54 feet (775 mm), to apply 3 foot-pounds (4.08 J) of energy.

Figure 60.1
Jarring test



(1)
Test Method For Unit Intended to be Mounted Vertically

(2)
Test Method For Unit Intended to be Mounted Horizontally

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60.3 During this test, the alarm is to be in the standby condition and connected to a rated source of supply in accordance with 33.3.1. Following the test, sensitivity measurements shall vary not more than specified in 34.4.1.

60.3 revised and effective date changed from August 21, 1998 to August 10, 1998

61 Corrosion Test

61.1 General

61.1.1 An alarm shall operate as intended after being subjected to the corrosive atmosphere tests described in 61.1.2 – 61.2.1. The samples are to be placed in the test chambers that are located in an ambient room temperature of 23 ±2°C (73.4 ±3°F), maintained at 20 – 50 percent relative humidity, and are to be mounted in the intended position of use on a platform 2 inches (50.8 mm) above the bottom of the exposure chamber. The relative humidity inside the chamber during the test is to be 95 percent.

61.1.2 Moist Hydrogen Sulfide-Air Mixture Exposure – Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for a period of 10 days. The amount of hydrogen sulfide is to be equivalent of 0.1 percent of the volume of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

61.1.3 Moist Carbon Dioxide-Sulfur Dioxide-Air Mixture Exposure – Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist carbon dioxide-sulfur dioxide-air mixture in a closed glass chamber for a period of 10 days. The amount of carbon dioxide is to be the

equivalent of 1.0 percent, and the amount of sulfur dioxide is to be the equivalent of 0.5 percent of the volume of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

61.2 Test equipment

61.2.1 A typical test apparatus for the carbon dioxide-sulfur dioxide-moist air exposure test and the hydrogen sulfide-moist air exposure test consists of:

a) Compressed Gas Cylinders (Commercial Grade SO_2, Bone Dry Grade CO_2, C.P. Grade H_2S).

b) Needle Valves (to adjust flow).

c) Selector Valve (selects CO_2 or SO_2).

d) Flowmeters (used in conjunction with stopwatch to measure gas volume).

e) Gas inlets to exposure chamber.

f) Glass exposure chamber with glass cover (holes in cover for gas inlet and outlet).

g) Small motor and fan blade. [1550 rpm motor with aluminum fan blade, ten 3-1/2 inch (88.9 mm) wings providing air movement toward motor. Neoprene gasket used to seal shaft through-hole in glass cover.]

h) Support Platform (plastic "egg-crate" grid material).

i) Test Sample. Normally two employed.

Different type chambers shall not be used unless the equivalent gas concentrations and water are maintained.

61.2.2 The alarms are to be tested for sensitivity using gray smoke prior to exposure to the corrosive atmospheres. Following the corrosive exposures described in 61.1.2 and 61.1.3, the alarms are to be dried in a circulating air oven at a temperature of 40°C (104°F) for a period of at least 24 hours, after which the alarms are to be tested again for sensitivity. When sensitivity measurements following the exposure to the corrosive atmospheres vary by more than the limits specified in 34.4.1 in the direction of high sensitivity there shall be no false alarm. The sensitivity shall not vary by more than the limits specified in 34.4.1 in the direction of low sensitivity. In no case, shall the sensitivity exceed the limits specified in the Sensitivity Test, Section 37.

61.2.2 revised and effective date changed from August 21, 1998 to August 10, 1998

61.2.3 Alarms are to be subjected to the corrosive atmospheres while de-energized so as not to produce an alarm signal. Battery operated alarms are to be tested with the batteries in place, and the leads to the clips disconnected for the same reason. After the exposure the leads are to be reconnected and the Sensitivity Test, Section 37, conducted.

62 Reduction in Light Output Test

62.1 The sensitivity of an alarm employing an LED as the functional light source shall not be reduced abnormally when the light output from the LED is reduced to 50 percent of normal or to the light level anticipated at the end of the Reliability Prediction described in Alarm Reliability Prediction, Section 4.

62.2 To determine compliance with 62.1, five samples calibrated to the minimum sensitivity, are to be subjected to the Sensitivity Test, Section 37, while connected to a source of rated voltage and frequency. Following this, the light output from the LED is to be reduced to 50 percent of intended output, or to the light level anticipated at the end of the reliability prediction, when less than 50 percent, by reducing the supply voltage to the alarm, or an equivalent method. (The level of reduction of light is to be determined initially by means of a light meter, review of curve sheets, or the equivalent.) The samples shall then be subjected to the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45.

Effective date for 62.2 changed from August 21, 1998 to August 21, 1999

62.3 Effective date for deleted 62.3 changed from August 21, 1998 to August 21, 1999

Effective date for 62.3 changed from August 21, 1998 to August 21, 1999

63 Battery Tests

63.1 Where a battery is employed as the main source of power of a smoke alarm, it shall provide power to the unit under intended ambient conditions for at least 1 year in the standby condition, including novelty and weekly alarm testing, and then operate the alarm for a minimum of 4 minutes of alarm, followed by 7 days of trouble signal. See 36.3.1.

63.2 Six samples of the battery, or sets of batteries when more than one is used for primary power, are to be tested under each of the following ambient conditions for a minimum of 1 year while connected to the alarm or a simulated load to which the battery is to supply power.

a) Room Ambient – 23 ±3°C (73.4 ±5°F), 30 – 50 percent relative humidity, 760 mm Hg.

b) High Temperature – 45°C (113°F).

c) Low Temperature – 0°C (32°F).

d) Humidity – 30 ±2°C (86 ±3°F), 85 ±5 percent relative humidity.

63.3 For the test, either alarm samples or test loads simulating a maximum standby current drain are to be employed. The alarm load is to be the audible appliance intended to be used in the smoke alarm or an appropriate load simulating maximum alarm conditions. The batteries are to be tested in the mounting clips employed in the alarm.

63.4 Terminals or jacks are to be provided on each test means to facilitate measurement of battery voltage, standby, and alarm currents. The measuring means is to be separated from the battery test means by a wiring harness or equivalent at least 3 feet (0.9 m) long.

63.5 Prior to placing the battery test setups in the various ambient conditions, each battery is to be subjected to 25 cycles of alarm representing novelty testing. Each cycle is to consist of 5 seconds of alarm and at least 5 minutes between each application.

63.6 During the course of the test, the battery voltage and current in standby and alarm condition are to be recorded periodically. The alarm voltage is to be recorded 3 seconds after energization. The standby voltage and current are to be recorded prior to the alarm measurements. The smoke alarm is to be placed into an alarm condition weekly. The duration of the weekly alarm test signal is to be 3 seconds.

63.7 At the end of the year, all batteries shall have a capacity capable of operating the alarm signal for a minimum of 4 minutes, followed by 7 days of trouble signal. To obtain the trouble signal level it is sometimes required to continue the test with the standby current drain for longer than 1 year.

Batteries shall be subjected to the conditions described in 63.2 (b), (c), and (d) for a minimum of one year unless the alarm is marked to indicate the battery limitations for the condition involved. In no case shall the length of conditioning be less than 6 months.

64 Survivability Test

64.1 Two samples of the smoke alarm shall be exposed to a temperature of 121°C (250°F) for a period of 4 minutes. The units are to be removed from the test chamber and returned to room temperature. The units are then to be subjected to the Audibility Test, Section 65, and the Sensitivity Test, Section 37.

Effective date for 64.1 changed from August 21, 1998 to August 21, 1999

64.2 Following conditioning, the samples shall be capable of producing on audible output of 85 db (A), at 10 feet (3.05 m), and the sensitivity of each alarm shall not vary by more than specified in 34.4.1.

64.2 revised and effective date changed from August 21, 1998 to August 10, 1998

65 Audibility Test

65.1 General

65.1.1 Except as permitted in 65.2.1, the alarm sounding appliance, either integral with the smoke alarm or intended to be connected separately, shall be capable of providing for at least 4 minutes, a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 85 decibels (db) at 10 feet (3.05 m) with two reflecting planes assumed. To determine compliance with this paragraph the method described in 65.2.1 – 65.3.2 is to be employed. It is appropriate for alarms to be tested with the horn duty cycle specified in 34.3 defeated and emitting a continuous tone.

65.1.1 revised June 10, 1997

65.2 Sound output measurement

65.2.1 The sound power output of the alarm shall be measured in a reverberation room using procedures outlined in ANSI Standards S12.31 (Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms) or S12.32 (Precision Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow Band Noise Sources in Reverberation Rooms). The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power is to be determined on the basis of actual power. The total power is then to be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m). An additional 6 db is to be added to allow for two reflecting planes.

65.2.2 Each alarm is to be mounted to a 3/4 inch (19.1 mm) plywood board measuring 2 by 2 feet (610 by 610 mm), supported in a vertical plane, and positioned at an angle of 45 degrees to the walls of the reverberation room.

65.2.3 For this test an AC powered alarm is to be energized from a source of rated voltage and frequency. A battery powered alarm is to be energized from batteries under each of the following conditions along the trouble signal level curve illustrated in Figure 35.2, or equivalent:

a) Nondischarged battery (a battery with some unknown shelf life, such as those purchased at a retail outlet) with enough added resistance to obtain a trouble signal (Point D of Figure 35.2), or the maximum resistance for the particular battery based on documented data, whichever is less.

b) Battery depleted to the trouble signal level voltage, no added resistance.