c) Battery depleted to a voltage value between conditions A and B above which is evaluated to be the least favorable for sound output. For a straight line curve it is the midpoint voltage. For a nonlinear curve it is to be specified.

The equivalent of a battery shall be identified as a voltage source with a series resistance adjusted to a level at which a trouble signal is obtained during the normal standby condition. The resistance and voltages used are to be those that were determined during the Circuit Measurement Test, Section 35.

65.2.4 At least two samples shall be tested. Units intended for multiple-station connection shall also be tested interconnected as multiple-stations with the maximum line resistance as defined in 56.2.2. For AC powered units employing a nonrechargeable standby battery, the measurement shall be made with the detector connected to a rated AC voltage source, and then with the AC power de-energized and energy obtained from a standby battery depleted to 85 percent of rated battery voltage, or at the voltage level at which a trouble signal is obtained. For an AC unit employing a rechargeable standby battery, the measurement is to be made using a fully recharged battery.

65.3 Alarm duration test

65.3.1 An alarm sounding appliance of an alarm powered by a primary or secondary battery that has been discharged to the trouble level condition shall provide the equivalent of 85 db at 10 feet (3.05 m) after 1 minute of continuous alarm operation and shall provide at least 82 db after 4 minutes.

65.3.2 To determine compliance with 65.3.1, a measurement shall be made under the following conditions. The ambient noise level is to be at least 10 db below the measured level produced by the signaling appliance. The alarm is to be mounted 1 foot (302 mm) from the microphone placed in a direct line with the alarm. The alarm is then to be energized in the alarm condition and the sound output is to be measured at 1 minute intervals, using a sound level meter[P] employing the A-weighting network. A maximum of 3 db decrease from the original 1 minute reading, after 4 minutes shall determine compliance for a battery operated alarm that is providing a trouble signal.

[P]One meter for the purpose is a General Radio, Type 1551, sound level meter (Type II).

65.4 Supplementary remote sounding appliances

65.4.1 The sound output of a supplementary remote sounding appliance, intended to be installed in the same room as a user (such as a bedroom), shall not be less than 85 db unless the appliance is marked with the following, or equivalent, text to indicate the specific use:

"THIS UNIT IS TO BE INSTALLED IN A ROOM OCCUPIED FOR SLEEPING."

Under no circumstances is the sound output to be less than 75 db.

66 Tests of Thermoplastic Materials

66.1 General

66.1.1 Polymeric materials intended for the sole support of current carrying parts or as an enclosure of an alarm shall be subjected to the tests specified in 66.2 and 66.3. When possible, a complete alarm is to be used.

66.2 Accelerated air-oven aging test

66.2.1 There shall not be warping or exposure of high-voltage uninsulated current-carrying parts so as to impair operation or provide access to uninsulated high-voltage parts when representative samples of a plastic material are aged for 7 days in a circulating-air oven maintained at 90°C (194°F), or 28 days at a temperature of 70°C (158°F), and at a relative humidity of 0 – 10 percent.

66.2.1 revised August 10, 1998

66.2.2 At least three representative samples are to be mounted on supports as intended in service and placed in the oven. At the end of the aging period indicated in 66.2.1, the samples are to be removed, permitted to cool, and then examined for adverse distortion. Falling off of an alarm cover shall not occur during the test unless high-voltage parts are not exposed, operation for smoke is not affected, and the cover is replaceable as intended. Sensitivity measurements shall not vary by more than the limits specified in 34.4.1.

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

66.3 Flame test (3/4 inch)

66.3.1 When equipment is tested as described in 66.3.2 – 66.3.6, the material shall not flame for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame. The sample shall not be completely consumed.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, V-2, by the vertical burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the flammability test described in 66.3.2 – 66.3.6.

66.3.1 revised January 4, 1999

66.3.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature not less than 10°C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, and not less than 70°C (158°F) in any case. The samples are to remain in the oven for 7 days. After cooling to room temperature for a minimum of 4 hours, the samples are to be tested as described in 66.3.3 – 66.3.6.

Exception: Testing is required on only three unconditioned test samples when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

66.3.3 Three samples of the part are to be subjected to the Flame Test described in 66.3.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Nonpolymeric portions are not to be removed and insofar as possible, the internal mechanism of the equipment is to be in place. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. Each sample is to be tested with the flame applied to a different location.

Exception: Only three unconditioned test samples are required for testing when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

66.3.4 With reference to 66.3.3, the sections judged capable of becoming ignited are to be those adjacent to coil windings, splices, open-type switches, or arcing parts.

66.3.5 The flame of a Bunsen or Tirrill burner having a tube with a length of 9.5 ±0.3 mm (0.374 ±0.12 inch) and an inside diameter of 100 ±10 mm (3.94 ±0.39 inches) is to be adjusted to have a 3/4 inch (19 mm) height of yellow flame with no blue cone. Two 30 second applications of the tip of the flame are to be made to each section of the equipment specified as indicated above, with 1 minute intervals between the applications. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception: Natural gas having a heat content of 1000 Btu/ft^3 (37 MJ/m^3 at 23°C) has been found to provide similar results and is appropriate for use.

66.3.6 When one sample from a set of three does not comply with 66.3.1, an additional set of three samples shall be tested. All samples from the second set shall comply with 66.3.1.

66.4 Flame test (5 inch)

66.4.1 When equipment is tested as described in 66.4.1 – 66.4.5, all of the following results shall be obtained:

a) The material shall not continue to burn for more than 1 minute after the fifth 5-second application of the test flame, with an interval of 5 seconds between applications of the flame;

b) Flaming drops or flaming or glowing particles that ignite surgical cotton 12 inches (305 mm) below the test specimen shall not be emitted by the test sample at any time during the test; and

c) The material shall not be destroyed in the area of the test flame to such an extent that the integrity of the part is affected with regard to containment of fire or exposure of high voltage parts.

Exception: Parts that are molded from materials that are classed as 5VA by the five inch burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the flammability tests described in 66.4.1 – 66.4.6.

66.4.1 revised January 4, 1999

66.4.2 Three samples of the complete equipment or three test specimens of the molded part shall be subjected to this test. Consideration is to be given to leaving in place components and other parts that influence the performance. The test samples are to be conditioned in a full draft circulating air oven for 7 days at 10°C (18°F) greater than the maximum use temperature and not less than 70°C (158°F) in any case. Prior to testing, the samples are to be conditioned for a minimum of 40 hours at 23.0 ±2.0°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. When more than one part is near a source of ignition, each sample is to be tested with the flame applied to a different location.

Exception: Only three unconditioned test samples are required for testing when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

66.4.3 The three samples shall perform as described in 66.4.1. When one sample does not comply, the test is to be repeated on a set of three new samples with the flame applied under the same conditions as for the unsuccessful sample. All the new specimens shall comply with 66.4.1.

66.4.4 The Bunsen or Tirrill burner with a tube length of 9.5 ±0.3 mm (0.374 ±0.12 inch), and an inside diameter of 100 ±10 mm (3.94 ±0.39 inches), is to be placed remote from the specimen, ignited, and adjusted so that when the burner flame is 5 inches (127 mm), the height of the inner blue cone is 1-1/2 inches (38 mm). The tube is not to be equipped with end attachments, such as stabilizers.

66.4.5 When a complete enclosure is used to conduct the flame test, the sample is to be mounted as intended in service, as long as it does not impair the flame testing, in a draft-free test chamber, enclosure, or laboratory hood. A layer of surgical cotton is to be located 12 inches (305 mm) below the point of application of the test flame. The 5-inch (127-mm) flame is to be applied to any portion of the interior of the part judged as capable of being ignited (by its proximity to live or arcing parts, coils, wiring, or other possible sources of ignition) at an angle of 20 degrees from the vertical so that the tip of the blue cone touches the specimen. The test flame is to be applied to three different locations on each of the three samples tested. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception No. 1: The flame to shall be applied to the outside of an enclosure when the equipment is of the encapsulated type, or of a size that prohibits the flame being applied inside.

Exception No. 2: Natural gas having a heat content of 1000 Btu/ft^3 (37 MJ/m^3 at 23°C) has been found to provide similar results and is appropriate for use.

66.4.6 The flame is to be applied for 5 seconds and removed for 5 seconds. The operation is to be repeated until the specimen has been subjected to five applications of the test flame.

67 Replacement Test, Head and Cover

67.1 An alarm employing a cover that is intended to be attached or closed by a snap type action or a removable head shall withstand 50 cycles of removal and replacement, or opening and closing, as applicable, of the cover.

67.2 An alarm is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as specified by the manufacturer. The unit then is to be subjected to the Jarring Test, Section 60.

68 Battery Replacement Test

68.1 The battery clips and holders of a battery operated single station smoke alarm shall withstand 50 cycles of battery removal and replacement, at a rate not to exceed 6 cycles per minute, without any reduction in contact or mounting integrity. During battery replacement, the alarm device shall not sound for more than 1 second. The test shall have no adverse effect on the operation of the detector. [See 43.1 (f).]

68.2 For this test an alarm is to be installed as intended in service and the battery(s) removed and replaced as specified by the manufacturer. The unit shall then be tested for its intended operation.

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69 Polarity Reversal Test

69.1 A smoke alarm shall operate as intended after being connected in each polarity. While energized under either polarity, the alarm shall comply with the requirements of the Electric Shock Current Test, Section 69A. This includes high-voltage cord connected and fixed wiring (splice lead) types, battery types (main or standby), and multiple station interconnection leads. Each polarity is to be applied for at least 24 hours on all units unless a trouble signal or alarm signal is obtained. For battery operated alarms intended to be connected by a polarized clip assembly the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be permitted under any incorrect polarity applied. A maximum 1-second alarm is permitted when the correct polarity is connected.

Revised 69.1 effective October 13, 2003

69.2 Two samples are to be subjected to this test. Sensitivity measurements prior to and following the test are to be made in accordance with the Sensitivity Test, Section 37. Measurements following the polarity reversal shall vary not more than specified in 34.4.1.

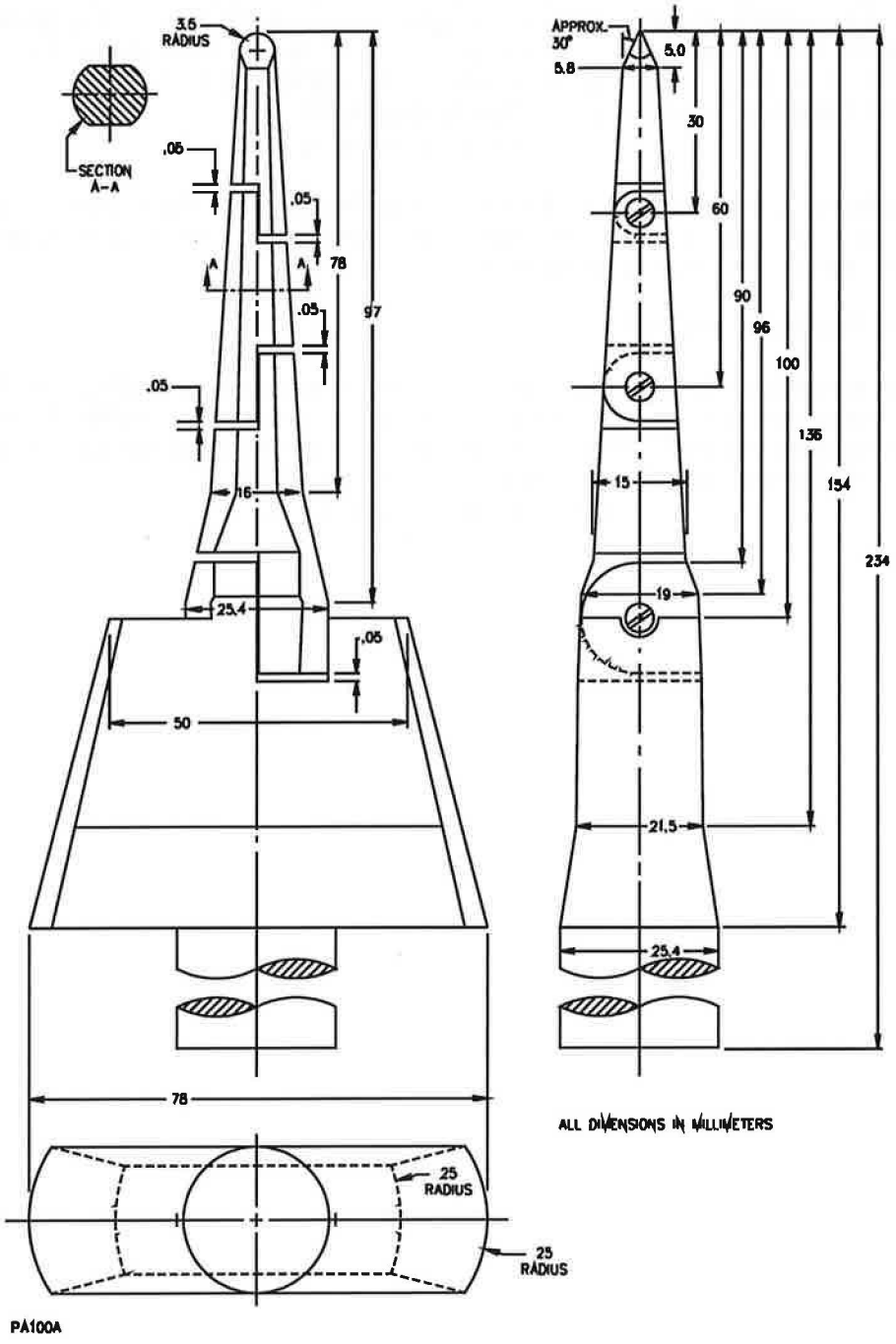
69A Electric Shock Current Test

69A.1 If the open circuit potential, between any part that may be contacted by the probe shown in Figure 69A.1 either during normal operation or during operator servicing (servicing as defined in the operating or installation instruction) and either earth ground or any other exposed accessible part, exceeds 42.4 volts peak, the part shall comply with the requirements of 69A.2 and 69A.4.

Added 69A.1 effective October 13, 2003

Figure 69A.1
Articulated probe

Added Figure 69A.1 effective October 13, 2003



69A.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 69A.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Added 69A.2 effective October 13, 2003

Table 69A.1
Maximum current during operator servicing

Added Table 69A.1 effective October 13, 2003

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

[a] Linear interpolation between adjacent values may be used to determine the maximum allowable current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

69A.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 69A.2 shall not exceed the following:

a) The value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I}\right)^{1.43}$$

in which:

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time;

I is the peak current in milliamperes; and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum acceptable transient current duration are shown in Table 69A.2.

Added 69A.3 effective October 13, 2003

69A.4 The maximum capacitance between the terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

$$C = \frac{88{,}400}{E^{1.43}(\ln E - 1.26)} \quad \text{for } 42.4 \leq E \leq 400$$

$$C = 35{,}288E^{-1.5364} \quad \text{for } 400 \leq E \leq 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge; E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like.

Typical calculated values of maximum capacitance are shown in Table 69A.3.

Added 69A.4 effective October 13, 2003

69A.5 With reference to the requirements in 69A.2 and 69A.3, the current is to be measured while the resistor is connected between ground and each accessible part individually or all accessible parts collectively if the parts are simultaneously accessible. The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

Added 69A.5 effective October 13, 2003

Table 69A.2
Maximum transient current duration

Added Table 69A.2 effective October 13, 2003

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak, seconds
7.1	7.22
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.013
700.0	0.010
809.0	0.0083

69A.6 With reference to the requirements in 69A.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is to be considered to be able to contact parts simultaneously if the parts are within a 4- by 8-inch (102- by 203-mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.83 m) apart.

Added 69A.6 effective October 13, 2003

Table 69A.3
Electric shock – stored energy

Added Table 69A.3 effective October 13, 2003

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.7
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00

69A.7 Electric shock current refers to all currents, including capacitively coupled currents.

Added 69A.7 effective October 13, 2003

69A.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct current supply circuit.

Added 69A.8 effective October 13, 2003

69A.9 Current measurements are to be made with any operating control, or adjustable control that is subject to user operation, in all operating positions, and either with or without a vacuum tube, separable connector, or similar component in place. These measurements are to be made with controls placed in the position that causes maximum current flow.

Added 69A.9 effective October 13, 2003

70 Strain Relief Test

70.1 General

70.1.1 A cord or lead that relies upon a thermoplastic enclosure or part for strain relief is to be subjected to the applicable tests specified in 70.2.1 – 70.3.1 following exposure to the temperature conditioning test described in 66.2.1.

70.2 Power-supply cord

70.2.1 When tested in accordance with 70.2.2, the strain relief means provided on the flexible cord shall withstand for 1 minute, without displacement, a pull of 35 pounds-force (156 N) applied to the cord with the connections within the alarm disconnected.

70.2.2 A 35 pound-mass (15.9 kg) weight is to be suspended on the cord and supported by the alarm so that the strain relief means are stressed from any angle that the construction of the alarm permits. The strain relief does not comply when, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress has resulted on the connections.

70.3 Field-wiring leads

70.3.1 Each lead employed for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 pounds-force (44.5 N) without any evidence of damage or of transmittal of stress to internal connections. A connector used in the lead assembly shall withstand a pull of 5 pounds-force (22.3 N) without any evidence of damage, transmittal of stress to internal connections, or separation.

71 Power Supply Tests

71.1 General

71.1.1 When a separate power supply is used to provide energy to one or more alarms, it is to be subjected to the test in 71.2.1 – 71.3.2.

71.2 Volt-amperes capacity

71.2.1 The volt-amperes capacity of the output circuit of a power supply that is separate from the alarms shall not be more than 100 volt-amperes and not more than 30 volts, 60 hertz rms, 42.4 volts peak or DC.

71.2.2 To determine compliance with the requirements of 71.2.1, a variable resistive load is to be connected to the output circuit of the power supply. With the power supply connected to a rated source of supply, the load is to be varied between open circuit to short circuit in an elapsed time of no less than 1-1/2 nor more than 2-1/2 minutes. Voltage and current measurements are to be recorded for each value and the maximum VA is to be calculated. When an overcurrent protective device is provided, it shall be shunted out during the test, when required.

71.3 Burnout test

71.3.1 There shall be no damage to the enclosure, charring or burning of the cheesecloth, nor emission of flame or molten metal when a power supply is operated under the conditions described in 71.3.2. While still in a heated condition following this test, the power supply shall comply with the requirements of the Leakage Current Test, Section 52, and the Dielectric Voltage-Withstand Test, Section 54.

71.3.2 With the output shorted, the supply circuit of the power supply is to be connected to a rated source of voltage and frequency, with the enclosure grounded, and operated for at least 7 hours or until burnout occurs. A single layer of mercerized cotton cheesecloth is to be loosely draped over the device during the test. When accessible fuses are provided on the power supply, they are to be shunted out, and inaccessible fuses are to remain in the circuit.

72 Fire Test (Heat Detector)

72.1 A heat detector, provided as part of a single station smoke alarm assembly, shall comply with the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521. It shall be sensitive enough to qualify for at least a 50 foot (15.2 m) spacing when subjected to the Fire Tests described in UL 521.

72.2 Two samples of the smoke alarm incorporating the heat detector shall be subjected to the Fire Tests described in the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521, while installed on a 50 foot (15.2 m) spacing.

73 Fire and Smoldering Smoke Tests

73.1 When the sensitivity of smoke alarms subjected to any one of the following tests exceeds the maximum value specified for that particular test then the same samples, adjusted to their minimum sensitivity setting, shall comply with the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45.

a) Undervoltage test, 56.1.1 – 56.1.3;

b) Overvoltage test, 56.2.1 – 56.2.4;

c) Jarring Test, Section 60;

d) Corrosion Test, Section 61;

e) Vibration Test, Section 59;

f) Dust Test, Section 57;

g) Lamp Interchangeability Test (Photoelectric), Section 42;

h) Reduction in Light Output Test, Section 62.

73.2 For 73.1 (a) and (b), the supply voltage to the alarms in the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45, shall be at the voltage indicated for the applicable test. For alarms employing a battery as the main power supply, the test voltage shall be at the trouble signal level, unless the minimum sensitivity is measured at rated battery voltage.

74 Accelerated Aging Test (Long-Term Stability Test)

74.1 This test is an alternate test method to the 90-day stability test requirements of 43.1 (a).

74.2 An alarm shall operate for its intended signaling performance after being subjected for 14 days to an ambient temperature of 66 ±3°C (150 ±6°F), 0 – 10 percent relative humidity, followed by 10 cycles of change of air velocity from 0 to 300 ±25 fpm (0 to 1.5 ±0.13 m/s). No false alarms shall occur during or following the aging or during exposure to the changes in air velocity.

74.3 Sensitivity measurements recorded before and after the exposures shall be in compliance with the Sensitivity Test, Section 37, and shall not vary more than specified in 34.4.1.

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

74.4 Two samples, one at maximum and one at minimum sensitivity, or both at the sensitivity that is most affected by the test temperature (as determined during the Variable Ambient Temperature Test, Section 50) are to be placed in a circulating air oven and energized for a period of 14 days from a source of rated voltage and frequency. Following removal, the energized samples are to be permitted to cool to room temperature for at least 24 hours and subjected, in turn, to 10 cycles of the change of air velocity test described in 43.1(d) and then to the Sensitivity Test, Section 37. Batteries are not required to be subjected to the elevated ambient temperature.

75 Drop Test

75.1 This test is to be conducted only on smoke alarms intended for transient use, such as a travel alarm, and is not to be conducted on alarms intended for stationary installation.

75.2 An alarm shall withstand five drops from a height of 7 feet (2.1 m) onto a tiled concrete floor without exposure of internal high-voltage parts and without affecting its intended operation and sensitivity. The sample is to be held so that each impact with the floor is at a different location on the alarm. Dislodgement of parts is not prohibited when:

a) The dislodged part does not affect operation or sensitivity of the unit,

b) The dislodged part is replaceable (such as a cover),

c) There are no high-voltage parts exposed, and

d) The condition is visually obvious.

75.3 Each of two alarms is to be raised to a height of 7 feet (2.1 m) and permitted to drop five times onto a concrete floor covered with a 1/8 inch (3.2 mm) thick uncushioned vinyl tile. Following the drops, the unit is to be examined for damage and tested for sensitivity. Sensitivity measurements, recorded after the drop test, shall vary not more than specified in 34.4.1.

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

SMOKE ALARMS FOR USE IN RECREATIONAL VEHICLES

76 General

76.1 A smoke alarm intended for use in recreational vehicles shall comply with the requirements specified in Sections 77 – 80, in addition to the requirements specified in Sections 1 – 75 and 81 – 90, inclusive.

77 Variable Ambient Temperature and Humidity Test

77.1 There shall be no false alarms or adverse change in performance when two units, one at maximum and one at minimum sensitivity, are subjected, in turn, to each of the following conditions:

a) Thirty days in air at 66 ±3°C (150 ±6°F).

b) At least 72 hours at minus 35 ±2°C (minus 17 ±4°F).

c) Ten days in 93 ±2 percent humidity at 61 ±2°C (142 ±4°F).

77.2 Sensitivity measurements, recorded in the environmental chamber smoke box, shall not vary more than specified in 34.4.1. During the sensitivity measurement, the environmental chamber is to be as close as possible to the test conditions specified in 77.1 (a), (b), and (c) (49°C for 66°C condition, 0°C for minus 35°C condition, and 85 percent relative humidity for the 93 percent relative humidity condition, respectively).

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

77.3 During each test condition, the alarm is to be connected to a source of rated voltage or battery.

78 Corrosion (Salt Spray) Test

78.1 A smoke alarm shall operate as intended and shall not false alarm after exposure for 48 hours to a salt spray in accordance with the procedure specified in the Standard for Salt Spray (Fog) Testing, ASTM B117-73.

78.2 Two alarms, one at maximum and one at minimum sensitivity, are to be subjected to the salt spray while in a de-energized condition. Following the exposure, the samples are to be removed, dried for at least 24 hours in an air circulating oven or air dried for at least 48 hours, and then subjected to the Sensitivity Test, Section 37.

78.3 It is not prohibited for sensitivity measurements following the exposure to vary by more than specified in 34.4.1 in the direction of high sensitivity under the following conditions:

1) the smoke alarm does not false alarm and

2) the sensitivity does not vary more than specified in 34.4.1 in the direction of low sensitivity.

In any case, the sensitivity shall not exceed the limits specified in the Sensitivity Test, Section 37.

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

79 Vibration Test

79.1 After vibration in accordance with 79.2, a smoke alarm shall not false alarm nor be adversely damaged. Sensitivity measurements shall not be greater than specified in 34.4.1 in the direction of low sensitivity, measurements greater than specified in 34.4.1 in the direction of high sensitivity are not prohibited. In no case shall the measurements exceed the limits specified in the Sensitivity Test, Section 37.

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

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79.2 Two smoke alarms, one at maximum and one at minimum sensitivity, are to be subjected to vibration for 120 hours in accordance with the Vibration Test, Section 59. Sensitivity measurements are to be recorded before and after the test.

79.2 effective August 10, 1998

80 Contamination Test (Cooking By-Products)

80.1 After exposure in accordance with 80.2 – 80.5, a smoke alarm shall not false alarm or otherwise be adversely affected. Sensitivity measurements following the exposure shall not be greater than specified in 34.4.1 in the direction of low sensitivity, (measurements greater than specified in 34.4.1 in the direction of high sensitivity are not prohibited). In no case shall measurements exceed the limits of the Sensitivity Test, Section 37.

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

80.2 Two samples are to be subjected to the vaporization of a mixture of 50 grams of animal fat (lard), 50 grams of vegetable fat (Crisco), and 100 grams of beef gravy (Franco-American). The mixture is to be placed in an 8 inch (203 mm) diameter aluminum plate that is heated on an 8-1/2 inch (216 mm) diameter hotplate located on the bottom center of a galvanized sheet metal enclosure.

80.3 The enclosure is to measure 3 feet (914 mm) high, 16 inches (406 mm) square and have an open top and a 16 inch square opening at the bottom of one side. A sheet metal cover, 18 inches (457 mm) square, with 1 inch (25 mm) flanges, is to be supported at the enclosure top by 7/8 inch (20 mm) high standoffs. See Figure 80.1.

80.4 The alarm under test is to be supported on the end of a threaded 1/4 inch (61 mm) steel rod positioned so that the exposed face of the alarm is 12 inches (304 mm) below the enclosure cover and 16 inches (406 mm) above the aluminum plate. The alarm is not to be energized during the test.

80.5 Each sample is to be subjected to five complete vaporization exposures. Following the fifth exposure, each sample is to be removed, permitted to cool for at least 3 hours, and then tested for sensitivity as specified in the Sensitivity Test, Section 37.

81 Conformal Coatings on Printed-Wiring Boards

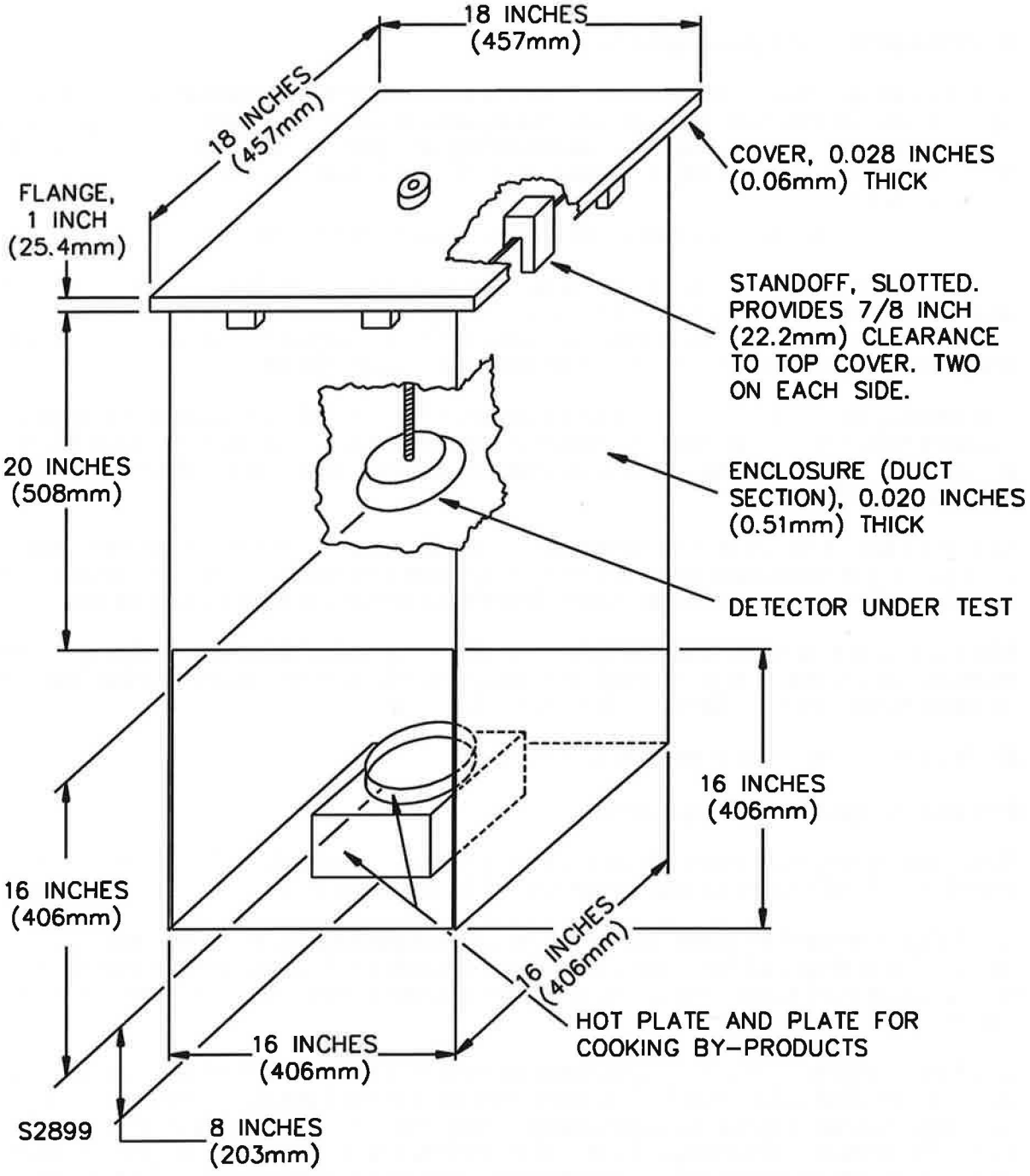
81.1 Low voltage printed-wiring boards

81.1.1 The following test program is to be utilized to determine the acceptability of a conformal coating in lieu of full electrical spacings for circuits at potential of 30 volts rms or less.

81.1.2 Eight samples of the printed-wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to this test. Test leads are to be attached to the printed-wiring (prior to the application of the coating) so as to provide for convenient application of the specified test potential.

81.1.3 Four specimens are to be conditioned to room ambient by exposure to ambient air at a temperature of 23 ±2°C (73, minus 3, +4°F) and 50 ±5 percent relative humidity for not less than 24 hours. Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 54, for the 0 – 30 volt range. There shall not be indication of dielectric breakdown as a result of the test. All specimens shall be smooth, homogeneous, and free of heat deformation such as bubbles and pin holes, as determined by visual examination.

Figure 80.1
Contamination test (cooking by-products)



81.1.4 Four samples are to be exposed to ambient air at a temperature chosen from the applicable temperature index line shown in Figure 81.1 corresponding to the "in service" operating temperature of the coating. It is advised that the aging temperature chosen from index line correspond to not less than 1000 hours of exposure. However, any value of temperature chosen shall correspond to not less than 300 hours of exposure. The samples are then to be subjected to the Dielectric Voltage-Withstand Test, Section 54, for the 0 – 30 volts range. All specimens shall be smooth, homogeneous, and free of defects such as bubbles and pin holes, as determined by visual examination. There shall not be crazing, chipping, or other visual evidence of deterioration or separation of the coating from the board after conditioning. There shall not be indication of a dielectric breakdown.

81.2 High voltage printed-wiring boards

81.2.1 The following test program is to be utilized to determine the acceptability of a conformal coating in lieu of full electrical spacing for circuits at potential greater than 30 volts rms. The test shall be performed between tracks on the printed-wiring board. The coating shall not be less than 0.008 inch (0.2 mm) thick.

81.2.2 Three samples of the printed-wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to this test. Test leads are to be attached to the printed wiring board (prior to the application of the coating) for convenient application of the specified test potential. Each sample shall be subjected to a 5,000 volt AC dielectric voltage-withstand test potential for one minute.

a) A 7 day heating-cooling cycling period, each cycle consisting of 4 hours "on" at 105°C (189°F) followed by 4 hours "off" at 25°C (77°F);

b) A 7 day oven conditioning period of 100°C (212°F);

c) A 7 day oven conditioning period at 85 percent relative humidity at 65°C (149°F); and

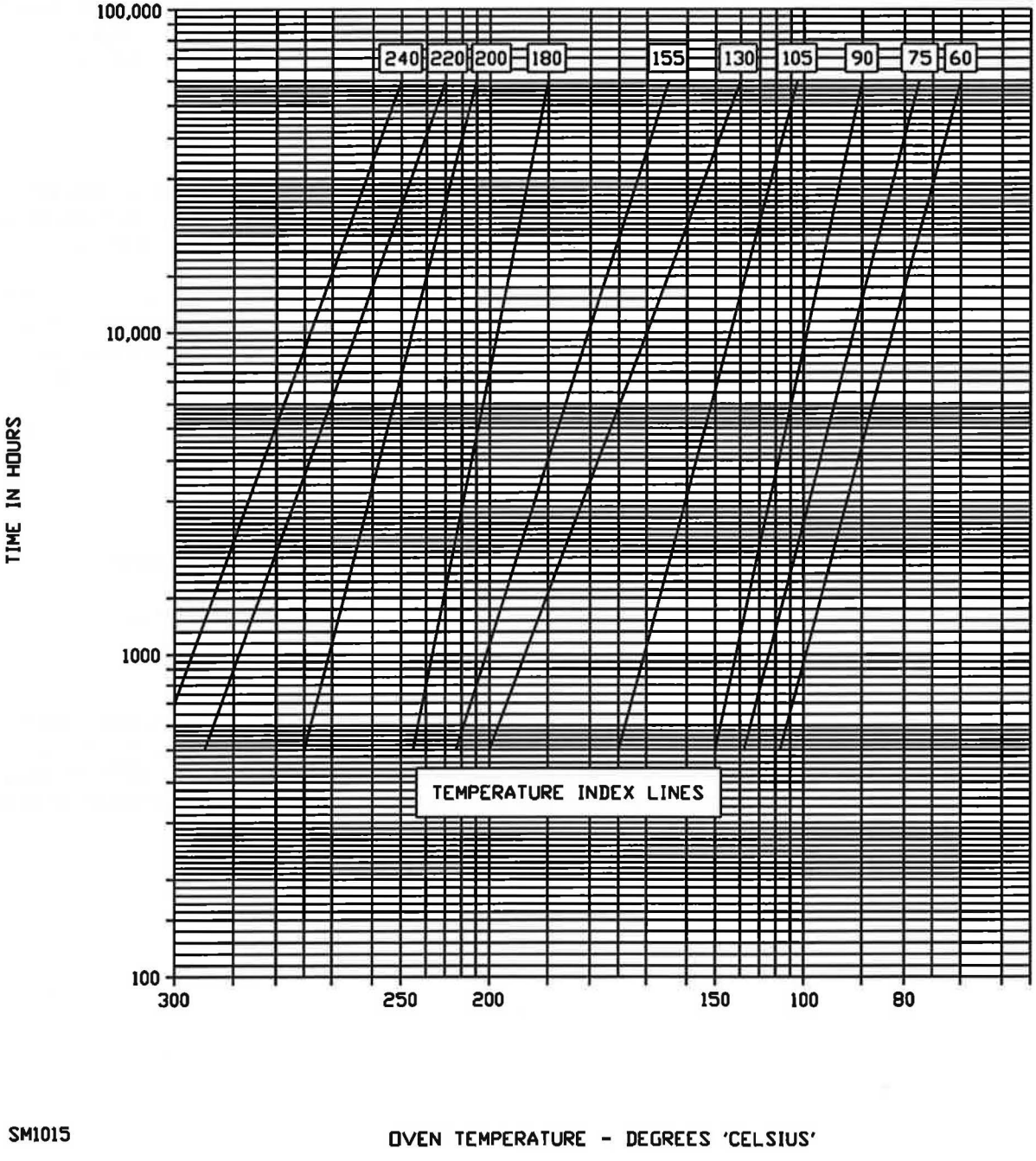
d) A dielectric voltage-withstand test potential at 2,500 volts AC repeated 10 times.

There shall not be peeling or other deterioration of the coating material as a result of the conditioning.

81.2.3 A sample of the coated printed-wiring board, equipped with test leads, without electrical components installed, shall be subjected to this test. The sample shall be subjected to an atmosphere having a relative humidity of 93 ±2 percent at a temperature of 32 ±2°C (89°F, minus 3, +4°F) for a period of 24 hours, followed by a 500 volt dielectric voltage-withstand test with the sample maintained in the conditioning atmosphere. There shall not be indication of a dielectric breakdown.

Figure 81.1
Aging time versus aging temperature

Figure 81.1 revised January 4, 1999



MANUFACTURING AND PRODUCTION TESTS

82 General

82.1 To verify compliance with these requirements in production, the manufacturer shall provide the required production control, inspection and tests. The program shall include at least the Sensitivity Calibration Tests, Section 83, and the Photocell Illuminating Lamp Test (Photoelectric Smoke Alarms), Section 84, conducted on 100 percent of the production.

83 Sensitivity Calibration Tests

83.1 The sensitivity of each smoke alarm is to be checked, following the warm-up period specified by the manufacturer, using appropriate instruments to determine that the sensitivity levels are within the marked rating including tolerance, which is within the specified limits of the alarm. The test equipment is to verify the value or range of sensitivities marked on the alarm. The value of indication is to be in the form of percent per foot obscuration.

No Text on This Page

83.2 For the warm-up period, the alarms are to be energized from a source of supply in accordance with 33.3.1. In situations where the smoke alarm sensitivity is not within the manufacturer's specifications, the unit is to be corrected and retested. When a retested sample is still outside the specification, it is to be rejected.

83.3 A warm-up period is required for those alarms employing components whose characteristics vary during initial warm-up, such as solid-state devices operating at greater than 25 percent of rating, lamp filaments, resistors, and other components that affect sensitivity.

83.4 A warm-up period is not required when the alarm components are operated at not more than 25 percent of rating in the standby condition or when the individual components are burned-in prior to assembly.

84 Photocell Illuminating Lamp Test (Photoelectric Smoke Alarms)

84.1 The manufacturer is to provide facilities for measurement of all the photocell illuminating lamps, including any replacement lamps provided, to determine that the illumination output is uniform and within the specifications for the intended use.

85 Production Line Dielectric Voltage-Withstand Tests

85.1 Each alarm rated at more than 30 volts AC rms (42.4 volts DC or AC peak) shall withstand, without breakdown, as a routine production-line test, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between high-voltage live parts and the enclosure, high-voltage live parts and exposed dead metal parts, and live parts of circuits operating at different potentials or frequencies. The test potential is to be:

a) For an alarm rated at 250 volts AC rms or less – either 1000 volts (1414 volts, when a DC potential is used) applied for 60 seconds or 1200 volts (1697 volts, when a DC potential is used) applied for 1 second or

b) For an alarm rated at more than 250 volts – either 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, when a DC potential is used) applied for 60 seconds or 1200 volts plus 2.4 times the rated voltage (1697 volts plus 3.394 times the rated AC rms voltage, when a DC potential is used) applied for 1 second.

Exception: A product, the housing of which is entirely comprised of polymeric materials, is not required to be subjected to this test when there are no exposed dead metal parts that become energized under fault conditions.

85.2 When the alarm employs high-voltage and low-voltage circuits, the test is to be conducted with the low-voltage circuit connected to the cabinet, chassis, or other dead metal parts so that the potential that is applied between the high-voltage live parts and dead metal parts is applied simultaneously between high-voltage live parts and low-voltage circuits.

85.3 A printed-wiring assembly or other electronic-circuit component that is damaged or short-circuited, 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 to be tested instead of an entire unit.

85.4 A 500 volt-amperes or larger transformer, the output voltage of which is able to be varied, is to be used to determine compliance with 85.1. A 500 volt-amperes or larger transformer is not required when the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment for the duration of the tests.

85.5 The test equipment used for this test is to include a visible indication of application of the test potential and an audible or visible indication, or both, of breakdown. In the event of breakdown, manual reset of an external switch is to be required, or an automatic reject of the unit under test is to result. Other arrangements are to be evaluated and accepted when found to achieve the results contemplated.

85.6 Where the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is enough to prevent maintaining the specified AC test potential, the alarm is to be tested using a DC test potential in accordance with 85.1

86 Production Line Grounding Continuity Tests

86.1 The manufacturer shall test each alarm that has a power-supply cord terminating in an attachment-plug employing a grounding pin to verify electrical continuity between the device and the grounding blade of the attachment-plug.

86.2 For this test, the manufacturer is to employ a resistance-indicating instrument with leads and terminals which determine the grounding circuit continuity.

86.3 When an investigation of the alarm has shown all exposed dead metal parts that become energized and all dead metal parts within the enclosure that are exposed to contact during servicing to be acceptably bonded to the frame and enclosure of the alarm, a test that determines the electrical continuity between the grounding blade and the frame or enclosure is satisfactory.

87 Smoke Alarm Shipment

87.1 The battery intended to be employed with the alarm shall be shipped from the factory with the alarm in the same package. To prevent unnecessary drain during shipment and storage, the battery shall not be connected in the alarm.

87.2 A nonrechargeable standby battery of an AC operated accessory to a single- or multiple-station smoke alarm is not required to be shipped with the unit when instructions on the unit specify the battery to be used by model number and manufacturer, as well as a source of purchase. A rechargeable standby battery shall be shipped with the unit in which it is to be employed.

MARKING

88 General

88.1 A smoke alarm shall be permanently marked with the following information unless specifically indicated that it appears on the installation wiring diagram. The marking shall be in a contrasting color, finish, or equivalent. Unless the letter height is specified, all markings shall be at least 3/64 inch (1.2 mm) high.

a) Name or identifying symbol and address of the manufacturer or vendor.

b) Model number and date of manufacture. The date of manufacture shall be non-coded and in the format YEAR (in 4 digits), MONTH (in letters), DATE (in 2 digits) located on the outside of the smoke alarm.

c) Electrical rating, in volts, amperes, or watts, and frequency. Not required for battery operated alarms.

d) Correct mounting position when a unit is intended to be mounted in a definite position. (It is not prohibited for this to appear in the installation instructions.)

e) Identification of lights, switches, meters, and similar devices regarding their function unless their function is obvious.

f) Maximum rating of fuse in each fuseholder and temperature rating of supplementary heat detector, when provided, in degrees Fahrenheit and Celsius.

g) Identification of spare lamps and batteries by part number, manufacturer's model number or equivalent. Located adjacent to the component.

h) Reference to an installation diagram and/or owner's manual.

i) For a smoke alarm that employs a radioactive material, the following information shall be indicated directly on the exterior of the unit:

1) The statement "CONTAINS RADIOACTIVE MATERIAL,"

2) Name or Radionuclide and quantity (no abbreviations), and

3) The statement, "U.S. NRC License No. XXX." (XXX – No. of License) or the name of the Licensee.

j) An alarm shall be marked on the outer surface of the enclosure with the following or equivalent notice: "Do Not Paint." The letters shall not be less than 1/8 inch (3.2 mm) high and shall be located so as to be readily visible after the alarm is mounted in its intended manner.

k) The following or equivalent qualifying statement on a battery-operated alarm where battery operation, under other than normal room temperature conditions during the long term (minimum 1 year) battery tests, is less than 1 year:

"CONSTANT EXPOSURES TO HIGH OR LOW TEMPERATURES OR HIGH HUMIDITY MAY REDUCE BATTERY LIFE."

Applicable wording shall be used.

l) Distinction between alarm and trouble signals on those units employing both.

m) Reference to a source for battery replacement. (It is not prohibited for this to appear in the homeowner's manual.)

n) For a battery operated alarm, the word "WARNING" and the following or equivalent marking shall be included on the unit: "Use Only Batteries Specified In Marking. Use Of A Different Battery Will Have A Detrimental Effect On Smoke Alarm Operation." The letter height shall be a minimum of 1/8 inch (3.2 mm) for "WARNING" and 3/64 inch (1.2 mm) for the rest of the notice.

o) For a smoke alarm employing a nonrechargeable standby battery the marking information described in 14.1, 14.3, and 14.4 shall be in letters not less than 1/8 inch (3.2 mm) high.

p) Test instructions and frequency. Not less than once per week for battery-powered alarms and not less than once per month for other than battery-powered alarms.

q) Maintenance instructions, such as cleaning, lamp and battery replacement.

r) Name and address of firm to whom alarm is to be sent for servicing.

s) Sealed units intended to be returned to the manufacturer for servicing shall be marked as follows on the outside of the alarm: "RETURN TO (+) FOR SERVICING," or equivalent. It is not prohibited for units on which the cover is removable, and that are also intended to be returned to the manufacturer for servicing, to have the marking on the inside of the alarm.

(+) Name and address of manufacturer or supplier.

t) An AC operated alarm without a standby battery shall be marked with the word "WARNING" and the following or equivalent wording: "UNIT WILL NOT OPERATE DURING POWER FAILURE." The marking shall be in a location on the unit that is visible after installation. The letter height shall be a minimum of 1/8 inch (3.2 mm).

u) The sensitivity setting for a smoke alarm having a fixed setting. For an alarm which is intended to be adjusted in the field, the range of sensitivity shall be indicated. The marked sensitivity shall be indicated as a percent per foot obscuration level. The marking shall include a nominal value plus tolerance.

v) For a battery operated smoke alarm employing a non-replaceable 10 year battery, the words "10 Year Battery. Replace Alarm After _____" or equivalent marking shall be provided on the unit.

Effective date for 88.1 changed from August 21, 1998 to August 21, 1999

88.2 Information required to appear directly on the alarm shall be readily visible after installation. Except for 88.1(j), the removal or opening of an enclosure cover not requiring a tool, or an equivalent arrangement to view the marking is not prohibited.

88.3 When markings are placed on the base (bottom) of an alarm intended for permanent installation, the word "CAUTION" and the following or equivalent marking in letters 1/8 inch (3.2 mm) high is to be provided on the outside or inside of the alarm: "Additional marking on back. Disconnect power."

88.4 Additional marking requirements are specified by 9.2.1, 11.6.4, 14.1, 14.3, 14.4, 19.2.1, 25.2, and 90.2.

88.5 For manufacturers producing alarms at more than one factory, each such assembly shall have a distinctive marking to identify each subassembly as the product of a particular factory.

88.6 With regard to the requirement in 8.2, a warning flag, hinged cover as described in 8.1 (inside or outside), or equivalent, shall be marked with the word "WARNING" and the following or equivalent text: "Smoke Alarm is Non-Operational." The letter height shall be a minimum of 3/8 inch (9.5 mm) unless it is in a contrasting color, visible from 6 feet (1.83 m).

Exception: Not required for supervised RF detectors.

89 Packaging Marking

89.1 The point-of-sale carton, in which a smoke alarm employing a radionuclide is packaged, shall be permanently marked on the exterior with the following information. The letter height shall be at least 3/64 inch (1.2 mm) high and shall be in contrasting color, finish, or equivalent.

a) Name of radionuclide and quantity (no abbreviations).

b) The statement, "U.S. NRC License No. XXX" (XXX – No. of License) or the name of the Licensee.

c) The following or equivalent statement:

"THIS SMOKE ALARM CONTAINS RADIOACTIVE MATERIAL AND HAS BEEN MANUFACTURED IN COMPLIANCE WITH U.S. NRC SAFETY CRITERIA IN 10 CFR 32.27. THE PURCHASER IS EXEMPT FROM ANY REGULATORY REQUIREMENTS."

INSTRUCTIONS

90 General

90.1 Each single and multiple station smoke alarm shall be provided with installation instructions which shall include the following information:

a) Typical installation drawing layouts for the unit(s) indicating recommended locations and wiring methods which shall be in accordance with the National Fire Alarm Code (NFPA 72) Chapter 2. Locations where smoke alarm installations are not recommended shall also be included.

b) Description of the operation, testing, and proper maintenance procedures for the unit(s). The frequency of testing shall be in accordance with NFPA 72, Chapter 2.

c) Replacement parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent, and information included as to where a homeowner is able to obtain the part.

d) The following text:

"For your information, the National Fire Protection Association's Standard 72, reads as follows:

"2-2.1.1.1 Smoke detectors shall be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms and on each additional story of the family living unit including basements and excluding crawl spaces and unfinished attics. In new construction, a smoke detector shall be installed in each sleeping room. "

"A-2.5.2.1 Smoke Detection - Are More Smoke Detectors Desirable? The required number of smoke detectors might not provide reliable early warning protection for those areas separated by a door from the areas protected by the required smoke detectors. For this reason, it is recommended that the householder consider the use of additional smoke detectors for those areas for increased protection. The additional areas include the basement, bedrooms, dining room, furnace room, utility room, and hallways not protected by the required smoke detectors. The installation of smoke detectors in kitchens, attics (finished or unfinished), or garages is not normally recommended, as these locations occasionally experience conditions that can result in improper operation. "

e) Description of the various situations against which the smoke alarm is not be effective; for example, smoking in bed.

f) More detailed information on the alarm and trouble signals and an indication where false alarms or trouble signals are anticipated.

g) Identification of the homeowner's manual or instruction sheet by number or equivalent.

h) An indication that the device shall not be installed in locations where the normal ambient temperature is below 4.4°C (40°F) or exceeds 37.8°C (100°F), unless the alarm has been determined to be capable of being used at installation points with higher or lower ambient temperatures.

i) Reference to a source(s) of power limited cable for multiple station interconnection or connection of supplementary devices.

j) The manufacturer shall either provide information on an evacuation plan or include a copy of a separate booklet, or equivalent, which is published by the National Fire Protection Association, National Fire Prevention and Control Administration, or an equivalent agency. When the manufacturer provides information on an evacuation plan, it shall be in accordance with published information available from the National Fire Protection Association.

k) The following information:

1) Name and address of manufacturer or vendor.

2) Model number.

3) Electrical rating in volts, amperes or watts, and frequency. Not required for battery operated alarms.

4) Temperature rating of heat detector, when provided.

5) Test instructions and frequency.

6) Maintenance instructions such as cleaning and lamp and battery replacement.

7) Name and address of firm to whom alarm is to be sent for servicing.

8) The following notice: THIS EQUIPMENT SHOULD BE INSTALLED IN ACCORDANCE WITH THE NATIONAL FIRE PROTECTION ASSOCIATION'S STANDARD 72 (National Fire Protection Association, Batterymarch Park, Quincy, MA 02269).

l) For smoke alarm-transmitters intended to be installed with compatible audible signal receiver units, instructions shall include the limitations of use in typical single level and multilevel dwelling units as well as in apartment buildings where it is possible that adjacent apartments have similar systems.

m) For alarms also recognized for installation in recreational vehicles, the word "WARNING," and the following or equivalent text: "TEST SMOKE ALARM OPERATION AFTER VEHICLE HAS BEEN IN STORAGE, BEFORE EACH TRIP, AND AT LEAST ONCE PER WEEK DURING USE. An identical marking is to be provided by the recreational vehicle manufacturer that shall be permanent and located, visibly, within 24 inches (610 mm) of the smoke alarm."

90.2 It is not prohibited that the instructions be incorporated on the outside of the unit, on a separate sheet, or as part of a manual. When not included directly on the device, the instructions or manual shall be referenced in the marking information on the unit.

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90.3 The material shipped with the alarm, including the package, instructions, or user's manual, shall not include information other than that specified in 90.1, such as manufacturer's claims on the operation of the alarm which have not been substantiated by the performance tests included in this standard, or that are not covered in Household Fire Warning Equipment, ANSI/NFPA 74, or other applicable NFPA standards of the National Fire Protection Association.

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SUPPLEMENT SA - SMOKE ALARM RELIABILITY PREDICTION

SA1 Instructions for Determining a Reliability Prediction for Smoke Alarms

SA1.1 Make a list of every component in the alarm.

SA1.2 By circuit analysis or experimentation, determine the effect of any failure mode (short or open) of each component on the smoke alarm operation and the rationale for the decision. This determines that a component is to be identified as critical, conditionally critical, or noncritical.

SA1.3 A component is identified as noncritical when all failure modes of the component result in a trouble signal[a], or have no effect on the intended operation of the smoke alarm for alarm and trouble signals, and do not affect the alarm sensitivity.

[a] A trouble signal is indicated by energization of an audible signal, energization of a separate visual indication (amber or orange), or de-energization of a power-on light. When a visual indication is relied on to denote a trouble condition, it shall have a documented predicted failure rate of not greater than 2.5 failures per million hours.

SA1.4 A component is identified as critical when two or more failure modes of the component, which affect the intended operation or the sensitivity of the smoke alarm, do not result in a trouble signal[a].

SA1.5 A component is identified as conditionally critical when only one failure mode of the component affects the intended operation or the sensitivity of the smoke alarm, and does not result in a trouble signal[a].

SA1.6 Make a list of all critical and conditionally critical components in the alarm.

SA1.7 For each critical and conditionally critical component, the expected failure rate, based upon a minimum confidence factor of 60 percent, shall be determined from either the screening burn-in or published component reliability data method.

SA1.8 For each conditionally critical component, the expected failure rate shall be determined by calculating only the failure rate for the mode meeting the conditions of SA1.5 or by applying a 0.75 multiplying factor to the value determined by the PARTS COUNT or PARTS STRESS ANALYSIS method described in MIL-HDBK 217B.

SA2 Methods of Determining Failure Rate

SA2.1 PARTS COUNT METHOD – When using this method the failure rate is to be determined as follows, using Section 3 of MIL-HDBK 217B :

a) Employ generic failure rate from Tables SA2.1 – SA2.6 which most closely approximates the component employed.

b) Determine the quality factor multiplier for each component from Tables SA2.7 – SA2.9.

c) Multiply each generic failure rate by its associated quality factor multiplier to obtain the final failure rate for the component. See sample calculation, Table SA2.10.

d) Add all individual failure rates of critical and conditionally critical components to obtain the overall failure rate for the alarm.

Note: Mil-specification numbers in Tables SA2.4 and SA2.5 are provided for reference only to determine general component type.

Table SA2.1
Generic failure rate for standard bipolar digital devices (TTL and DTL) in failures per million hours

Circuit complexity	Failure rate
1 to 20 gates[a]	0.029
21 to 50 gates	0.062
51 to 100 gates	0.094
101 to 500 gates	0.38
Greater than 500 gates	6.0
Memories, less than or equal to 1000 bits	0.30
Memories, 1001 to 4000 bits	0.70
Memories, 4001 to 8000 bits	1.2
[a] Assume 1 gate is equivalent to four transistors.	

Table SA2.2
Generic failure rate for standard bipolar beam lead and ECL, bipolar and MOS linear, and all other MOS devices in failures per million hours

Circuit complexity	Failure rate
1 to 20 gates[a]	0.048
21 to 50 gates	0.19
51 to 100 gates	0.31
101 to 500 gates	1.4
Greater than 500 gates	23
Linear, less than or equal to 32 transistors	0.052
Linear, 33 to 100 transistors	0.12
Memories, less than or equal to 1000 bits	1.2
Memories, 1001 to 4000 bits	2.7
Memories, 4001 to 8000 bits	4.5
[a] Assume 1 gate is equivalent to four transistors.	

Table SA2.3
Generic failure rate for discrete semiconductors in failures per million hours

Part type		Failure rate
Transistors		
	Silicon NPN	0.18
	Silicon PNP	0.29
	GePNP	0.41
	GeNPN	1.1
	FET	0.52
	UJT, PUT[a]	1.7
Diodes		
	Silicon, general purpose	0.12
	Germanium, general purpose	0.26
	Zener and avalanche	0.16
	Thyrister	0.16
	Silicon microwave detector	2.2
	Ge microwave detector	5.6
	Silicon microwave mixer	3.0
	Ge microwave mixer	10.0
	Varactor, step	1.5

[a] A lower failure rate (0.16 failures/10^6hrs) shall be assigned only when the construction of the device is comparable to that of a thyrister.

Table SA2.4
Generic failure rate for resistors in failures per million hours

Resistors, fixed			Failure rate
Construction	Style	Mil-R-Spec. (reference only)	
Composition	RCR	39008	0.002
Composition	RC	11	0.01
Film	RLR	39017	0.015
Film	RL	22684	0.075
Film	RNR	55182	0.017
Film	RN	10509	0.017
Film, power	RD	11804	0.96
Wire wound, accurate	RBR	39005	0.056
Wire wound, accurate	RB	93	0.28
Wire wound, power	RWR	39007	0.033
Wire wound, power	RW	26	0.17
Wire wound, chassis mount	RER	39009	0.062
Wire wound, chassis mount	RE	18546	0.31
Resistors, variable			
Wire wound, trimmer	RTR	39015	0.066
Wire wound, trimmer	RT	27208	0.33
Wire wound, precision	RR	12934	2.7
Wire wound, semi-precision	RA	19	2.3
Wire wound, semi-precision	RK	39002	2.3
Wire wound, power	RP	22	2.3
Non-wire wound, trimmer	RJ	22097	4.6
Composition (common pot)	RV	94	
Factory preset and sealed			0.46
Field variable			3.7

Table SA2.5
Generic failure rate for capacitors in failures per million hours

Dielectric	Style	Mil-C-Spec. (reference only)	Failure rate
Paper/plastic	CHR	39022	0.0006
Paper/plastic	CPV	14157	0.0006
Paper/plastic	CQR	19978	0.0006
Paper/plastic	CQ	19978	0.006
Mica	CMR	39001	0.0032
Mica	CM	5	0.032
Mica	CB	10950	0.58
Glass	CYR	23269	0.011
Ceramic	CKR	39014	0.022
Ceramic	CK	11015	0.22
Tantalum, solid	CSR	39003	0.026
Tantalum, nonsolid	CLR	39006	0.034
Tantalum, nonsolid	CL	3965	0.34
Aluminum, oxide	CU	39018	0.23
Aluminum,			
dry electrolyte	CE	62	0.41
ceramic, variable	CV	81	1.1
piston, variable	PC	14409	0.11

Table SA2.6
Generic failure rate for miscellaneous parts in failures per million hours

Part type	Failure rate
Pulse transformers	0.0027
Audio transformers	0.0066
Power transformer and filters	0.021
RF transformers and coils	0.022
Connectors	0.45
Connections	
solder, reflow lap to printed-circuit boards	0.00012
solder, wave to printed-circuit boards	0.00044
other hand solder connections (e.g., wire to terminal board)	0.0044
crimps	0.0073
welds	0.002
wirewraps	0.0000037
Coaxial connectors	0.63
Toggle switches	0.57
Push button switches	0.38
Sensitive switches	0.90
Rotary switches	1.4
General purpose relays	0.30
High current relay	1.0
Latching relays	0.29
Reed relays	0.26
Meters and bimetal	5.7
Two sided printed-wiring boards	0.0024
Multilayer printed-wiring board	0.30
Quartz crystals	0.20
Thermistor	
beads	0.10
discs	0.31
Fuses	0.10
Neon lamps	0.20
Photocells	0.02
Light emitting diodes (LED)	
General use (indicator light)	0.20
Light source of photoelectric detectors	2.50[a]

[a] This is the maximum value permitted and is based on the failure rate of half light output. LED's having projected lower failure rates at half light output are usually employed. The reliability is to be evaluated on data supplied by LED manufacturer.

Table SA2.7
Quality factors for Tables SA2.1 and SA2.2

Quality level or screen class	Description	Quality factor
A	Mil-M-38510, Class A	0.5
B	Mil-M-38510, Class B	1
B-1	Mil-Std-883A, Method 5004, Class B	2.5
B-2	Vendor equivalent of Mil-Std-883A, Method 5004, Class B	5
C	Mil-M-38510, Class C	8
D	Commercial (or non-Mil Standard) part with no screening beyond the manufacturer's regular quality assurance practices	75
E	Screening procedure per Table SA5.1	8

Table SA2.8
Quality factor for Table SA2.3

Part class	Quality factor
JANTXV	0.1
JANTX	0.2
JAN	1.0
Commercial grade	1.0

Table SA2.9
Quality factor for Tables SA2.4 and SA2.5

Failure rate level (established reliability parts)	Quality factor
L	1.5
M	1.0
P	0.3
R	0.1
S	0.01
NOTE – For nonestablished reliability parts the quality factor equals 1.5. The quality factor for all miscellaneous parts equals 1.0.	

Table SA2.10
Detector reliability prediction – parts count method sample calculation

Component	Generic failure rate (A)	Quality factor multiplier (B)	Failure rate failures/ 10^6 hrs A times B
Composition resistor	0.01	1	0.01
Composition resistor	0.01	1	0.01
Composition resistor	0.01	1	0.01
Film resistor	0.075	1	0.075
Film resistor	0.075	1	0.075
Wire wound resistor, power	0.17	1	0.17
Capacitor, plastic	0.006	1	0.006
Capacitor, plastic	0.006	1	0.006
Capacitor, tantalum, solid	0.026	1	0.026
Capacitor, dry electrolyte	0.41	1	0.41
Transistor, silicon NPN	0.18	0.3	0.06
Transistor, silicon NPN	0.18	0.3	0.06
Thyrister (SCR)	0.16	1	0.16
Diode, silicon	0.12	1	0.12
Diode, silicon	0.12	1	0.12
Relay, reed	0.26	1	0.26
Relay, general purpose	0.30	1	0.30
Connector	0.45	1	0.45
Printed-wiring board	0.0024	1	0.0024
Switch, push button	0.38	1	0.38
Potentiometer, factory preset	0.46	1	0.46
LED (indicator lamp)	0.20	1	0.20
		Total Detector Failure Rate	3.371

SA2.2 PARTS STRESS ANALYSIS METHOD[b] – The failure rate is calculated using the procedure in MIL-HBK-217B, Section 2. Calculations and supporting data on rating of components for the determination are required for review. See also Table SA2.11 and Figure SA2.1 for equations and tabulation sheets.

[b] When a Mil-Spec component is required in a smoke alarm and it does not employ a specific marking to that effect, it is required that the alarm manufacturer provide documentation to verify that the component is Mil-Spec graded. The documentation shall be in the form of a shipping order, invoice, or equivalent, provided by the component vendor.

SA2.3 SCREENING BURN-IN METHOD – This method is required for the evaluation of custom integrated circuit "chips" although it is also able to be applied to any other component of an alarm, including generic "chips." The evaluation shall consist of a burn-in test program to determine the numerical failure rate coupled with a minimum quality assurance screening program for all production units. Refer to Sections SA4 – SA6.

SA2.4 ALTERNATE METHOD (GENERIC DEVICES ONLY) – An alternate for generic components only shall consist of the burn-in test program to determine the numerical failure rate coupled with the component manufacturer's standard screening program which is employed for the device family[c] of the component. The condition of acceptance of the limited screening shall include the following:

a) A test sample lot shall be screened in accordance with the component manufacturer's standard program and then subjected to the burn-in test described in Sections SA4 – SA6.

b) The component manufacturer shall provide failure rate data on the particular device being tested or the device family[c] from a second source, such as field failure rate data or a separate burn-in test.

c) A comparison of the burn-in test data from (a) and (b) shall be made and results from (a) shall not be worse than those in (b) by one order of magnitude (10:1).

[c]Similar devices manufactured under same process and design rules.

SA2.5 PUBLISHED RELIABILITY DATA – It is appropriate to employ this method for the evaluation of generic integrated circuit "chips" as well as any other component of an alarm, except for a custom "chip." The evaluation is derived by the use of generic failure rate data from industry and military recognized publications on component reliability based on field accumulated data. Examples of such publications include "Micro-Circuit Device Reliability," "Linear/Interface Data and Micro-Circuit Device Reliability," "Digital Generic Data." Devices evaluated by this method shall comply to the identification program in SA4.3, and minimum screening program of Table SA5.1.

SA2.6 It is not prohibited for the overall failure rate of the components of an alarm to be evaluated by any combination of two or more of the failure rate determination methods described in SA2.1, SA2.2, SA2.3, SA2.4, and SA2.5.

Table SA2.11
Parts stress analysis method references

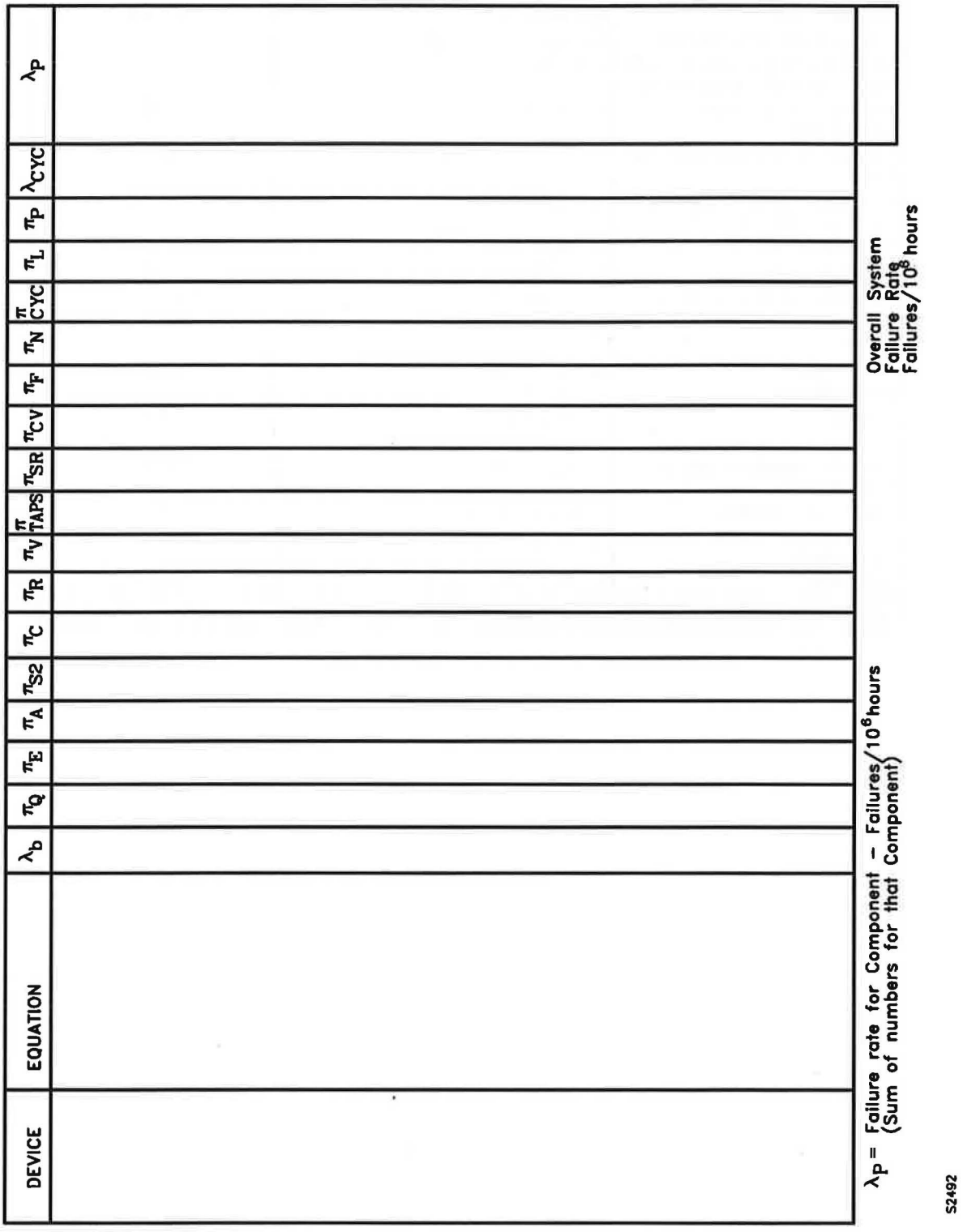
Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
Monolithic bipolar and MOS digital SI/MSI devices < 100 gates or 400 transistors	$\lambda_p = \pi_L\pi_Q(C_1\pi_T+C_2\pi_E)$	2.1.1-1
Monolithic bipolar and MOS linear devices	$\lambda_p = \pi_L\pi_Q(C_1\pi_{T2} + C2\pi_E)$	2.1.2-1
Monolithic bipolar and MOS digital LSI devices ≥ 100 gates or 400 transistors	$\lambda_p = \pi_L\pi_Q(C_1\pi_T + C_2\pi_E)$	2.1.3-1
Monolithic MOS and bipolar memories	$\lambda p = \pi_L\pi_Q(C_1\pi_T + C_2\pi_E)$	2.1.4-1
Hybrid devices	$\lambda_p = \lambda_b(\pi_T \times \pi_E \times \pi_Q \times \pi_F)$	2.1.7-1
Transistors group I general purposes	$\lambda_p = \lambda_b(\pi_E \times \pi_A \times \pi_Q \times \pi_{S2} \times \pi_C)$	2.2.1-1
Transistors group II field effect transistors	$\lambda_p = \lambda_b(\pi_E \times \pi_A \times \pi_Q \times \pi_C)$	2.2.2-1
Transistors group III unijunction	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.3-1
Diodes, group IV general purpose	$\lambda_p = \lambda_b(\pi_E \times \pi_Q \times \pi_A \times \pi_{S2} \times \pi_C)$	2.2.4-1
Diodes, group V zeners	$\lambda_p = \lambda_b(\pi_E \times \pi_A \times \pi_Q)$	2.2.5-1
Diodes, group VI thyristers	$\lambda_p = \lambda_b \times \pi_Q \times \pi_E$	2.2.6-1
Diodes, group VII microwave detectors and mixers	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.7-1
Diodes, group VIII varactor step recovery tunnel	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.8-1
RCR and RC insulated fixed composition	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.1-1
RLR, RL, RNR, RN fixed film insulated	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.2-1
RD/P power film	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.2-5
RBR and RB fixed wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-1
RWR and RW power type fixed wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-3
RER and RE power type, chassis mounted fixed wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-5
RTH bead and disc type thermistors	Read direct from Table	2.5.4-1
RTR and RT variable lead screw activated wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q \times \pi_V)$	2.5.5-1
RR precision wire wound potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} \times \pi_Q(\pi_R \times \pi_V \times \pi_C \times \pi_E)$	2.5.5-3
RA and RK (not ER) semi-precision wire wound potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS}(\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.5-7
RP high power wire wound potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} \times \pi_Q(\pi_R \times \pi_V \times \pi_C \times \pi_E)$	2.5.5-13
RJ non-wire wound trimmers	$\lambda_p = \lambda_b \times \pi_{TAPS}(\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.6-1
RV composition potentiometers	$\lambda_p = \pi_b \times \pi_{TAPS}(\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.6-5
CPV paper and plastic film, Est. Rel.; CHR metalized paper, Est. Rel.; CQ& CQR paper and plastic film, ER & NON-ER	$\lambda_p = \lambda_b (\pi_E \times \pi_Q)$	2.6.1-1
CM mica molded; CMR mica dipped, Est. Rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_Q)$	2.6.2-1

Table SA2.11 Continued on Next Page

Table SA2.11 Continued

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
CB button mica	$\lambda_p = \lambda_b(\pi_E)\ (\pi_Q)$	2.6.2-3
CYR glass capacitors, Est. Rel.	$\lambda_p = \lambda_b\ (\pi_E \times \pi_{CV} \times \pi_Q\ )$	2.6.3-1
CK ceramic, general purpose; CKR ceramic, general purpose, Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_Q)$	2.6.4-1
CC ceramic, temperature compensating	$\lambda_p = {}_b(\pi_E)\ (\pi_Q\ )$	2.6.4-5
CSR solid tantalum electrolytic, Est. Rel.	$\lambda_p = \lambda_b\ (\pi_E \times \pi_{SR} \times \pi_Q\ )$	2.6.5-1
CLR nonsolid tantalum, Est. Rel.; CL nonsolid tantalum, NON Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_Q\ )$	2.6.5-3
CU aluminum oxide electrolytic	$\lambda_p = \lambda_b\ (\pi_E) \times \pi_Q$	2.6.6-1
CE aluminum, dry electrolyte	$\lambda_p = \lambda_b\ (\pi_E) \times \pi_Q$	2.6.6-3
CV variable ceramic capacitors	$\lambda_p = \lambda_b\ (\pi_E) \times \pi_Q$	2.6.7-1
PC variable, piston type tubular trimmer	$\lambda_p = \lambda_b\ (\pi_E) \times \pi_Q$	2.6.8-1
Transformers	$\lambda_p = \lambda_b\ (\pi_E \times \pi_F\ )$	2.7-1
Motors high speed	$\lambda_p = (\lambda_E + \lambda_W)\ \pi_E$	2.8.1-1
Blowers	$\lambda_p = \lambda_E + \lambda_W$	2.8.2-1
Relays	$\lambda_p = \lambda_b(\pi_E \times \pi_C \times \pi_{CYC} \times \pi_F\ )$	2.9-1
Switches, snap-action toggle or pushbutton	$\lambda_p = \lambda_b\ (\pi_E \times \pi_C \times \pi_{CYC}\ )$	2.10-1
Basic sensitive switches	$\lambda_p = \lambda_b(\pi_E \times \pi_{CYC})$	2.10-2
Rotary, ceramic or glass wafer silver alloy contacts	$\lambda_p = \lambda_b(\pi_E \times \pi_{CYC})$	2.10-3
Connectors	$\lambda_p = \lambda_b(\pi_E \times \pi_p) + N\lambda_{CYC}$	2.11-1
NOTE: – π_Q multiplier same as for JAN Class C when Table SA5.1 screening is conducted		

Figure SA2.1
Tabulation sheet



SA3 Maximum Smoke Alarm Failure Rates

SA3.1 The overall failure rates for the alarm shall not be greater than as indicated in Table SA3.1.

Table SA3.1
Smoke alarm failure rates

Method of failure rate computation	Maximum alarm failure rate (failures per million hours)
Parts count	3.5
Parts stress analysis	4.0
Screening burn-in	4.0
Published reliability data	4.0
Any combination of above	Lower failure rate number

SA4 General

SA4.1 The evaluation and criteria for acceptance of microelectronic devices consists of a two part procedure:

a) Part I consists of a quality assurance screening program either by the component vendor or detector manufacturer, to assure uniformity of production.

b) Part II includes a determination of a failure rate for the device supplemented by a one time burn-in test.

SA4.2 Although this program is oriented primarily to custom integrated circuit "chips," it is also applied for other microelectronic devices.

SA4.3 Components that comply to the requirements of this program shall be distinctively marked for identification purposes. The detector manufacturer shall maintain on file, accessible to an inspector, copies of the purchase and shipping orders for all alarms and "chips" so that a comparison of the tally of alarms shipped to the quantity of screened devices procured from the component vendor is able to be performed.

SA5 Quality Assurance Screening Program

SA5.1 The following minimum screening program (see Table SA5.1) is to be established by either the component manufacturer (vendor) or the alarm manufacturer. When the screening program is conducted by the component manufacturer, each lot or shipment to the alarm manufacturer is to be accompanied by a certificate of compliance with the Quality Assurance Screening Program.

SA5.2 The test methods and conditions referenced in Table SA5.1 are based on MIL-STD-883B dated July 31, 1977 and its most current revisions.

Table SA5.1
Minimum screening program

Hermetic packages	
1. Internal visual (Method 2010.1, condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample basis[a]
3. Stabilization bake (Method 1008C, 150°C, 24 hours)	100 percent[b]
4. Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	100 percent[c]
5. Seal (fine leak, Method 1014B, $5x10^{-8}$ CC/sec)	100 percent[d]
6. Seal (gross leak – 1014B fluorocarbon)	100 percent
7. Functional electrical, 25°C	100 percent
8. External visual, Method 2009	100 percent
9. Quality conformance	AQL 1.5 percent per MIL-STD 105 Level II
a) Functional electrical, 25°C [Run last, after b), c), and d)]	
b) Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	
c) Seal (Fine leak, Method 1040B, $5x10^{-8}$ CC/sec)[c]	
d) External visual, Method 2009	
Plastic packages	
1. Internal visual (Method 2010.1, condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample basis[a]
3. Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	100 percent[c,f]
4. Functional electrical test, 25°C	100 percent
5. External visual, Method 2009	100 percent
6. Quality conformance	AQL 1.5 percent per MIL-STD 105 Level II
a) Functional electrical test, 25°C [run last, after b) and c)]	
b) Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	
c) External visual, Method 2009	

[a] Modified procedures or sample lot sizes are to be submitted for review.

[b] Stabilization bake is not required when the production process includes equivalent conditioning.

[c] Thermal Shock, Method 1011.1, Condition B or C, is not prohibited as a substitute.

[d] Reduced to 1.5 percent AQL when vendor's first lot of 25,000 units shows statistical justification.

[e] Not required when justified by the reject rate in item 5.

[f] Not required when the sample lot used in the burn-in test is subjected to 100 cycles of the temperature cycling and no devices fail as a result of the temperature cycling. The manufacturer shall then perform an annual audit of the device package type. A method of performing This audit is by choosing samples from the same package type and subjecting them to the Temperature Cycling or Thermal Shock (Methods 1010C or 1011.1, Conditions B or C, MIL-STD-883D, April 9, 1979). Records shall be maintained for inspection.

SA6 Determination of Failure Rate Number Supplemented by Burn-In Test

SA6.1 General

SA6.1.1 The objective of this part is to determine a numerical failure rate for the device to be employed in the overall reliability calculation of the alarm. The method employs Arrehenius calculations and activation energy tables to correlate elevated temperature operation to a failure rate of 38°C (100°F) (maximum installation ambient temperature of the alarm).

SA6.2 Determination sequence

SA6.2.1 The following step-by-step procedure is to be employed in determining the failure rate number:

a) Estimate numerical failure rate.

b) Choose test temperature for acceptance test.

c) Using chosen test temperature, refer to curves in Figure SA6.1 to determine related test time for initial conditional acceptance and final acceptance.

d) Using the equation in SA6.5.1 and the initial conditioning test time determined in (c) calculate the failure rate of the device for conditional acceptance.

e) Sample lot size to be used in temperature test is determined from Table SA6.1. This table lists initial sample lot sizes based on expected failure rates in percent per 1000 hours at a 60 percent confidence level and number of devices that fail during the test, the latter listed as accept numbers. When a different temperature is employed, lot sizes are derived from a table of Summation of Terms of Poisson's Exponential Binomial Limit[d] a 60 percent confidence level.

f) Using the Arrehenius equation and the final test time determined in (c), calculate the failure rate of the device for final acceptance.

[d]Reliability Handbook by W. Grant Ireson

Figure SA6.1
Time-temperature regression and time limits for test condition

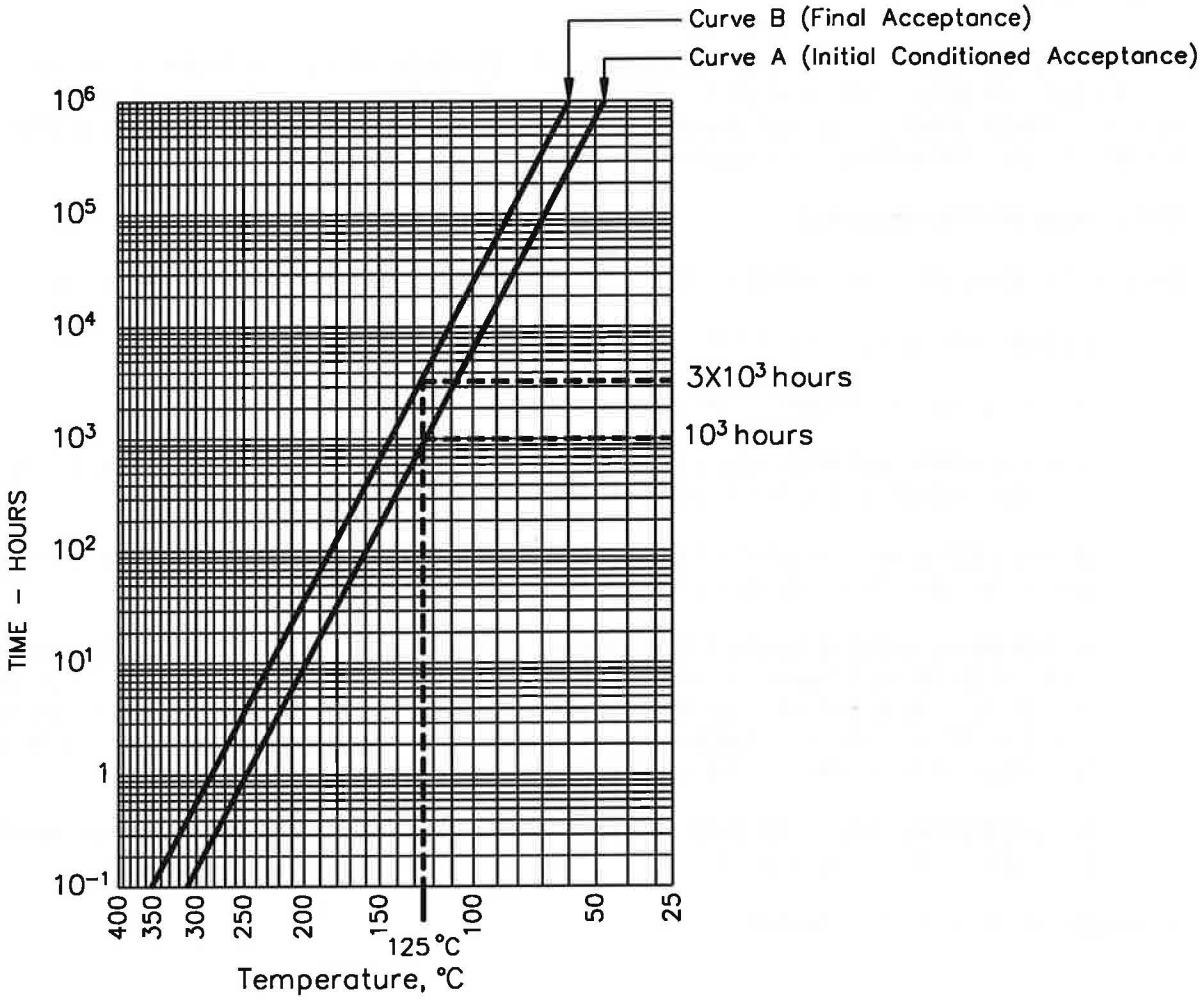


Table SA6.1
Sample lot size for burn-in test

Accept number (C)	Failure rate — percent per 1000 hours																		
	20.00	18.00	15.00	12.00	10.00	8.00	7.00	6.00	5.00	4.00	3.00	2.00	1.50	1.00	0.70	0.30	0.20	0.15	0.10
0	5	5	6	8	9	12	13	16	19	23	31	47	62	93	133	311	466	622	933
1	11	12	15	18	22	27	31	36	44	54	73	109	145	218	311	725	1088	1451	2176
2	15	17	21	26	31	39	44	52	62	77	103	155	206	309	442	1031	1547	2062	3093
3	20	22	27	34	40	50	58	67	81	101	134	201	268	403	575	1342	2013	2684	4026
4	27	30	36	45	54	67	77	89	107	134	179	268	358	536	766	1788	2682	3576	5364
5	32	35	42	53	63	79	90	105	126	158	210	315	420	631	901	2102	3153	4204	6307
6	36	40	48	60	73	91	104	121	145	181	242	363	484	726	1037	2419	3629	4838	7257
7	41	45	54	68	81	101	116	135	162	203	270	405	540	810	1158	2701	4052	5403	8104
8	45	50	60	76	91	113	129	151	181	227	302	453	604	906	1295	3021	4531	6042	9063
9	50	56	67	84	100	125	143	167	200	251	334	501	668	1002	1432	3342	5012	6683	10025
10	60	67	80	100	120	150	171	200	240	300	399	599	799	1198	1712	3994	5991	7988	11982
11	65	72	86	108	129	162	185	216	259	324	431	647	863	1294	1849	4314	6472	8629	12943
12	70	77	93	116	139	174	199	232	278	348	464	696	927	1391	1987	4637	6956	9275	13912
13	74	83	99	124	149	186	212	248	297	372	496	744	991	1487	2124	4957	7435	9913	14870
14	77	85	102	128	153	192	219	255	307	383	511	766	1022	1533	2190	5109	7663	10218	15327
15	82	91	109	136	163	204	233	272	326	408	543	815	1087	1630	2329	5434	8151	10868	16302

SA6.3 Test calculations and procedures

SA6.3.1 Figure SA6.1 illustrates basic curves which represent burn-in test conditions of a device of 1000 hours for initial conditional acceptance and is continued to 3000 hours for final acceptance when tested at an elevated temperature of 125°C (251°F).

SA6.3.2 It is not prohibited that the elevated test temperature and related time periods (using the illustrated curves) be increased or decreased except the minimum chosen temperature for the burn-in test shall not be less than 100°C (212°F).

SA6.3.3 The following examples illustrate the use of the curves in Figure SA6.1 for calculations of final and initial conditional acceptance at temperatures other than 125°C (251°F):

a) Example 1 – Assuming a test temperature of 150°C (302°F):

    1) Time for Initial Conditional Acceptance – 167 hours (using Curve A).

    2) Time for Final Acceptance – 650 hours (using Curve B).

b) Example 2 – Assuming a test temperature of 100°C (212°F):

    1) Time for Initial Conditional Acceptance – 5700 hours (using Curve A).

    2) Time for Final Acceptance – 25,000 hours (using Curve B).

SA6.4 Test conditions

SA6.4.1 Appropriate sockets or other mounting means shall be provided to make firm electrical contact to the terminals of devices under test in the specified circuit configuration. The mounting means shall be constructed so that they do not remove internally dissipated heat from the device by conduction, other than that removed through the device terminals and the required electrical contacts, which shall be maintained at or above the specified ambient temperature. The apparatus is to provide for maintaining the specified biases at the terminal of the device under test and, when specified, monitoring of the input excitation. When the device incorporates on board elements which directly drive such things as the smoke alarm horn, battery pulse test or beacon LED of a photoelectric smoke alarm, these shall be pulsed during the test for a number of cycles equivalent to the operation life of the intersection of curve B, Figure SA6.1, with the 38°C (100°F) line.

SA6.4.2 Power supplies and current-setting resistors shall be capable of maintaining the specified operating conditions, as minimal throughout the testing period with normal variations in their source voltages,and ambient temperatures. The test equipment is preferably to be arranged so that only natural convection cooling of the devices occurs. When test conditions result in significant power dissipation, the test apparatus is to be arranged so as to result in the average power dissipation for each device whether devices are tested individually or in a group. The test circuits are not required to compensate for normal variations in individual device characteristics and shall be arranged so that the existence of failed or abnormal (for example open, or short) devices in a group does not negate the effect of the test for other devices in the group.

SA6.5 Failure rate number calculation

SA6.5.1 The following equation is to be used in determining the initial conditional and final failure rates for the device in concert with the burn-in test. Extrapolations are made from the chosen elevated test temperature to the 38°C (100°F) smoke detector operating condition by use of the Arrehenius Equation.

$$\lambda = A_e^{\left(\frac{-E}{KT}\right)}$$

in which:

λ is the failure rate per million hours

A is the constant

E is the activation energy in electron volts (ev) (varies between 0.65 ev to 1.1 ev for a large number of integrated circuits). Documentation shall be provided to support value employed. When documentation is not provided, value of 0.65 ev is to be used.

K is Boltzman's constant (8.62×10^{-5} ev/°K).

T is the absolute temperature in degrees Kelvin.

Example:

a) Numerical failure rate $\lambda_2 = 0.1$ Failure per 10^6 hours.

b) Test ambient temperature is 125°C (257°F).

c) Required test time from Figure SA6.1 for conditional acceptance is 1000 hours and for final acceptance is 3000 hours.

d) Using the equation in SA6.5.1 and assuming an Activation Energy (E) of 0.65 ev, the following calculations are performed:

$$\lambda_1 = A_e^{\left(\frac{-E}{KT}\right)} \text{ for } 125°C$$

$$\lambda_2 = A_e^{\left(\frac{-E}{KT}\right)} \text{ for } 38°C$$

Then

$$\frac{\lambda_1}{\lambda_2} = \ln^{-1}\left[\frac{-E}{K}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]$$

in which:

λ_2 is 0.1 failure per 10^6 hours

E is 0.65 ev

K is 8.62×10^{-5} ev/°K

T_1 is 398°K

T_2 is 311°K

Then

$$\lambda_1 = \lambda_2 \ln^{-1}\left[\frac{-0.65}{8.62 \times 10^{-5}}\left(\frac{1}{398} - \frac{1}{311}\right)\right]$$

in which:

λ_1 is 20×10^{-6} failures/hour.

λ_1 is 20 failures/10^6 hour.

λ_1 is 0.02 failure/1000 hour.

λ_1 is 2.0 percent/1000 hour.

e) Referring to Table SA6.1, the following sample lot size for the appropriate Accept Number (C – the number of failures or less), is usable at the conditional acceptance point (1000 hours). For 2.0 percent/1000 hours:

C = 0 N = 47

C = 1 N = 109

C = 2 N = 155

From the equation and Table SA6.1, with no failures from a sample lot size of 47 at a test ambient of 125°C, the failure rate is 0.1 Failure/10^6 hours at the conditional acceptance point of 1000 hours. It is possible for the failure rate to be less at the final acceptance point of 3000 hours.

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APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard – UL Standard Designation

Control Units for Fire-Protective Signaling Systems – UL 864
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Motors, Overheating Protection for – UL 2111
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape – UL 510
Printed-Wiring Boards – UL 796
Switches, Snap, General-Use – UL 20
Transformers, Specialty – UL 506
Tubing, Extruded Insulating – UL 224
Wire Connectors and Soldering Lugs for Use with Copper Conductors – UL 486A
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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APPENDIX B

Obscuration – Optical Density Chart

Obscuration – optical density chart Based on a 5-foot (1.52-m) light beam

Light transmission (meter reading), microamperes	Obscuration (Ou)		Total obscuration, Od	Optical density (OD)		Total optical density, ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
100.0	0.000	0.000	0.000	0.0000	0.0000	0.0000
99.5	0.100	0.328	0.500	0.0004	0.0014	0.0022
99.0	0.201	0.657	1.000	0.0009	0.0029	0.0044
98.5	0.302	0.987	1.500	0.0013	0.0043	0.0066
98.0	0.403	1.317	2.000	0.0018	0.0058	0.0088
97.5	0.505	1.648	2.500	0.0022	0.0072	0.0110
97.0	0.607	1.979	3.000	0.0027	0.0087	0.0132
96.5	0.710	2.311	3.500	0.0031	0.0102	0.0155
96.0	0.813	2.643	4.000	0.0036	0.0116	0.0177
95.5	0.917	2.976	4.500	0.0040	0.0131	0.0200
95.0	1.021	3.310	5.000	0.0045	0.0146	0.0223
94.5	1.125	3.644	5.500	0.0049	0.0161	0.0246
94.0	1.230	3.979	6.000	0.0054	0.0176	0.0269
93.5	1.335	4.314	6.500	0.0058	0.0192	0.0292
93.0	1.441	4.650	7.000	0.0063	0.0207	0.0315
92.5	1.547	4.987	7.500	0.0068	0.0222	0.0339
92.0	1.654	5.324	8.000	0.0072	0.0238	0.0362
91.5	1.761	5.662	8.500	0.0077	0.0253	0.0386
91.0	1.869	6.001	9.000	0.0082	0.0269	0.0410
90.5	1.977	6.340	9.500	0.0087	0.0285	0.0434
90.0	2.085	6.680	10.00	0.0092	0.0300	0.0458
89.5	2.194	7.020	10.50	0.0096	0.0316	0.0482
89.0	2.304	7.362	11.00	0.0101	0.0332	0.0506
88.5	2.414	7.703	11.50	0.0106	0.0348	0.0531
88.0	2.524	8.046	12.00	0.0111	0.0364	0.0555
87.5	2.635	8.389	12.50	0.0116	0.0381	0.0580
87.0	2.747	8.733	13.00	0.0121	0.0397	0.0605
86.5	2.859	9.077	13.50	0.0126	0.0413	0.0630

Obscuration – optical density chart Based on a 5-foot (1.52-m) light beam Continued

Light transmission (meter reading), microamperes	Obscuration (Ou)		Total obscuration, Od	Optical density (OD)		Total optical density, ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
86.0	2.971	9.423	14.00	0.0131	0.0430	0.0655
85.5	3.085	9.768	14.50	0.0136	0.0446	0.0680
85.0	3.198	10.12	15.00	0.0141	0.0463	0.0706
84.5	3.312	10.46	15.50	0.0146	0.0480	0.0732
84.0	3.427	10.81	16.00	0.0152	0.0497	0.0757
83.5	3.542	11.16	16.50	0.0157	0.0514	0.0783
83.0	3.658	11.51	17.00	0.0162	0.0531	0.0809
82.5	3.774	11.86	17.50	0.0167	0.0548	0.0836
82.0	3.891	12.21	18.00	0.0172	0.0566	0.0862
81.5	4.009	12.56	18.50	0.0178	0.0583	0.0889
81.0	4.127	12.91	19.00	0.0183	0.0600	0.0915
80.5	4.246	13.27	19.50	0.0188	0.0618	0.0942
80.0	4.365	13.62	20.00	0.0194	0.0636	0.0969
79.5	4.48	13.48	20.5	0.0199	0.0654	0.0996
79.0	4.61	14.33	21.0	0.0204	0.0672	0.1023
78.5	4.73	14.64	21.5	0.0210	0.0690	0.1051
78.0	4.85	15.04	22.0	0.0215	0.0708	0.1079
77.5	4.97	15.40	22.5	0.0221	0.0726	0.1107
77.0	5.09	15.76	23.0	0.0227	0.0745	0.1135
76.5	5.22	16.12	23.5	0.0232	0.0763	0.1163
76.0	5.34	16.48	24.0	0.0238	0.0782	0.1191
75.5	5.47	16.84	24.5	0.0244	0.0801	0.1220
75.0	5.59	17.20	25.0	0.0249	0.0820	0.1249
74.5	5.72	17.56	25.5	0.0255	0.0839	0.1278
74.0	5.84	17.93	26.0	0.0261	0.0858	0.1307
73.5	5.97	18.29	26.5	0.0267	0.0877	0.1337
73.0	6.10	18.66	27.0	0.0273	0.0897	0.1366
72.5	6.23	19.02	27.5	0.0279	0.0916	0.1396
72.0	6.36	19.39	28.0	0.0285	0.0936	0.1426
71.5	6.49	19.76	28.5	0.0291	0.0956	0.1456
71.0	6.62	20.13	29.0	0.0297	0.0976	0.1487

Obscuration – optical density chart Based on a 5-foot (1.52-m) light beam Continued

Light transmission (meter reading), microamperes	Obscuration (Ou)		Total obscuration, Od	Optical density (OD)		Total optical density, ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
70.5	6.75	20.50	29.5	0.0303	0.0996	0.1518
70.0	6.89	20.87	30.0	0.0309	0.1016	0.1549
69.5	7.02	21.24	30.5	0.0316	0.1037	0.1580
69.0	7.15	21.61	31.0	0.0322	0.1057	0.1611
68.5	7.29	21.98	31.5	0.0328	0.1078	0.1643
68.0	7.42	22.36	32.0	0.0335	0.1099	0.1674
67.5	7.56	22.73	32.5	0.0341	0.1120	0.1707
67.0	7.70	23.11	33.0	0.0347	0.1141	0.1739
66.5	7.84	23.49	33.5	0.0354	0.1163	0.1771
66.0	7.97	23.86	34.0	0.0360	0.1184	0.1804
65.5	8.11	24.24	34.5	0.0367	0.1206	0.1837
65.0	8.25	24.62	35.0	0.0374	0.1228	0.1870
64.5	8.40	25.00	35.5	0.0380	0.1250	0.1904
64.0	8.54	25.39	36.0	0.0387	0.1272	0.1938
63.5	8.68	25.77	36.5	0.0394	0.1294	0.1972
63.0	8.83	26.15	37.0	0.0401	0.1317	0.2006
62.5	8.97	26.54	37.5	0.0408	0.1339	0.2041
62.0	9.12	26.92	38.0	0.0415	0.1362	0.2076
61.5	9.26	27.31	38.5	0.0422	0.1385	0.2111
61.0	9.41	27.70	39.0	0.0429	0.1409	0.2146
60.5	9.56	28.09	39.5	0.0436	0.1432	0.2182
60.0	9.71	28.48	40.0	0.0443	0.1456	0.2218
59.5	9.86	28.87	40.5	0.0451	0.1480	0.2254
59.0	10.01	29.26	41.0	0.0458	0.1504	0.2291

NOTE – See 37.3.1.

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Superseded requirements for
the Standard for
Single and Multiple Station Smoke Alarms

UL 217, Fifth Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

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 , 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 of a permanently installed alarm is to be made at the supply connection polarity indicated on the installation wiring diagram supplied with the alarm. When a connection polarity is not indicated, the measurement is to be made at each polarity. See Figure .

69.1 A smoke alarm shall operate as intended after being connected in each polarity. This includes high-voltage cord connected and fixed wiring (splice lead) types, battery types (main or standby), and multiple station interconnection leads. Each polarity is to be applied for at least 24 hours on all units unless a trouble signal or alarm signal is obtained. For battery operated alarms intended to be connected by a polarized clip assembly the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be permitted under any incorrect polarity applied. A maximum 1-second alarm is permitted when the correct polarity is connected.

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