

9.39.6 With reference to the requirements in Clause 9.39.5, 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 102- by 203-mm (4- by 8-in) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 1.83 m (6 ft) apart.

9.39.7 Electric shock current refers to all currents, including capacitively coupled currents.

9.39.8 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.

9.39.9 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.

9.40 DIELECTRIC VOLTAGE-WITHSTAND TEST

9.40.1 A detector shall withstand for 1 min, without breakdown, the application of a sinusoidal ac potential of a frequency within the range of 40 – 75 Hz, or a dc potential, between live parts and the enclosure, between live parts and exposed dead metal parts, and between live parts of hazardous- and *extra-low-voltage circuits*. The test potential is to be as follows:

- A For a detector rated 30 V ac rms (42.4 V dc or ac peak) or less – 500 V ac (707 V, when a dc potential is used);
- B For a detector rated between 31 and 150 V ac rms – 1000 V ac (1414 V, when a dc potential is used);
- C For a detector rated more than 150 V ac rms – 1000 V ac plus twice the rated voltage (1414 V plus 2.828 times the rated ac rms voltage when a dc potential is used).

9.40.2 Any reference or component grounds shall be disconnected prior to the test applications.

9.40.3 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintaining the specified AC test potential, it is permissible to test the capacitors and capacitor-type filters using a DC potential in accordance with Clause 9.40.1.

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

9.40.5 When there is the possibility of short circuit or damage to a printed-wiring assembly or other electronic-circuit component by application of the test potential, the component is to be removed, disconnected, or otherwise rendered inoperative before the test. It is permissible to test a representative subassembly instead of an entire unit.

9.41 DIELECTRIC VOLTAGE-WITHSTAND TESTING IN LIEU OF MEASURING CLEARANCES

9.41.1 For printed circuit assemblies contained within metal enclosures, if one or more components would cause the indication of a breakdown because they complete the path between the points being tested, those components may have one termination disconnected, so long as the points in question are subjected to the same test voltage.

9.41.2 Clearance values for printed circuit assemblies contained within metal enclosures may be verified by conducting the impulse withstand voltage test described in Clause 9.41.4. The equipment shall withstand the voltage impulse without breakdown or disruptive discharge. Breakdown is considered to have occurred when the leakage current exceeds 4 mA or when the test voltage is interrupted prior to completion. Operation of an overvoltage protective device is not considered a breakdown.

9.41.3 If a disruptive discharge occurs through an overvoltage protective device or system, that device or system is to be removed from the circuit and the test voltage is to be reduced to the impulse withstand voltage of that device or system. The test voltage is then to be applied across the load side at the point where the overvoltage protection was connected.

9.41.4 With reference to Clause 8.6.12.2.2 and Clause 8.6.12.3.6, a previously untested product is to be used. The voltage is to be full lightning 1.2/50 microsecond impulses in accordance with Techniques for High-Voltage Testing, ANSI/IEEE 4-1978. Three positive and three negative impulses are to be applied. The minimum interval between pulses is to be 1 s. Other equivalent methods, as shown in Table 8, Test Voltages for Verifying Through Air Spacings (Clearances), or Table 10, Minimum Clearances for Equipment, as appropriate, may be used. The test voltage is to be applied at the supply input to the product under consideration.

9.42 BURNOUT TEST

9.42.1 A continuous-duty resistor shall not be burned out or adversely affected by carrying the full normal current on any step continuously. A resistor intended for intermittent use shall be able to carry its rated current on any step for as long a time as permitted by the character of the apparatus which it controls.

9.42.2 There shall not be manifestation of a *risk of fire* or electric shock when an *unreliable component*, such as an electrolytic capacitor, is opened or shorted. The device is to be connected to a source of rated voltage and frequency and with the enclosure grounded. Each fault is to be applied separately until temperatures stabilize or burnout occurs. Components operating at 50% or less of the manufacturer's ratings, or those known to be highly reliable, are not included under this requirement.

9.42.3 When a time-limit cut-out or a mercury-tube switch is employed in such a manner that a fault, either a short circuit or a ground, will cause it to carry current in excess of its maximum normal load, the cutout or switch shall be capable of withstanding, without introducing a *risk of fire*, a short circuit as described in Clauses 9.42.4 through 9.42.6.

9.42.4 The time-limit cut-out or mercury-tube switch is to be connected in series with a protective fuse(s) of the marked maximum rating with which it is intended to be used, as indicated by the marking of the control unit. The cutout or switch is to be tested while mounted normally in the control unit; all openings of the enclosure of the control unit are to be covered with surgical cotton, and the enclosure, if of metal, is to be connected to ground through a fuse of the same rating as the protective fuse mentioned in Clause 9.42.10.

9.42.5 The open-circuit voltage of the test circuit is to be within 5% of the rated voltage of the control unit circuit in which the device is applied, except that a voltage of more than 105% of the rated voltage may be employed if agreeable to those concerned. The source of current and the test circuit are to be of sufficient capacity to deliver 1000 A when the system is short-circuited at the testing terminals.

9.42.6 There shall not be ignition of the cotton or of insulation on circuit conductors, emission of flame or molten metal (mercury excepted), from the enclosure, blowing of the fuse in the grounding conductor, damage to other parts of the control unit, or any manifestation of a *risk of fire*. The burnout of pigtail leads or of a thermal element, or the welding of contacts, is not prohibited.

9.42.7 The cutout or switch is to be tested while mounted normally in the device; all openings of the enclosure of the device are to be covered with surgical cotton, and the enclosure, when of metal, is to be connected to ground through a fuse of the same rating as the protective fuse mentioned in Clause 9.42.10.

9.42.8 When a power transformer other than a transformer supplying a low-voltage circuit is operated as described below, there shall not be damage to the enclosure or emission of flame or molten metal.

9.42.9 The device is to be operated continuously at the voltage and frequency specified in Clause 9.2.2 with the enclosure grounded. The load connected to the output terminals is to be a resistance of such value that three times the full-rated current will be drawn from the secondary winding of the device, and operation is to be continued until constant temperatures are attained on the enclosure or until burnout occurs.

9.42.10 A circuit on which a transformer is tested is to be protected by fuses rated at least ten times the primary current rating of the transformer. Opening of the fuses is not prohibited. The test is to be conducted with the output terminals short-circuited, when such a condition results in less than three times full-rated current being drawn from the secondary. When other means of limiting the load to less than three times normal is inherent in or provided as part of the device, these features are to be given consideration and the burnout test conducted at the maximum load permitted by the limiting features. These features may be external to the transformer and include, but are not limited to, the following:

- A Nonresettable thermal elements that are integral with the transformer windings;
- B Wire wound, or other types of resistors that limit the load current;
- C Positive temperature coefficient (PTC) resistors;
- D Inherent limitation due to impedance of the transformer windings; and
- E Nonreplaceable fusing elements that are soldered into the product.

9.42.11 A transformer supplying a low-voltage circuit is to be tested with output (secondary) wiring terminals short circuited.

9.43 AUDIBLE SIGNALING APPLIANCE

9.43.1 The internal and/or external audible signaling appliance associated with each of two detectors shall operate as intended when the detectors are operated for 8 h of alternate 5-min periods of activation and de-activation of the audible *alarm signal*, followed by 72 h of continuous activation of the *alarm signal*. For this test, the detectors shall be connected to a source of rated voltage and frequency. For a battery operated detector, a filtered DC supply shall be employed that has an output voltage equivalent to the fresh battery voltage. The sound level output following endurance shall meet the requirements of Subsection 9.47, Audibility Test.

9.44 JARRING TEST

9.44.1 A detector shall withstand jarring resulting from impact and vibration such as that experienced in service, without causing an *alarm signal* or *trouble signal*, without dislodgment of any parts, and without impairing its subsequent operation.

Exception: Dislodgment of parts is acceptable if the dislodged part(s) does not affect the operation of the unit, and there are no high voltage parts exposed.

9.44.2 The detector and associated equipment, if any, shall be mounted in a position of intended use to the centre of an 1800 by 1200 mm (6 by 4 ft), nominal 19 mm thick (nominal 3/4 in) plywood board which is secured in place at four corners.

9.44.3 A 100 by 100 mm $\pm 10\%$ (3.94 x 3.94 in $\pm 10\%$) steel plate, 3.2 mm $\pm 10\%$ (1/8 in $\pm 10\%$) thick, shall be rigidly secured to the centre of the reverse side of the board.

9.44.4 An impact of 4.08 J (3 ft-pounds) shall be applied once to the centre of the reverse side of this board by means of a 540 g (1.18 pound), 50 mm (2 in) diameter steel sphere either:

- A Swung through a pendulum arc from a height (h) of 775 mm (2.54 ft) in order to apply 4.08 J of energy; or
- B Dropped from a height (h) of 775 mm (2.54 ft) to apply 4.08 J (3 ft-lbs) of energy, depending upon the mounting of the equipment (see Figure 14, Jarring Test).

9.44.5 The test is to be conducted by supporting the detector in its intended mounting position and conducting the jarring with the detector in the standby condition and connected to a rated source of supply in accordance with 9.2.2.

9.44.6 Following the jarring, the detector shall be tested for *sensitivity* in accordance with Subsection 9.9, Electrical Supervision Test. *Sensitivity* measurements shall vary not more than specified in Subsection 9.4, *Sensitivity Limits*.

9.45 STRAIN RELIEF TEST

9.45.1 General

9.45.1.1 Each lead employed for field connections or an internal lead or cord subjected to movement or handling during installation and servicing, including a battery clip lead assembly, shall withstand for 1 min a pull force of 44.5 N (10 pounds) without any evidence of damage or of transmitting the stress to internal connections.

9.45.1.2 A connector used in the lead assembly shall withstand for 1 min a pull force of 22.3 N (5 pounds force) without any evidence of damage, transmittal of stress to internal connections, or separation.

9.45.1.3 A strain relief test on a cord or leads which depend upon a thermoplastic enclosure or part is to be conducted following exposure to either temperature conditioning test described in Subsection 9.50.2, Temperature Test. The test is to be performed after the sample has been placed in room temperature for at least 3 h.

9.45.2 Strain Relief (Special Field-Wiring Terminals)

9.45.2.1 To determine suitability as a field-wiring connection in compliance with Subsection 8.3.4, Special Field-Wiring Terminals (Qualified Application), representative samples shall comply with all of the tests specified in 9.45.2.2 and 9.45.2.3.

9.45.2.2 A terminal connection shall withstand the application of a straight pull of 22.2 N (5 pounds), applied for 1 min to the wire in the direction which would most likely result in pullout, without separating from the terminal.

9.45.2.3 Six samples of the terminal are to be connected to the wire sizes with which they are intended to be used, in accordance with the manufacturer's instructions. When a special tool is required to assemble the connection, it is to be used. Each sample is to be subjected to a gradually increasing pull on the wire until the test pull of 22.2 N (5 pounds) is reached and maintained at 22.2 N (5 pounds) for 1 min.

9.46 REPLACEMENT TEST, HEAD AND COVER

9.46.1 A detector 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, and shall comply with the requirements of Subsection 9.44, Jarring Test.

9.46.2 A detector is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as recommended by the manufacturer. The unit is then to be subjected to Subsection 9.44, Jarring Test.

9.47 AUDIBILITY TEST

9.47.1 Sound Output Measurement

9.47.1.1 A detector for emergency use that incorporates an audible device shall be capable of providing an output of at least 85 dBA at 3 m for at least 4 min after being subjected to the endurance test described in Subsection 9.35, Endurance Test, while connected to a source of rated voltage and frequency and mounted as described in 9.47.1.4 with the front of the detector at 90° with the horizontal and facing the microphone. At least two samples shall be tested.

9.47.1.2 All other devices that incorporate an audible signal shall be capable of producing an output of at least 45 dBA at 3 m.

9.47.1.3 It is permissible for detectors to be tested with the horn duty cycle defeated and emitting a continuous tone.

9.47.1.4 The measurement shall be made in a free field condition to minimize the effect of reflected sound energy. The ambient noise level is to be at least 10 dB below the measured level produced by the signal appliance. Free field conditions may be simulated by mounting the device on a wood surface at least 125 by 150 mm not less than 3 m from the ground and with the microphone located 3 m from the detector and conducting the test outdoors on a clear day with a wind velocity of not more than 8 kph and an ambient temperature of 15 to 25 °C.

9.47.1.5 Alternately, an anechoic chamber of not less than 28 m³, with no dimension less than 2 m, and with an absorption factor of 0.99 or greater from 100 Hz to 10 kHz for all surfaces may be used for this measurement.

9.47.2 Alarm duration test

9.47.2.1 An alarm sounding appliance of a sample powered by a primary battery that has been discharged to the trouble level condition shall produce a sound power output level per the intended application or the equivalent of 85 db at 3.05 m (10 ft) after 1 min of continuous alarm operation and shall provide at least 82 db after 4 min.

9.47.2.2 To determine compliance with Clause 9.47.2.1, a measurement shall be made under the following conditions:

- A The ambient noise level is to be at least 10 db below the measured level produced by the signaling appliance;
- B The detector is to be mounted 302 mm (1 ft) from the microphone placed in a direct line with the detector;
- C The detector is then to be energized in the alarm condition and the sound output is to be measured at 1 min intervals, using a sound level meter employing the A-weighting network. A maximum of 3 db decrease from the original 1 min reading after 4 min shall determine compliance for a battery operated detector that is providing a *trouble signal*.

9.47.3 Supplementary Remote Sounding Appliances

9.47.3.1 The sound output of a supplementary remote sounding appliance, shall not be less 85 dbA for primary signaling or less than the sound output rating specified by the manufacturer.

9.48 PAINT LOADING TEST

9.48.1 Unless marked in accordance with Clause 10.1.1 (N), a detector shall be tested as described in Subsection 9.16, *Sensitivity* Test, before and after painting, if the detector assembly, screens, openings, or similar items are capable of becoming clogged or covered by painting.

9.48.2 The exterior surface of two samples, including screened openings, or the like are to be coated with a latex based paint which is spread at approximately two times the paint manufacturer's recommended spreading rate. The paint is to be allowed to dry for 5 d at room temperature. Following this, the samples are to be given a second identical application of paint and again permitted to dry for 5 d. *Sensitivity* measurements following this test shall not exceed the limits specified in Subsection 9.4, *Sensitivity* Limits.

9.49 LOCKED ROTOR TEST – MOTORS

9.49.1 All motors shall be protected by thermal or by overcurrent protective devices, or a combination thereof.

NOTE: A motor employing thermal protection which complies with CSA C22.2 No. 77, Motors with Inherent Overheating Protection, are considered to comply with this requirement. Motors such as direct-drive fan motors, which are not normally subjected to over-loads, and which are determined to be adequately protected against overheating due to locked-rotor current by a thermal or overcurrent protective device may be accepted under this requirement provided that it is determined that the motor will not overheat under the performance requirements of this Standard. (A thermal or overcurrent protective device shall not open the circuit during the temperature test.)

9.49.2 A motor having openings in the enclosure or frame shall be arranged so that particles dropping out of the motor will not fall onto combustible material within or under the detector.

9.50 TESTS ON POLYMERIC MATERIALS

9.50.1 General

9.50.1.1 Polymeric materials intended for the sole support of current-carrying parts or as an enclosure of a device shall be subjected to the following tests. Where possible a complete unit shall be used.

9.50.2 Temperature Test

9.50.2.1 There shall not be warping that impairs intended operation or exposes hazardous-voltage uninsulated current-carrying parts when representative samples of a polymeric material are in a circulating-air oven for the number of days associated with the test temperature per the equation below, and at a relative humidity of 0 – 10%.

$$t_{\text{test-time}} = t_{\text{real-time}} / 2^{(T_{\text{oven}} - T_{\text{installation}}) / 10}$$

Where

$t_{\text{real time}} = 257$ days,

$T_{\text{oven}} =$ oven temperature (70°C minimum)

$T_{\text{installation}} =$ maximum installation temperature (as specified by the manufacturer)

For example, for a detector with a maximum installation ambient temperature of 38°C (100°F) shall be tested at an oven temperature of 90°C (194°F), the calculation below would apply;

$$t_{\text{test-time}} = 257 / 2^{(90-38)/10}$$

$$t_{\text{test-time}} = 7 \text{ days}$$

9.50.2.2 Three representative samples shall be mounted on supports as intended in service and placed in the oven. Following the aging period indicated in Clause 9.50.2.1, the samples shall be viewed (while in the oven) for distortion, removed, permitted to cool to room temperature, and then reexamined for compliance with the requirements of Clause 9.50.2.1. The detector cover shall be allowed to fall off only when hazardous-voltage parts are not exposed, operation for gas or vapour is not affected, and the cover is able to be replaced as intended. *Sensitivity* measurements shall not vary more than specified in Subsection 9.4, *Sensitivity* Limits.

9.50.3 Flame Test 19 mm (3/4 Inch)

9.50.3.1 When equipment is tested as described in Clauses 9.50.3.2 – 9.50.3.6, the material shall not flame for more than 1 min after two 30-s applications of a test flame, with an interval of 1 min 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, or V-2 are not required to be subjected to the flammability test described in Clauses 9.50.3.2 – 9.50.3.6.

9.50.3.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature no less than 10 °C (18 °F) higher than the maximum temperature of the material measured under normal operating conditions, and no 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 h, the samples are to be tested as described in Clauses 9.50.3.3 – 9.50.3.6.

Exception: It is permissible that the test be conducted 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.*

9.50.3.3 Three samples of the part shall be subjected to the flame test described in Clause 9.50.3.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Non-polymeric 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 ignitable because of its proximity to a source of ignition. Each sample shall be tested with the flame applied to a different location.

Exception: It is permissible that the test be conducted 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.*

9.50.3.4 With reference to Clause 9.50.3.3, the sections most ignitable shall be identified as those adjacent to coil windings, splices, open-type switches, or arcing parts.

9.50.3.5 The flame of a Bunsen or Tirrill burner having a tube with a length of 100 ± 10 mm (3.94 ± 0.39 in) and an inside diameter of 9.5 ± 0.3 mm (0.374 ± 0.12 in) is to be adjusted to have a 19-mm (3/4-in) height of yellow flame with no blue cone. Two 30-s applications of the tip of the flame shall be made to each section of the equipment chosen as indicated in Clause 9.50.3.4, with 1 min 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 37 MJ/m^3 (1000 Btu/ft^3) at 23 °C (73°F) has been found to provide similar results and is permissible for use.

9.50.3.6 When one sample from a set of three does not comply with Clause 9.50.3.1, an additional set of three samples shall be tested. All samples from the second set shall comply with Clause 9.50.3.1.

9.50.4 Flame Test 127 mm (5 inch)

9.50.4.1 When equipment is tested as described in 9.50.4.2 – 9.50.4.6, all of the following results shall be obtained:

- A The material shall not continue to burn for more than 1 min after the fifth 5-s application of the test flame, with an interval of 5 s between applications of the flame.*

- B Flaming drops or flaming or glowing particles that ignite surgical cotton 305 mm (12 in) 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 are not required to be subjected to the flammability tests described in Clauses 9.50.4.2 to 9.50.4.4.

9.50.4.2 Three samples of the complete equipment, or three test specimens of the molded part, are to 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) over 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 h at 23.0 ± 2 °C (73.4 ± 3.6 °F) and $50 \pm 5\%$ 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: The test shall be conducted on 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.*

9.50.4.3 The three samples are to result in the performance described in Clause 9.50.4.1. 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 three new specimens shall comply with Clause 9.50.4.1.

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

9.50.4.5 When a complete enclosure is used to conduct the flame test, the sample is to be mounted as intended in service in a draft-free test chamber, enclosure, or laboratory hood. A layer of surgical cotton is to be located 305 mm (12 in) below the point of application of the test flame. The 127-mm (5-in) 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° 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: It is permissible that the flame 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 37 MJ/m³ (1000 Btu/ft³) at 23 °C (73°F) has been found to provide similar results and is permissible for use.

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

9.51 CONFORMAL COATINGS ON PRINTED CIRCUIT BOARDS

9.51.1 General

9.51.1.1 *Conformal coatings* are for use only on printed circuit boards where the acceptability of the combination has been investigated for flammability in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials, and the dielectric property after environmental, humidity, and thermal conditioning in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials.

9.51.2 Low Voltage Printed Circuit Boards

9.51.2.1 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 V rms or less.

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

9.51.2.3 Four specimens shall be conditioned to room ambient by exposure to ambient air at a temperature of 23 ± 2 °C (73, minus 3, +4 °F) and $50 \pm 5\%$ relative humidity for not less than 24 h. Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-Withstand Test, Subsection 9.40, for the 0 – 30 volt range. There shall be no 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.

9.51.2.4 Four samples shall be exposed to ambient air at a temperature chosen from the applicable temperature index line shown in Figure 15, Aging Time Versus Aging Temperature, corresponding to the “in service” operating temperature of the coating. The aging temperature chosen from the index line shall correspond to not less than 1000 h of exposure. It is permissible for any value of temperature to be chosen when it corresponds to no fewer than 300 h of exposure. The samples are then to be subjected to Subsection 9.40, Dielectric Voltage-Withstand Test. 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.

9.51.2.5 As an option to the use of *conformal coating* for circuits at a potential of 30 V rms (42.4 V DC or AC peak) or less and less than 100 volt-A, four samples of the printed circuit board shall be subjected to the following tests. The samples shall be conditioned in the environment described in Subsection 9.20, Humidity Test. Following the conditioning, the four samples shall be subjected to Subsection 9.40, Dielectric Voltage-Withstand Test, for the 0 – 30 V range. There shall not be indication of dielectric breakdown as a result of the test.

9.51.3 High Voltage Printed Circuit Boards

9.51.3.1 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 V rms. The coating shall not be less than 0.2 mm (0.008 in) thick.

9.51.3.2 Three samples of the printed circuit board without electrical components installed, and coated with the *conformal coating*, shall be subjected to this test. Test leads shall be attached to the printed circuit (prior to the application of the coating) so as to allow for convenient application of the specified test potential. Each sample shall be subjected to a 5,000 V AC Dielectric Voltage-Withstand Test potential for 1 min:

- A The test shall be performed between tracks on the printed circuit board;
- B A 7-day heating-cooling cycling period, each cycle consisting of 4 h "on" at 105 ± 2 °C (221 ± 4 °F) followed by 4 h "off" at 25 ± 2 °C (77 ± 4 °F);
- C A 7-day oven conditioning period of 100 ± 2 °C (212 ± 4 °F);
- D A 7-day oven conditioning period at $85 \pm 2\%$ relative humidity at 65 ± 2 °C (149 ± 4 °F); and
- E A Dielectric Voltage-Withstand Test potential at 2,500 V AC repeated 10 times.

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

9.51.3.3 A sample of the coated printed circuit 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 $93 \pm 2\%$ at a temperature of 32 ± 2 °C (89, minus 3, +4 °F) for a period of 24 h followed by a 500 V Dielectric Voltage-Withstand Test with the sample maintained in the conditioning atmosphere. There shall be no indication of a dielectric breakdown.

9.52 MECHANICAL STRENGTH TESTS FOR METAL ENCLOSURES AND GUARDS

9.52.1 The enclosure or guard of a unit, when of metal, shall withstand a force of 45.4 kg (100 lbs) for 1 min without:

- A Permanent distortion to the extent that spacings are reduced more than 50% of the values specified in Subsection 8.6.12, Spacings;
- B Transient distortion that results in contact with live parts; or
- C Developing openings that do not comply with the accessibility requirements in Subsection 8.2.11, Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts. The force is to be applied by means of a metal sphere 12.7 mm (1/2 in) in diameter.

9.52.2 The enclosure or guard of a unit, when of metal, shall withstand an impact of 6.8 N-m (5 ft-lbs) without:

- A Permanent distortion to the extent that spacings are reduced below the values specified in Subsection 8.6.12, Spacings;
- B Transient distortion that results in contact with live parts; or
- C Developing openings that do not comply with the accessibility requirements in Subsection 8.2.11, Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts.

The impact is to be applied by means of a smooth, solid, steel sphere 50.8 mm (2 in) in diameter and having 0.54 kg (1.18 lb) mass. The sphere is to fall freely from rest through a vertical distance of 1.30 m (51 in). See Figure 16, Ball-Pendulum Impact Test.