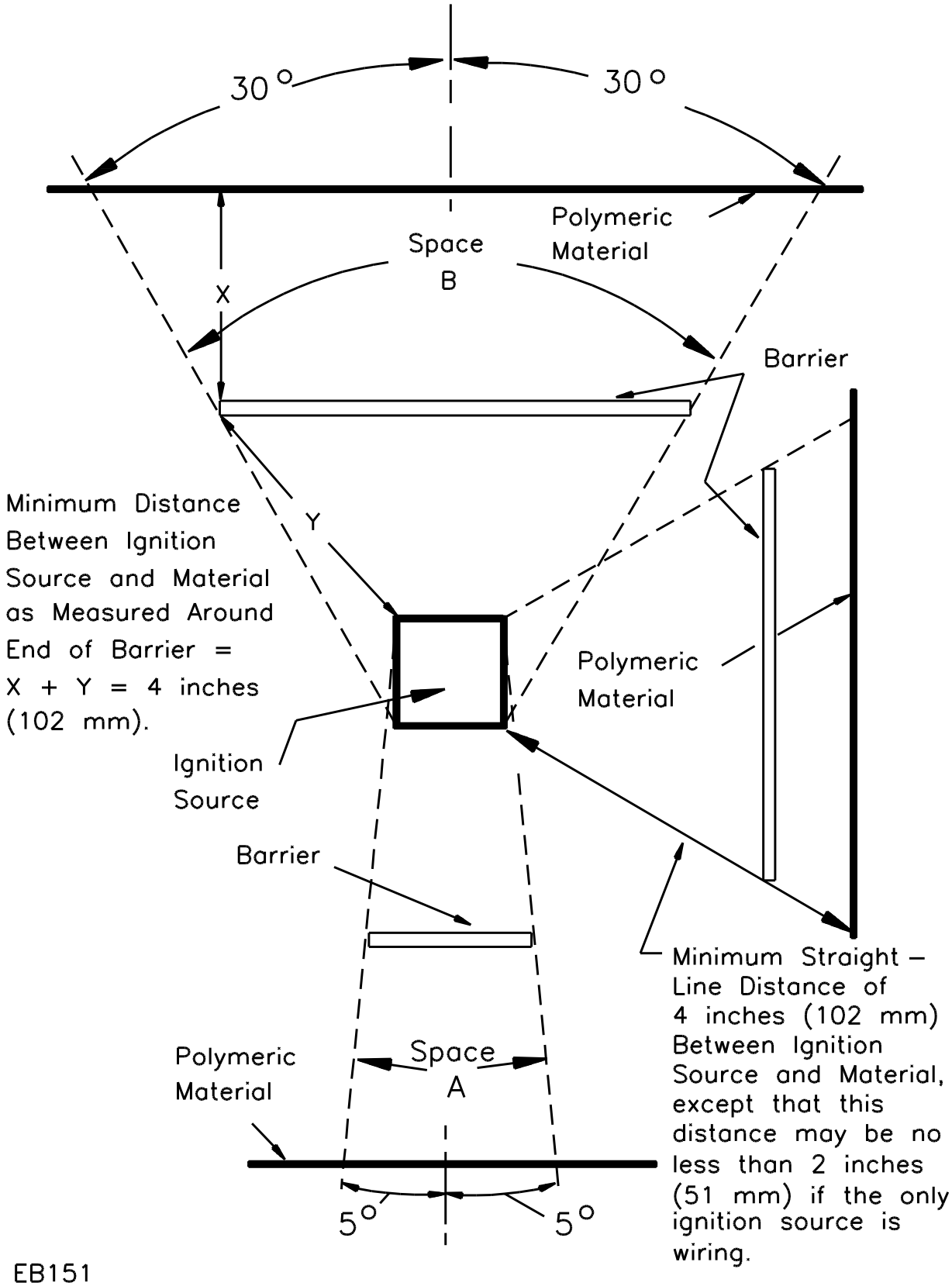
Figure 33.1

Exposure to ignition source



34 Polymeric and Other Nonmetallic Materials

34.1 General

34.1.1 This section specifies the construction requirements applicable to polymeric and other nonmetallic materials used in a unit. Details of the performance requirements are specified in Tests for Polymeric Materials, Section 67.

34.1.2 These requirements apply to a unit intended for indoor use only, having a maximum normal operating temperature on the material that does not exceed 100°C (212°F). See Temperature test, Section 47.

34.1.3 The acceptability of polymeric material for use in a unit shall be determined for each application. See Table 34.1 for properties to be evaluated depending on use of the material.

Table 34.1
Evaluation of properties of polymeric materials

Characteristics to be evaluated	Enclosures	Structural parts	Thermal and acoustical insulation	Functional parts
Flammability[a]				
Source of ignition				
External	Yes	Yes		
Internal	Yes	Yes	Yes	Yes
Heat deflection	Yes	Yes		Yes
Water absorption	Yes	Yes[b]		
Environmental exposure	Yes	Yes		
Air oven aging	Yes	Yes		
Tensile and flexural strength	Yes	Yes		
Izod or tensile impact strength	Yes	Yes		
Impact	Yes	Yes		
Volume resistivity	Yes[c]	Yes[c]	Yes[c]	Yes[c]

[a] A material having a flame-spread rating of no more than 25 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, is acceptable from a flammability standpoint.

[b] When applicable.

[c] When applicable, see 34.1.4.

34.1.4 For the purpose of evaluating electrical spacings between an uninsulated live part and a polymeric material, the material shall be treated as a metal part unless it complies with the requirements of the Volume resistivity test, 67.11.1 and 67.11.2.

34.1.5 Consideration shall be given to the possibility of external ignition of a nonmetallic outer enclosure and of a structural part.

34.2 Material classification

34.2.1 A polymeric material or other nonmetallic material used in a unit shall have flammability classification of 5V, V-0, V-1, V-2, HF-1, HF-2, HBF, or HB as indicated in Table 33.1.

34.3 Ignition sources

34.3.1 With reference to 34.4.3, Figure 33.1, and Table 33.1, possible ignition sources within the unit are considered to be wiring in a high-voltage circuit, and any other electrical component such as a switch, relay, transformer, or motor winding not completely enclosed in:

a) Metal not less than 0.010 inch (0.25 mm) thick, or

b) 5V polymeric material.

Exception: Wiring need not be isolated as indicated in 34.4.1 – 34.4.4 if it complies with the VW-1 flame test or the vertical flame test described in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

34.4 Material applications

34.4.1 Material employed for sole or partial support of live parts shall be classed 5V.

34.4.2 A barrier as illustrated in Figure 33.1 shall be of metal or of 5V material, and shall be mechanically secured in place.

34.4.3 The acceptability of an opening in a control compartment, other than that of minimum size for the passage of a control shaft or rod, shall be judged on the basis of the necessity for its existence. On any one surface, the minor dimension of an opening shall not exceed 3/8 inch (9.5 mm) and the maximum area shall not exceed 0.25 inch^2 (1.61 cm^2) except that this may be increased to a maximum of 1.00 inch^2 (6.45 cm^2) if a barrier of metal or 5V polymeric material is secured in place and interposed between ignition sources and combustible material. In any case, the maximum aggregate area of all openings in any one surface shall not exceed 1.0 inch^2 (6.45 cm^2).

34.4.4 With reference to 34.4.3, wiring in the control compartment is to be routed away from any openings that expose the wire to combustible materials. In judging the need for a barrier, consideration is to be given to grouped openings that have an aggregated area exceeding 0.25 inch^2 (1.61 cm^2).

35 Overload-Protective Devices

35.1 A protective device, the intended functioning of which requires replacement or resetting, shall be in a readily accessible location.

35.2 A protective device shall be inaccessible from outside the appliance without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the enclosure.

35.3 In addition to the requirements specified in this Standard, fuseholders shall comply with the requirements in the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1 and

a) The Standard for Fuseholders – Part 4: Class CC, UL 4248-4;

b) The Standard for Fuseholders – Part 5: Class G, UL 4248-5;

c) The Standard for Fuseholders – Part 6: Class H, UL 4248-6;

d) The Standard for Fuseholders – Part 8: Class J, UL 4248-8;

e) The Standard for Fuseholders – Part 9: Class K, UL 4248-9;

f) The Standard for Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse, UL 4248-11;

g) The Standard for Fuseholders – Part 12: Class R, UL 4248-12; or

h) The Standard for Fuseholders – Part 15: Class T, UL 4248-15.

35.4 A fuseholder shall be constructed and installed so that no uninsulated live part other than the screw shell or clips will be exposed to contact by a person removing or replacing a fuse. The screw shell of a plug-type fuseholder shall be connected toward the load.

35.5 A door or cover of an enclosure shall be hinged or attached in an equivalent manner if it gives access to any overload-protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device.

35.6 Means shall be provided for holding closed a door or cover over a fuseholder, and the door or cover shall fit tightly.

35.7 A thermal protective device shall not open the circuit during intended operation of the appliance.

35.8 In an automatic appliance, if breakdown of a capacitor that is not part of a permanent-split-capacitor motor or a part of a capacitor-start motor would result in a risk of fire or electric shock, thermal or overcurrent protection shall be provided in the appliance to prevent the establishment of such a condition.

35.9 In addition to the requirements specified in this Standard, supplemental fuses shall comply with the requirements in the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1 and the Standard for Low-Voltage Fuses – Part 14: Supplemental Fuses, UL 248-14.

36 Switches, Including Motor Controllers

36.1 A switch or other control device shall:

a) Be acceptable for the application,

b) Have a current and voltage rating not less than that of the load that it controls, and

c) Be located within the confines of the frame or enclosure of the appliance or be additionally protected so as to reduce the likelihood of contact by external objects.

Exception: With reference to (c), the actuating part of a switch need not be located within the confines of the frame or enclosure.

36.2 With reference to the requirement in 36.1, the current rating of a switch that controls an inductive load, such as a transformer or a fluorescent-lamp ballast, shall not be less than twice the rated full-load current of the transformer or ballast, unless the switch is acceptable for the particular application.

36.3 A switch that controls a medium-base lampholder shall be acceptable for use with tungsten-filament lamps.

36.4 If an appliance provided with a power-supply cord and an attachment plug employs a motor rated more than 1/3 horsepower (250 W output), a motor controller – a device for starting and stopping the motor – shall be provided in the appliance.

36.5 An acceptable speed-control switch shall be provided with an appliance that employs a multispeed motor – a motor with a winding capable of various pole groupings.

36.6 A solid-state speed control shall comply with the applicable requirements in the supplement for solid-state fan speed controls in the requirements for Industrial Control Equipment, UL 508.

36.7 In addition to the requirements specified in this Standard, switches shall comply with the requirements in the:

a) Standard for Clock-Operated Switches, UL 917;

b) Standard for Enclosed and Dead-Front Switches, UL 98;

c) Standard for General-Use Snap Switches, UL 20;

d) Deleted

e) Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

36.8 In addition to the requirements specified in this Standard, Switchgear and Controlgear shall comply with the requirements in the:

a) Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1;

b) Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1; or

c) Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2.

37 Controls – End Product Test Parameters

37.1 General

37.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Controls, Section 9.

37.1.2 Where reference is made to declared deviation and drift, this indicates the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

37.2 Auxiliary controls

37.2.1 Auxiliary controls shall not introduce a risk of electric shock, fire, or personal injury.

37.2.2 Auxiliary controls shall comply with the requirements of this end product standard.

37.3 Operating controls (regulating controls)

37.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. Appendix A provides more examples of controls intended to be used as operating controls:

a) Control Types 1 or 2;

b) Unless otherwise specified in this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;

c) Installation class 2 per Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test, IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 37.1;

e) For the applicable Material Group, see Table 37.2; and

f) For the applicable Pollution Degree, see Table 37.3.

Table 37.1
Overvoltage categories

Appliance	Overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected	II
Control located in low-voltage circuit	I
NOTE – Applicable to low-voltage circuits if a short circuit between the parts involved may result in operation of the controlled equipment that would increase the risk of fire or electric shock.	

Table 37.2
Material group

CTI PLC value of insulating materials	Material group
CTI ≥600 (PLC = 0)	I
CTI ≥ 400 < 600 (PLC = 1)	II
CTI ≥ 175 < 400 (PLC = 3)	IIIa
CTI ≥ 100 < 175 (PLC = 4)	IIIb
NOTE – PLC stands for Performance Level Category, and CTI stands for Comparative Tracking Index as specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.	

Table 37.3
Pollution degree

Appliance control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically hermetically sealed or encapsulated controls without contaminating influences, or printed wiring boards with a protective coating can achieve this degree.	1
Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected. Typically indoor appliances for use in household or commercial clean environments achieve this degree.	2
Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected. Typically controls located near and may be adversely affected by motors with graphite or graphite composite brushes, or outdoor use appliances achieve this degree.	3

37.4 Protective controls (limiting controls)

37.4.1 An electronic control that performs a protective function shall comply with the requirements in 9.1.4, while tested using the parameters in this section. Examples of protective controls are a control used to sense abnormal temperatures of components within the appliance; temperature protection of the motor due to locked rotor, running overload, loss of phase; or other function intended to reduce the risk of electric shock, fire, or injury to persons. During the evaluation of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control/circuit.

37.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. Appendix A provides more examples of controls intended to be used as protective controls:

a) Failure-Mode and Effect Analysis (FMEA) or equivalent Risk Analysis method;

b) Power Supply Voltage Dips, Variation and Interruptions within a temperature range of 10°C (50° F) and the maximum ambient temperature determined by conducting the Temperature Test. See Temperature Test, Section 47;

c) Surge immunity test –installation class 3 shall be used;

d) Electrical fast transient/burst test, a test level 3 shall be used;

e) Electrostatic Discharge Test;

f) Radio-frequency electromagnetic field immunity:

1) Immunity to conducted disturbances – When applicable, test level 3 shall be used; and

2) Immunity to radiated electromagnetic fields; field strength of 3 V/m shall be used;

g) Thermal Cycling test of clause H.17.1.4.2 shall be conducted at ambient temperatures of 10 +2°C (50 +4°F) and the maximum ambient temperature determined by conducting the Temperature Test; The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test;

i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class B;

j) Thermal Cycling test of clause H.17.1.4.2 shall be conducted at ambient temperatures of 10 +2°C (50 +4°F) and the maximum ambient temperature determined by conducting the Temperature Test. See Temperature Test, Section 47. The test shall be conducted for 14 days;

k) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test; and

l) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class B.

37.4.3 The test parameters and conditions used in the investigation of the circuit covered by 37.4.1 shall be as specified in the Standard for Test for Safety-Related Controls Employing Solid-State Devices, UL 991, using the following test parameters:

a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed

portion of the appliance meets the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication;

b) A field strength of 3 V per meter is to be used for the Radiated EMI Test;

c) The Composite Operational and Cycling Test is to be conducted for 14 days at temperature extremes of 0°C (32°F) and 70°C (158°F);

d) The Humidity Class is to be based on the appliance's intended end use and is to be used for the Humidity Test;

e) A vibration level of 5 g is to be used for the Vibration Test;

f) When a Computational Investigation is conducted, I_p shall not be greater than 6 failures/10^6 hours for the entire system. The Operational Test is to be conducted for 14 days;

g) When the Demonstrated Method Test is conducted, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C (77°F) use ambient;

h) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60°C (140°F), or 10°C (50°F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing normal use;

i) For the Electrical Fast Transient Burst Test, test level 1 is to be used;

j) Conduct a failure-mode and effect analysis (FMEA); and

k) If software is relied upon as part of the protective electronic control, it shall be evaluated as software class 1 in accordance with the Standard for Software in Programmable Components, UL 1998.

37.4.4 Unless otherwise specified in the Standard for Nonducted Heat Recovery Ventilators, UL 1815, protective controls shall be evaluated for 100,000 cycles for Type 2 devices, and 6,000 cycles for Type 1 devices, with rated current.

37.5 Controls using a temperature sensing device

37.5.1 A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control, shall be tested using the following number of cycles when testing a sensing device in accordance with the endurance test:

a) For a device employed as a operating device – 6000 cycles,

b) For a device employed as a protective device – 100,000 cycles, or

c) For a device employed as a combination operating and protective device – 100,000 cycles.

UL 60335-1 BASED REQUIREMENTS FOR THE EVALUATION OF ELECTRONIC CIRCUITS

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37A General

37A.1 These requirements provide an alternate path for the investigation of electronic controls and other circuits used in appliances covered by this standard.

37A.2 Thermal motor protectors in direct contact with motor windings and intended for direct control of the motor supply are outside the scope of this Standard even if they incorporate one or more electronic components.

37A.3 The requirements in Sections 37A – 37K are intended to apply to the electronic circuit and how it is integrated in the appliance. The overall appliance construction, performance testing and marking requirements are applicable as specified in this standard except as cited in the following requirements.

37B Components

37B.1 Capacitors

37B.1.1 A capacitor connected between two line conductors in a primary circuit, or between one line conductor and the neutral conductor or between primary and accessible secondary circuits or between the primary circuit and protective earth (equipment grounding conductor connection) shall comply with one of the subclasses of the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14 and shall be used in accordance with its rating.

Note: Details for damp heat, steady state test can be found in 4.12 of Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains – Edition 4.1; Consolidated Reprint, IEC 60384-14.

37B.2 Isolation devices

37B.2.1 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this standard shall be constructed in accordance with the Standard for Optical Isolators, UL 1577, and shall be able to withstand for 1 minute, without breakdown, an ac dielectric voltage withstand potential of 2500 volts as specified in 35.1 between the input and output circuits.

37B.2.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall be constructed in accordance with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted at a dielectric potential of 2500 volts as specified in 35.1 for 1 minute.

37B.2.3 A power switching semiconductor device that is relied upon to provide isolation between primary and secondary circuits or between other circuits shall be a device (such as a solid state motor controller) that complies with the Standard for Industrial Control Equipment, UL 508.

Exception: A power switching semiconductor device located within a component that has been separately evaluated to the requirements for that component is not required to be further evaluated, provided the component is used within its established ratings and limitations.

37B.2.4 A relay that is relied upon to provide isolation between primary and secondary circuits shall comply with the Standard for Industrial Control Equipment, UL 508.

37B.3 Printed-wiring boards

37B.3.1 Printed wiring boards shall comply with the Standard for Printed Wiring Boards, UL 796, and shall have a flammability rating and other characteristics as specified in this standard.

Exception: A printed circuit board solely in a Low-Power Circuit and whose failure would not constitute a risk of electric shock is not permitted to comply with UL 796.

37B.3.2 Any printed-wiring board that complies with the requirements for Direct Support in the Standard for Printed-Wiring Boards, UL 796, is considered to provide an insulating base with a Comparative Tracking Index (CTI) of minimum 100.

37B.4 Bridging components – switch mode power supplies

37B.4.1 Components connected between the primary and secondary circuits of an isolating device such as a switching transformer or between primary and secondary earth reference points shall be evaluated to provide the specified level of isolation for the application under normal and abnormal (single component fault) conditions.

37B.4.2 A capacitor connected between primary and accessible secondary circuits shall comply with Capacitors, 37B.1. This shall consist of a single Class Y1 capacitor or two Class Y2 capacitors connected in series.

37B.5 Switch mode power supply insulation system

37B.5.1 Insulation used within a transformer of switch mode power supply shall comply with the Standard for Systems of Insulating Materials – General, UL 1446, for the specified temperature class of the insulation system or the Standard for Single- and Multi-Layer Insulated Winding Wire, UL 2353.

37C Identification of Safety Critical Circuit Functions

37C.1 General

37C.1.1 Electronic circuits or parts of circuits shall be analyzed to determine if the function of the control is necessary for compliance with this standard. A function is considered a Safety Critical Function (SCF) if failure (loss or malfunction) of its functionality would result in the risk of fire, electric shock, mechanical Risk of injury or a Dangerous Malfunction.

37C.1.2 Safety Critical Functions shall be identified as either Protective Electronic Circuits as detailed in 37C.2 or as those of operating circuits that mitigate Dangerous Malfunctions as detailed in 37C.3.

37C.1.3 In the evaluation of electronic circuits, all the contacts of relays or contactors that cycle during the Normal Temperature Test shall be simultaneously short-circuited.

37C.2 Protective electronic circuits

37C.2.1 An electrical component shall not be connected across the contacts of a Protective Electronic Circuit.

Exception: Electrical components may be connected across the contacts provided that any single component fault does not result in a loss of protective function.

37C.2.2 Protective Electronic Circuit functions are as specified in Appendix A.

37C.3 Operating circuits that mitigate a dangerous malfunction of the appliance

37C.3.1 The suitability of stand-by or electronic disconnect circuits shall be as specified in this standard.

37C.3.2 An electronic disconnection circuit whose failure could result in a Dangerous Malfunction shall have at least two components whose combined operation provides the load disconnection.

37C.3.3 Operating circuits whose functions are relied upon to mitigate Dangerous Malfunctions of the appliance are as specified in Appendix A.

37D Evaluation of the Different Types of Electronic Circuits

37D.1 All circuit functions mandated by this standard shall be validated. This includes operating functions not designated as Safety Critical Functions.

37D.2 All circuits shall be evaluated to determine the effects of electronic circuit faults.

37D.3 When the applicable component/hardware faults specified in 37H.10 are imposed one at a time they shall not result in:

a) The appliance presenting a risk of fire, electric shock or mechanical hazard; or

b) The loss of any Safety Critical Function either in that circuit or others.

37D.4 The risk of electrically generated fire from the faults of the Abnormal Operation and Fault Tests, Section 37H is considered to be mitigated in Low-Power Circuits.

37E Circuits that Provide Safety Critical Functions

37E.1 In addition to the requirements of the Evaluation of the Different Types of Electronic Circuits, Section 37D, circuits that provide Safety Critical Functions shall incorporate measures to control the fault/error conditions that would impair the safety functions.

37E.2 The evaluation of the programmable component shall be in accordance with Annex R of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, Edition 5.

37E.3 Circuits that provide Safety Critical Functions that rely upon a programmable component for one or more of its safety functions shall be subjected to the test of the Programmable Component Reduced Supply Voltage Test, Section 37I, unless restarting at any point in the operating cycle after interruption of operation due to a supply voltage dip will not result in a hazard. The test is carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during mains supply voltage dips, interruptions and variations.

37E.4 Circuits that provide Safety Critical Functions shall maintain their required functions when subjected to the EMC related stresses specified in the Electromagnetic Compatibility (EMC) Requirements – Immunity, Section 37J.

37E.5 The tests of Electromagnetic Compatibility (EMC) Requirements – Immunity, Section 37J are carried out with surge protective devices disconnected, unless they incorporate spark gaps.