

23 Alternate Spacings – Clearances and Creepage Distances

23.1 As an alternative to the specified spacing requirements of this Standard, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are able to be used for spacings on printed wiring boards. The spacing requirements in UL 840 are not to be used for field wiring terminals and spacings to a dead metal enclosure. In determining the pollution degree and overvoltage category, the end-use application is to be identified and is to modify those characteristics given in [23.2](#) – [23.3](#), as appropriate.

23.2 When applying specific requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the degree of pollution expected or controlled will be as indicated in [Table 23.1](#).

Table 23.1
Degrees of pollution

Equipment pollution degree	Equipment pollution degree
Hermetically sealed or encapsulated equipment without contaminating influences or printed wiring boards with a protective coating.	1
Totally enclosed equipment for use in a clean environment.	2
Open equipment for use in a clean environment.	3

23.3 When applying specific requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the equipment will be identified by overvoltage categories as indicated in [Table 23.2](#).

Table 23.2
Overvoltage categories

Equipment overvoltage category	Equipment overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected.	II
Power-limited and safety low voltage.	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.	

23.4 Printed-wiring boards constructed of Types XXXP, XXXPC, G-10, FR-2, FR-3, FR-4, FR-5, CEM-1, CEM-3, GPO-2, or GPO-3 industrial laminates in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed-Wiring Boards, UL 746E, are determined to have a minimum comparative tracking index of 100 without further investigation.

24 Antisiphoning

24.1 An aquarium air pump provided with a power supply cord shall also be supplied with a check valve, or other means determined to be equivalent, to reduce the risk of backflow of liquid that may result in a risk of electric shock. This check valve may be provided as part of the air hose if applicable installation instructions are provided. The means of backflow prevention shall be investigated by testing in accordance with [52.1](#). In lieu of the backflow prevention, a pump may be marked as shown in [68.1.4](#).

Exception: An aquarium air pump intended for direct connection to an outlet receptacle by means of integral attachment plug blades, with no power supply cord provided shall not be marked as described in [68.1.4](#). Such a pump shall be provided with a check valve or other means determined to be equivalent to reduce the risk of liquid backflow.

25 Reduction of Risk of Injury to Persons

25.1 General

25.1.1 If the operation and maintenance of a product by the user involves the risk of injury to persons, means shall be provided to reduce the risk.

25.2 Sharp edges

25.2.1 A material (including glass) that is used as a portion of an appliance other than on an immersible heater shall be such that no sharp edges are exposed to contact by the user when the appliance is subjected to a mechanical abuse test as outlined in [53.1](#) and [53.2](#).

25.2.2 An edge, projection, or corner of an enclosure, opening, frame guard, knob, handle, or similar part of an appliance shall be smooth and rounded, and shall not cause lacerations or cuts during intended use or user maintenance.

25.3 Switches, controls, interlocks

25.3.1 The details of guards, safety releases, interlocks, and the like are not specified, but the need for such accessory protection and its acceptability shall be determined from a study of the complete appliance, its operating characteristics, and the likelihood of injury occurring from other than gross negligence.

25.3.2 A motor control switch on the appliance (other than a momentary contact switch) shall have a plainly marked off position.

Exception: A switch is not required to be marked if energization of the appliance cannot result in a risk of injury to persons.

25.3.3 If an automatic reset protective device is employed in an appliance, the automatic restarting of the motor shall not result in the risk of injury to persons.

25.3.4 The requirement in [25.3.3](#) specifies the use of an electrical interlock in the appliance when moving parts or the like can cause injury to persons upon the automatic restarting of the motor.

25.4 Materials

25.4.1 The material of a part (such as an enclosure, a frame, a guard, or similar parts), the breakage or deterioration of which might result in the risk of injury to persons, shall have such properties as to meet the demand of expected loading conditions.

25.4.2 The requirement in [25.4.1](#) applies to those portions of a part adjacent to a moving part considered to be capable of causing an injury.

25.5 Rotating or moving members

25.5.1 A rotating member, the breakage of which might result in a risk of injury to persons, shall be constructed so as to reduce that risk of breakage or the release or loosening of a part that could become a hazard.

25.5.2 An appliance employing a series motor shall be tested as described in [46.4.2.1](#) to determine whether it complies with the requirement in [25.5.1](#).

25.5.3 A rotating or moving part shall be provided with a means to retain a part in place under conditions of use if that part has a tendency to become disengaged or cause a risk of injury to persons.

26 Switches and Controllers

26.1 A switch or other control device shall be of a type for the intended use and shall not have a rating less than that of the load it controls. An aquarium appliance shall not employ a through-cord switch.

26.2 With reference to the requirement in [26.1](#), the current rating of the switch that controls an inductive load other than a motor, such as a transformer or an electric discharge lamp ballast, shall be at least twice the full load current of the inductive load unless the switch has been evaluated for the intended use.

26.3 A switch or other device that controls a solenoid, relay, coil, or similar part, and that has not been previously evaluated shall be subjected to an overload test as described in [54.1.1](#).

26.4 A manually operated motor control switch shall be provided in a cord-connected appliance that employs a motor rated greater than 1/3 horsepower (249 W).

26.5 A switch that controls a lampholder for an incandescent lamp, other than a 15 watt or smaller pilot or indicating lamp, shall be for use with tungsten filament lamps or shall have a current rating at least equivalent to six times the steady state tungsten load for alternating current, or ten times the steady state load for direct current.

26.6 A switch of the single-pole type shall not be connected in the conductor intended to be grounded as described in [10.3.3.2](#) and [10.3.3.3](#).

27 Controls – End Product Test Parameters

27.1 General

27.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Controls, [6.6](#).

27.1.2 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.

27.2 Auxiliary controls

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

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

Exception: An auxiliary control that complies with a component standard(s) specified in Controls, [6.6](#), is considered to fulfill this requirement

27.3 Operating controls (regulating controls)

27.3.1 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:

- a) Control action 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 27.1](#);
- e) For the applicable Material Group, see [Table 27.2](#);
- f) For the applicable Pollution Degree, see [Table 27.3](#).

27.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using other than the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1:

- a) Control action 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) For the applicable Overvoltage Category, see [Table 27.1](#);
- d) For the applicable Material Group, see [Table 27.2](#);
- e) For the applicable Pollution Degree, see [Table 27.3](#).

Table 27.1
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 27.2
Material group

CTI PLC value of insulating materials	Material group
$CTI \geq 600$ (PLC = 0)	I
$400 \leq CTI < 600$ (PLC = 1)	II
$175 \leq CTI < 400$ (PLC = 2 or 3)	IIIa
$100 \leq CTI < 175$ (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 27.3
Pollution degrees

Appliance control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically hermetically sealed or encapsulated control 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

27.4 Protective controls (limiting controls)

27.4.1 An electronic control that performs a protective function shall comply with the requirements in Controls, [6.6](#), 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; an interlock function to de-energize a motor; 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.

27.4.2 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:

- 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 and the maximum ambient temperature determined by conducting the Normal Temperature Test; see Section [41](#);
- 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 of UL 60730-1 shall be conducted at ambient temperatures of 10.0+2°C and the maximum ambient temperature determined by conducting the Normal Temperature Test; see Section [41](#). The test shall be conducted for 14 days; and
- h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Normal Temperature Test; see Section [41](#)
- i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software Class B.

27.4.3 The test parameters and conditions used in the investigation of the circuit covered by [27.4.1](#) shall be as specified in the Standard for Tests 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 (0°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) The computational investigation is not applicable to equipment covered by this end product standard;
- 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 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 (18°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; and
- j) Conduct a failure-mode and effect analysis (FMEA).
- 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.

27.4.4 Unless otherwise specified in this Standard, protective controls shall be evaluated for 100,000 cycles for Type 2 devices, and 6,000 cycles for Type 1 devices, with rated current.

27.5 Controls using a temperature sensing device

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

28 Lampholders

28.1 The screw shell metal of a lampholder shall be stainless steel, nickel-plated aluminum, or nickel-plated copper alloy unless the lampholder is located so that it is unlikely to be exposed to moisture.

28.2 The spacing between an uninsulated live part, such as a screw shell or lamp envelope, and water in an aquarium tank shall not be less than 1/2 inch (12.7 mm). In measuring the distance between the water and a lamp envelope, it is to be assumed that the lamp envelope is symmetrical about the screw shell axis. The spacing shall be evaluated with the appliance installed as discussed in the instruction manual, on an aquarium tank having the dimensions specified in the instruction manual. The aquarium tank is to be filled with the maximum quantity of water it can hold. Any accessory or part of the appliance that is removable without the use of a tool is to be removed for the purpose of this requirement.

28.3 A lampholder shall be constructed of porcelain, cold-molded phenolic, urea, or other moisture-resistant material determined to be equivalent.

28.4 The requirements in [28.3](#) preclude the use of fiber as electrical insulation in lampholders.

29 Capacitors

29.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line (such as for radio interference elimination or power factor correction) shall be housed within an enclosure or container so that the plates will not be subject to mechanical abuse, and there will not be emission of flame or molten metal resulting from failure of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm). Sheet metal less than 0.026 inch (0.66 mm) thick is not recommended.

Exception: The individual container of a capacitor may be of sheet metal thinner than specified or of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the appliance, provided that such a box, case, and similar housing is acceptable for the enclosure of current-carrying parts.

29.2 If a capacitor that is not part of a capacitor motor or a capacitor start motor is connected in an appliance that is automatically or remotely controlled so that capacitor failure would result in a risk of fire or electric shock, thermal or overcurrent protection shall be provided in the appliance to reduce the risk of such a condition.

30 Electronic Control Equipment

30.1 Electronic control components or devices shall have a performance level determined to be equivalent to other such controls or devices.

30.2 Electronic control equipment shall be investigated as a system in addition to the investigation of individual components.

30.3 Breakdown of any electronic component shall not result in a risk of fire, electric shock, or injury to persons within the unit or in the equipment controlled.

30.4 Compliance with [30.3](#) requires analysis of the circuit and may require the opening and shorting of each component in turn while observing the ultimate operating condition. If the circuit opening or shorting of a component may result in a risk of fire, injury to persons, or electric shock, the reliability of the component (the probability that the component will perform its intended function under a specified set of environmental conditions and over a specified period of time) shall be investigated.

30.5 Environmental and field conditions such as ambient temperature, vibration, thermal shock, electrical transients, moisture, and the like shall be considered in investigating electronic control systems.

31 Printed Wiring Boards

31.1 General

31.1.1 A resistor, capacitor, inductor, transformer, transistor, diode, or other component or part that is mounted on a printed wiring board to form a printed wiring assembly shall be securely held in place.

31.1.2 Consideration is to be given to the mechanical protection and electrical insulation afforded to a component or part by the presence of a barrier or partition.

31.2 Spacings on printed wiring boards

31.2.1 As an alternative to the spacing requirements of Spacings at other than field-wiring terminals, [Table 22.2](#), the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 are able to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

31.2.2 The following end use factors from this Standard shall be applied:

- a) For the applicable Overvoltage Category, see [Table 27.1](#);
- b) For the applicable Material Group, see [Table 27.2](#);
- c) For the applicable Pollution Degree, see [Table 27.3](#).

31.2.3 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product. This voltage limiting device or system shall comply with the Standard for Surge Protective Devices, UL 1449.

31.2.4 All printed wiring boards are identified as having a minimum comparative tracking index (CTI) of 100 without further investigation, for evaluation to the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

32 Thermostats

32.1 A thermostat shall comply with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, and shall be subjected to the test described in [55.1.1](#). Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception: A thermostat is not required to be subjected to the test specified in [55.1.1](#) if:

- a) The heater does not exceed the maximum allowable temperature when the thermostat is bypassed (shorted out) and*
- b) The thermostat is not likely to be defeated by the user.*

33 Fusible Links

33.1 A fusible link shall comply with the requirements for such a component. It shall be capable of opening the circuit in the intended manner. It shall not cause the short circuiting of live parts nor cause them to be grounded to the enclosure when the appliance is connected to a voltage circuit as specified in [37.2](#) and operated to cause abnormal heating. Such a fusible link shall comply with the test requirements in [55.2.1](#).

34 Rectifiers

34.1 When an appliance uses a combination of a rectifier and an electrolytic capacitor, no increase in the risk of fire, electric shock, or injury to persons shall result when either component is short circuited.

35 Heating Elements

35.1 A heating element shall be supported and shall be guarded against mechanical damage and contact with outside objects. In the investigation of an element supporting means, consideration is to be given to sagging, loosening, and other adverse results of continuous heating.

35.2 Any heating element that may be contacted by the user during intended use or cleaning shall not be of the open wire type.

35.3 An appliance in which the heating element is intended for operation only when provided with a cooling air blast shall be wired or constructed so that the element can be operated only when the cooling effect of the air blast is provided. An appliance in which the cooling effect of the motion of a part is required to preclude excessive temperatures shall be wired or constructed so that the element cannot be operated without such motion.

36 Attachments

36.1 A functional attachment that is made available or recommended by the manufacturer for use with the basic appliance shall be included in the investigation of the appliance. Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time is to be investigated with the appliance.

36.2 The literature accompanying a package containing a basic appliance and attachments intended to be marketed as a complete unit shall indicate what attachments are intended for use with the basic appliance if use of such attachments exposes the user to the likelihood of injury.

36.3 An attachment that is packaged and marketed separately from the basic appliance and recommended by the manufacturer for use on the basic appliance shall be marked in a manner that identifies the basic appliance with which it is intended to be used. The identification shall appear in at least one of the following locations:

- a) On the attachment,
- b) On the package housing the attachment,

- c) In the instruction book for the basic appliance, or
- d) In information furnished with the attachment.

PERFORMANCE

37 General

37.1 The tests outlined in these requirements are to be conducted, if possible, in the order in which they are presented.

37.2 Unless otherwise specified, test voltages used in all tests are to be as shown in [Table 37.1](#).

Table 37.1
Test voltages

Voltage rating of appliance	Test voltage
Appliances rated with a single voltage within the ranges 110 – 120 (inclusive) or 240 – 250 (inclusive)	Highest voltage of range
Appliances rated with a single voltage not within one of the ranges given above	Rated single voltage
Appliances rated with a range of voltages that may or may not coincide with one of the ranges given above	Highest voltage of rated range

38 Leakage Current Test

38.1 The leakage current of a cord-connected aquarium appliance (including any accessory intended for use with the appliance) when tested in accordance with [38.3](#) – [38.7](#) shall not exceed:

- a) 0.5 milliamperere for an ungrounded 2-wire product,
- b) 0.5 milliamperere for a grounded 3-wire portable product, and
- c) 0.75 milliamperere for a grounded 3-wire product:
 - 1) Employing a standard attachment plug rated 20 amperes or less and
 - 2) Intended to be fastened in place or located in a dedicated space.

38.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of an appliance and ground or other exposed conductive surfaces of the appliance.

38.3 Any exposed conductive surface is to be tested for leakage current. The leakage current from such a surface is to be measured to the grounded supply conductor individually as well as collectively where more than one surface is simultaneously accessible, and from one such surface to another. A surface is considered accessible unless protected against inadvertent contact by an enclosure or equivalent that meets the requirements of Accessibility of Live Parts, Section [8](#). Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are considered not to present a risk of injury.

38.4 If part or all of an enclosure is of a material other than metal, a piece of metal foil measuring 4 by 8 inches (100 by 200 mm) is to be placed on the enclosure so that all of the foil is in close contact with the