

UL 244A

Solid-State Controls for Appliances





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Revisions: This Standard contains revisions through and including October 31, 2007.

SUMMARY OF TOPICS

These revisions to UL 244A are being issued to address universal upkeep of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated October 31, 2007 include a reprinted title page (page1) for this Standard.

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INTRODUCTION

1 Scope

1.1 These requirements cover component electronic controls intended to be factory installed on or in appliances and other utilization equipment rated 600 V or less, used in ordinary dry locations as defined in the National Electrical Code, NFPA 70, and that comply with the requirements for such appliances and equipment.

1.2 For a control covered by this standard, it is assumed that:

- a) No voltage greater than 600 V above ground will be present in a control,
- b) An isolation transformer, if provided, will generally furnish power at a lower potential than the primary voltage, and
- c) The output of the control will not be located in a circuit operating at greater than 600 V above ground in the end-use product.

If conditions other than these are provided, consideration shall be given to the need for additional requirements.

1.3 A control covered by this standard is a single device or a series of separate components with interconnecting wiring employing one or more input power and possibly signal ports, solid-state circuitry, and one or more output switching components to directly control all or a portion of the end-use product load. Included are controls that respond directly or indirectly to changes in temperature, humidity, or pressure to affect operation of an appliance, function as an electronic timer, or electronically store or process information by virtue of a memory system.

1.4 These requirements cover controls intended for connection only to a low-voltage circuit of limited power supplied by a primary battery or by a Class 2 transformer, where a failure of such a control would result a risk of fire, electric shock, or injury to persons in the end-use product.

1.5 These requirements do not cover a control intended for installation in or on refrigeration or air conditioning equipment that is used in industrial applications or in hazardous locations as defined in the National Electrical Code, NFPA 70. Such equipment is covered in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873.

1.6 These requirements do not cover controls for use where exposed to oil, grease vapors, lint, other contaminants, or high humidity in the end application.

1.7 These requirements address the potential risks unique to the electronic nature of a control. Equipment or components employing an electronic feature shall also comply with the basic requirements contained in the applicable end-product or component standard. These requirements are intended to supplement applicable end-product or component standards and are not intended to serve as the sole basis for investigating all risks associated with a control. For example, requirements for the means of enclosing live parts, mechanical assembly of components, corrosion protection, use of polymeric materials, evaluation of internal wiring and connections within the control, calibration, and similar requirements, are not included in this standard.

2 Undated References

2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.2 CLASS 2 CIRCUIT – An isolated secondary circuit involving a potential of not more than 42.4 V peak supplied by:

- a) An inherently-limited Class 2 transformer;
- b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently-limited Class 2 transformer;
- c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;
- d) Any combination of (a), (b), and (c) that together comply with the performance requirements for an inherently-limited Class 2 transformer; or
- e) One or more combinations of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A circuit derived from a line-connected circuit by connecting impedance in series with the supply circuit as a means of limiting the voltage and current is not a Class 2 circuit. See Class 2 Circuits, Section 20.

3.3 CONFORMAL COATING – An insulating coating which conforms to the configuration of the object coated and is used as a protective covering against environmental conditions or when electrical spacings are insufficient.

3.4 CONTROLLED ENVIRONMENT – An environment:

- a) Relatively free of conductive contaminants, such as normal cooking vapors, carbon dust, and similar contaminants, which are a result of the end-use product in which a control will be installed or due to the location of the end-use product, and
- b) Not subject to humidity and the formation of condensation. A controlled environment is provided, for example, by means of a:
 - 1) Hermetically sealed enclosure;
 - 2) Encapsulation;
 - 3) A conformal coating; or
 - 4) A gasketed, tight-fitting enclosure or filter system preventing contamination in conjunction with a system preventing condensation –for example, the maintaining of the surrounding air at constant temperature and a suitably low relative humidity.

3.5 DEAD-CASE-MOUNTED SEMICONDUCTOR – A semiconductor, such as a triac or silicon-controlled rectifier, employing an integral metal tab or stud that is insulated from live parts.

3.6 ELECTRICAL STRESS FACTOR – For a circuit component, the ratio of operating electrical stress to rated electrical stress. Examples include the ratio of operating wattage to maximum rated wattage of a resistor and operating voltage to maximum rated voltage of a capacitor. A circuit component having no assigned maximum operating electrical rating is made the subject of an investigation.

3.7 HAZARDOUS ENERGY – Circuit energy that involves a risk of fire or electric shock.

3.8 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolated secondary winding of a transformer and that has no direct connection back to the line-connected circuit, other than through the grounding means. A secondary circuit that has a direct connection back to the line-connected circuit is considered part of the line-connected circuit.

3.9 LIMITED-ENERGY CIRCUIT – A line-connected circuit in which the wattage from any point in the circuit to any return to the power supply is limited to 15 W; or an isolated secondary circuit in which the wattage from any point in the circuit to any return to the power supply is limited to 50 W.

3.10 LINE-CONNECTED CIRCUIT – A circuit in which the wiring and components are conductively connected to the branch circuit. It is also called a primary- or direct-connected circuit. See also 3.8.

3.11 OPPOSITE POLARITY – A difference in potential between two points, such that shorting of these two points results in a condition involving an overload; rupturing of printed wiring-board-tracks, components, or fuses; or similar condition.

3.12 OPTICAL ISOLATOR (PHOTON-COUPLED ISOLATOR) – A circuit-coupling device that provides circuit isolation by means of a light source and sensor integrated into a single package.

3.13 SAFETY CIRCUIT – A primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, injury to persons, operation of controlled equipment that is capable of resulting in a risk of fire, electric shock, or injury to persons. Examples include an interlock circuit, a circuit which limits leakage current to accessible parts, a circuit which limits the wattage to a limited-energy circuit, or a phase control or other circuit designed to limit temperatures in the end-use product to acceptable levels.

3.14 THYRISTOR – A bistable semiconductor device comprised of three or more junctions that can be switched from the off state to the on state or vice versa, by means of the controlled conductivity of the semiconductor, with such switching occurring within at least one quadrant of the principal voltage-current characteristics. Such switching includes random switching in which conduction occurs at any phase angle of the alternating current load voltage cycle or regulated switching in which conduction occurs at some precise phase angle or load-voltage magnitude. A phase-controlled semiconductor device is one in which the semiconductor conducts for some portion of the load-voltage cycle.

a) **Bidirectional Triode Thyristor (Triac)** – A three-terminal thyristor having substantially the same switching behavior in the first and third quadrants of the principal voltage-current characteristics.

b) **Silicon-Controlled Rectifier (SCR)** – A reverse blocking triode thyristor. A three-terminal thyristor that conducts only for positive anode-to-cathode voltages and exhibits a reverse blocking state for negative anode-to-cathode voltages.

3.15 TRANSFORMER – The term includes a motor-transformer or an autotransformer. For the purpose of these requirements, the types of transformers typically encountered in or supplying power to controls are:

- a) Class 2 – An isolation type transformer as specified in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.
- b) Power – A transformer other than Class 2 that is intended to transmit power. Included are isolation and nonisolation (such as an autotransformer) types.
- c) Pulse – An isolation-type transformer designed to pass pulse waveforms as distinguished from sine waves. It is not considered to be a power transformer.
- d) Current Sensing – An isolation-type transformer designed to have the primary winding connected in series with a circuit carrying current to be measured or controlled. In window type current transformers, the primary winding is provided by a separate conductor and is not an integral part of the transformer.
- e) Isolating – A transformer in which one or more secondary windings are electrically separated by insulation, spacings, or both, from the primary windings. Secondary windings are not required to be electrically separated from other secondary windings.

3.15 revised October 31, 2007

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

4.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

4.3 A component shall be used in accordance with its rating established for the intended conditions of use.

4.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

5 Units of Measurement

5.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

5.2 Unless indicated otherwise, voltage and current values specified in this standard are rms, and wattage values are average power.

CONSTRUCTION

6 General

6.1 A control shall employ materials that are rated for the particular use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 A control shall be formed and assembled so that the control has the strength and rigidity necessary to resist the foreseeable abuse to which the control is subjected, without resulting in a risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.3 A risk of electric shock exists at any conductive part of a control if the open circuit voltage between the part and other conductive parts or between the part and earth ground exceeds the values specified in 8.2. A risk is not considered to exist if the available current through an impedance, equivalent to that in the end-use product, connected between the parts in question is less than the value specified in the end-use product standard for normal operation as determined by the type of product involved. A current measurement on the control alone is compared with the currents from other parts of the end-use product.

6.4 For a controlled environment, the means used to prevent contamination and condensation shall be rated for the purpose. The controlled environment in a nonproduction indoor area in an ordinary location free of conductive contaminants shall be investigated for the means used to prevent condensation only.

7 Frame and Enclosure

7.1 A partial or complete enclosure of a control that is considered part of the enclosure of the end-use product shall comply with the enclosure requirements for the end-use product.

7.2 A part, such as a control knob, button, cover, dial, window, switch casing, or similar part, that is mounted in or covers an opening and serves as a barrier to live parts, shall be considered part of the enclosure.

8 Accessibility of Live Parts

8.1 The method of determining the accessibility of an uninsulated live part that involves a risk of electric shock and other electrical parts, such as those in a safety circuit or nonlimited energy circuit, is to be in accordance with the end-use product standard.

8.2 A live part of a control is considered to involve a risk of electric shock unless it is in one of the following circuits:

a) A circuit supplied by one or more isolated secondary windings of a transformer in which the maximum open circuit voltage at the transformer is less than:

- 1) 30 V (42.4 V peak) where wet contact is not likely to occur; and
- 2) 15 V (21.2 V peak) where wet contact is likely to occur.

b) A circuit derived from a primary or isolated secondary circuit in which the maximum open circuit voltage, including voltage to earth ground, is less than the values specified in (a) by virtue of circuit impedance, regardless of the polarity.

c) A circuit derived from a primary or isolated secondary circuit in which the maximum open circuit voltage, including voltage to earth ground, is greater than the values specified in (a) but the available current measured through an impedance, equivalent to that in the end-use product, is limited by virtue of the circuit impedance to the value specified in the end-product standard for normal operation.

Each line in a circuit that employs such impedance shall satisfy the following equation:

$$Z \geq \frac{V}{I}$$

in which:

Z is the minimum impedance, including tolerances;

V is the open-circuit voltage; and

I is the current limitation of the end-product standard.

8.3 With reference to 8.2 (a) and 8.2 (b), if the circuit incorporates a voltage-multiplier or other circuit which increases the steady state potential, the maximum steady state potential shall not exceed the values specified.

8.4 Circuit elements, such as resistors, capacitors, rectifiers, and similar elements, which constitute the circuit impedance referred to in 8.2(b) and 8.2(c), shall be of the fixed type and shall be investigated as a unit for acceptability with respect to end-use conditions.

8.5 An electronic circuit element relied upon to limit the voltage, current, or both to the values specified in 8.2 shall not experience an electrical stress factor:

- a) Greater than 0.5 during all conditions of normal operation; or
- b) Greater than 1.0 after single component failure.

8.6 For supplies of circuits of the types specified in 8.2(b) and 8.2(c):

- a) Minimum electrical spacings shall be in accordance with Spacings, Section 17, up to the point at which the voltage, current, or both is limited, regardless of the maximum available power involved.
- b) A risk of fire, electric shock, or injury to persons shall not result when the circuit is subjected to the 7-h short-circuit test specified in 30.1.1.

9 Current-Carrying Parts

9.1 A current-carrying part shall be of silver, copper, a copper-base alloy, aluminum, or other material rated for the application. Iron or steel shall not be used as a current-carrying part.

Exception No. 1: Stainless steel is acceptable as a current-carrying part.

Exception No. 2: Plated iron or steel is acceptable as a current-carrying part if it is used in the construction of a frame or enclosure that is intended for connection to an isolated secondary circuit or it is used as part of a component in accordance with the requirements for that component. See 11.3.1.

10 Internal Wiring

10.1 The method of determining compliance of the protection of the wiring and connections between parts of a control shall be determined in accordance with the end-use product standard.

10.2 Internal wiring shall be routed and secured so that the wiring and related electrical connections are not subjected to stress or mechanical damage, especially wiring smaller than 24 AWG (0.21 mm²) or having insulation less than 1/32 in (0.79 mm) thick. Flexing, vibration, impact, and exposure of the wiring shall comply with the requirements of the end-product standard.

10.2 revised October 31, 2007

10.3 The internal wiring of a control, including grounding conductors, shall be rated with respect to temperature, voltage, exposure to oil, grease, or moisture, and other conditions of service to which the wiring is subjected.

11 Splices and Connections

11.1 General

11.1.1 Each splice and connection shall be mechanically secure and shall provide electrical continuity without strain on connections and terminals. Vibration, flexing, motion, and similar conditions shall be taken into account when determining compliance of the mechanical security of an electrical connection.

11.1.2 A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection results in a risk of fire, electric shock, or injury to persons.

11.1.3 A lead is considered to be mechanically secure when one or more of the following is provided prior to soldering:

- a) A minimum of one full wrap is provided around a terminal;
- b) A lead not integral with a component on a printed wiring board is passed through an eyelet or opening and if hand-soldered is bent 90 degrees to the board;
- c) A lead integral with a component is inserted through an opening of a printed wiring board;
- d) A lead is twisted with other conductors; or
- e) A lead is inserted into a U- or V-shaped slot in the terminal.

11.1.4 Placement of a lead along a flat surface and tack soldering is not acceptable unless the construction is such that a risk of fire, electric shock, or injury to persons does not result when the lead is detached.

11.1.5 Other means of securing leads, such as push-on terminals, spade-type connectors, and wire wrapping shall be investigated to determine if the means provides mechanical security. Quick-connect terminals shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Mechanical splicing devices shall comply with the Standard for Wire Connectors, UL 486A-486B.

11.1.5 revised October 31, 2007

11.1.6 A nongeneral use attachment plug or receptacle, or a printed-wiring board connector intended to facilitate interconnection within a control or to the end-use product shall be:

- a) Rated for the current, voltage, and temperature involved; and
- b) Provided with mechanical locking or securing means other than friction for providing electrical continuity, maintenance of spacings, and separation of circuits.

Exception: This requirement is not applicable if loosening or removal of the connector does not result in a risk of fire, electric shock, or injury to persons.

11.1.7 Factors to be taken into account in the investigation of factory-wiring terminals and leads are the type and size of wire to be connected, the current rating of the terminals, and mechanical protection. These factors are dependent upon requirements for the end-use product.

11.2 Wire-wrapped connections

11.2.1 Solderless wrapped connections are not acceptable if subject to movement or flexure on the wires during normal operation or user servicing.

11.2.2 The wire for a wire-wrapped connection shall be solid, copper wire and shall be a wire size of 24, 22, or 20 AWG (0.511, 0.643, or 0.813 mm). Other sizes and types of wires shall be subjected to an investigation.

11.2.2 revised October 31, 2007

11.2.3 A terminal shall be made of copper or brass and have at least two sharp edges.

11.2.4 The wrap shall:

- a) Have a minimum of 20 points on the corners of the terminal in contact with the wire; and
- b) Have a minimum of 16 points closely wrapped with no overlapping.

See Table 11.1. A smaller number of wraps shall be subjected to an investigation. Contact points shall produce compression or flow of the conductor rather than a nick that weakens the mechanical strength of the conductor such that fracture is able to occur.

Table 11.1
Typical number of wraps

Number of sharp corners on the terminal	Number of closely wrapped turns	Total number of turns
4	4	5
2	8	10

11.2.5 The term "closely wrapped" in 11.2.4 (b) means:

- a) There shall not be gaps between adjacent turns greater than one half of the diameter of the wire exclusive of gaps on the first and last turns; and
- b) The sum of all gaps on any side of a connection shall not exceed the diameter of the wire exclusive of gaps on the first and last turns.

11.2.6 11.2.5 applies only to the actual number of wraps that are required. Gaps between any additional wraps that have been added at the manufacturer's option are not included when determining compliance with 11.2.5.