UL 1559

STANDARD FOR SAFETY

Insect-Control Equipment – Electrocution Type

UL Standard for Safety for Insect-Control Equipment – Electrocution Type, UL 1559

Fifth Edition, Dated March 21, 2011

Summary of Topics

This revision of ANSI/UL 1559 dated September 22, 2022 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated September 22, 2017.

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Standard for Insect-Control Equipment – Electrocution Type

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Fifth Edition

March 21, 2011

This ANSI/UL Standard for Safety consists of the Fifth edition including revisions through September 22, 2022.

The most recent designation of ANSI/UL 1559 as a Reaffirmed American National Standard (ANS) occurred on September 22, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 1559 on February 25, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover insect-electrocution equipment of the household and commercial types with an input rating of 250 V or less and are intended for use in ordinary locations in accordance with the National Electrical Code.

1.2 These requirements cover products that employ electrocution as the primary means of exterminating insects.

1.3 These requirements assume the use of an isolating type transformer for electrocuting insects. Constructions without such isolation may be investigated in accordance with these requirements and supplemented and modified by other appropriate requirements.

1.4 These requirements do not cover insect exterminators of the type that utilize chemicals, ultrasonic or mechanical trapping devices.

1.5 *Deleted*

2 Units of Measurement

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

2.2 Unless indicated otherwise all voltage and current values mentioned in this standard are root-mean-square (rms).

3 References

3.1 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.

4 Glossary

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

4.2 APPLIANCE COUPLER – A single-outlet, female contact device for attachment to a flexible cord as part of a detachable power-supply cord to be connected to an appliance inlet (motor attachment plug).

4.3 APPLIANCE INLET (Motor Attachment Plug) – A male contact device mounted on an end product appliance to provide an integral blade configuration for the connection of an appliance coupler or cord connector.

4.4 APPLIANCE (FLATIRON) PLUG – An appliance coupler type of device having a cord guard and a slot configuration specified for use with heating or cooking appliances.

4.5 COMMERCIAL EQUIPMENT – Equipment intended to be used on commercial, industrial or institutional premises, such as restaurants, motels, schools, public and commercial campsites, public swimming pools and beaches, golf courses, food processing plants, canneries, beverage bottling plants, farms and similar sites.

4.6 COMPONENT – A device or fabricated part of the appliance covered by the scope of a safety standard dedicated to the purpose. When incorporated in an appliance, equipment otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as thermoplastic or copper, are not considered components.

4.7 CONTROL, AUTOMATIC ACTION – A control in which at least one aspect is non-manual.

4.8 CONTROL, AUXILIARY – A device or assembly of devices that provides a functional utility, is not relied upon as an operational or protective control, and therefore is not relied upon for safety. For example, an efficiency control not relied upon to reduce the risk of electric shock, fire, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

4.9 CONTROL, MANUAL – A device that requires direct human interaction to activate or rest the control.

4.10 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which a thermal cutout/limiter or another layer of protection would mitigate the potential hazard, is considered an operating control. Operating controls are also referred to as “regulating controls”.

4.11 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the appliance. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as “limiting controls” and “safety controls”.

Note: During the evaluation of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control.

4.12 CONTROL, TYPE 1 ACTION – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence has not been declared and tested under this Standard.

4.13 CONTROL, TYPE 2 ACTION – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence have been declared and tested under this Standard.

4.14 CORD CONNECTOR – A female contact device wired on flexible cord for use as an extension from an outlet to make a detachable electrical connection to an attachment plug or, as an appliance coupler, to an equipment inlet.

4.15 ELECTRODE TRANSFORMER – A transformer whose primary function is to supply the voltage and current necessary for electrocuting insects.

4.15.1 FIXED APPLIANCE – Appliance that is intended to be used while fastened to or hung from a support or while secured in a specific location.

4.16 HOUSEHOLD EQUIPMENT – Equipment intended for use in or around a residence. Portable cord-connected insect-electrocution equipment intended for personal use during camping or similar activities is also considered household equipment.

4.17 INDOOR-USE EQUIPMENT – Equipment intended for use in a sheltered area that is not normally subject to dampness or wetness and not exposed to weather.

4.18 OUTDOOR-USE EQUIPMENT – Equipment intended for use in locations exposed to weather including partially protected locations under canopies, roofed open porches, barns and similar locations that may be damp or wet.

4.18.1 PORTABLE EQUIPMENT – Appliance that is intended to be moved while in operation or an appliance, other than a FIXED APPLIANCE, having a mass less than 18 kg.

4.19 PRIMARY CIRCUIT – A circuit that is conductively connected to the branch circuit supply source.

4.20 SECONDARY CIRCUIT – A circuit that is conductively connected to a secondary winding of an isolating transformer.

4.21 STATIONARY APPLIANCE – Fixed appliance or an appliance which is not a portable appliance.

CONSTRUCTION

5 General

5.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as indicated in Sections 6 – 23;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability;

d) Additionally comply with the applicable requirements of this end product standard; and

e) Not contain mercury, with the exception of fluorescent tubes.

Note: 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.

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product, or

b) Is superseded by a requirement in this standard, or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

Exception No. 2: A component complying with a UL component standard other than those cited in Sections 6 – 23 is acceptable if:

a) The component also complies with the applicable component standard of Sections 6 – 23; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements NFPA 70, where appropriate;

2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, and

3) Any use limitations of the other component standard is identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.

5.2 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable UL standard(s) that cover devices that provide those functions.

Exception: Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component standard(s) need not be applied.

5.3 A component not anticipated by the requirements of this standard, not specifically covered by the component standards of Sections 6 – 23, and that involves a potential risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 5.1 (b) – (d).

5.4 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of UL 1559.

6 Attachment Plugs, Receptacles, Connectors, and Terminals

6.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See 6.9.

Exception: Attachment plugs and appliance couplers integral to cord sets or power supply cords are covered under the requirements of UL 817 and need not comply with UL 498.

6.2 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with UL 310.

6.3 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977. See 6.9.

6.4 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

6.5 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, UL 486C.

6.6 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459. See 6.9.

6.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

6.8 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

6.9 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current in the end product, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector. For example, an appliance coupler that can be used to interrupt the current of a motor load shall have a suitable horsepower rating when tested with its mating plug.

7 Boxes and Raceways

7.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of NFPA 70 and that comply with the relevant UL standard (such as UL 514A, UL 514C, UL 514D) and Section 5, are considered to fulfill the requirements of this Standard.

8 Filters

8.1 Electromagnetic interference filters with integral enclosures shall comply with the Standard for Electromagnetic Interference Filters, UL 1283.

9 Controls

9.1 General

9.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product Standard and the parameters in Section 44.

9.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 9.2 – 9.4, and if applicable, the parameters in Section 44, unless otherwise specified in this end product standard.

9.1.3 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a hazard, such as a speed control unexpectedly changing its output, shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

9.1.4 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 9.2 – 9.4, and if applicable, the parameters in Section 44, unless otherwise specified in this end product Standard.

9.1.5 Solid-state protective controls that do not rely upon software as a protective component shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except Clause 11.12(h) (Controls using software).

9.1.6 Protective controls that rely upon software as a protective component shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

9.1.7 An electronic, non-protective control that is simple in design need only be subjected to the applicable requirements of this end-product standard. A control that does not include an integrated circuit or microprocessor, but does consist of a discrete switching device, capacitors, transistors, and resistors, is considered simple in design. See Abnormal Operation Test, Section 53.

9.2 Electromechanical and electronic controls

9.2.1 A control, other than as specified in 9.2 – 9.4, shall comply with the:

a) Standard for Solid-State Controls for Appliances, UL 244A; or

b) Standard for Temperature-Indicating and -Regulating Equipment, UL 873; or

c) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

9.3 Temperature controls

9.3.1 A temperature control shall comply with the:

a) Standard for Solid-State Controls for Appliances, UL 244A;

b) Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) Standard for Industrial Control Equipment, UL 508; or

d) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

9.3.2 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 comply with the Standard for Thermistor-Type Devices, UL 1434.

9.3.3 A thermal cutoff shall comply with the Standard for Thermal-Links - Requirements and Application Guide, UL 60691.

9.4 Timer controls

9.4.1 A timer control shall comply with the:

a) Standard for Solid-State Controls for Appliances, UL 244A; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

10 Cords, Cables, and Internal Wiring

10.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

10.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to fulfill this requirement when preassembled in a cord set or power supply cord complying with the Standard for Cord Sets and Power Supply Cords, UL 817.

10.3 Internal wiring composed of insulated conductors shall comply with the Standard for Appliance Wiring Material, UL 758.

Exception No. 1: Insulated conductors need not comply with UL 758 if they comply with one of the following:

a) Standard for Thermoset-Insulated Wires and Cables, UL 44;

b) Standard for Thermoplastic-Insulated Wires and Cables, UL 83;

c) Standard for Fixture Wire, UL 66; or

d) the appropriate UL standard(s) for other insulated conductor types specified in Chapter 3 (Wiring Methods and Materials) of NFPA 70.

Exception No. 2: Insulated conductors for specialty applications (e.g. data processing or communications) and located in a low-voltage circuit not involving the risk of fire or personal injury need not comply with UL 758.

11 Film-Coated Wire (Magnet Wire)

11.1 The component requirements for film coated wire and Class 105 (A) insulation systems are not specified.

11.2 Film coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

12 Gaskets and Seals

12.1 Gaskets and seals shall comply with the Standard for Gaskets and Seals, UL 157.

13 Ground-Fault, Arc-Fault, and Leakage Current Detectors / Interrupters

13.1 Ground-fault circuit-interrupters (GFCI) for protection against electrical shock shall comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943. The following statement, or equivalent, shall be included as a marking near the GFCI, or as an instruction in the manual: " Press the TEST button (then RESET button) every month to assure proper operation."

13.2 Appliance-leakage-current interrupters (ALCI) for protection against electrical shock shall comply with the Standard for Appliance-Leakage-Current Interrupters, UL 943B.

Note: An ALCI is not considered an acceptable substitute for a GFCI when NFPA 70 requires a GFCI.

13.3 Equipment ground-fault protective devices shall comply with the Standard for Ground-Fault Sensing and Relaying Equipment, UL 1053, and the applicable requirements of the Standard for Ground-Fault Circuit-Interrupters, UL 943.

13.4 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

13.5 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

14 Light Sources and Associated Components

14.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

Exception: Lampholders forming part of a luminaire that complies with an appropriate UL luminaire standard are considered to fulfill this requirement.

14.2 Lighting ballasts shall comply with the:

a) Standard for Fluorescent-Lamp Ballasts, UL 935; or

b) Standard for High-Intensity Discharge Lamp Ballasts, UL 1029.

Exception No. 1: Ballasts forming part of a luminaire that complies with an appropriate UL luminaire standard are considered to fulfill this requirement.

Exception No. 2: Ballasts for other light sources shall comply with the appropriate UL standard(s).

14.3 Light emitting diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Equipment For Use In Lighting Products, UL 8750.

Exception No. 1: LED light sources forming part of a luminaire that complies with an appropriate UL luminaire standard are considered to fulfill this requirement.

Exception No. 2: Individual LED light sources mounted on printed wiring boards and intended for indicating purposes need not comply with UL 8750, but shall comply with the applicable requirements of this end product standard.

14.4 Fluorescent lampholders and starter holders for fluorescent shall comply with the Standard for Fluorescent Lamp Starters, UL 542.

15 Marking and Labeling Systems

15.1 A marking and labeling system shall comply with UL 969(Marking and Labeling Systems) under the specified environmental conditions.

16 Overcurrent Protection

16.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another appropriate UL standard for the fuse are considered to fulfill this requirement.

16.2 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9).

16.3 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A, need not comply with UL 489.

16.4 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

16.5 Supplementary protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

16.6 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

17 Polymeric Materials and Enclosures

17.1 Unless otherwise specified in this end product standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

17.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. This requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

18 Power Supplies

18.1 A Class 2 power supply shall comply with one of the following:

a) Standard for Class 2 Power Units, UL 1310; or

b) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

18.2 A non-Class 2 power supply shall comply with one of the following:

a) Standard for Power Units Other Than Class 2, UL 1012; or

b) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

19 Printed-Wiring Boards

19.1 Printed-wiring boards, including the coatings, shall comply with the Standard for Printed-Wiring Boards, UL 796.

20 Semiconductors and Small Electronic Components

20.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Section 51, of this end product Standard.

20.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product Standard shall comply with the Standard for Optical Isolators, UL 1577. The dielectric voltage withstand tests required by UL 1577 shall be conducted applying the criteria of Section 51, of this end product Standard.

20.3 Except as specified in 20.4, component requirements are not specified for small electronic components on printed-wiring boards, including diodes, transistors, resistors, inductors, integrated circuits, and capacitors not directly connected to the supply source.

20.4 Where an electronic component is determined to be a critical component during the testing of UL 1559, Section 53 (Abnormal Operation Test), one of the following standards shall be applied. See 44.4 of this end product Standard for the test parameters to be used.

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, including its Follow-Up Program; and as applicable, the Standard for Software in Programmable Components, UL 1998 for controls that rely upon software as a protective component; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

20.5 A critical component is a component that performs one or more safety-related functions whose failure results in a condition, such as the risk of fire, electric shock, or injury to persons, in the end product application.

20.6 A critical component may also be identified using a failure-mode and effect analysis (FMEA) in accordance with Failure-Mode and Effect Analysis (FMEA), Section 7 of UL 991.

20.7 Portions of a circuit comprised of a microcontroller or other programmable device that performs a back-up, limiting, or other safety function intended to reduce the risk of fire, electric shock, or injury to persons shall comply with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, Annex H.

21 Supplemental Insulation, Insulating Bushings, and Assembly Aids

21.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 33.3.3 or a performance requirement of this Standard. In such cases:

a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;

b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441;

c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

21.2 Wire positioning devices shall comply with 33.4 and Section 34, Electrical Insulation. A device that complies with the Standard for Positioning Devices, UL 1565, is considered to fulfill this requirement.

21.3 Insulating bushings that comply with Section 5, General, of this end product Standard, and the Standard for Insulating Bushings, UL 635, are considered to fulfill the requirements of this Standard. Tests specified in this Standard (e.g. Strain Relief Test) may still need to be performed to confirm the combination of the insulating bushing and the supporting part are suitable.

22 Switches

22.1 Switches shall comply with one of the following, as applicable:

a) *Deleted*

b) Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;

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

d) Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 773A.

Exception: Switching devices that comply with the appropriate UL standard for specialty applications (e.g. transfer switch equipment), industrial use (e.g. contactors, relays, auxiliary devices), or are integral to another component (e.g. switched lampholder) need not comply.

22.2 A clock-operated switch, in which the switching contacts are actuated by a clock-work, by a gear-train, by electrically-wound spring motors, by electric clock-type motors, or by equivalent arrangements shall comply with one of the following:

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

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

22.3 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, that functions as a protective control, shall comply with the requirements for a protective control; see 9.1.4.

23 Transformers

23.1 General-purpose transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

Exception No. 1: A transformer that is completely enclosed within the end product enclosure, and that meets the applicable construction and performance requirements of this end product Standard when tested in conjunction with the end product, meets the intent of this requirement.

Exception No. 2: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, and that is used in a circuit involving an audio or video component, meets the intent of this requirement.

24 Frame and Enclosure

24.1 Insect-electrocution equipment shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses that it is likely to be subjected to, without increasing the likelihood 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.

24.2 All electrical parts, except a supply cord, that may involve a risk of fire, electric shock, or injury to persons under any condition of use, shall be enclosed in an acceptable enclosure.

24.3 A knockout in a sheet metal enclosure shall be effectively secured and removable without undue deformation of the enclosure.

24.4 A knockout shall be surrounded by a flat surface to provide for seating of a conduit bushing or locknut of the appropriate size.

24.5 Sheet metal to which a wiring system is to be connected in the field shall have a minimum thickness of 0.032 inch (0.81 mm) if uncoated steel, 0.034 inch (0.86 mm) if galvanized steel, and 0.045 inch (1.14 mm) if nonferrous metal.

24.6 Cast metal to which a wiring system is to be connected in the field shall have an average thickness not less than 1/8 inch (3.2 mm).

24.7 The enclosure of insect-electrocution equipment for outdoor use shall be constructed so as to exclude a beating rain. See Water Spray Test, Section 54.

24.8 A gasket or seal relied upon to comply with the requirements in Water Spray Test, Section 54, shall comply with Section 12, Gaskets and Seals.

24.9 A polymeric enclosure, frame, or cover shall be evaluated with respect to mechanical strength, resistance to impact, moisture absorption properties, combustibility, resistance to arcing, dielectric strength, aging characteristics and other environmental conditions to which the enclosure may be subjected.

24.10 To determine compliance with 24.9, a polymeric enclosure, frame, or cover shall be evaluated in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and other applicable tests in this standard.

24.11 A polymeric enclosure, frame, or cover of insect-electrocution equipment intended for outdoor use shall additionally be evaluated in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, for exposure to ultraviolet light and water.

24.11.1 A polymeric enclosure, frame or cover of insect-electrocution equipment which generate ultraviolet (UV) radiation shall be suitable for UV exposure or shall be suitably shielded if degradation would result in non-compliance with other requirements of this Standard.

24.11.2 Components provided within the enclosure or enclosed by sleeving composed of non-metallic materials (ie. wiring, capacitors, etc.) exposed to direct or reflected ultraviolet (UV) radiation shall be suitable for UV exposure or shall be suitably shielded from UV exposure, if degradation would result in non-compliance with other requirements of this Standard.

24.12 An insect catch tray shall be provided with insect-electrocution equipment not marked for “Outdoor Use Only” or the equivalent. The insect catch tray shall be removable without the use of a tool to facilitate insect disposal.

24.13 A polymeric enclosure, frame, cover or insect catch tray shall be classified not less than V-2 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

24.14 A flame retardant coating on a polymeric enclosure shall not be used, unless the uncoated polymeric material complies with 24.13 and the coating complies with the applicable Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

24.15 A keyhole slot in the enclosure shall be provided with a barrier to protect against the likelihood of the hanger (nail, screw, or similar fasteners) from contacting live parts or falling into the enclosure, if an increase in the risk of fire or electric shock may result.

25 Protection Against Corrosion

25.1 General

25.1.1 Ferrous metal parts shall be protected against corrosion by enameling, galvanizing, plating, Sherardizing, or other equivalent means.

Exception No. 1: Ferrous parts not relied upon for maintaining the integrity of the product are not required to be protected against corrosion.

Exception No. 2: Parts made of stainless steel are not required to be additionally protected against corrosion.

25.2 Enclosure intended for outdoor use

25.2.1 A sheet steel enclosure intended for outdoor use shall be protected against corrosion by one of the following coatings:

a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G90 in Table 1 of the Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. See 25.2.5.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.0155 mm) on each surface with a minimum thickness of 0.00054 inch (0.0137 mm). See 25.2.6.

c) A zinc coating as specified in 25.2.1 (c)(1) or (2) below and with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each side. The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests if these are considered necessary.

1) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in Table 1 of ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM specification. See 25.2.5.

2) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm).

d) A cadmium coating not less than 0.0010 inch (0.025 mm) thick on both surfaces. See 25.2.6.

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The paint shall be as specified in (c). See 25.2.6.

f) Other finishes, including paints, metal finishes, or combinations of the two may be accepted when comparative tests with galvanized sheet steel – without annealing, wiping, or other surface treatment – specified in (a), indicate they provide equivalent protection.

Among the factors that are taken into consideration when evaluating such coating systems are exposure to salt spray, moist carbon dioxide-sulphur dioxide-air mixtures, moist hydrogen sulphide-air mixtures, ultraviolet light, and water.

25.2.2 An annealed coating on sheet steel that is bent or similarly formed or extruded or rolled at the edge of holes after annealing shall be additionally painted in the affected area if the process damages the zinc coating.

Exception: If the width of the damaged area is less than the thickness of the sheet steel, the area is not required to be additionally painted.

25.2.3 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged.

25.2.4 Simple sheared or cut edges and punched holes are not required to be additionally protected.

25.2.5 The weight of the zinc coating specified in 25.2.1 (a) and (c)(1) may be determined by any acceptable method; however, in case of question the weight of coating shall be established in accordance with the Standard Test Method for Weight [Mass] of Coating on Iron or Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90/A90M.

25.2.6 The thickness of the cadmium or zinc coating specified in 25.2.1 (b), (c)(2), (d), and (e) shall be established by the Metallic-Coating Thickness Test described in Section 63.

26 Leakage Current

26.1 Leakage current from any part that is accessible during normal use, shall be within the limit specified in 46.1 if the open-circuit potential between the accessible part and earth ground or any other accessible part is more than:

a) 42.4 V peak for indoor use only equipment, and

b) 21.2 V peak for outdoor-use equipment or where wet contact is likely to occur.

27 Electric Shock

27.1 Risk of electric shock is considered to exist at any live part, if the open-circuit potential between the part and earth ground or any other accessible part is more than:

a) 42.4 V peak for an indoor use only unit or

b) 21.2 V peak for an outdoor unit or where wet contact is likely to occur, and:

1) The continuous current flow through a 500-ohm resistor is more than 5.0 mA, or

2) The combination of magnitude and duration of peak current flow exceeds the limits specified in 27.2, or

3) The combination of capacitance and voltage exceeds the limits specified in 27.3.

27.2 The duration of a transient current (unidirectional or alternating) through a 500-ohm resistor, connected between any exposed part and earth ground or any other accessible part, shall satisfy the following equation:

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

in which:

I is the peak current in milliamperes; and

T is the duration, measured in seconds, from the time that the instantaneous value of the current first exceeds 7.1 mA peak until the time that the current falls below 7.1 mA and remains so for at least one second. Typical calculated values appear in Table 27.1.

Exception: The peak current shall not exceed 809 mA regardless of duration.

Table 27.1
Electric shock – transient

Maximum current in milliamperes peak through 500-ohm resistor	Maximum acceptable time in seconds of envelope containing excursions greater than 7.1 milliamperes peak
Less than 7.1	Not applicable
7.1	7.22
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016

Table 27.1 Continued on Next Page

Table 27.1 Continued

Maximum current in milliamperes peak through 500-ohm resistor	Maximum acceptable time in seconds of envelope containing excursions greater than 7.1 milliamperes peak
600.0	0.012
700.0	0.010
809.0	0.0083
Greater than 809.0	See exception to 27.2

27.3 The maximum capacitance between capacitor terminals or any part conductively connected to the terminals shall satisfy the following equations:

$$C = \frac{88{,}400}{E^{1.43}(\log_e E - 1.26)} \text{ for } E \text{ equal to or less than } 400V$$

$$C = 35{,}288\,E^{-1.5364} \text{ for } E \text{ greater than } 400V$$

in which:

C is the maximum capacitance of the capacitor in microfarads; and

E is the peak potential in volts across the capacitor measured 5 seconds after the capacitor terminals or uninsulated live parts electrically connected to the capacitor terminals are accessible by the removal or opening of the enclosure. Typical calculated values appear in Table 27.2.

27.4 Polarization of an attachment plug on cord-connected equipment is to be disregarded when evaluating the risk of electric shock.

Table 27.2
Electric shock – stored energy

Potential in volts, across capacitor(s) prior to discharge	Maximum acceptable capacitance in microfarads
5,000	0.0732
4,500	0.0861
4,000	0.103
3,500	0.127
3,000	0.160
2,500	0.212
2,000	0.299
1,500	0.465
1,250	0.616
1,000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52

Table 27.2 Continued on Next Page

Table 27.2 Continued

Potential in volts, across capacitor(s) prior to discharge	Maximum acceptable capacitance in microfarads
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124
45	150
42.4	167
40[a]	186
30[a]	319
25[a]	452
21.2[a]	625

[a] Values less than 42.4 V do not apply to indoor use equipment

28 Accessibility of Parts Involving the Risk of Electric Shock

28.1 An opening in the enclosure is acceptable if the appropriate probe, when inserted through the opening, cannot be made to touch any uninsulated part involving the risk of electric shock or coated-magnet wire that involves risk of electric shock. The probe shall be applied in all possible articulated positions before, during, and after insertion.

28.2 The probe shown in Figure 28.1 is to be used for determining the accessibility of a primary circuit part.

28.3 The probe shown in Figure 28.2 is to be used for determining the accessibility of a secondary circuit part.

28.4 In connection with the requirements in 28.1, a part of the outer enclosure that may be removed without the use of a tool is to be disregarded – that is, it is not to be assumed that the part in question affords protection against electric shock.

Figure 28.1

Accessibility probe for primary circuit parts

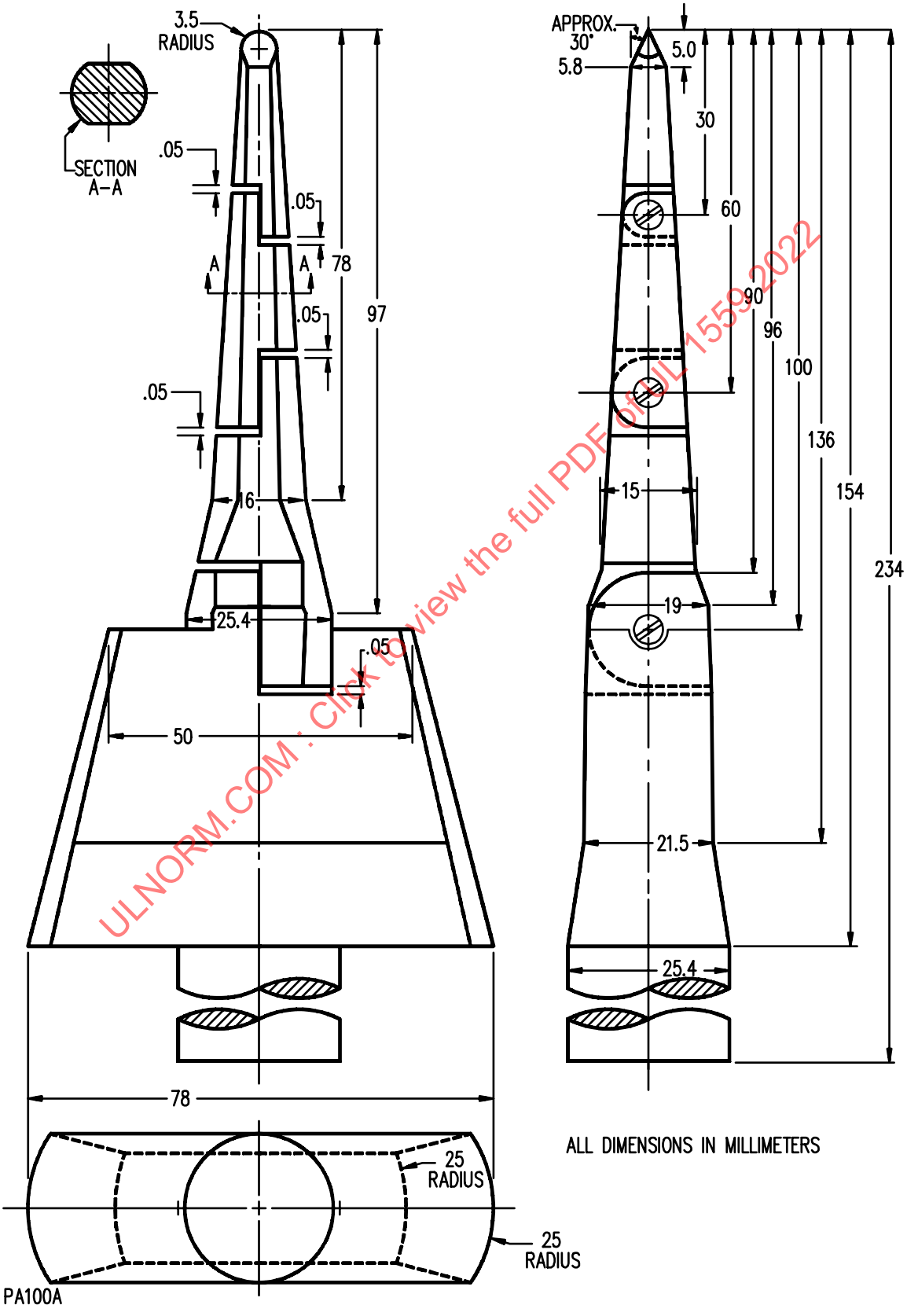


Figure 28.2

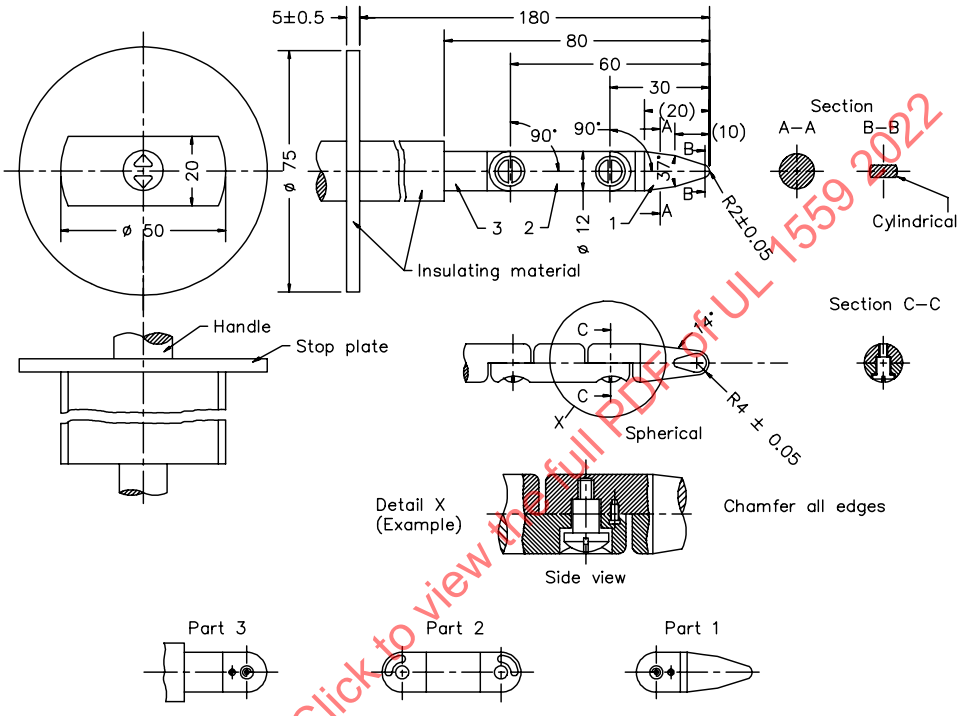
Accessibility probe for secondary circuit parts

International Electrotechnical Commission (IEC)

Articulate accessibility probe with stop plate

(All dimensions in millimeters)

Courtesy of IEC



mm	2	4	10	12	20	30
(inches)	(5/64)	(3/32)	(25/64)	(15/32)	(25/32)	(1-5/64)

50	60	75	80	180
(1-61/64)	(2-23/64)	(2-61/64)	(3-9/64)	(7-3/32)

29 User Servicing

29.1 The necessary routine maintenance of insect-electrocution equipment, such as removal of insects and replacing lamps and starters, shall not result in a risk of fire, electric shock (see Electric Shock, Section 27) or injury to persons (see Protection Against Injury to Persons, Section 30).

Exception: The requirement does not apply to the contacts of a lampholder or starter holder that is associated with the component being replaced. See Section 5, General, and 37.5.

29.2 The equipment shall be constructed such that while performing routine maintenance (such as insect removal, changing a lamp or lamp starter, or similar activities), the equipment will remain intact except for an enclosure part(s) that must be removed to perform the maintenance.

29.3 A part that must be removed during user servicing is to be removed when determining the accessibility of live parts that involve a risk of electric shock.

29.4 An interlock device provided to reduce the risk of electric shock shall be constructed so that it cannot be unintentionally activated to energize the equipment during servicing.

29.5 The interlock device described in 29.4 shall be constructed and installed so as to be reliable, substantial and not easily defeated by improper disassembly or reassembly of the equipment.

29.6 A seal relied upon to preclude rain from entering the enclosure of insect-electrocution equipment intended for outdoor use shall not be adversely affected by opening the enclosure during user servicing. See 54.5.

30 Protection Against Injury to Persons

30.1 General

30.1.1 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or other feature of insect-electrocution equipment shall be smooth and well-rounded and not sufficiently sharp to cause a cut-type injury when contacted during intended use or user maintenance.

30.1 relocated as 30.1.1

30.1.2 If the sharpness of an edge is questionable, the requirements for the determination of sharpness of edges on equipment, UL 1439 are to be used.

30.2 relocated as 30.1.2

30.2 Protection from overexposure to ultraviolet (UV) radiation

30.2.1 Insect-electrocution equipment shall be investigated for emission of ultraviolet (UV) radiation in accordance with the Ultraviolet Irradiance Test, Section 64A. The emission of UV shall not exceed an Effective Irradiance value of 0.1 microwatt/cm^2 when measured at the general use distance and an Effective Irradiance value of 3 microwatt/cm^2 when measured at the relamping/servicing distance.

Exception No. 1: Products exclusively identified for the use with lamps rated "Exempt Risk Group", ANSI/IESNA RP-27.1, are considered to comply with this requirement without test.

Exception No. 2: Products generating UV in excess of 3 microwatt/cm^2 when measured at the relamping/servicing distance are acceptable if the product cannot be operated continuously during relamping or servicing.

30.2.2 Interlocks used to minimize risk of overexposure to ultraviolet (UV) radiation per Exception No. 2 of 30.2.1 shall be reliable, see 30.2.3. The actuator of an interlock shall be located so the unintentional operation is unlikely. Also refer to 29.4 and 29.5.

30.2.3 An interlock that is required to reduce a risk of overexposure to ultraviolet (UV) radiation shall withstand 100,000 cycles of operation controlling a load not less than that controlled in the product, and shall function normally upon completion of the test.

31 Supply Connections

31.1 General

31.1.1 Insect-electrocution equipment intended for permanent securement to the building structure shall be provided with a means for permanent connection to the branch-circuit supply.

31.2 Permanently-connected equipment

31.2.1 General

31.2.1.1 Equipment intended for permanent connection to the branch-circuit supply shall have provision for the connection of one of the wiring methods that, in accordance with the National Electrical Code, ANSI/NFPA No. 70, would be acceptable for the purpose.

31.2.1.2 The location of a wiring compartment, in which branch-circuit connections to permanently-wired equipment are to be made, shall be such that these connections can be readily inspected without disturbing the wiring of the equipment after the equipment is installed as intended.

31.2.1.3 No electrical component shall be mounted on a part, such as a box cover, that must be removed for the examination of field-wiring connections.

31.2.1.4 A wiring compartment intended for connection of a supply raceway shall be so attached to the equipment that it can not turn with respect thereto.

31.2.2 Field wiring terminals and leads

31.2.2.1 Insect-electrocution equipment intended for permanent connection to the power supply shall be provided with wiring terminals or leads for the connection of conductors having an ampacity (current-carrying capacity in amperes) according to the National Electrical Code, ANSI/NFPA No. 70, appropriate for the equipment.

31.2.2.2 Pigtail leads provided for connection to the branch-circuit supply shall have an ampacity not less than that of the conductor of the next smaller size than that listed in the National Electrical Code, ANSI/NFPA No. 70, as appropriate for the rating of the equipment. The conductor size in any case is to be not less than 16 AWG (1.3 mm^2). See 31.2.2.3.

31.2.2.3 For the purpose of these requirements it is assumed that 60°C (140°F) wire will be installed, unless the equipment is marked in accordance with 71.2.

31.2.2.4 A field-wiring terminal assembly shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by two screws or rivets, square shoulders or mortises, a dowel pin, lug or offset, a connecting strap or clip fitted into an adjacent part, or some other equivalent method.

31.2.2.5 A field-wiring terminal shall be provided with a soldering lug or pressure wire connector firmly bolted or held by a screw.

Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor, if upturned lugs, cupped washers, or the equivalent are provided to hold the wire in position.

31.2.2.6 Upturned lugs or a cupped washer shall be capable of retaining a power-supply conductor, corresponding in size to that mentioned in 31.2.2.1, under the head of the screw or the washer.

31.2.2.7 A wire-binding screw at a wiring terminal shall not be smaller than 10 (4.8 mm diameter). The threads shall not be finer than that of the National Fine Thread Series for the screw size.

Exception: A No. 8 (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) or smaller conductor, and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm^2) conductor.

31.2.2.8 The free length of a lead inside an outlet box or field-wiring compartment shall be 6 inches (152.4 mm) or more.

31.2.2.9 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick, except that a plate not less than 0.030 inch (0.76 mm) thick is acceptable if the tapped threads have adequate mechanical strength. There shall not be less than two full threads in the metal of the plate.

31.2.2.10 A terminal plate formed from stock having the minimum acceptable thickness mentioned in 31.2.2.9 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

31.2.3 Grounding terminals and leads

31.2.3.1 A field-wiring terminal or lead for connection of an equipment-grounding conductor shall be provided.

31.2.3.2 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the particular application, in accordance with the National Electrical Code, ANSI/NFPA No. 70. See 31.2.3.4.

31.2.3.3 The surface of an insulated lead intended for the connection of an equipment-grounding conductor shall be green, with or without one or more yellow stripes, and no other lead shall be so identified in the field-wiring compartment.

31.2.3.4 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified by being marked “G ,” “GR ,” “GND ,” “Ground ,” “Grounding” or similar designation or by a marking on the wiring diagram provided on the equipment.

31.2.3.5 The wire-binding screw, pressure wire connector, or grounding lead shall be so located that it is unlikely to be removed during the servicing of the equipment, not involving the supply connection.

31.2.3.6 A quick-connect terminal or solder lug shall not be used for the grounding terminal.

31.2.3.7 Sheet metal screws shall not be used for:

a) Field connection of equipment grounding conductors to an enclosure; nor

b) Connection of a factory-provided grounding lead to an enclosure.

For the purposes of this requirement, a sheet metal screw is defined as a screw with a thread pitch that exceeds the thickness of the sheet metal and is designed to engage an unextruded, unthreaded hole in the metal.

31.2.4 Grounded terminal and leads

31.2.4.1 If provided with a single-pole switch, Edison-base lampholder, single-pole circuit breaker, or a fuse, permanently connected insect-electrocution equipment rated 125 or 125/250 V (three-wire) or less shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit.

31.2.4.2 The identification required in 31.2.4.1 shall be by a metal or metal coating substantially white in color or the word “white” located adjacent to the grounded terminal. If wire leads are provided instead of terminals, the surface of the grounded lead shall be finished to show white or grey color and shall be easily distinguishable from the other leads.

31.3 Cord-connected equipment

31.3.1 General

31.3.1.1 Cord-connected insect-electrocution equipment (equipment intended to be connected to the power-supply circuit by means of a flexible cord) shall be provided with a length of attached flexible cord with a molded-on attachment plug, or a motor-attachment plug for connection to a supply circuit.

31.3.1.2 The flexible cord shall be a Type SJ, SJE, or SJT or shall have such properties that will be at least equally serviceable for the application.

Exception: Type SP-2, SPT-2, or SPE-2 cord or a cord having such properties that it will be at least equally serviceable may be used on products intended for indoor household use only. See 70.2.6.

31.3.1.3 A power-supply cord shall be provided with a grounding conductor unless the equipment is double-insulated. The grounding conductor of the flexible cord shall be conductively connected to all exposed dead metal that may become energized, by means of a screw and lockwasher or by equivalent means that is not likely to be removed during the servicing operation not involving the supply cord. Neither a quick-connect type connector nor solder alone shall be used for securing the grounding conductor. The grounding conductor shall be connected to the grounding member of a grounding-type attachment plug. Sheet metal screws shall not be used for:

a) Field connection of equipment grounding conductors to an enclosure; nor

b) Connection of a factory-provided grounding lead to an enclosure.

For the purposes of this requirement, a sheet metal screw is defined as a screw with a thread pitch that exceeds the thickness of the sheet metal and is designed to engage an unextruded, unthreaded hole in the metal.

Exception: Grounding is not required on equipment intended for household indoor use only and intended for connection to a supply circuit of 150 V or less to ground, unless the steady-state output voltage of the fluorescent lamp ballast, if provided, is more than 150 V. However, the attachment plug shall be a polarized type if the equipment is provided with a single-pole switch or circuit protector, or an Edison-base lampholder.

31.3.1.4 The length of flexible cord shall be not less than 5.5 ft (1.7 m), as measured external to the equipment to the face of the attachment plug.

Exception: For equipment marked "Outdoor Use Only," the length of the flexible cord may be 8 inches (203.2 mm) or more.

31.3.1.5 A power-supply cord shall have a minimum flammability classification of VW-1.

31.3.1.6 A motor-attachment plug provided with insect-electrocution equipment shall be appropriate for the application, and shall be protected from rain and direct sunlight.

31.3.1.7 The flexible cord used with insect-electrocution equipment intended for outdoor use shall be surface marked with the suffix "W" on its jacket.

31.3.1.8 The current and voltage ratings of a flexible cord provided with insect-electrocution equipment, shall not be less than that of the equipment.

31.3.2 Strain relief

31.3.2.1 Strain relief shall be provided so that a mechanical stress on a power-supply cord will not be transmitted to terminals, splices, or interior wiring.

31.3.2.2 Means shall be provided so that a power-supply cord can not be pushed into or twisted inside the enclosure of the equipment through the cord-entry hole if such displacement is likely to:

a) Subject the cord to mechanical damage, or

b) Expose the cord to a temperature higher than that for which it is acceptable, or

c) Reduce spacings (such as to a metal strain-relief clamp) below the minimum acceptable values.

31.3.2.3 The strain-relief means shall not adversely affect the supply-cord insulation.

31.3.2.4 The strain-relief means provided shall comply with the test in Strain Relief Test, Section 58.

31.3.3 Bushings

31.3.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be substantial, reliably secured in place, and shall have a smooth, well-rounded surface against which the cord may bear. For cord lighter than Type SJ or SJT, such as Type SPT-2 cord, the bushing shall be an insulating type.

31.3.3.2 A cord hole in nonconducting material, having a smooth, well-rounded surface is considered to be equivalent to a bushing.

32 Current-Carrying Parts

32.1 A current-carrying part involving a risk of fire or electric shock shall be of aluminum, silver, copper, a copper alloy, or other material acceptable for the purpose.

32.2 Stainless steel or plated iron or steel may be used for a current-carrying part of the electrocution electrodes. The plating shall be equivalent to the corrosion protection required for the enclosure.

32.3 An uninsulated live part and its support shall be so secured to the base or mounting surface that it will not turn or shift in position if such motion may result in a reduction of spacings below the minimum acceptable values.

32.4 Friction between surfaces is not acceptable as the sole means to restrict the turning of a live part, but a lockwasher or a factory-assembled press-fit, if properly applied, is acceptable for this purpose.

33 Internal Wiring

33.1 General

33.1.1 The internal wiring of insect-electrocution equipment shall be VW-1 and consist of types of wires that are acceptable for the particular application, with consideration given to the temperature and voltage to which the wiring is likely to be subjected, and other environmental conditions such as ultra-violet light and water. The voltage rating of the wire shall be acceptable for the peak voltage involved.

33.1.2 Unsplit flexible cord, equivalent to Type SP-2, SPT-2, or SPE-2 or heavier, may be used for internal wiring if it is found acceptable for the particular application.

33.2 Protection of wiring

33.2.1 Internal wiring leads or flexible cord that are exposed to the weather shall be of a type acceptable for outdoor use, such as Types SPT-2W-A, SJTW-A, or SPE-2W-A.

33.2.2 Internal wiring that is likely to be handled or disturbed during user servicing, such as during replacement of a lamp or starter, shall not be smaller than 18 AWG (0.82 mm^2) conductor having insulation thickness of not less than 1/32 inch (0.79 mm). These wires shall be provided with a strain relief means so that stresses will not be transmitted to terminals or splices. See 58.3.

33.2.3 A wire within an enclosure, compartment or wireway shall be so located or protected that the conductor insulation will not be damaged as a result of contact with any rough, sharp, or moving part.

33.2.4 A hole in an internal sheet metal wall for the passage of insulated wires shall be provided with a supplementary insulating bushing, unless the wire is provided with insulation thickness of at least 1/32 inch (0.79 mm) and the sheet metal is formed to provide a rounded edge within the hole.

33.3 Splices and connections

33.3.1 All splices and connections shall be mechanically secured and shall provide good electrical contact. A soldered connection shall be made mechanically secure before being soldered, if breaking or loosening of the connection may result in any risk of fire or electric shock.

33.3.2 A splice shall be provided with insulation equivalent to that of the wires involved, if permanence of spacing between the splice and other metal parts is not provided.

33.3.3 In determining acceptance of splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing, consideration shall include dielectric properties, heat-resistant and moisture-resistant characteristics. See Electrical Insulation, Section 34.

33.3.4 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire will be prevented from contacting other live parts not always of the same polarity as the wire and from contacting dead-metal parts.

33.3.5 An electrical connection involving aluminum to aluminum conductors or, aluminum to other metal conductors shall be terminated by a method appropriate for the combination of metals at the connection point.

33.3.6 The wire connection mentioned in 33.3.5 shall be evaluated with respect to temperature, heat cycling, vibration and exposure to moisture.

33.4 Separation of circuits

33.4.1 Internal wiring and components of different circuits shall either be:

a) Provided with insulation rated for the highest voltage involved,

b) Provided with insulation on at least one of the wires or components rated for the sum of the voltages involved,

c) Separated by a barrier, or

d) Reliably spaced apart. See Spacings, Section 35.

33.4.2 Secondary and primary circuits, for example, are considered to be different circuits with reference to the requirement in 33.4.1.

33.4.3 A barrier used to provide separation between wiring or components or both of different circuits shall have sufficient physical strength, and be secured in place. Openings in a barrier for the passage of wires shall be no larger than required for the passage of the wires, but sufficiently large so as not to cause injury to the wire insulation. See also 33.2.4.

33.4.4 A metal barrier, if provided, shall be electrically connected to the grounding conductor of the supply circuit.

33.4.5 A barrier of insulating material used to provide separation between conductors of primary and secondary circuits shall be moisture resistant and acceptable for the sum of the voltages involved, and shall comply with 34.4.

34 Electrical Insulation

34.1 An insulating washer, bushing, or similar protective part that is an integral part of a unit or accessory, and bases or supports for the mounting of live parts, shall be of a moisture-resistant material that will not be affected adversely by the temperatures to which they will be subjected under conditions of actual use. A molded part shall be so constructed that it will have mechanical strength and rigidity to withstand the stresses of intended service.

34.2 Investigation of a material to determine acceptance shall include consideration of its:

a) Mechanical strength,

b) Dielectric properties,

c) Insulation resistance,

d) Tracking resistance,

e) Heat-resistant qualities,

f) The degree to which it is enclosed or protected, and

g) Any other features having a bearing on the risk of fire and electric shock involved, in conjunction with conditions of actual service such as exposure to partial discharge (corona), ultra-violet light, ozone, water, high humidity and other environmental exposure.

All of these factors are considered with respect to thermal aging. A polymeric material shall be additionally evaluated in accordance with the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

34.3 In the mounting or supporting of small, fragile, insulating parts, screws or other fastenings should not be tight enough to cause cracking or breaking of these parts with expansion and contraction.

34.4 Insulating material employed to maintain spacing between uninsulated live parts or as direct or indirect support of live parts shall be a material acceptable for the application in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and shall have a flammability classification of at least V-2.

Exception: Insulating material used in circuits over 600 V may be classified HB.

34.5 Insulating material used to insulate, support, enclose or maintain electrical spacings shall withstand the arc tracking test in Arc-Tracking Test, Section 52.

Exception: The test may be waived if:

a) The available power is not more than 15 W, and the maximum potential is not greater than 600 V; or

b) The insulating material has an established high voltage arc tracking resistance rate of 1 inch (25.4 mm) per minute or less in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

35 Spacings

35.1 General

35.1.1 Spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be in accordance with Table 35.1 at field-wiring terminals and the following equation at other than field-wiring terminals.

$$S = \frac{V^{0.59}}{176}$$

in which:

V equals the sum of the peak voltages of the parts involved, and

S equals the minimum through air and over-surface spacing in inches. (Multiply S times 25.4 to obtain S in millimeters.) See Figure 35.1 for the curve generated by the equation.

Exception No. 1: Spacing between an uninsulated live part and a metal enclosure shall not be less than 1/2 inch (12.7 mm).

Exception No. 2: Spacing between the functioning parts of the killing electrodes may be less than specified by the equation, provided:

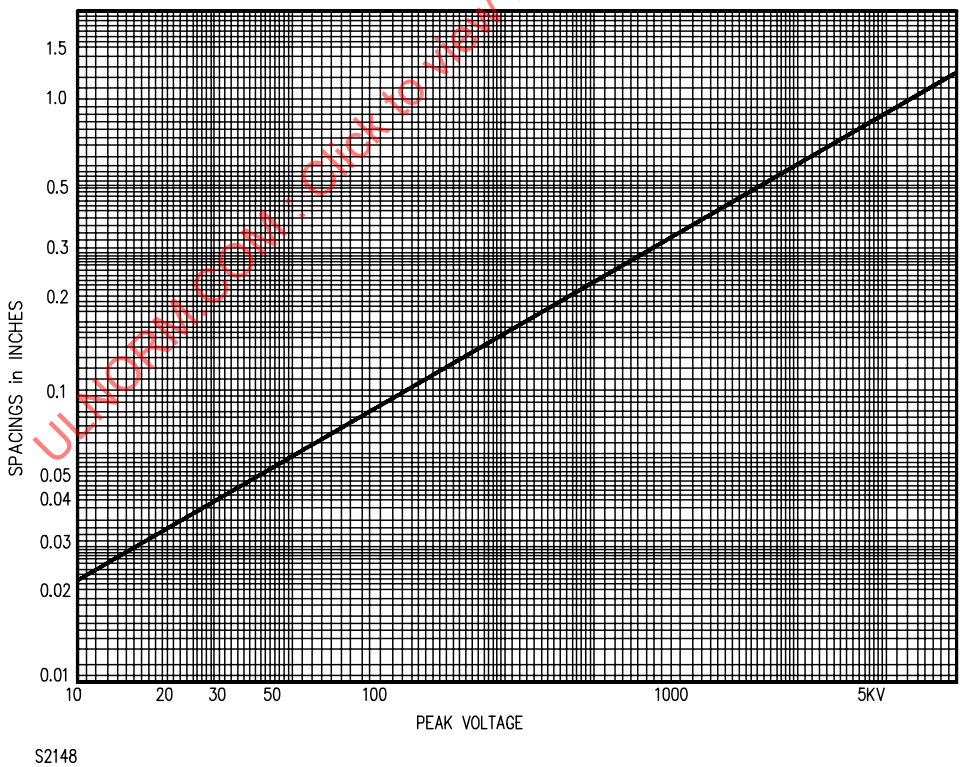
a) There is no risk of fire or electric shock, and

b) The electrodes do not form part of the enclosure.

Table 35.1
Minimum acceptable spacings at field-wiring terminals

Potential involved, volts	Over surface		Through air	
	Inches	mm	Inches	mm
0 – 150	1/4	6.4	1/4	6.4
151 – 250	3/8	9.5	1/4	6.4

Figure 35.1
Graphical illustration spacing through air and over surface at other than field-wiring terminals



35.1.2 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity and shall be judged on the basis of the sum of the voltages involved.

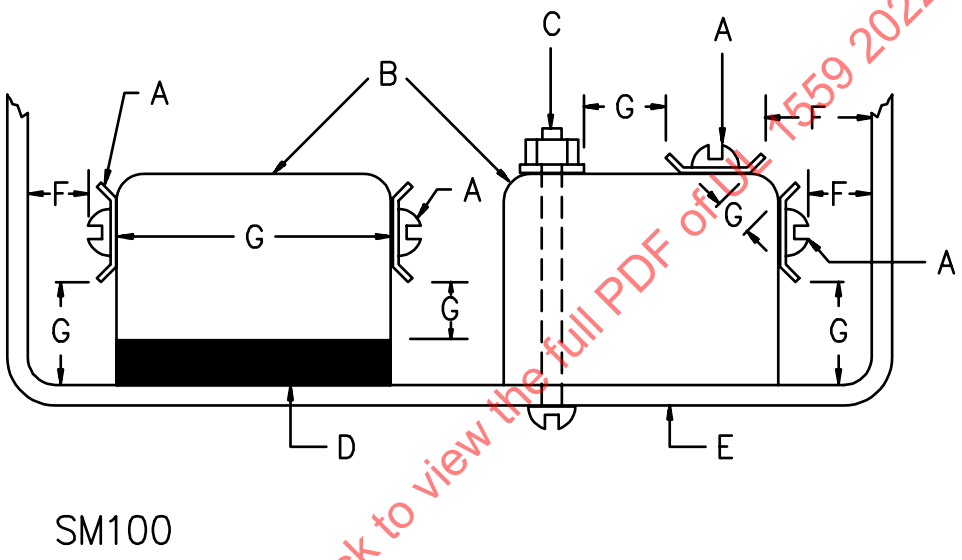
35.1.3 The spacing at a field-wiring terminal, as specified in Table 35.1, is to be measured with wire of the appropriate size for the rating connected to the terminal as in actual service.

35.1.4 Field-wiring terminals are considered to be terminals to which connections are made in the field.

35.1.5 The spacings in a component device, such as a snap switch, lampholder, or similar parts, supplied as part of insect-electrocution equipment shall not be less than the minimum spacings required for the component device or the spacings specified in 35.1.1. See Figure 35.2.

Figure 35.2

Spacings in components



SM100

A – Uninsulated live metal parts of wiring device.

B – Insulated material of wiring device.

C – Mounting screw of wiring device.

D – Dead metal parts of wiring device.

E – Dead metal parts of product.

F – Spacings to which the equation in 35.1.1 apply.

G – Spacings required for the component device.

Note: The equation for the curve is

$$S = \frac{V^{0.59}}{176}$$

in which:

V equals peak voltage and

S equals spacings in inches. See 35.1.1. For the spacing in millimeters, multiply S by 25.4.

35.1.6 A ceramic, vitreous-enamel, or similar coating is not acceptable as insulation in place of spacings unless, upon investigation, the coating is found to be uniform, of adequate minimum thickness, reliable, and otherwise acceptable for the purpose.

35.1.7 Coated-magnet wire is considered to be an uninsulated live part in determining compliance of a device with spacing requirements.

35.1.8 Insulation that is not rated for the highest of the voltages involved between the parts under consideration shall be considered uninsulated for the purpose of determining compliance with 35.1.1.

35.1.9 An insulating barrier employed in place of the spacings between uninsulated live parts of opposite polarity and between uninsulated live parts and dead metal parts, shall be acceptable for the sum of the voltages involved and moisture resistant, and shall comply with 34.4. It shall be:

a) Of adequate mechanical strength if exposed or otherwise subject to mechanical damage,

b) Reliably held in place, and

c) Located so that it will not be adversely affected by operation of the product in service – particularly arcing.

35.1.10 Spacings between live secondary circuit parts of opposite polarity, and between a live secondary circuit part and a dead-metal part may be less than the values specified by the equation in 35.1.1 if:

a) A short circuit of the parts involved will not result in a risk of fire or electric shock – see Abnormal Operation Test, Section 53,

b) There is no dielectric breakdown when tested in accordance with Dielectric Voltage-Withstand Test, Section 51, and

c) The insulating material, if any, used to maintain the spacing complies with the high-voltage arc tracking test of Arc-Tracking Test, Section 52.

36 Transformers

36.1 An isolating transformer shall be employed to energize the insect killing electrodes.

36.2 There shall be no electrical connection between primary and secondary windings of a transformer.

36.3 The transformer shall have a single secondary winding that may be tapped, or may have two or more secondary windings that are electrically interconnected.

36.4 Coils shall be constructed to provide insulation between the primary and secondary windings, and between the windings and dead metal parts.

36.5 Insulation between windings and between the windings and the core shall be electrical grade paper, polymeric, or other acceptable material. The insulation shall be acceptably resistant to moisture and have dielectric and thermal properties acceptable for the application. The film coating on the magnet wire alone is not acceptable for this application.

37 Edison-Base Lampholders

37.1 An Edison-base lampholder employed in insect-electrocution equipment shall comply with Section 14, Light Sources and Associated Components.

37.2 An Edison-base lampholder used in equipment intended for outdoor use shall have a body of porcelain or molded composition. The porcelain body shall be glazed. Absorptive insulating material, such as untreated fiber, shall not be employed.

37.3 An Edison-base lampholder shall not incorporate a switching mechanism, if it is intended for outdoor use.

37.4 An Edison-base lampholder having an aluminum screwshell shall not be used in equipment intended for outdoor use.

37.5 An Edison-base lampholder shall be wired so that the screw shell is connected to the grounded (white) conductor of the supply circuit.

Exception: A lampholder is not required to be connected as indicated above, if it is connected to a double-pole interlock switch or the equivalent that disconnects the lampholder from the power supply during servicing.

38 Fluorescent Lampholders and Starter Holders

38.1 The fluorescent lampholder and the starter holder for fluorescent lamps shall comply with Section 14, Light Sources and Associated Components.

38.2 A fluorescent lampholder shall be of a type acceptable for use with the ballast and type of lamp employed.

38.3 A fluorescent lampholder and starter holder provided on insect-electrocution equipment intended for outdoor use, shall be a weatherproof type.

Exception: A non-outdoor use type holder may be employed if it is protected by an enclosure, and is constructed of moisture resistant insulating material. Absorptive materials, such as untreated fiber, shall not be used.

39 Fluorescent Lamps and Lamp Ballasts

39.1 Fluorescent lamp ballasts

39.1.1 A fluorescent lamp ballast shall be acceptable for the application, and shall comply with the Section 14, Light Sources and Associated Components requirements in the Standard for Fluorescent Lamp Ballasts, UL 935.

39.1.2 A fluorescent lamp ballast employed in insect-electrocution equipment intended for outdoor use shall be a Type 1, Type 2 or weatherproof ballast.

Exception: Ballasts of other than Type 1, Type 2, or weatherproof may be employed if they are acceptably enclosed and tested in accordance with 55.2 and 55.4.

39.2 Fluorescent lamps

39.2.1 A fluorescent lamp shall be of the type for which the ballast is intended.

39.3 Lamps that emit ultraviolet (UV) radiation

39.3.1 Insect-electrocution equipment shall not employ lamps designed to emit ultraviolet (UV) radiation in wavelengths less than 250 nm. Incidental UV radiation in wavelengths less than 250 nm is allowed provided that the radiation shall not exceed an effective irradiance level greater than 1% of that generated in the 300-400 nm bands. Care shall be taken in measuring spectral irradiance at wavelengths below 300 nm to exclude instrument noise, which may give an erroneous indication of UV-C radiation. See 64A.4 for proper measurements and good laboratory practice.

40 Printed Wiring Boards

40.1 A printed wiring board that directly or indirectly supports live parts shall comply with Section 19, Printed Wiring Boards.

40.2 A printed wiring board that directly or indirectly supports live parts shall be rated minimum V-1.

40.3 A component mounted on a printed wiring board shall be soldered, welded or otherwise securely connected. A soldered connection shall be mechanically secured before soldering. Integral leads of a small component such as a resistor, capacitor, and inductor, may be inserted through holes in the printed wiring board and soldered.

40.4 A small component on a printed wiring board, such as a resistor, capacitor and inductor, that is in the user's serviceable area shall be so protected against any displacement that is likely to involve a risk of electric shock or fire.

40.5 Spacings between uninsulated live parts on a printed wiring board shall be in accordance with the requirements in Spacings, Section 35.

41 Capacitors

41.1 A capacitor, its enclosure, or both shall preclude emission of flame from the enclosure of the product in the event of malfunction of the capacitor or some component in surrounding circuitry.

41.2 The voltage rating of a capacitor shall not be less than the maximum steady-state potential to which the capacitor is subjected during operation of the equipment at rated voltage.

41.3 A liquid-electrolyte, metallized-film, or conductive-foil type electrolytic capacitor connected in a circuit capable of delivering more than 15 W of power, and having a diameter of more than 0.39 inch (10 mm), shall be provided with a means of relieving excessive internal pressure.

42 Switches

42.1 A switch shall have a rating adequate for the application and shall be properly secured.

42.2 Through cord switches and pendant switches shall not be provided with insect-electrocution equipment intended for outdoor use.

42.3 A manually operated switch other than those indicated in 42.2, if provided with outdoor insect-electrocution equipment, shall be protected against high humidity and water.

42.4 A single-pole switch, if in a primary circuit, shall be connected to the ungrounded conductor only.

43 Protective Devices

43.1 An overcurrent or thermal protective device shall be of a type acceptable for the application and designed for the purpose of overload protection.

43.2 A manual reset protective device or a fuse that is intended for resetting or replacement by the user shall be in a readily accessible location.

43.3 The resetting or replacement of a protective device shall not result in risk of electric shock, fire, or injury to persons.

43.4 A protective device provided in insect-electrocution equipment intended for outdoor use shall be enclosed to protect it against the weather.

43.5 A single-pole protective device shall be connected to the ungrounded conductor only. The screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

44 Controls – End Product Test Parameters

44.1 General

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

44.1.2 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.

44.2 Auxiliary controls

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

44.2.2 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 Section 9, Controls, is considered to fulfill this requirement.

44.3 Operating controls (regulating controls)

44.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using UL 60730-1:

a) Control action Types 1 or 2;

b) Unless otherwise specified in UL 1559, 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 IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 44.1;

e) For the applicable Material Group, see Table 44.2;

f) For the applicable Pollution Degree, see Table 44.3.

44.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using other than UL 60730-1:

a) Control action Types 1 or 2;

b) Unless otherwise specified in UL 1559, 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 44.1;

d) For the applicable Material Group, see Table 44.2;

e) For the applicable Pollution Degree, see Table 44.3.

Table 44.1
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 44.2
Material Group

CTI PLC value of insulating materials	Material group
CTI ≥ 600 (PLC = 0)	I
400 ≤ CTI < 600 (PLC = 1)	II
175 ≤ CTI < 400 (PLC = 2 or 3)	IIIa
100 ≤ 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 44.3
Pollution Degrees

Appliance control micro-environment	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

44.4 Protective controls (limiting controls)

44.4.1 An electronic control that performs a protective function shall comply with the requirements in Section 9, Controls, 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.

44.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated using 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 49;

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:

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

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

g) Thermal Cycling test in the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, Annex H, 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 49. 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 49.

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

44.4.3 The test parameters and conditions used in the investigation of the circuit covered by Clause 44.4.1 shall be as specified in 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.

44.4.4 Unless otherwise specified in UL 1559, protective controls shall be evaluated for 100,000 cycles for Type 2 devices, and 6,000 cycles for Type 1 devices, with rated current.

44.5 Controls using a temperature sensing device

44.5.1 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) or a device employed as a combination operating and protective device – 100,000 cycles.

PERFORMANCE

45 General

45.1 Representative units of the insect-electrocution equipment shall be subjected to the applicable tests described in Sections 46 – 64. Each test shall be conducted at the input voltage indicated in Table 45.1 and at the rated frequency or frequencies, unless otherwise specified.

Table 45.1
Values of test voltages

Rated voltage, volts	Test voltage, volts
105 – 120	120
Between 121 – 207	1.1 times rated voltage
208 – 240	240
Between 241 – 250	1.1 times rated voltage

46 Leakage Current Test

46.1 The leakage current of cord-connected equipment when tested in accordance with 46.2 – 46.6 shall not be more than 0.5 mA.

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

46.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually, as well as collectively, if simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for protection against electric shock as defined in Electric Shock, Section 27. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time.

46.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 cm in contact with the surface. If the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the equipment.

46.5 The measurement circuit for the leakage current measurements is to be as shown in Figure 46.1. The ideal measurement instrument is defined in (a) – (d). The meter actually used for a measurement is required only to indicate the same numerical value for a particular measurement as the defined ideal instrument. The meter used is not required to have all the attributes of the defined ideal instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 µfd.

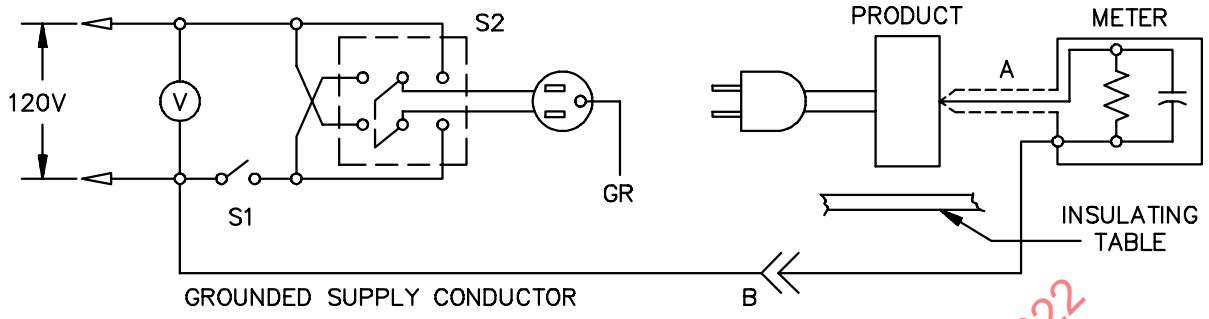
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500 ohm resistor shunted by a 0.15 µfd capacitor to 1500 ohms. At an indication of 0.5 mA, the measurement is to have an error of not more than 5 percent at 60 Hz.

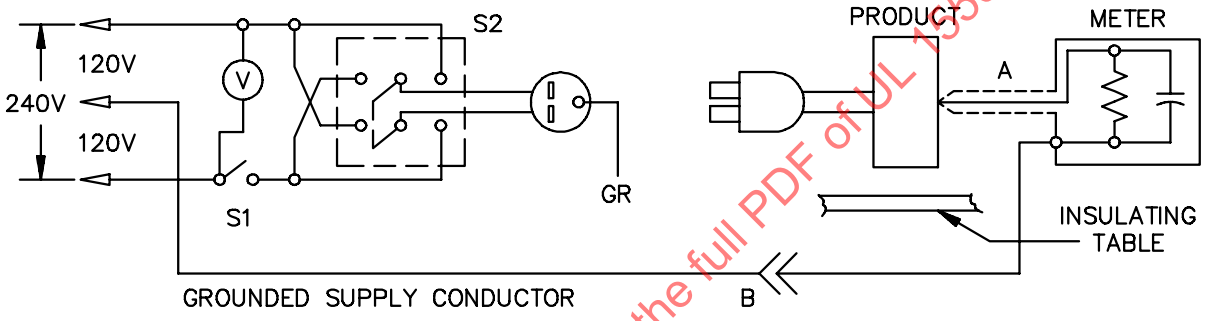
d) Unless the meter is being used to measure leakage from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

Figure 46.1

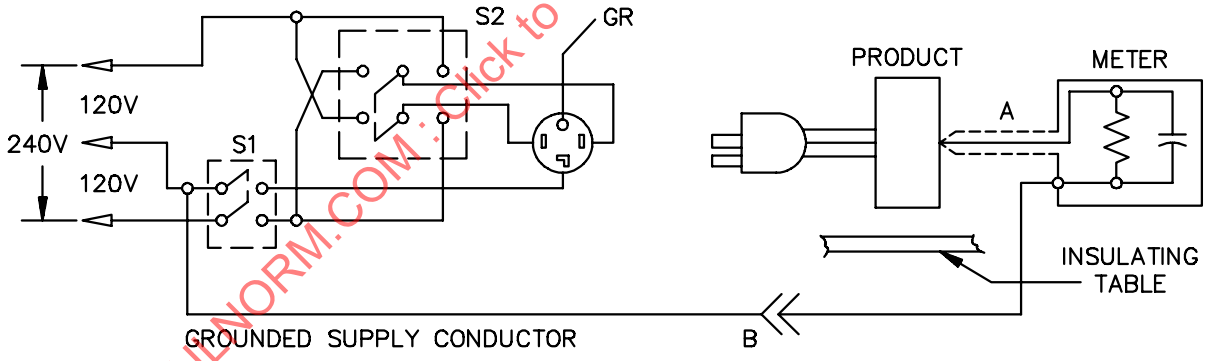
Leakage current measurement circuits



1 – Insect–electrocution equipment intended for connection to a 120–volt power supply.



2 – Insect–electrocution equipment intended for connection to a three–wire, grounded neutral power supply, as illustrated above.



3 – Insect–electrocution equipment intended for connection to a three–wire, grounded neutral power supply, as illustrated above.

LC300K

A – Probe with shielded lead.

B – Separated and used as clip when measuring from one part of insect-electrocution equipment to another.

46.6 A representative product is to be tested for leakage current starting with the as-received condition – the as-received condition being without prior energization, except as is able to occur as part of the production-line testing. The supply voltage is to be adjusted to rated voltage. The test sequence, with reference to the measuring circuit, Figure 46.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their normal operating positions.

b) Switch S1 is then to be closed, energizing the product, and within 5 seconds the leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their normal operating positions.

c) Leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

47 Input Test

47.1 The input current or power to insect-electrocution equipment shall not be greater than 110 percent of the marked rating.

47.2 To determine compliance with 47.1, the insect-electrocution equipment shall be connected to a supply source having a voltage equal to the maximum marked voltage. The input current or power is to be measured while a 500 ohm noninductive resistor is connected across the electrodes.

48 Output Test

48.1 Under any condition of loading, the current output between the electrodes shall not exceed 12 mA for cord-connected insect-electrocution equipment and 20 mA for permanently-connected insect-electrocution equipment. See 70.2.10 and 71.3.

48.2 To determine compliance with 48.1, the insect control equipment shall be connected to a supply source having a voltage in accordance with Table 45.1. A noninductive variable resistor is to be connected between the electrodes. The value of the resistance is to be varied until maximum output current is obtained.

48.3 The maximum voltage and current at the electrodes shall not exceed the marked rating, if any, by more than 10 percent. See 70.1.3.

49 Normal Temperature Test

49.1 Under any condition of operation for which it is designed, the insect-electrocution equipment shall not attain a temperature exceeding the limit for any material employed in the product. See Table 49.1.

Table 49.1
Maximum acceptable temperature rises

	Material and component parts	Degrees C	Degrees F
1.	A point on or within a terminal box or compartment of permanently wired insect-electrocution equipment on which conductors to be connected may rest, unless the equipment is marked in accordance with 71.2	35	63
2.	Varnished-cloth insulation	60	108
3.	Fuses	65	117
4.	Fiber employed as electrical insulation or as cord bushings	65	117
5.	Wood and other combustible material	65	117
6.	Surface upon which a product may be mounted in service and a surface that may be adjacent to the product when so mounted	65	117
7.	Phenolic composition employed as electrical insulation or as a part whose deterioration would result in risk of fire, electric shock, or injury to persons	125[a]	225[a]
8.	Insulated wire or cord	35[a]	63[a]
9.	Capacitor		
	Electrolytic	40[b]	72[b]
	Other types	65[c]	117[c]
10.	Sealing compound	d	d
11.	Polymeric Material	f	f
12.	Transformer coil with a Class 105 insulation system, or lamp ballast		
	Thermocouple method	65	117
	Resistance method	75	135
13.	Transformer coil with a Class 130 insulation system		
	Thermocouple method	85	153
	Resistance	95	171
14.	Selenium rectifier	50[e]	90[e]
15.	Silicon rectifier	75[e]	135[e]
16.	Surfaces subject to incidental contact during normal use		
	Metallic	45	81
	Nonmetallic	70	126

[a] The limitations of phenolic composition, and of rubber or thermoplastic insulation, do not apply to a compound that has been investigated and accepted as having special heat-resistant properties.

[b] A capacitor operating at a temperature rise higher than 40°C (72°F) may be evaluated on the basis of its marked temperature rating or, if not marked with a temperature rating, may be investigated to determine its acceptability at the higher temperature.

[c] A capacitor that operates at a temperature rise of more than 65°C (117°F) can be evaluated on the basis of its marked temperature limit.

[d] Unless a thermosetting material, the maximum sealing-compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined by the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus, ASTM E28.

[e] The limitation does not apply to a rectifier that has been investigated and accepted for a higher temperature.

[f] 25°C (45°F), unless investigated for a higher temperature.

49.2 A protective device, such as, a fuse, thermal protector, or similar measures, shall not operate during the test.

49.3 No flame or molten material shall be emitted either within or outside the enclosure of the equipment during the test.

49.4 Unless investigated and found acceptable, a supporting means formed of soft rubber or a rubber-like material is to be removed prior to the test. If the supporting means has a metal insert, such as a screw or rivet, the test is to be conducted with the product supported by the metal insert.

49.5 To determine compliance with 49.1, the unit is to be connected to a supply source of specified voltage; see Table 45.1. The product is to be operated continuously until thermal equilibrium is attained under the following operating conditions:

a) Electrodes open-circuited (normal standby condition),

b) Electrodes short-circuited,

c) Arcing between electrodes with a duty cycle of 1 second “ON” and 2 seconds “OFF”. The spark gap is to be adjusted for the maximum distance possible while maintaining the arc, and

d) A resistive load connected between the electrodes, and adjusted so as to result in the maximum input current or power.

49.6 Winding temperatures are to be measured by the resistance method. In addition, winding temperatures may be measured by thermocouples located on winding surfaces unless the coil is inaccessible for mounting of thermocouples, such as a coil embedded in sealing compound or a coil wrapped with thermal insulation. If the temperature is affected by an external source of heat, the temperature rise measured by thermocouple at a point on the surface of a coil may be 5°C (9°F) more than the indicated in items 12 and 13 in Table 49.1, if the temperature rise of the coil as measured by the resistance method is no more than that specified.

49.7 The temperature rise of a winding is to be calculated using the equation

$$\Delta t - \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise in degrees Celsius,

R is the resistance of the coil at the end of the test,

r is the resistance of the coil when the coil temperature is at a known room temperature,

t_1 is the coil temperature, and the room temperature, in degrees Celsius when r is measured,

t_2 is the room ambient temperature in degrees Celsius at the end of the test, and

k is 234.5 for copper or 225.0 for electrical-conductor grade aluminum.

49.8 All values of temperature rise in Table 49.1 are based on an assumed ambient temperature of 25°C (77°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

49.9 A short length of rubber- or thermoplastic-insulated flexible cord within the product exposed to a temperature of more than 60°C (140°F) is acceptable if supplementary insulation, acceptable for the measured temperature and of adequate dielectric properties, is employed on each individual conductor.

49.10 Except as indicated in 49.6, temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouples and the related instrument are to be accurate and calibrated in accordance with standard laboratory practice. The thermocouple wire is to conform with the requirements Special Tolerances thermocouples as

listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M. Thermocouples using iron and constantan 30 AWG (0.05 mm^2) wires are to be used with a potentiometer-type instrument whenever a referee temperature measurement by thermocouple is necessary.

49.11 A thermocouple junction and adjacent thermocouple lead wires are to be securely held in good thermal contact with the surface of the material being measured. In most cases, good thermal contact will result from securely taping or cementing the thermocouple in place, but if a metal surface is involved, brazing or soldering of the thermocouple to the metal may be necessary.

49.12 With reference to 49.5, thermal equilibrium is considered to exist if two successive readings taken at least 30 minutes apart indicate no change.

50 Abnormal Temperature Test

50.1 The electrode transformer windings, under a condition of continuous arcing of the secondary, shall not have a temperature rise of more than 110°C (198°F) for Class 105 and 135°C (243°F) for Class 130 insulation when measured by the resistance method.

50.2 To determine compliance with 50.1, the product is to be connected to a supply source of specified voltage; see Table 45.1. The product is to be operated continuously until thermal equilibrium is attained during a condition of sustained arcing between electrodes. The spark gap is to be adjusted for the maximum distance possible while maintaining the arc.

51 Dielectric Voltage-Withstand Test

51.1 Insect-electrocution equipment shall withstand for 1 minute without a breakdown that could result in the risk of fire or electric shock, the application of an essentially sinusoidal potential of an appropriate frequency with the product at the maximum operating temperature reached in the temperature test:

a) One thousand volts plus twice the primary voltage (test voltage per Table 45.1) applied between the primary circuit and exposed or grounded dead-metal parts.

b) 125 percent of the maximum measured secondary-circuit voltage applied between

1) The primary and secondary circuit(s), and

2) Between a secondary circuit and exposed dead-metal parts.

c) A primary voltage applied to the ends of the primary winding of the electrode transformer with one side of the primary winding solidly connected to the enclosure. The test shall be made first with one end of the secondary, and then the other in turn, connected to the enclosure. The primary voltage shall be increased to cause a secondary voltage equal to 150 percent of the maximum normal secondary voltage.

d) One thousand volts plus twice the primary voltage (test voltage per Table 45.1) between the terminals of a capacitor used for radio-interference elimination or arc suppression in the primary circuit.

e) 150 percent of the maximum voltage obtained in normal operation between the terminals of a capacitor connected across the secondary of a transformer.

f) One thousand volts plus twice the secondary voltage applied between secondary circuit parts of opposite polarity. Both the transformer and the electrodes may be disconnected during the test, if necessary.

51.2 If one end of the electrode-transformer secondary winding is connected to the frame or enclosure, the insect-electrocution equipment shall be subjected to the following additional tests without breakdown. The test voltage shall be essentially sinusoidal of an appropriate frequency, and shall be maintained for 1 minute. The tests specified in 51.1 (b) and (c) are to be waived:

a) Twice the sum of maximum primary circuit voltage and maximum secondary circuit voltage plus 1000 V between primary and secondary circuits.

b) The electrode transformer primary winding is to be connected to a sinusoidal supply source, with one end of the primary winding also connected to a common connection of the secondary winding and the frame or enclosure. The supply voltage shall be increased so as to cause the voltage in the secondary to equal 3 times the maximum normal secondary voltage.

c) The test in (b) shall be repeated with the other end of the electrode transformer primary winding connected to the common connection of the secondary winding and frame or enclosure.

51.3 To determine if a unit complies with the requirements in 51.1 and 51.2, it is to be tested by means of a transformer of 500-VA capacity or larger, having an output voltage that is essentially sinusoidal and can be varied. The tests are to be conducted at the rated frequency, except that the test specified in 51.1(c) and 51.2 (b) and (c), is to be conducted at a higher frequency to preclude the exciting current from causing excessive heating of the transformer. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

52 Arc-Tracking Test

52.1 The insulating material referenced in 34.5 and 35.1.10 shall be subjected to the tests in 52.2 and 52.3 without increasing the risk of fire or electric shock.

52.2 The arc, using the energy available from the parts involved, is to be established between the high-voltage part and any adjacent part of different potential where breakdown is likely to occur. The arc is to be used to attempt to ignite materials forming parts of the high-voltage enclosure or to ignite materials located between the parts of different potential. The arc is to be established by means of a conductive probe. The conductive probe is to be used to break through insulation or to create arc-tracking across the surface of insulating materials. The arcing is to be continued for 15 minutes at each location. During the 15-minute period, if flaming occurs the arcing is to be stopped, and the time of flaming measured. If the flame extinguishes in less than 30 seconds, the arcing is to be reestablished and continued for a total arcing time of 15 minutes. If the material is ignited, the flame shall self-extinguish within 30 seconds.

52.3 There shall be no permanent carbon conductor path determined by the application of a dielectric voltage-withstand potential equal to twice the voltage in the circuit plus 1000 V, applied for 60 seconds between the parts involved.

53 Abnormal Operation Test

53.1 General

53.1.1 If a semiconductor device (rectifier, transistor, or similar component), or an electrolytic capacitor is provided, there shall not be a risk of fire or electric shock resulting from short-circuiting, singly, of any of these components.

53.1.2 To comply with 53.1.1, one representative unit of the insect-electrocution equipment is to be connected to a supply circuit with the appropriate voltage (Table 45.1), with the component short-circuited. Only two terminals are to be short-circuited together at one time, if there are more than two terminals on

the component. The test is to be repeated on two additional units, if it is interrupted by the opening of a component or protective device in the equipment without evidence of a risk of fire or electric shock. However, the test may be discontinued if it continues for 7 hours without evidence of a risk of fire or electric shock.

53.1.3 During the test, a user-replaceable fuse shall be replaced with a fuse having the maximum ampere rating which can be accommodated in the product.

53.1.4 During the test, the complete product is to be covered with a layer of cheesecloth. The cloth is to be bleached cheesecloth 36 inches (914 mm) wide, running 14 – 15 yd/lb (approximately 28 – 30 m/kg), and having what is known to the trade as a “count of 32 x 28” – that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 in the other direction).

53.1.5 A risk of fire is considered to exist if there is ignition of components or materials or emission of flame or molten metal.

53.1.6 Following the test in 53.1.2, the unit shall withstand a dielectric test potential equal to 1000 V plus twice the rated voltage (Table 45.1) applied for 60 seconds between the primary circuit and metal parts that may be accessible during intended use or during user servicing (lamp replacement, insect removal, and other actions).

53.2 Electronic components

53.2.1 A single malfunction (short or open) of any circuit component, such as a resistor, capacitor, solid state device, and the like shall not result in a risk of fire or electric shock or increased risk of personal injury. For a discrete, multiple (more than two) terminal device, such as a transistor, SCR, triac, or an integrated circuit device, any combination of terminals taken two at a time shall be open- or short-circuited.

Exception: Abnormal operation testing of multiple terminal circuit devices may be reduced if it can be determined by circuit analysis that an open- or short-circuit of the terminal(s) is not likely to result in a risk of fire, electric shock or injury to persons.

53.2.2 The Dielectric Voltage-Withstand Test, Section 51 need be conducted only after the last abnormal operation test unless it is necessary to replace components after conducting the other tests.

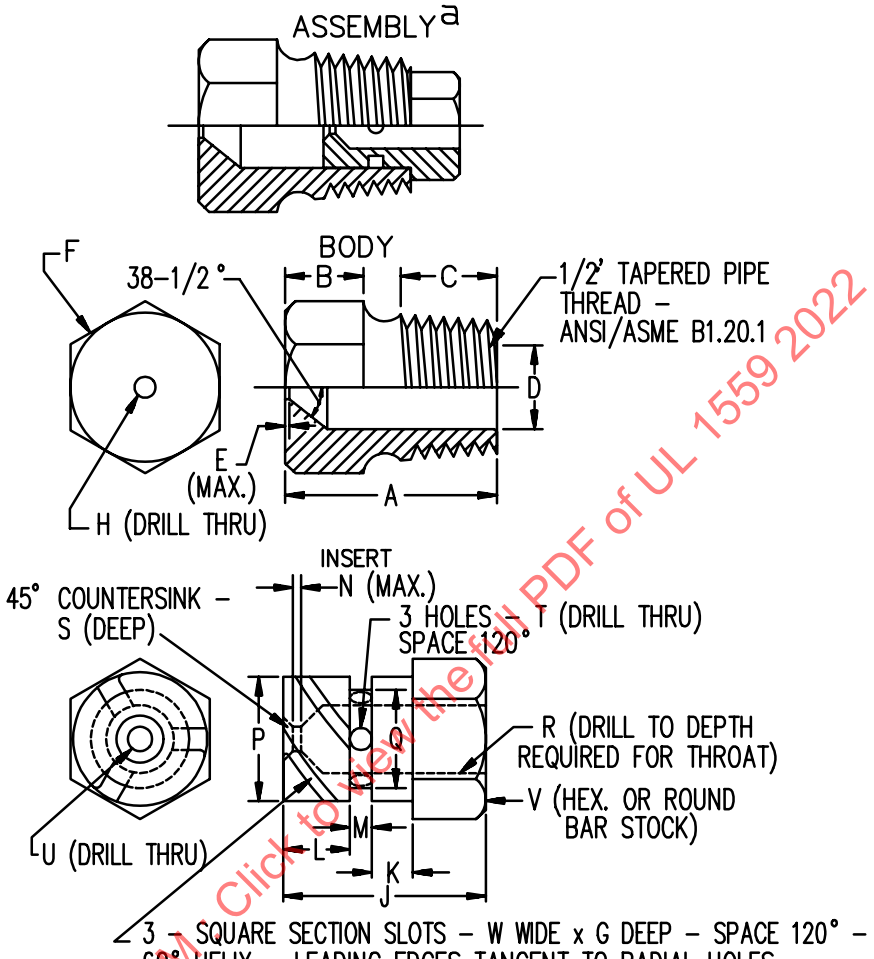
54 Water Spray Test

54.1 Insect-electrocution equipment intended for outdoor use shall be subjected to the equivalent of a beating rain on its top and sides. The spray is to be applied for 4 hours as described in 54.2. During the test the equipment is to be energized, or unenergized, whichever results in the most severe condition.

54.2 The water spray test apparatus is to consist of three spray heads constructed in accordance with the details shown in Figure 54.1 and mounted in a water-supply pipe rack shown in Figure 54.2. The water pressure is to be maintained at each spray head at approximately 5 lbf/in^2 (3500 N/m^2). The product is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water, if any, will enter it.

Figure 54.1

Spray head



Item	inch	mm	Item	inch	mm
A	1 7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35) [b]	2.80
H	(No.9) [b]	5.0	U	(No. 40) [b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain–Test Spray Heads are available from Underwriters Laboratories

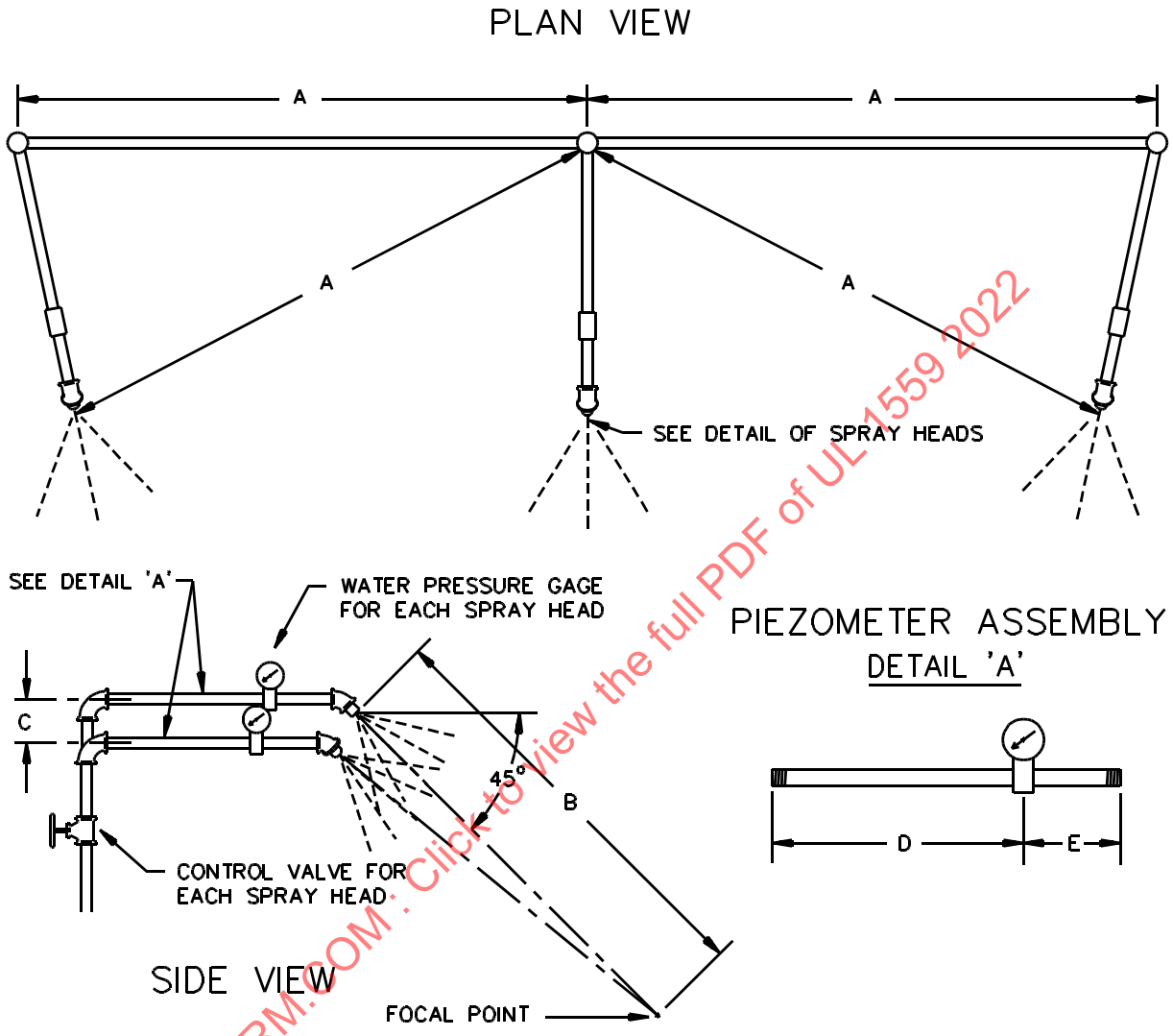
[b] ANSI B94.11M Drill Size

[c] Optional – To serve as a wrench grip.

RT100E

Figure 54.2

Water-spray piping



Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101E

54.3 After exposure to the water spray test described in 54.1 and 54.2, insect-electrocution equipment that is cord-connected shall comply with the leakage current requirements of Leakage Current Test, Section 46. Equipment not required to be tested for leakage current shall have an insulation resistance of not less than 50,000 ohms between live parts and accessible dead-metal parts. Following the leakage-current or insulation-resistance measurements, the equipment shall be tested for dielectric voltage-withstand between primary circuitry and accessible metal parts and between primary circuitry and secondary circuitry in accordance with Dielectric Voltage-Withstand Test, Section 51.

54.4 The insulation resistance is to be measured:

a) By a magneto megohmmeter that has an open-circuit output of 500 V,

b) By a voltmeter having an internal resistance of at least 30,000 ohms and using a 250-V direct-current circuit, or

c) By equivalent equipment.

54.5 Insect-electrocution equipment that employs a seal that may be adversely affected during user servicing shall be subjected to the tests in 54.1 – 54.4, after having the seal removed. See 29.6.

55 Humidity Conditioning Test

55.1 Insect-electrocution equipment shall be exposed for 48 hours to moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). Following the 48-hour period, and while still exposed to the moist air, cord-connected equipment is to be tested for leakage current in accordance with Leakage Current Test, Section 46. The insulation resistance of all other equipment is to be measured and shall not be less than 50,000 ohms.

55.2 If the insect-electrocution equipment is intended for outdoor use, a ballast of other than Type 1, Type 2, or weatherproof type, and a transformer shall be exposed for 168 hours to moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). Following the 168-hour period and while still exposed to moist air, the insulation resistance between live and dead metal parts shall be measured and shall not be less than 50,000 ohms.

55.3 Following the leakage-current or insulation-resistance measurements required in 55.1 and 55.2, the equipment is to be tested for dielectric voltage-withstand between primary circuitry and accessible metal parts in accordance with Dielectric Voltage-Withstand Test, Section 51.

55.4 The insulation resistance is to be measured:

a) By a magneto megohmmeter that has an open circuit output of 500 V,

b) By a voltmeter having an internal resistance of at least 30,000 ohms and using a 250-V direct-current circuit, or

c) By equivalent equipment.

56 Enclosure Pressure Test

56.1 The external enclosure shall withstand 20 lbf (89 N) without permanent distortion reducing spacings below the values specified in Spacings, Section 35, or transient distortion that results in contact with live parts. The force is to be applied for one minute by means of a 0.50 inch (12.7 mm) diameter rod with a hemispherical end. The acceptability of an opening that occurs during application of the force is to be determined under the requirements in Accessibility of Parts Involving the Risk of Electric Shock, Section 28.

Exception: The portion of the enclosure with the openings for insects to enter the electrode area is to be tested using 15 lbf (67 N) applied with a rod having a 1 inch (25.4 mm) square flat end.

57 Enclosure Impact Test

57.1 Insect-electrocution equipment shall not involve risk of fire, electric shock or injury to persons when subjected to the impact tests described in 57.2 – 57.5. For outdoor-use insect-electrocution equipment, impacting shall not impair the water tightness of the enclosure.

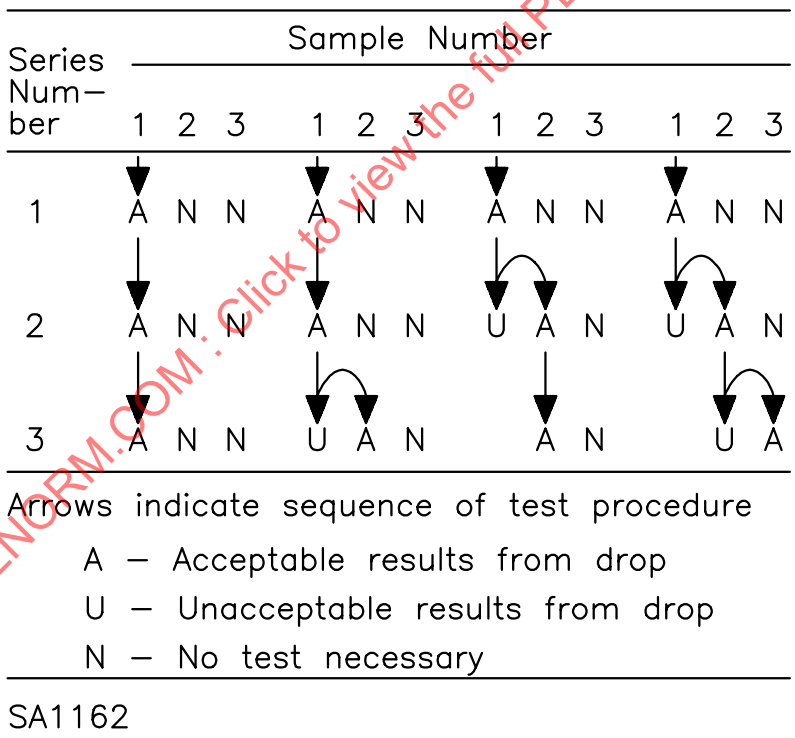
57.2 Each of three representative units of insect-electrocution equipment shall be subjected to three impacts of 5 ft-lb (6.8 J) on surfaces that are likely to be exposed to impacting during use.

Exception: If the manufacturer so elects, fewer units may be used in accordance with Figure 57.1. The overall performance is acceptable upon completion of any one of the sequences represented in Figure 57.1.

Figure 57.1

Procedures for impact tests

Each series consists of three ball impacts



57.3 The impact specified in 57.2 is to be performed by dropping or swinging as a pendulum a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 lb (0.535 kg) from the height necessary to cause the specified impact. See Figure 57.2.